Reducing CO2 emissions from drained peatlands

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Published in:
Default journal

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Document Version
Publisher's PDF, also known as Version of record

Publication date:
2008

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

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PREFACE

This report was written in the context of the master’s degree programme Energy and Environmental Sciences at the University of Groningen. It is the result of my research thesis at IVEM, the Center for Energy and Environmental Studies.

I had a nice time writing this report and presenting it to other IVEM students and staff members. During my research thesis I have learned to have more confidence in myself considering my presentation and writing skills.

I would like to thank my supervisor A.J. Schilstra, who kept me motivated for the subject and who has been a big help during the process. Also, I enjoyed the talks with him on subjects that were irrelevant for the research, such as family and music. Further, I would like to thank Wytze van der Gaast from the Foundation Joint Implementation Network (JIN) in Paterswolde for his advice and suggestions.

Altogether, I can say that my research thesis was a very good learning experience for me in terms of productiveness, time management and presentation— and writing skills. I am sure that I will benefit from this during the last part of my master programme.
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SUMMARY

The drainage of peatlands leads to the oxidation of the upper peat layer. As a result, greenhouse gas carbon dioxide (CO₂) is emitted into the atmosphere. Worldwide the drainage of peatlands results in the release of 800 million tons of CO₂ per year, thus contributing substantially to global warming.

The Kyoto Protocol to the United Nations Framework Convention on Climate Change could offer a solution to this problem, since this Protocol aims to reduce greenhouse gases (GHG’s) such as CO₂ by setting legally binding emission reduction targets for countries. In theory, the restoration of drained peatlands (by rewetting) could be applied under the Kyoto Protocol since this reduces the emitted CO₂. However, this has not been done whatsoever.

In this research, it was analyzed whether it is possible to use the restoration of drained peatlands under the Kyoto Protocol. Further, the potential of peatland restoration projects under the Kyoto Protocol was examined. The Republic of Belarus was chosen to serve as an example of what the restoration of drained peatlands could mean under the Kyoto Protocol. Because the largest share of peatlands in Belarus was drained for agricultural purposes, this research focuses on the restoration of those peatlands only.

It was concluded that the restoration of drained peatlands is in fact allowed under the Kyoto Protocol as a revegetation activity, which falls under Article 3.4 of the Protocol. Considering the Republic of Belarus, peatland restoration has great potential under the Kyoto protocol. Belarus could profit from peatland restoration under the Joint Implementation and emission trading mechanisms of the Kyoto Protocol. Further, the costs of reducing emissions per ton CO₂ are very low compared to other CO₂ reducing projects. Besides the reduction of CO₂, there are also several other environmental benefits associated with the restoration of drained peatlands.

However, although the restoration of drained peatlands can be implemented under the Kyoto Protocol, there are some problems associated with this. Especially concerning the greenhouse gas methane (CH₄). The restoration of a drained peatlands not only results in a reduction of CO₂ emissions, it also results in the release of methane due to anaerobic decomposing processes that start after rewetting. Since both these GHG’s need to be accounted for under the Kyoto Protocol, this can result in a problem considering the Kyoto commitment period 2008-2012; the period in which countries need to achieve their emission reduction target.

Due to increasing CH₄ emissions in the beginning of the peatland restoration process, a peatland restoration project may result in a higher warming effect than a drained peatland has. Even though it is very likely that eventually a peatland restoration project will result in positive effect on the climate (cooling effect), it is not certain whether this will be before or after the Kyoto commitment period. This depends on several factors such as the moment of time that the project was started, the height of the water level, the type of peat and the location. If a peatland restoration project has a warming effect during the Kyoto commitment period than such projects may be useless for countries considering implementation under the Kyoto Protocol. This problem should be remedied in the post-Kyoto protocols.

It should not be forgotten, however, that the restoration of drained peatlands results in many other benefits besides CO₂ emission reduction. It is a fact that peatlands are unique ecosystems with several important functions. Therefore, even if it turns out to be useless under the Kyoto protocol, the restoration of drained peatlands should be implemented anyway and needs to get more attention in environmental policies.
1 INTRODUCTION

1.1 Linking peatlands, climate and Kyoto

Peatlands are a unique type of wetland that can be found all over the world. Peatlands are important ecosystems for many reasons; they are essential for characteristic plant and animal species and for water quality (Maltby & Proctor, 1996). Also, they are important to human communities because of their social, economic and cultural values (Costanza et al., 1997; Joosten & Clarke, 2002). However, many peatlands are severely threatened by human actions such as mining for fuel and drainage for forestry or agricultural purposes. Especially the drainage of peatlands has been, and still is, a major threat to peatlands (Holden et al., 2004).

The drainage of peatlands results in severe degradation of peatlands; it causes the loss of unique wildlife habitats and a disturbance in the water regime. Drainage also causes peatlands to lose their ability to store carbon (Armentano & Menges, 1986).

In undisturbed state peatlands act as carbon sinks, storing over thousands of years huge quantities of carbon from the atmosphere. Drainage promotes rapid oxidation of the stored carbon and the consequence of this is the release or emission of carbon dioxide (CO$_2$) into the atmosphere (Martikainen et al., 1995; Moore & Knowles, 1989). The emission of CO$_2$ from drained peatlands can happen either slowly due to decomposition, or fast in the case of fires. Peat fires occur mostly in the tropics, whereas slow decomposition is often the case in the more northern peatlands.

The atmospheric gas CO$_2$ is a greenhouse gas (GHG) and the emission of greenhouse gases is not without consequences. According to the Intergovernmental Panel on Climate Change (IPCC), concentrations of GHG’s in the atmosphere have increased significantly due to human activities and this has resulted in global warming (IPCC, 2007d). The consequences of global warming can be catastrophic; coastal areas will possibly flood as a result of the rising sea level, major droughts will occur more frequently and weather conditions will become more extreme (IPCC, 2007d). The drainage of peatlands contributes to the global warming phenomenon, and it is therefore of importance to find a solution for this.

One of the solutions may lie in the Kyoto Protocol. The Kyoto Protocol is part of the United Nations Framework Convention on Climate Change (UNFCCC), which has the objective to combat climate change by stabilizing greenhouse gas concentrations such as CO$_2$ in the atmosphere (UNFCCC, 1992). The Kyoto Protocol tries to achieve this by making emission reduction commitments legally binding for any party that ratifies the Protocol. However, in the case of reducing CO$_2$ emissions from drained peatlands, the Kyoto Protocol has not shown to be effective. Why it is not working is unclear.

The restoration of drained peatlands would be a reasonable option under the Kyoto Protocol for more than one reason. Apart from ending the oxidation of the upper peat layer, restoration would lead to a CO$_2$ uptake which can contribute to fulfilling a Party’s Kyoto commitment. Further, it would also have other beneficial effects such as the return of plant and animal species or better water quality in the restored area. However, the restoration of drained peatlands is not applied under the Kyoto Protocol whatsoever.

Possible explanations for this may lie in the rules of the Kyoto Protocol or in their implementation. The articles of the Protocol may contain gaps or perhaps countries do not recognize the fact that it is possible to use the restoration of drained peatlands for their emission reduction commitment under the Kyoto Protocol. Further research is required in order to find out whether the Kyoto Protocol could nevertheless be an effective instrument in reducing the CO$_2$ emissions from drained peatlands.

In this research, drained peatlands in the Republic of Belarus will be used as an example of what peatland restoration could mean under the Kyoto Protocol. In the next paragraph the aim of the research, the method and the choice for Belarus are explained.
1.2 Aim of this study

Drainage of peatlands results in the degradation of these peatlands and the emission of CO$_2$, a greenhouse gas that contributes to global warming. The Kyoto Protocol aims to reduce the concentrations of GHG’s in the atmosphere and could offer a possible solution for the problems considering drained peatlands. The Kyoto Protocol could serve as a motivation for the restoration of drained peatlands because this would result in several benefits: the CO$_2$ emission reduction achieved by restoration can be reported under the Kyoto Protocol and various other important functions of peatland ecosystems are restored and preserved at the same time. However, the Kyoto Protocol has not yet been proved to be an effective instrument for the reduction of CO$_2$ emissions from drained peatlands. Why it is not effective or working is unclear (Schilstra, 2006a), and therefore an analysis is required. This leads to the following research question.

1.2.1 Research question

In summary the main research question is:
“Why has the Kyoto Protocol not yet been proved to be an effective instrument in reducing the emissions of CO$_2$ from drained peatlands?”

1.3 Method

In order to give an adequate answer to the research question, a literature study was performed and experts were consulted. The gathered information was analyzed on why the Kyoto Protocol is not working for the reduction of CO$_2$ from drained peatlands.

In this research the Republic of Belarus will play a special role. This country has been selected to serve as an example of what it could mean for a country when the restoration of drained peatlands is used to meet the commitments under the Kyoto Protocol. The criteria for the choice of Belarus are discussed below.

1.3.1 Belarus as a case

The Republic of Belarus (short: Belarus) is a landlocked nation-state in Eastern Europe, which borders Russia, Ukraine, Poland, Lithuania, and Latvia (see Figure 1-1).

![Figure 1-1: The Republic of Belarus](http://www.globalsecurity.org/military/world/belarus/maps.htm)

This research will focus specifically on the Republic of Belarus because of a number of criteria. First of all, this country is covered for 14.2 % by peatlands, compared to approximately 3.4% for the globe on average (Joosten & Clarke, 2002). Secondly, many countries in the world deal with continued drainage of peatlands and the negative consequences of this. The Republic of Belarus is an important example of this (UNDP, 2004). Because the largest share of drained peatlands in Belarus are (or were) used in
the agricultural sector, the focus in this research will be on those peatlands and not on drained peatlands in for example the forestry or energy sector.

And thirdly, the Republic of Belarus is listed in Annex I of the Kyoto Protocol, which means that Belarus signed the protocol. However, at the time when Belarus signed the Protocol it was not included in the Protocol’s Annex B, which contains the nations with an emission reduction commitment. Only since November 2006, Belarus has been included in Annex B of the Kyoto Protocol. The Republic of Belarus now has an emission reduction target of 8%, taking the year 1990 as the base year and it is highly likely that Belarus will meet this target in the Kyoto commitment period 2008-2012 (Grebenkov, 2006). The inclusion of Belarus in Annex B makes it possible for this country to intensify its activities in combating climate change.

For the above reasons, the Republic of Belarus will be used as a case of a more general problem considering drained peatlands.
2 PEATLANDS

Peatlands are a type of wetlands that can be found on all continents. In total they cover about 400 million hectares of land or 3% of the Earth's terrestrial and freshwater surface (Joosten & Clarke, 2002).

2.1 What are peatlands?

Peatlands are ecosystems where the production of biomass exceeds its decomposition (Quinty & Rochefort, 2003). The result is the slow accumulation and storage of dead organic matter underneath the living surface. This unique feature can take place because of waterlogged conditions (Joosten & Clarke, 2002); the lack of oxygen prevents micro-organisms from rapidly decomposing the dead plants.

Of particular importance in peat accumulation are *Sphagnum* mosses (Laine & Vasander, 1996). *Sphagnum* moss has specific characteristics that allow it to play a major role. *Sphagnum* mosses have the ability to retain water and because of this, they contribute directly to the maintenance of water-logged conditions in peatlands. *Sphagnum* mosses are also very efficient at absorbing and keeping nutrients and this makes them very harsh competitors against other plant species (Quinty & Rochefort, 2003). *Sphagnum* mosses grow a few centimetres a year in height, but because of the subsequent decomposition and compaction processes, the rate of accumulation of peat is only about 0.5 to 1 mm per year (Quinty & Rochefort, 2003). Thus, deep peat deposits are the result of thousands of years of accumulation of organic matter.

2.2 The importance of peatlands

Peatlands have been globally recognized as one of the most valuable types of natural habitats (Joosten & Clarke, 2002). Several functions of peatlands make them such valuable ecosystems.

First, the biogeochemistry of peatlands is of great importance for the gas composition of the atmosphere (Martikainen, 1996). Though northern (boreal and subarctic) peatlands occupy only about 2.5% of the global terrestrial surface, they contain up to about 32% of the total organic carbon of the world’s soils (Armentano & Menges, 1986; Gorham, 1991). Since the last glacial period, which ended about 10,000 years ago, 300-455 Pg carbon has accumulated in these northern peatlands. This corresponds to 20-30% of the global soil carbon pool and 40-60% of the atmospheric carbon pool (Gorham, 1991). The accumulation of carbon in peatlands has thus removed a great amount of the greenhouse gas CO\(_2\) from the atmosphere.

Peatlands play an important role in biodiversity as well. Since peatlands are such unique ecosystems, they provide habitats for many characteristic plant and animal species (Maltby & Proctor, 1996). Also, peatlands are important for water regulation. By storing water, peatlands act as buffers in case of heavy rainfall (Quinty & Rochefort, 2003). Further, peatlands are of importance to human communities. Peatlands are used by humans for many different purposes; for agriculture, forestry, energy production (peat extraction), industry, pollution control, recreation and tourism, nature conservation and research (Joosten & Clarke, 2002).

Yet, the use of peatlands by humans is not without consequences. The effect of human pressure on peatlands is elaborated further in the next paragraphs, where the Republic of Belarus is used as an example of a country that struggles with managing peatlands in a sustainable way.
2.3 Human pressure on peatlands

Though peatlands are considered extremely important and valuable for many reasons, they are also one of the most threatened types of ecosystems in the world. Especially the drainage of peatlands has been (and still is) one of the largest threats to peatlands worldwide (Joosten & Clarke, 2002). Since 1800, the area of peatlands worldwide has already been reduced significantly due to human pressure. Many European countries have a history of extensive peatland drainage including The Netherlands, Finland, Russia, Ireland, Germany and the UK (Holden et al., 2004). The Republic of Belarus is also an example of a country that has applied peatland drainage in the past and struggles with the consequences (UNDP, 2004).

2.3.1 Peatland drainage in Belarus

In the early 1960s, natural peatlands covered a total of 2,399,000 hectares (ha) or 14.2% of the Republic of Belarus. However, large-scale drainage during the Soviet period (1950-1990) decreased the number of natural peatlands in Belarus by more than half (UNDP, 2004). In the first couple of years after drainage, the productivity on the drained Belarusian peatlands was high. However, this situation has changed dramatically over the last decade (UNDP, 2004). The repeated use of drained peatlands in agriculture required the introduction of fertilizers and implementation of complex mechanisms to regulate the water levels and this has led eventually to the over-drying and degradation of many peatlands in Belarus (UNDP, 2004). Today, many of these peatlands are still used in agriculture, though ineffectively, whereas others have been abandoned because they have become useless due to severe degradation. About 1,345,000 ha of peatlands in Belarus, equalling 6.4% of the country, have still remained in their natural state (UNDP, 2004). Several environmental problems are associated with drainage of peatlands (Holden et al., 2004), as explained next.

2.4 Impact of drainage on the environment

Undisturbed peatlands are characterized by high water levels and nutrient poor conditions (Joosten & Clarke, 2002). These specific circumstances make them very sensitive; activities such as drainage can cause severe damage to these vulnerable ecosystems.

2.4.1 Carbon dioxide emissions

Peatlands act as sources and sinks of different gases, of which the most important are carbon dioxide (CO\textsubscript{2}) and methane (CH\textsubscript{4}), both greenhouse gases (GHG’s). Under natural circumstances peatlands are a carbon sink; they bind and store atmospheric carbon (CO\textsubscript{2}) through peat accumulation and plant growth. In contrast to CO\textsubscript{2}, natural peatlands are emitters of CH\textsubscript{4} due to anaerobic decomposition processes (Martikainen, 1996).

However, when peatlands are drained the peat becomes exposed to air, resulting in the oxidation of the upper peat layer. The consequence of this is an altering in the GHG fluxes. It has been shown in several studies that after drainage, CO\textsubscript{2} emissions tend to increase, while those of CH\textsubscript{4} decrease (Martikainen et al., 1995; Moore & Knowles, 1989). According to the Intergovernmental Panel on Climate Change (IPCC), the increase of CO\textsubscript{2} in the atmosphere, due to human activities, is the most important cause of increasing temperatures on Earth (IPCC, 2007d). Climate change and the consequences of global warming are further elaborated in chapter 3.

The drained peatlands of Belarus contribute to the emission of CO\textsubscript{2} and consequently to climate change. According to the estimates of the Institute of Problems of the Use of Natural Resources and Applied Ecology of the National Academy of Sciences, one hectare of a Belarusian drained peatland currently emits 5.5 to 22.0 tons of CO\textsubscript{2} annually (UNDP, 2004). Together, these drained peatlands release millions of tons CO\textsubscript{2} into the atmosphere each year.
2.4.2 Land degradation

As stated before, drainage causes the oxidation of the upper peat layer which leads to the degradation of peatlands. In the southern part of Belarus, currently about 1.5 million ha of peat soils are used in agriculture (UNDP, 2004). The destruction of these peatlands by drainage is huge; around 200,000 ha of such agricultural peat soils have completely turned from peatlands into sands and a large anthropogenic desert is now establishing itself in the southern parts of Belarus (UNDP, 2004).

2.4.3 Loss of biodiversity

Peatlands, once drained and degraded, are a direct cause of biodiversity loss at both species and habitat levels (UNDP, 2004). In Belarus, populations of rare fauna and rare flora declined because the drainage of peatlands resulted in fragmentation of their habitats; for example 11 plant species in Belarus have already disappeared because of the large scale drainage (UNDP, 2004). Today, the area of degraded and abandoned peatlands resulting from drainage is still growing, declining the populations of threatened plant species even further.

2.4.4 Impact on water and increased risk of fires

Peatlands play an important role in water flow regulation and water quality. Drainage results in a disturbance of the water regime. It changes the microclimate and can increase the run-off of nutrients and minerals into rivers and lakes, resulting in increasing eutrophication (UNDP, 2004). Further, due to a significant drop in the groundwater table, drained and degraded peatlands can contribute to an increased risk of fire overall. Not only do peat fires result in an increase of CO$_2$ emissions, it causes the loss of ecosystems and habitats as well. On a yearly basis, from 4,000 to 12,000 ha of drained peatlands and surrounding forests and other habitats are destroyed by fire in Belarus (UNDP, 2004). Also, peat fires are a critical problem in the Chernobyl-affected areas, because fires can result in substantial releases of radioactive materials into the atmosphere.

2.5 Peatland restoration

Successfully restored peatlands should be self-sustaining and start accumulating peat again without further human intervention (Quinty & Rochefort, 2003). The restoration of drained peatlands has two specific objectives (Holden et al., 2004; Quinty & Rochefort, 2003):

- Rewetting harvested sites by re-establishing a high water table, and;
- Re-establishing a plant cover dominated by peat forming species such as Sphagnum mosses.

These two objectives can not be separated from each other; since Sphagnum is essential for peat growth and restoration, water tables must be maintained at a high level without great fluctuation (Schouwenaars, 1993). Where drainage has resulted in water table lowering and changes to peat properties there is the need to reconstruct the water storage capacity of the peat in order to allow Sphagnum to re-grow and survive.

The primary aim of the management of drained peatlands is normally to minimize water loss through a strategy of ditch blockage (Holden et al., 2004). Nevertheless, in many cases, it is necessary to provide additional water (of sufficient quality) during the growing season and this requires a more intensive restoration approach than simply blocking ditches. Creating terraces or polders is one such method that can retain sufficient water to avoid excessive drying in summer. Shallow basins bulldozed into the peat have a similar effect.

A less intensive approach is the use of companion species (e.g. Eriophorum) or a straw mulch, whose shading and shelter reduce evaporation losses or otherwise protect Sphagnum diaspores on the surface (Price et al., 2003).
3 CLIMATE CHANGE

According to the Intergovernmental Panel on Climate Change (IPCC), the concentrations of various greenhouse gases (GHG’s) have increased significantly since 1750, resulting in a higher mean global temperature (IPCC, 2007d).

3.1 Human influence on the Earth’s climate

Human actions such as agricultural activities, burning fossil fuels and land-use change produce GHG’s which are emitted into the Earth’s atmosphere. In Figure 3-1 is shown that since the beginning of the industrial revolution (around 1750), the atmospheric concentrations of important GHG’s (carbon dioxide, methane and nitrous oxide) have risen significantly (IPCC, 2007a).

The consequence of the rising concentrations of GHG’s in the atmosphere, in particular CO$_2$, is an increase in the heat retaining capacity of the atmosphere. It is very likely that human activities that produce GHG’s enhance the Earth’s natural greenhouse effect and consequently influence the Earth’s climate. An important indicator of global climate change is the mean global surface temperature and as shown in Figure 3-2 this temperature has increased rapidly since 1980.
According to the IPCC, this global warming can not be entirely explained by natural fluctuation of the climate systems. The observed increase in mean global temperature is related (at least to some extent) to the growth of GHG emissions by human activities (IPCC, 2007d). The possible consequences of global warming are briefly discussed in the next paragraph.

3.2 Consequences of global warming

One result of the higher global temperature is a rise in sea level due to thermal expansion of sea water and the melting of glaciers and land-locked ice masses. Already new data show that losses from the ice sheets of Greenland and Antarctica have very likely contributed to sea level rise over 1993 to 2003 (IPCC, 2007d). Global warming can result in severe problems on continental and regional scale. The rising sea level can cause coastal areas to flood and weather conditions can become more extreme. Heat waves and droughts have already been observed more frequent and also heavy precipitation events have increased over most land areas (IPCC, 2007d). Other possible consequences of global warming can be the expansion of disease carriers, such as malaria mosquitoes, or the extinction of vulnerable species that are unable to adapt to the changing climate.

3.3 International action: the UNFCCC

In response to the growing concerns that anthropogenic GHG emissions were influencing the Earth’s climate, most nations of the world joined together at the Rio Earth summit of June 1992 to sign the United Nations Framework Convention on Climate Change (UNFCCC). This treaty was one of the first international attempts in combating climate change and included a legally non-binding, voluntary promise that the major developed nations would reduce their greenhouse gas emissions to 1990 levels by the year 2000. Further, all nations would undertake voluntary actions to measure, report, and limit greenhouse gas emissions (Fletcher, 2005).

3.3.1 Additional measures: the Kyoto Protocol

However, it soon became apparent that major nations such as the United States and Japan would not meet their voluntary stabilization targets by 2000. Negotiations began on a protocol with more powerful and legally binding measures and during the third Conference of the Parties (COP-3) in December 1997 in Kyoto, Japan, a number of nations approved an addition to the UNFCCC treaty: the Kyoto Protocol. The details of the Kyoto Protocol are explained in chapter 4.
4 THE KYOTO PROTOCOL

In 1997 the UNFCCC was supplemented with the Kyoto Protocol. This protocol was adopted during the third Conference of the Parties (COP-3) in December 1997 in the city Kyoto, Japan, hence the name Kyoto Protocol.

4.1 Status of ratification

The Kyoto Protocol opened for signature on March 16, 1998. However, to enter into force, the Protocol needed to be ratified by at least 55 Parties to the UNFCCC, including Annex I Parties whose combined 1990 emissions of CO₂ accounted for 55% of the Annex I total. In the United States of America, neither the Clinton administration nor the Bush administration ratified the Kyoto Protocol. The Bush administration rejected the protocol in March 2001 (Fletcher, 2005). For a long time it depended on Russia whether the Kyoto Protocol would come into force or not. On November 5th 2004 Russia ratified the Protocol and on February 16th 2005 it finally came into force (Fletcher, 2005). The Kyoto Protocol now covers more than 160 countries globally and over 55% of global greenhouse gas emissions (http://unfccc.int).

4.2 Basis of the protocol

The Kyoto Protocol aims to regulate the decrease of the emission of CO₂ and five other greenhouse gases; N₂O, CH₄, HFC, PFC and SF₆. In order to decrease the emission of these gases, the Protocol sets legally binding emission reduction targets for countries that ratify the Kyoto Protocol. Counties may reduce their emissions by decreasing their fossil fuel consumption and by managing terrestrial carbon sinks (Roulet, 2000).

In the Kyoto Protocol, countries are separated into two main groups: the Annex I Parties and the non-Annex I Parties. The Annex I Parties are those countries that have ratified the Protocol and committed themselves to individual legally binding greenhouse gas emission reduction targets. Annex I Parties include the industrialized countries, plus countries with economies in transition, including the Russian Federation, the Baltic States, and several Central and Eastern European States. The individual targets for Annex I Parties are listed in the Kyoto Protocol’s Annex B. These add up to a total cut in greenhouse gas emissions of at least 5% from 1990 levels in the commitment period 2008-2012. The Kyoto Protocol does not contain emission reduction targets for the non-Annex I countries, which are mostly developing countries.

The Kyoto Protocol recognizes that the costs of limiting emissions can vary considerably from region to region. Nevertheless, the benefit for the atmosphere is the same wherever the action is taken (http://unfccc.int). Therefore, the flexibility mechanisms of the Kyoto Protocol enable Parties to reduce emissions or to remove carbon from the atmosphere in other countries.

4.3 Flexibility mechanisms

The Kyoto Protocol defines three flexibility mechanisms: Joint Implementation (JI), the Clean Development Mechanism (CDM) and emission trading (Sijm et al., 2000).

4.3.1 Joint Implementation

Under Article 6 of the Kyoto Protocol the Joint Implementation (JI) mechanism is described. The JI mechanism enables Annex I countries to reduce their emissions by investing in Joint Implementation projects that take place in another Annex I country. JI projects generate Emission Reduction Units (ERUs). The host country (the country in which the project takes
place) will transfer the ERUs to the investing country, which helps the investing country achieving its Kyoto target.

The number of credits that a JI project generates depends on the baseline scenario. This scenario stands for the amount of emissions that would occur without the JI project. JI projects will start generating credits in 2008, although the projects themselves may begin earlier. In chapter 6, the JI mechanism is described more detailed.

4.3.2 Clean Development Mechanism

The Clean Development Mechanism (CDM) is proposed under Article 12 of the Kyoto Protocol. CDM has much in common with Joint Implementation. However, the most important difference between them is that the host countries of JI are Annex I countries, whereas those of CDM projects are non-Annex I countries; countries that are not committed to reduce their GHG emissions. Another difference is that JI projects can only start to generate credits from 2008 while credits from CDM can be earned much earlier; already from 2000. CDM projects generate a certified emission reduction (CER). Both ERUs from JI projects and CERs from CDM projects are tradable under the third mechanism of the Kyoto Protocol: emission trading.

4.3.3 Emission trading

In contrast to JI and CDM, emission trading is not a mechanism that includes projects. Emission trading, as set out in Article 17 of the Kyoto Protocol, enables countries that can easily reduce emissions to sell these abatements to countries that face higher costs for reducing emissions. In this way, the emission trading mechanism enhances market efficiency with regard to reducing GHG emissions. Only Annex I Parties to the Kyoto Protocol with emission limitation and reduction commitments inscribed in Annex B to the Protocol may participate in emission trading.

The units which may be traded under emissions trading, each equal to one metric ton of emissions (in CO$_2$-equivalent terms), may be in the form of (Schulze et al., 2002):
- AAU: Assigned Amount Units, which contain the rights for emissions from 2008-2012.
- RMU: Removal Units generated by sinks.
- ERU: Emission Reduction Units generated by JI projects.
- CER: Certified Emission Reductions generated by CDM projects.

The trading of these units takes place on so called carbon markets, which is explained in the next paragraph. For more information on emission trading, see also chapter 6.

4.4 Carbon markets

The units generated under the Kyoto Protocol (AAUs, RMUs, ERUs and CERs) can be traded through the emission trading mechanism on carbon markets. The transaction of carbon that occurs on the carbon market can be divided into two main categories (Capoor & Ambrosi, 2007):
- Allowance-based transactions
- Project-based transactions

At allowance based-transactions the buyer purchases emission allowances created and allocated (or auctioned) by regulators under emission trading regimes (Capoor & Ambrosi, 2007). Examples of allowance-based transactions are the transaction of Assigned Amount Units (AAUs) under the Kyoto Protocol or European Union Allowances (EUAs) under the European Union Emission Trading Scheme (EU ETS). Such schemes combine environmental performance (which is defined by the level of emission reduction targets set) and flexibility through emission trading. This makes it possible for participants to meet their targets at the lowest possible cost.

In the case of project-based transactions the buyer purchases emission credits from a project that can verifiably demonstrate GHG emission reductions compared with what would have happened otherwise (Capoor & Ambrosi, 2007). Examples of such transaction are the trading
of ERUs under the Joint Implementation mechanism and CERs under the Clean Development Mechanism.

4.5 Belarus and the Kyoto Protocol
As mentioned in section 4.2, the Kyoto Protocol separates countries into two general categories, the Annex I and the non-Annex I countries. The Annex I counties have accepted greenhouse gas emission reduction obligations. The individual emission commitments for Annex I countries are listed in the Kyoto Protocol’s Annex B. The non-Annex I countries do not have greenhouse gas emission reduction obligations.

4.5.1 Proposal to amend Annex B of the Kyoto Protocol
Although listed in the Convention’s Annex I, Belarus was not included in the Protocol’s Annex B as it was not a Party to the Convention when the Protocol was adopted. In accordance with Articles 18, 20 and 21 of the Kyoto Protocol, Belarus, by a letter dated 9 February 2006, proposed an amendment in the form of the addition of Belarus to Annex B to the Kyoto Protocol (Carter et al., 2006). Belarus proposed that this amendment be adopted at the second session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (COP/MOP 2), in Nairobi (Kenya), which took place from 6-17 November 2006. The proposal from Belarus to amend Annex B to the Kyoto Protocol, allowing Belarus to join the group of countries with emissions reduction commitments, was the subject of long negotiations during the conference in Nairobi because some parties had concerns about the proposal (Carter et al., 2006). These concerns were related to technical and legal uncertainties and also to the “level of commitment” proposed by Belarus in terms of its suggested emissions target. A number of countries preferred more time to consider the issues. However, Belarus resolved the issues and during COP/MOP 2’s final hours, a compromise agreement was finally reached on the decision to amend the Protocol to add Belarus to Annex B, with an emissions reduction target of minus 8% for the first Kyoto commitment 2008-2012 (Carter et al., 2006).

4.5.2 Fulfilment of the Kyoto target
Belarus belongs to the group of Annex I parties with an economy in transition; its economy is characterized by a considerable decline in GDP during the 1990s as a consequence of the economic recession that followed the collapse of the Soviet Union in 1991 (Grebenkov, 2006). The emission of GHG’s in Belarus fell from 127,4 million ton (Mton) of CO\textsubscript{2} equivalents in 1990 to 74,4 million ton in 2004 (Grebenkov, 2006). If Belarus sustains this level of emission during the Kyoto period 2008-2012, they will stay far below their Kyoto target, resulting in a large amount of excessive carbon credits. These credits could for example be sold on the carbon market during the period 2008-2012.

In order to assess whether this credit is going to disappear as a result of economic development, an international group of experts under the TACIS program\textsuperscript{1} prepared an analysis that predicted the emission for the period 2005 to 2015 (Grebenkov, 2006). This analysis indicated that the Republic of Belarus is highly likely to fulfil their Kyoto target of minus 8% compared to the 1990 level; it is expected that Belarus will stay under their target by more than 190 Mton of CO\textsubscript{2}-equivalents (Grebenkov, 2006). This can either be sold on the global carbon market (equalling 190 Mton AAUs) or credited to the next Kyoto commitment period. In spite of this expected positive situation, the Government of Belarus takes its responsibility for climate change seriously (Grebenkov, 2006). It plans actions to stabilize emissions and

\textsuperscript{1} Under the TACIS program the European Commission provides grant-financed technical assistance to 12 countries of Eastern Europe and Central Asia, which includes the Republic of Belarus.
increase greenhouse sinks. The restoration of Belarusian peatlands can make a valuable contribution to this.
5 PEATLAND RESTORATION UNDER THE KYOTO PROTOCOL

As mentioned before, a large share of Belarusian peatlands has been drained in the past and these peatlands release CO\textsubscript{2} into the atmosphere. When taking into consideration the Kyoto Protocol’s goal (reducing GHG emissions), it should be possible in theory to use the restoration of drained peatlands under this Protocol since this could reduce the emitted CO\textsubscript{2} significantly (Van den Bos, 2003). However, the restoration of drained peatlands has not been applied under the Kyoto Protocol so far. This may be the result of gaps or faults in the Kyoto Protocol’s Articles or perhaps there are other reasons for it.

In this chapter is discussed whether it is allowed to use the restoration of drained peatlands in order to fulfil the emission reduction commitment under the Kyoto Protocol.

5.1 Sinks under the Kyoto Protocol

The Kyoto Protocol to the UNFCCC focuses mainly on the reduction of greenhouse gas emissions from fossil fuel consumption. Nonetheless, two articles of the Kyoto Protocol allow countries to use the management of sinks for achieving their emission reduction targets. These articles are respectively Article 3.3 and 3.4 (see Box 5-1).

Box 5-1: Article 3.3 and 3.4 of the Kyoto Protocol (UNFCCC, 1998)

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.”

Article 3.4:
“…the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, decide upon modalities, rules and guidelines as to how, and which, additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils and the land-use change and forestry categories shall be added to, or subtracted from, the assigned amounts for Parties included in Annex I,”

Not all activities in the LULUCF sector are allowed under Article 3.3 and 3.4 of the Kyoto Protocol. Article 3.3 limits the use of LULUCF activities to a number of forestry activities, whereas Article 3.4 allows countries to elect certain ‘additional human-induced activities’ in the LULUCF sector. These decisions were not made at once; the eligible LULUCF activities under Article 3.3 and 3.4 have been subject of many negotiations in the past.

In section 5.1.2 the road to the final agreement on the Article 3.3 and 3.4 activities is discussed shortly. After this, it will be discussed whether the restoration of drained peatlands is in accordance with these activities, and thus an eligible LULUCF activity under the Kyoto Protocol.
5.1.2 Negotiation history

- At the fourth Conference of the Parties (COP-4), held in Buenos Aires, November 1998, it was decided to recommend draft decisions on definitions related to activities under Article 3.3 and modalities, rules and guidelines as to how, and which, additional human-induced activities might be included under Article 3.4.

- COP-5 was held in Bonn, October/November 1999, and endorsed a work program and a decision-making framework on LULUCF to enable these draft decisions to be adopted by COP-6.

- At the COP-6 negotiations in The Hague, November 2000, Parties failed to reach an agreement on LULUCF matters, as part of a package of decisions under the Buenos Aires Plan of Action. The COP-6 negotiations collapsed mainly because the United States and the European Union could not come to a mutual agreement considering the sink issue. This is explained more detailed in Box 5-2.

The United States proposed at COP-6 in The Hague (2000), that land use changes acceptable under the Kyoto Protocol should not only include forests, but also the sequestration of carbon by soil and vegetation (Fletcher 2005).

When the United States put numbers to this proposal, the U.S. credits from these carbon sinks appeared to represent about 125 million tons of carbon, against a Kyoto commitment of about 600 million tons of carbon for the first commitment period 2008-2012 (Fletcher, 2005).

The US proposal was strongly opposed by the EU and other countries, mainly because of discussions on how to attain precision in measuring absorption and release of carbon from land-based sources and how permanent such land use mechanisms would be. Another point of discussion was to what extent a country like the United States would receive credits for a scenario that did not involve the harder emissions reductions from fuel sources and technological measures (Fletcher, 2005).

Despite several adjustments of the U.S proposal and EU attempts to accept a much smaller amount, Parties failed to reach an agreement on the LULUCF matters. The sink issue eventually lead to the collapse of the COP-6 negotiations at The Hague (Michaelowa & Schwarze, 2001).


When COP-6 in The Hague ended, the negotiating texts on LULUCF issues were forwarded to a resumed session of COP-6 for further consideration.

- At COP-6 part II, held in Bonn, July 2001, Parties adopted the Bonn Agreement on the implementation of the Buenos Aires Plan of Action, registering political agreement on key issues, including those on LULUCF. The most important issues regarding LULUCF included definitions for all activities under Article 3.3 and 3.4, and rules by which activities under Article 3.4 will operate for the first commitment period.

- A draft decision text was finalized at COP-7 in Marrakesh, October/November 2001. Outstanding issues such as the definitions of LULUCF activities under Article 3.3 and Article 3.4 and the rules for accounting of these activities were later resolved and agreed on as part of the Marrakesh Accords. The Marrakesh Accords can be considered the most important breakthrough considering LULUCF. In section 5.2 the eligible activities under Article 3.3 and 3.4 of the Kyoto Protocol, as part of the Marrakesh Accords, are discussed.

- After Marrakesh a number of negotiations on LULUCF issues followed. These mainly included issues concerning the inventory and reporting of LULUCF under the UNFCCC, and the use of afforestation and reforestation activities under the Clean Development Mechanism.
5.2 Eligible LULUCF activities under the Kyoto Protocol

5.2.1 Article 3.3 activities
Under Article 3.3 of the Kyoto Protocol Parties decided that the changes in GHG removals and emissions resulting from direct human-induced land-use change and forestry activities must be accounted for in meeting the Kyoto Protocol’s emission targets. In accordance with decision 11/CP.7 of the Marrakesh Accords (UNFCCC, 2002), these activities are limited to afforestation, reforestation and deforestation (ARD) since 1990 (see also Box 5-1). The definitions of these activities are:

‘Afforestation is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources’.

‘Reforestation is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989’.

‘Deforestation is the direct human-induced conversion of forested land to non-forested Land’.

In order to ensure consistency and comparability among Parties, the ARD activities need to meet the ‘Kyoto forest’ definition, which is ‘a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees with the potential to reach a minimum height of 2-5 meters at maturity in situ’.

Some flexibility is allowed to take account of national circumstances. A Party may therefore choose its own definition of a forest as long as it is in accordance with the boundaries set by the Kyoto forest definition (a Party may choose for example to select a minimum tree height of 3 meters, because this is in between the Kyoto forest boundary of 2-5 meters). However, once the values are chosen they stay fixed.

5.2.2 Article 3.4 activities
Article 3.4 gives countries an opportunity to elect ‘additional human induced activities’ in the LULUCF sector that can help achieving the emission reduction commitment (see Box 5-1). These activities, also approved at COP-7 in Marrakesh, are forest management, cropland management, grazing land management and revegetation (UNFCCC, 2002). The definitions for these four activities are:

‘Forest management is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner.’

‘Cropland management is the system of practices on land on which agricultural crops are grown and on land that is set aside or temporarily not being used for crop production.’

‘Grazing land management is the system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced.’

‘Revegetation is a direct human-induced activity to increase carbon stocks on sites through the establishment of vegetation that covers a minimum area of 0.05 hectares and does not meet the definitions of afforestation and reforestation.’
Parties may choose to include any of these activities to help meet their emission targets, and this choice is then fixed for the first commitment period of the Kyoto Protocol (2008-2012).

### 5.3 Is peatland restoration allowed under the Kyoto Protocol?

The question is now whether the restoration of peatlands falls under the LULUCF activities that are allowed for meeting the Kyoto commitment. However, in order to do an adequate analysis of this, it first needs to be clear which peatlands are considered in this research. These limitations are explained in the next paragraph.

#### 5.3.1 Research limitations

The limitations of this research are divided in three parts and are illustrated in Figure 5-1.

- **Pre-drainage state:**
  Before the large-scale drainage of peatlands started in Belarus, the state of these peatlands was undisturbed or natural (see Figure 5-1).

- **Land use:**
  The largest share of Belarusian drained peatlands are (or were) used in the agricultural sector (about 65%). The focus is therefore on peatlands that were drained for agricultural purposes only (see Figure 5-1). Peatlands drained for other purposes, such as forestry or energy, are excluded from this research.

- **Restored state:**
  Peatland restoration (the re-establishment of a high water table) results in the return of important peat forming plant species, especially *Sphagnum* mosses. In this research, peatland restoration does not include the planting of trees by men; therefore a restored peatland will be non-forested (see Figure 5-1). Further, restored peatlands are no longer used in agriculture because such actions only slow down or prevent successful restoration of peatlands.

![Figure 5-1](image)

Figure 5-1: The peatlands considered in this research were drained for agricultural purposes and are restored back to a non-forested state.

Now that the limitations are set, it can be analyzed whether the restoration of the peatlands considered for this research is in compliance with the eligible LULUCF activities under Article 3.3 and 3.4 of the Kyoto Protocol. The answer to this was found through three ways: analyzing the definitions of the eligible LULUCF activities (see 5.3.2), studying the IPCC Good Practice Guidance for LULUCF (see 5.3.3) and studying the IPCC Special Report on LULUCF (see 5.3.4).
5.3.2 Analysis of LULUCF definitions

In this research, the drained peatlands considered are restored to a non-forested state (see Figure 5-1). It is obvious that such a non-forested area is not in compliance with the Kyoto forest definition. Consequently, the restoration of these drained peatlands cannot be seen as an afforestation or reforestation activity under Article 3.3 of the Kyoto Protocol. Also, the restoration of the drained peatlands does not meet the definition of forest management. The reason for this is, again, because in this research restored peatlands are non-forested (see Figure 5-1).

Further, the restoration of drained peatlands is not in accordance with the definitions of crop-land management and grazing land management. These management approaches imply that the land areas continue to be used for the production of crops or live stock. This is however not the case on the restored (non-forested) peatlands.

However, successful restoration of drained peatlands (by rewetting) does increase the carbon stock, since restored peatlands absorb CO₂ from the atmosphere. Also, the restoration of drained peatlands does not meet the definitions of afforestation and reforestation, as explained earlier. These two criteria are in fact in accordance with the definition of revegetation as given in the Marrakesh Accords.

The first argument is thus that the restoration of drained peatlands as considered in this research (drained for agriculture and then restored to a non-forested state, see Figure 5-1) is in accordance with the definition of a revegetation activity under the Kyoto Protocol, see paragraph 5.2.2.

5.3.3 IPCC Good Practice Guidance for LULUCF

In response to the invitation by the UNFCCC to the Intergovernmental Panel on Climate Change (IPCC) to develop good practice guidance for land use, land-use change and forestry (LULUCF), the IPCC report Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG-LULUCF) was published in 2003. This report provides supplementary methods and good practice guidance for estimating, measuring, monitoring and reporting on carbon stock changes and greenhouse gas emissions from LULUCF activities under a number of Articles of the Kyoto Protocol, including Article 3.3 and 3.4.

In the GPG-LULUCF, an overview is given of the relationship between UNFCCC land-use categories and the LULUCF activities under Article 3.3 and 3.4 of the Kyoto Protocol (IPCC, 2003b). The UNFCCC land-use categories are forest land, cropland, grassland, wetland, settlements and other land. The activities under Article 3.3 and 3.4 under the Kyoto Protocol are the activities as explained in section 5.2.

Table 5-1: The conversion from a UNFCCC land-use category to wetland is either deforestation or revegetation, after IPCC (IPCC, 2003b).

<table>
<thead>
<tr>
<th>Conversion</th>
<th>To Wetland</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Managed forest land</td>
<td>Deforestation</td>
</tr>
<tr>
<td>From Unmanaged forest land</td>
<td>Deforestation</td>
</tr>
<tr>
<td>From Cropland</td>
<td>Revegetation</td>
</tr>
<tr>
<td>From Managed grassland</td>
<td>Revegetation</td>
</tr>
<tr>
<td>From Wetland</td>
<td>Revegetation</td>
</tr>
<tr>
<td>From Settlements</td>
<td>Revegetation</td>
</tr>
<tr>
<td>From Other land</td>
<td>Revegetation</td>
</tr>
</tbody>
</table>
Table 5-1 is derived from the GPG-LULUCF and from this table can be concluded that the conversion of a UNFCCC land-use category to wetland is considered either a deforestation activity or a revegetation activity under the Kyoto Protocol.

In this research, only peatlands drained for agricultural purposes are taken into account (see Figure 5-1). Due to this, the UNFCCC land-use categories ‘managed forest land’ and ‘unmanaged forest land’ are already eliminated (grey in Table 5-1). Further, peatlands drained for agricultural purposes are not in compliance with the definitions of wetlands or settlements (IPCC, 2003a) and so these categories are eliminated as well (grey in Table 5-1).

According to the GPG-LULUCF, peatlands drained for agricultural purposes can fall under cropland, managed grassland, or other land, depending on the activities that take place on it (IPCC, 2003a). Cropland includes arable land, tillage land, and agro-forestry systems and managed grassland includes rangelands and pasture land that is not considered as cropland. The ‘other land’ category includes peatlands that were used in agriculture, but are now abandoned.

The conversions from cropland to wetland, from managed grassland to wetland, and from other land to wetland all constitute a revegetation activity according to the GPG-LULUCF (see Table 5-1). This supports the earlier statement that the restoration of drained peatlands (as considered in this research) under the Kyoto Protocol.

5.3.4 IPCC Special Report on LULUCF

At its eighth session in Bonn in June 1998, the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) requested a report examining the scientific and technical state of understanding for carbon sequestration strategies related to LULUCF activities and relevant Articles of the Kyoto Protocol. In response, the Special Report on Land Use, Land-Use Change, and Forestry (2000) was prepared by the IPCC. In this report the IPCC compiled a long list of ‘additional human-induced activities’ that might be considered for inclusion under article 3.4. In this list the restoration of former wetlands is also included (IPCC, 2000a) and this can be accepted as another argument that supports the eligibility of restoring drained peatlands (as considered in this research) under the Kyoto Protocol.

5.4 Conclusion: revegetation activity

The restoration (to a non-forested state) of drained peatlands used for agriculture is allowable and accountable as a revegetation activity under Article 3.4 of the Kyoto Protocol. It is thus an eligible LULUCF activity and this offers opportunities for Annex I Parties to the Kyoto Protocol. What the restoration of drained peatlands under the Kyoto Protocol could mean for a country such as the Republic of Belarus is explained in the next chapter.
POTENTIAL UNDER THE KYOTO PROTOCOL – CASE BELARUS

The restoration of drained peatlands is an eligible LULUCF activity under Article 3.4 of the Kyoto Protocol, as explained in the previous chapter. This offers opportunities for countries such as Belarus. In this chapter there will be discussed how Belarus can benefit from the restoration of drained peatlands under the Kyoto Protocol. Also, the costs of a peatland restoration project and the total potential of such a project are calculated.

6.1 Implementation possibilities

For some of the drained peatlands in Belarus the possibility exists to restore their natural state. The government of Belarus considers the restoration of these peatlands one of its highest environmental priorities (UNDP, 2004). The restoration of peatlands drained for agricultural purposes is an eligible activity under the Kyoto Protocol, and Belarus can implement such activities under Joint Implementation (JI) and emission trading, two of the three flexibility mechanisms of the Kyoto Protocol. The third mechanism, the Clean Development Mechanism (CDM), is not an option for Belarus since CDM projects can only take place in non-Annex I parties and Belarus is an Annex I party.

6.1.1 Joint Implementation

In article 6 of the Kyoto Protocol the Joint Implementation (JI) mechanism is described. Joint Implementation is based on the knowledge that emission reductions can be achieved more easily and cheaper in some countries than in others. Therefore JI allows Annex I countries to finance emission reducing projects (JI projects) in other Annex I countries. In exchange for this, the financing (investing) country receives emissions reduction units (ERUs), which equal the amount of GHG reductions realized by the JI project. The ERUs can be used by the investing country for meeting its Kyoto target for the Kyoto commitment period 2008-2012. In Figure 6-1 the Joint Implementation mechanism is described schematically.

![Figure 6-1: Joint Implementation](image)

Under Joint Implementation it is allowed to use Article 3.4 LULUCF activities. Since the restoration of peatlands (drained for agriculture) is an eligible LULUCF activity (revegetation), such activities can be used under Joint Implementation. In many areas the JI mechanism is still being fine tuned and this is also true for projects in the LULUCF sector. However, considering the large areas of degraded land in Eastern European countries, such as Belarus, LULUCF projects may have significant potential under the JI mechanism. A peatland restoration project, concerning the restoration of exhausted peat deposits, was already part of a preliminary long-list of JI projects in Belarus (Grebenkov & Levchenko, 2005). This list was compiled under TACIS Regional Project EuropeAid/115123 which has the objective to assist Ukraine and Belarus with respect to their global climate change com-
mitments. The details of the project, with ID code Land Use 1 (LU1), are described in Table 6-1. As indicated in Table 6-1, project LU1 would generate a reduction of 15,000 ton CO$_2$ per year, which equals 15,000 ERUs under the Joint Implementation mechanism.

Table 6-1: Details of project LU1 (Grebenkov & Levchenko, 2005)

<table>
<thead>
<tr>
<th>ID</th>
<th>Project title</th>
<th>Description</th>
<th>JI indices estimated</th>
</tr>
</thead>
<tbody>
<tr>
<td>LU1</td>
<td>Waterlogging of exhausted</td>
<td>Reclamation of a unique marsh systems of 520 ha</td>
<td></td>
</tr>
<tr>
<td></td>
<td>peat deposits</td>
<td>in Osveya area</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>130 (feasibility study)</td>
<td>15000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recovery of unique ecosystems. Mitigation of</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>probability of peat fires</td>
<td></td>
</tr>
</tbody>
</table>

The restoration of drained peatlands under the JI mechanism can have a number of benefits for Belarus and the investing country. First of all, the host country, in this case the Republic of Belarus, obtains financial, technical and expert support from the investing country (see also Figure 6-1). Participation in Joint Implementation would give Belarus the possibility to attract additional resources for introduction of new advanced technologies, and to continue modernization of its economy with the result of GHG emission reduction. Further, as shown in Table 6-1, the restoration of peatlands results in other environmental benefits besides CO$_2$ emission reduction; such as the mitigation of peat fires and the rehabilitation of unique ecosystems. Some more environmental benefits are discussed in chapter 8. For the investing country, the JI mechanism is an economically attractive option. The countries that invest in JI projects abroad are always those countries that have to cope with high costs for reducing domestic emissions. The ERUs that an investing country receives are always generated in a cheaper way compared to emission reductions generated in the investing country itself.

6.1.2 Emission trading

The restoration of peatlands can also be used under emission trading (Article 17 of the Kyoto Protocol). In contrast to Joint Implementation, the emission trading mechanism of the Kyoto Protocol is not a project related instrument. Emission trading allows those Annex I Parties that can easily or cheaply reduce their emissions to sell these abatements (in the form of RMUs, AAUs, ERUs or CERs) to other Parties which have to cope with higher costs in meeting emission reductions. In Figure 6-2 the emission trading mechanism is described.

![Figure 6-2: Emission trading](image-url)
If Belarus would implement peatland restoration under the emission trading mechanism, this would result in the generation of so-called Removal Units (RMUs). For the use of RMUs under the Kyoto Protocol some special rules apply; RMUs cannot be transferred to the next commitment period and are not accepted on every carbon market. Further, RMUs may only be available after 2013, depending on the timing of monitoring and reporting.

Due to all of this, the market value of RMUs is uncertain at present and consequently RMUs are not very attractive units to sell under the emission trading mechanism. However, a potential way out of this dilemma is to exchange the RMUs for a different type of unit; the Assigned Amount Units (AAUs). These are the carbon credits that are assigned to governments and internationally tradable (Kägi & Schmidtke, 2005). How the exchange of RMUs for AAUs works is schematically explained by Figure 6-3.

In Figure 6-3, column 1 and 2 indicate the assigned amount (Kyoto target) of Belarus and the expected emissions for the Kyoto Period 2008-2012 (both in AAUs). Because it is expected that Belarus will stay an \( -x \) amount of AAUs under its target (see 4.5.2), Belarus can sell these excess AAUs to other countries which are not able to meet their Kyoto targets (see column 2, Figure 6-3). As mentioned earlier, the implementation of peatland restoration under the emission trading mechanism results in the generation of RMUs. The exchange of RMUs for AAUs (see column 3 and 4, Figure 6-3) increases the available amount of AAUs that can be sold on the emission trading market and this is a simple but effective way out of the RMUs dilemma.

Figure 6-3: It is expected that Belarus will stay under its Kyoto target and this results in an excess amount of AAUs which can be sold on the carbon market (column 1-2). The restoration of drained peatlands results in the generation of RMUs; exchanging these credits for AAUs increases the amount of AAUs that is available for sale on the carbon market (column 3-4).

Under emission trading the restoration of drained peatlands would result in a financial benefit (profit) for Belarus, since they can sell a large share of AAUs on the carbon market (which is not the case under the JI mechanism). Nonetheless, Belarus would have to implement such activities all by itself, and not with the help and technical assistance of an investing country. The environmental benefits (reduction of CO\(_2\) emissions, rehabilitation of unique ecosystems, decreased risk of peat fires etc.) are the same under Joint Implementation and emission trading, since drained peatlands are restored similarly under both mechanisms.
6.2 Costs of reducing one ton CO\(_2\)

Next, the costs of reducing one ton CO\(_2\) are calculated. Due to lack of data, project LU1 (Table 6-1) is not used. Instead, another peatland restoration project in Belarus will be used. This project is implemented jointly by the United Nations Development Program (UNDP), the Global Environment Facility (GEF) and the Ministry of Forestry of Belarus and is titled “Renaturalization and sustainable management of peatlands in Belarus to combat land degradation, ensure conservation of globally valuable biodiversity and mitigate climate change”. The aim of this project is to restore a wetland ecosystem of 17 drained and degraded peatlands with a total area of over 40,000 ha. This will result in global benefits in the areas of sustainable land management, global climate, and biodiversity (UNDP, 2004).

Amongst the 17 drained and degraded peatlands, one site is degraded as a result of agricultural drainage. This is the site that will be used for the calculation of the costs of reducing emissions with one ton CO\(_2\), since the peatlands considered for this research are limited to agricultural use only (see 5.3.1). The details of this site are described in Table 6-2. As shown from this table, the costs per ton CO\(_2\) reduced are in the order of €1.

<table>
<thead>
<tr>
<th>Site name</th>
<th>Key feature</th>
<th>Area (ha)</th>
<th>Costs per year (€)</th>
<th>CO(_2) emission reduction per year (ton)</th>
<th>Emission reduction per ha (ton CO(_2)/yr)</th>
<th>Costs per ton CO(_2) reduced (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beloozerskoe</td>
<td>Damaged by agricultural drainage</td>
<td>7300</td>
<td>30077</td>
<td>30164</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

6.2.1 Comparison with other projects

In the case of peatland restoration at the Beloozerskoe site in Belarus, the costs of reducing emissions with one ton CO\(_2\) are in the order of €1 (see Table 6-2). In Table 6-3 this is shown together with the costs of some other CO\(_2\) reduction projects. These projects are all located in Eastern European countries and are part of the World Bank Carbon Finance Unit (CFU). As shown in Table 6-3, all of these CO\(_2\) reduction projects are far more expensive than the peatland restoration project at the Beloozerskoe site. It can be concluded that the restoration of drained peatlands is an attractive option for the reduction of CO\(_2\), considering the relative low costs.

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2 The CFU uses money contributed by governments and companies in OECD countries (countries part of the Organisation for Economic Co-operation and Development) to purchase project-based greenhouse gas emission reductions in developing countries and countries with economies in transition. The emission reductions are purchased through one of the CFU’s carbon funds on behalf of the contributor, and within the framework of the Kyoto Protocol’s Clean Development Mechanism or Joint Implementation (http://carbonfinance.org).
Table 6-3: Costs of different CO$_2$ reduction projects, in € per ton CO$_2$ reduced
(source: http://carbonfinance.org)

<table>
<thead>
<tr>
<th>Project title</th>
<th>Costs per ton CO$_2$ reduced (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belarus: Renaturalization and sustainable management of peatlands in Belarus to combat land degradation, ensure conservation of globally valuable biodiversity and mitigate climate change, site: Beloozerskoe</td>
<td>1</td>
</tr>
<tr>
<td>Bulgaria: Svilosa Biomass Project</td>
<td>2</td>
</tr>
<tr>
<td>Moldova: Biomass Heating and Energy Conservation</td>
<td>4</td>
</tr>
<tr>
<td>Romania: Afforestation of Degraded Agricultural Land Project</td>
<td>7</td>
</tr>
<tr>
<td>Bulgaria: Sofia Pernik District Heating Project</td>
<td>60</td>
</tr>
</tbody>
</table>

6.3 Total emission reduction potential in Mton CO$_2$ per year

In total, around 432,500 ha of drained peatlands are suitable for restoration in Belarus. However, since this research only focuses on peatlands used for agriculture, this area will not be used completely. Of the 432,500 ha about 223,000 ha are ineffectively used in agriculture (UNDP, 2004) and this is the number that will be used for calculating the total potential of peatland restoration in Belarus.

The amount of CO$_2$ emission that a peatland restoration project can reduce per hectare varies greatly from area to area. This is caused by differences in water table height, climate, fertility and peat type (Freibauer et al., 2004). In Germany, it was estimated that peatland restoration could decrease emissions from 1 to 12 ton CO$_2$/ha/yr (Neufeldt, 2004). A similar reduction in emission of about 6 ton CO$_2$/ha/yr was estimated across Europe (Freibauer et al., 2004).

In Table 6-4 these emission reduction values are used for calculating the total emission reduction that is possible on the area of 223,000 ha. Also the emission reduction in ton CO$_2$/ha/yr of the Beloozerskoe site is included in Table 6-4, which equals an emission reduction per hectare of 4 ton CO$_2$/yr (from Table 6-2).

Table 6-4: Emission reduction potential of the restoration of 223,000 ha of peatland.

<table>
<thead>
<tr>
<th>reduction per ha (ton CO$_2$/yr)</th>
<th>1</th>
<th>4</th>
<th>6</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total reduction in Mton CO$_2$/yr</td>
<td>0,2</td>
<td>0,9</td>
<td>1,3</td>
<td>2,7</td>
</tr>
</tbody>
</table>

Table 6-4 shows that the restoration of 223,000 hectares of peatland can result in an emission reduction varying from 0,2 to 2,7 Mton CO$_2$/yr. It is likely, however, that in reality the emission reduction will lie somewhat in the middle (close to 0,9 or 1,3 ton CO$_2$/yr), since the emission reduction values of 1 and 12 ton CO$_2$/ha/yr can be considered extremes.

In the case of Belarus, it would be a favourable option to reduce some of these emissions through Joint Implementation, and to reduce a part under the emission trading mechanism because in this way Belarus would get both technical support (under JI) and financial profit (under emission trading).
7 PROBLEMS

For the Republic of Belarus, the restoration of drained peatlands under the Kyoto Protocol can be a very attractive option: the costs are low and it can reduce CO₂ emissions with a couple of million tons per year. Further, a number of environmental benefits are associated with peatland restoration. However, there are some problems associated with the implementation of such projects, especially under the Kyoto Protocol. In this chapter these problems are discussed.

7.1 Methane emissions

Simply put, when a drained peatland is restored, CO₂ is no longer emitted into the atmosphere. Instead, CO₂ is sequestered by plant growth and peat formation. Further, CH₄ is emitted as a result of anaerobic (underwater) peat decomposition. Because CH₄ also needs to be reported and accounted under the Kyoto Protocol, this can create problems considering the implementation of peatland restoration projects under the Kyoto Protocol. An example of such an issue is explained by the use of a conceptual model, of which the basis is clarified in the next paragraph.

7.1.1 Conceptual model

Figure 7-1 illustrates a conceptual model (not to scale) that shows the radiative forcing of CO₂ and CH₄ over time in a restored peatland. The calculations that were made in order to establish this model are based on table 2.14 (pp. 212) of the IPCC report ‘Climate Change 2007: The Physical Science Basis’ (IPCC, 2007b). In Figure 7-1, t=0 indicates the point in time where the restoration process is started.

As mentioned, a restored peatland sequesters CO₂ and thus the radiative forcing of CO₂ is negative (−), or in other words, the restoration has a cooling effect (see CO₂ curve). Since CH₄ is emitted by restored peatlands, the radiative forcing of CH₄ is positive (+), which means it...
has a warming effect (see CH\textsubscript{4} curve). Yet, since both CO\textsubscript{2} and CH\textsubscript{4} need to be accounted for under the Kyoto Protocol, it is necessary to combine the effects these two gases. This is illustrated by the CO\textsubscript{2}+CH\textsubscript{4} curve, which shows the net radiative forcing of a restored peatland. Initially, the CO\textsubscript{2}+CH\textsubscript{4} curve shows a positive radiative forcing because in the model of Figure 7-1 the positive radiative forcing of the emitted CH\textsubscript{4} exceeds the negative radiative forcing of the sequestered CO\textsubscript{2}.

However, after a certain point (the break-even point), the net radiative forcing of peatland restoration becomes negative which means that after this point the restoration of peatlands becomes beneficial in terms of the effect on the climate. This point occurs because in a restored peatland the radiative forcing of the emitted CH\textsubscript{4} (here assumed to be constant) slowly develops towards a limit, whereas the radiative forcing of the sequestered CO\textsubscript{2} continues to decrease. The CH\textsubscript{4} curve develops towards a limit due to the fact that CH\textsubscript{4} has a short atmospheric lifetime. The atmospheric lifetime of CH\textsubscript{4} is 12 yr (IPCC, 2007b), which means that a given amount of emitted CH\textsubscript{4} will decay by 50% in 12 years. The behaviour of CO\textsubscript{2} in the atmosphere is more complex (IPCC, 2007b). In contrast to the CH\textsubscript{4} curve, the CO\textsubscript{2} curve does not level off, but keeps decreasing.

The fact that the restoration of a drained peatland results in an initial warming effect (due to CH\textsubscript{4} emissions) can result in problems considering the implementation of such projects under the Kyoto Protocol. In paragraph 7.1.2 such a problem is illustrated.

### 7.1.2 Issue: baseline scenarios for JI projects

As mentioned in chapter 6, peatland restoration projects can be implemented under the Joint Implementation mechanism. Joint Implementation is based on the use of so-called baseline scenarios. In the Kyoto Protocol’s Article 6 it is stated that the GHG benefits (which can be a reduced emission or enhanced removal of greenhouse gases) generated by a Joint Implementation project must be ‘additional to any that would otherwise occur’ (UNFCCC, 1998). This means that the scenario with such a project has to be compared with a scenario without such a project: the baseline scenario. In Figure 7-2, this is illustrated in the case of the restoration of drained peatlands.

![Figure 7-2: Radiative forcing over time of a peatland that is restored or left drained. Before time-point t* the radiative forcing of a restored peatland is higher than the radiative forcing of that same peatland in drained state.](image)
In Figure 7-2 the net radiative forcing of an area of restored peatland is shown again (derived from Figure 7-1), but this time together with the radiative forcing of this peatland if it was left drained. The latter only considers CO$_2$, since CH$_4$ fluxes more or less cease completely after drainage (Freibauer et al., 2004). A drained peatland has a positive radiative forcing (a warming effect) because it emits CO$_2$ due to peat oxidation.

If the restoration of a drained peatland would be implemented as a JI project, than the drained peatland curve (the CO$_2$ curve) would constitute the baseline scenario. The arrow indicates the difference with what would have occurred otherwise.

In Figure 7-2 a specific time point t* is indicated. Before t* the restoration of a peatland results in a higher radiative forcing (more emissions) in comparison to the baseline scenario. However, after t* the restoration of a drained peatlands would result in a lower radiative forcing compared to the baseline scenario. So, the implementation of a peatland restoration project under Joint Implementation would only result in GHG benefits if time point t* takes place before the Kyoto commitment period 2008-2012 since this is the period in which the GHG benefits must be measured under the JI mechanism.

However, since Figure 7-2 also represents a conceptual model, which is not to scale, it is very difficult to say anything about the timeframe of a peatland restoration project. Whether t* will occur before, during or after the period 2008-2012 depends on several factors, such as the moment of time that the project was started, the height of the water level, the type of peat and the type of climate. Yet, the fact that at a certain point t* will be reached in time is very relevant considering the restoration of drained peatlands under the Kyoto Protocol.

7.2 Project boundaries

Adequate determination of the boundaries of an emission reducing project is a critical step in the project design and implementation, because this determines the amount of units that the project can generate under the Kyoto Protocol. In the case of peatland restoration projects, it is also very important to define the boundaries. For example, the restoration of a drained peatland often includes the spreading of mulch on that particular area. The inclusion of mulch within the project boundaries influences the course of the net radiative forcing curve (the CO$_2$+CH$_4$ curve) as shown in Figure 7-1. This is explained next.

7.2.1 Issue: the inclusion of straw mulch

In peatland restoration, research has repeatedly shown that besides rewetting and the recolonization of *Sphagnum* moss, straw mulch is also a key element for success in any peatland restoration project (Quinty & Rochefort, 2003). The use of straw mulch on a drained peatland induces a cooler daytime temperature and a higher relative humidity around *Sphagnum* fragments. Further, straw mulch helps maintaining a higher water level, and prevents damage caused by frost to establishing plants (Quinty & Rochefort, 2003). Next is explained what happens if the use of mulch is included within the boundaries of a peatland restoration project. Due to the decomposition of the mulch layer in the very beginning of the restoration process, the peatland becomes a source of CO$_2$, despite the uptake of CO$_2$ by plant growth and peat formation (Waddington et al., 2003). The result of this is that in the mulch-including scenario the restored peatland has a net radiative forcing that is positive for a longer period compared to the scenario in which mulch falls outside the boundaries of the project (see Figure 7-1). Considering the fact that the CH$_4$ emissions alone can cause problems (see paragraph 7.1), it is not so difficult to realize that the inclusion of mulch within the boundaries (and the consequent CO$_2$ emissions) would only result in more difficulties considering the restoration of drained peatlands and the Kyoto commitment period 2008-2012.

Even though some researchers have included the use of mulch within the boundaries of a peatland restoration project, it is not necessary to do so, as mulch is a waste product that will decompose anyway.
7.3 Hot air

7.3.1 Issue: AAU prices
In the negotiation history of the Kyoto Protocol the issue of country’s surplus Assigned amount Units (AAUs) has been, and still is, a very big issue. The share of surplus AAUs is often referred to as ‘hot air’ (Gorina, 2006). Especially countries in Eastern Europe will have a large share of surplus AAUs in the Kyoto commitment period 2008-2012 due to the economic recession that followed the fall of the Soviet Union in 1991. It is expected that they will have an emission level during the Kyoto commitment period 2008-2012 that is much lower than their Kyoto target, which is based on the year 1990. Consequently, they can sell a large share of AAUs on the emission trading market in the commitment period 2008-2012 (see also paragraph 4.5.2).

However, not all of the available hot air will be sold on the carbon market, since this would result in extreme low prices for AAUs. It is very likely that the selling parties will act strategically by selling only a restricted amount of AAUs and by banking some for the post-2012 period. In the case of the restoration of drained peatlands, an AAU price higher than €1 would probably be profitable, suggested by the fact that it costs in the order of €1 to reduce one ton of CO₂ from the drained peatland used as an example (see paragraph 6.2).

7.3.2 Issue: where does the money go?
As mentioned in paragraph 6.3, Belarus will have more AAUs for sale when they exchange the RMUs (generated by peatland restoration) for AAUs. However, there are no restrictions on how the money generated by the sale of AAUs should be spent next. Belarus could invest this money in polluting industrial processes, or in some other environmental damaging business. This is of course not the intention of the Kyoto Protocol. Luckily, some countries (including Germany, The Netherlands and Austria) have already affirmed that they will not buy hot air if it is not linked to some global or local environmental benefits. Also, so called Green Investment Schemes (GIS) can offer a solution to this problem. The aim of these schemes is to connect the revenues from the sale of surplus AAUs to investments in environmental activities in the selling country (Gorina, 2006).

7.4 Other issues

7.4.1 Risks
A major concern about using LULUCF activities under the Kyoto Protocol is the temporary nature and potential reversibility of carbon sequestration (Garcia-Olivia & Masera, 2004). The carbon stored by ecosystems such as peatlands is subject to a variety of risks. LULUCF projects can be exposed to a number of risks, including natural risks, political risks, economic risks and market risks (IPCC, 2000b). In case of the Belarusian peatlands, especially natural risks such as high summer temperatures can affect the expected carbon storage.

7.4.2 Leakage
Leakage is defined as the unanticipated decrease or increase in GHG benefits outside of the project's accounting boundary as a result of project activities (IPCC, 2000b). There are two mechanisms that can be held responsible for the occurrence of leakage: activity shifting and market effects (Garcia-Olivia & Masera, 2004). Activity shifting occurs when the activity that causes emissions in the project area is displaced outside the project boundary. For example, the restoration of peatlands that would otherwise be left drained for agriculture may lead to the movement of farmers to an area outside of the project's boundaries. In this area, the farmers may start or continue to drain natural peatlands and the resulting GHG emissions are referred to as leakage. A market effect is for example when a project alters the supply and demand of products (IPCC, 2000b).
8 BENEFITS

Peatland restoration can result in many benefits, including economical, environmental and social benefits. This is discussed next.

8.1 Economical

The restoration of drained peatlands can result in economic benefits. As mentioned in paragraph 6.3, it would be an attractive option for Belarus to exchange the RMUs (generated by the peatland restoration projects) for AAUs, and to sell these on the carbon market. However, as mentioned in paragraph 7.3 this will only be profitable if the AAU prices are above €1 since the costs are in the order of €1 to reduce emissions with one ton of CO$_2$ on a drained peatland.

Further, the implementation of a peatland restoration project under Joint Implementation would give the Republic of Belarus the possibility to attract additional resources for the introduction of new advanced technologies into this sector. JI projects would enable Belarus to continue modernization of its economy with the result of emission reduction and to produce and collect ERUs for the next Kyoto commitment period (Grebenkov & Levchenko, 2005). Once the drained peatlands have been restored and become healthy ecosystems again, they need to be managed to some extent in order to prevent these areas from becoming degraded again. This can create jobs in the local communities. Further, healthy peatland ecosystems are an attractive and unique type of landscape and this can attract tourists. Tourism can also bring economical benefits for the local and regional communities.

8.2 Environmental

Besides the (long term) global environmental benefit of the reduced CO$_2$ emissions, there are also other local environmental benefits associated with the restoration of drained peatland areas.

Peatlands are a unique type of ecosystem, providing habitats for a number of characteristic plant and animal species. However, the drainage of peatlands destroys habitats and due to this there has been a substantial decline in the populations of many plant and animal species in Belarus, especially water birds (UNDP, 2004). The restoration of drained peatland may lead to the return of these species and may decrease or reverse the loss of biodiversity.

Second, drained peatlands contribute to a higher risk at peat fires. In Belarus alone, thousands of hectares of drained peatlands, surrounding forests and other habitats are destroyed by fires annually. This problem is especially critical for the areas affected by Chernobyl, because fires in these areas provoke the spread of radioactive contamination (UNDP, 2004). The restoration of drained peatlands would decrease the risk of fires.

Further, peatlands have the unique ability to store, filter and provide water, but in drained peatlands this capacity is often lost (Quinty & Rochefort, 2003). The restoration of drained peatlands can have a positive impact on water quality and if the predicted change in climate occurs, the storage of water in peatlands may become even more important in the future.

To sum up, peatland restoration projects have a number of important environmental benefits including the reduction of CO$_2$, the conservation of biodiversity, the prevention of land degradation and radioactive contamination and the protection of important water resources.
8.3 Social

There are also social benefits related to the restoration of drained peatlands. Throughout history, people have used art (such as painting and poetry) to express their relationship with peatlands and the animals and plants that are a part of them. Museums display the art together with archaeological findings from peatlands. Also photographs of working people on the peatlands and the machinery that was used by them can be found in museums. These materials draw not only scientific interest, but also public interest (Schilstra, 2006b). By restoring and safeguarding peatlands, future generations can learn about peatlands and their cultural and social values not only from a museum, but also in nature. And as mentioned earlier, the sightseeing of peatlands by tourists or other type of visitors can result in economical benefits as well.
9 CONCLUSIONS

9.1 Chapter 5
1. The restoration of drained peatlands as considered in this research is allowed under the Kyoto Protocol. Peatland restoration is considered a revegetation activity, which falls under Article 3.4 of the Kyoto Protocol.

9.2 Chapter 6
1. Considering the Republic of Belarus, the restoration of peatlands could be implemented under two of the three flexibility mechanisms of the Kyoto Protocol; under Joint Implementation (JI) and emission trading.
2. The difference in benefits between implementation under JI and emission trading is that under JI Belarus would get support from another country, whereas under emission trading they would have to implement the project by itself. Under emission trading, however, Belarus could generate money (financial profit), which is not possible under JI.
3. Based on the data from the Beloozerskoe site, the costs of reducing emissions with one ton CO$_2$ are in the order of €1 for a peatland restoration project. Compared to some other CO$_2$ reducing projects this is by far the lowest cost.
4. The potential of peatland restoration in Belarus can be substantially. It was calculated that the restoration of 223,000 ha of drained peatland results in an emission reduction that equals approximately 1 Mton of CO$_2$/yr.

9.3 Chapter 7
1. Restored peatlands are emitters of CH$_4$. The development of CH$_4$ emissions over time in a restored peatland can create problems considering the Kyoto commitment period 2008-2012.
2. The boundary settings of a peatland restoration project can create problems considering the Kyoto period 2008-2012. For example, decomposing mulch increases CO$_2$ emissions substantially in the beginning of a peatland restoration process but this should not be included in the determination of the GHG benefits of such a project.
3. Even though peatland restoration projects can be used under the emission trading mechanism it is yet unclear what the prices of AAUs will be. Also, there are no legal restrictions on how the money generated through emission trading should be spent.
4. Other issues, such as risks and leakage, can also make the implementation of peatland restoration projects more difficult.

9.4 Chapter 8
1. Peatland restoration has economical benefits. For example, the implementation of peatland restoration projects under emission trading can result in the generation of money.
2. There are a lot of environmental benefits associated with the restoration of peatlands. Amongst them are a reduction in CO$_2$ emissions and the return of biodiversity.
3. The restoration of drained peatlands is valuable on a social level, since peatlands have played an important role throughout history in many countries (for example in art and archaeology).
9.5 Key message of this research

In the case of restoring drained peatlands under the Kyoto Protocol, the development of CO$_2$ and CH$_4$ fluxes over time in such projects can give problems considering the Kyoto commitment period 2008-2012. This may be the reason why the Kyoto Protocol has not yet been proved to be an effective instrument in reducing the emissions of CO$_2$ from drained peatlands, even though the restoration of drained peatlands (as considered in this research) is in fact allowed under the Kyoto Protocol and can have substantial potential under this Protocol.

The problems considering the CO$_2$ and CH$_4$ fluxes should be addressed in the sequel of the Kyoto Protocol. Yet, even if this turns out to be an unsolvable problem, peatland restoration should still be high on the list of priorities of countries such as Belarus. It is a fact that peatlands are very valuable ecosystems, with important functions, and this may not be forgotten, nor denied, in environmental policies on local, regional and global scale.
10 RECOMMENDATIONS

10.1 More research necessary on CO₂ and CH₄ fluxes
In the case of the implementation of Belarusian peatland restoration projects under the Kyoto Protocol it is of importance to measure the fluxes of CO₂ and CH₄ on these areas over a long period of time. However, the fluxes of these gases can vary greatly between different peatlands and within a peatland over time. Some researchers state that the restoration of drained peatland areas will result in a cooling effect (Borren & Bleuten, 2006), whereas others argue that it will result in a neutral climate effect (Joosten & Augustin, 2006) or even a (small) warming effect (Van den Bos, 2003). Thus, more research on this is necessary in order to get a complete picture of how CO₂ and CH₄ fluxes develop throughout the peatland restoration process. Reliable data on this would make it possible to put the conceptual model of this research (see paragraph 7.1.1) to scale and would show a reality based outcome. This would make it possible to see whether the restoration of drained peatlands would actually be profitable considering implementation under the Kyoto Protocol.

10.2 Post Kyoto: more attention towards peatlands
Though natural peatlands are considered very valuable and unique ecosystems, they have become threatened by drainage all over the world. This has resulted in huge releases of CO₂ into the atmosphere. Fires, mainly in South East Asia, are increasing these emissions even more. A study from Wetlands International and Delft Hydraulics has shown that there has been an average annual emission from Indonesian peatlands of an alarming 2.000 Mton CO₂. This includes 600 Mton from peat oxidation and 1.400 Mton from peat fires (Silvius et al., 2006). Since the emissions of CO₂ from drained peatlands are so huge, it is of importance to emphasize the role of peatlands in climate change. Consequently, there should be more attention towards peatlands in the coming Kyoto negotiations. Especially the timeframe of peatland restoration projects should be addressed carefully in post-Kyoto negotiations, since it takes time before a restored peatland has a positive effect on the climate.
Further, in this research it was quite difficult to find any information on the inclusion of peatland restoration under the Kyoto Protocol. In the future, the information on this must be extended and should become easier to obtain.
In future negotiations considering peatlands, not only the climate issue should be addressed but also ecological, economical and social factors should play an important role in the decision making.
11 APPENDICES

11.1 Appendix I: List of abbreviations

AAU = Assigned amount unit
ARD = Afforestation, deforestation and reforestation
CDM = Clean Development Mechanism
CER = Certified emission reduction
CFU = World Bank Carbon Finance Unit
CH₄ = Methane
CO₂ = Carbon dioxide
COP = Conference of the Parties
ERU = Emission reduction unit
EUA = European Union Allowance
EUETS = European Union Emission Trading Scheme
GDP = Gross domestic product
GEF = Global Environment Facility
GHG = Greenhouse gas
GIS = Green investment schemes
GPG LULUCF = Good Practice Guidance Land Use, Land-Use Change and Forestry
HFC = Hydro-fluorocarbon
IPCC = Intergovernmental Panel on Climate Change
JIN = Foundation Joint Implementation Network
JI = Joint Implementation
LU1 = Land Use 1
LULUCF = Land Use, Land-Use Change and Forestry
MOP = Meeting of the Parties
Mton = Million ton
N₂O = Nitrous oxide
OECD = Organisation for Economic Co-operation and Development
PFC = Per-fluorocarbon
RMU = Removal unit
SBSTA = Subsidiary Body for Scientific and Technological Advice
SF₆ = Sulfur hexafluoride
TACIS = Technical Assistance for the Commonwealth of Independent States
UNDP = United Nations Development Program
UNFCCC = United Nations Framework Convention on Climate Change
12 LITERATURE


