Land use, agriculture and greenhouse gas emissions in the Netherlands: omissions in the National Inventory Report and potential under Kyoto Protocol article 3.4.

Landgebruik, landbouw en broeikasgassen in Nederland: witte vlekken in de National Inventory Report en potenties voor artikel 3.4 van het Kyoto Protocol (samenvatting in Nederlands).

Commissioned by SENTERNOVEM and by Reseach Programme 421 on Climate Change by the Ministiry of Agriculture, Nature management and Fisheries.

Land use, agriculture and greenhouse gas emissions in the Netherlands: omissions in the National Inventory Report and potential under Kyoto Protocol article 3.4.

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ABSTRACT

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This report identifies options for activities within Land Use and Land Use Change and Forestry (LULUCF) that would stimulate the sequestration of carbon in soils (removal of CO_2) or reduce the emission of carbon dioxide and non – CO_2 greenhouse gases methane and nitrous oxide. This work is part of the preparation in the Netherlands towards completion and implementation of a National System for reporting of national greenhouse gas emissions from Land Use and Land Use Change and Forestry within the framework of the Climate Convention and the Kyoto Protocol to the UNFCCC secretariat in Bonn. Until now, the National Inventory Report for the Netherlands does not report all emissions or removals from land use and for agriculture only reports on CH_4 and N_2O. The experts' top – 5 of the identified options relevant to land – use, agriculture and forestry in the Netherlands include: land – use changes from agriculture to forest and nature, management of crop residues, management of soil C in organic and peat soils, use of organic wastes and establishment and management of parcel edges. The overall potential is estimated by the experts at 3.7 Mton C per year or 13.7 Mton CO2 equivalents per year. Experts have expressed the importance of a set of definitions which includes system boundaries for option identified. This allows for accurate quantification and avoid double counting of effects. Such definitions are not available yet. The report finally identifies an action list.

Keywords: Kyoto Protocol, Article 3.4, Carbon, Sequestration, Land use, Agriculture

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Contents

Preface

This report is part of the preparation in the Netherlands towards completion and implementation of a National System for reporting of Land Use and Land Use Change and Forestry Greenhouse gas emissions. According to international agreements, countries including the Netherlands are required to report on emissions of greenhouse gases to the United Nations Framework Convention on Climate Change (UNFCCC) including any activities that relate to the Kyoto Protocol article 3.3 and 3.4.

This project was commissioned by the Research Programma 421 on Climate Change from the Ministry of Agriculture, Nature Management and Fisheries and by SENTER – NOVEM.

Summary

This report identifies options for activities within Land Use and Land Use Change and Forestry (LULUCF) that would stimulate the sequestration of carbon in soils (removal of CO_2) or reduce the emission of carbon dioxide and non – CO_2 greenhouse gases methane and nitrous oxide. This work is part of the preparation in the Netherlands towards completion and implementation of a National System for reporting of national greenhouse gas emissions from Land Use and Land Use Change and Forestry within the framework of the Climate Convention and the Kyoto Protocol to the UNFCCC secretariat in Bonn.

A group of 10 experts joined in a one – day workshop to identify relevant options for activities under Kyoto Protocol article 3.4 and estimated the effectivity of these options. They were given the task to prioritize any article 3.4 options according to their effectivity to change emissions or to stimulate sink strength for conditions relevant to Dutch land use, forestry and agriculture.

The experts were further asked to identify any omissions in the National Inventory of the Netherlands in agriculture, forestry and land use (tables 4 and 5 of the UNFCCC Common Reporting Format) (see table 1). For these so called white spots, experts have estimated the source strength and compared these with other sources and emissions in the national inventory report (simple key source category analysis) which is relevant to the consideration of options eligible under Kyoto Protocol Article 3.4. This report is supplementary to the report on the consequences of the Good Practice Guidance for Land Use, Land Use Change and Forestry (IPCC, 2004) and the IPCC – tools for estimation of soil carbon stock changes by Nabuurs *et al.* (2003).

The results from the expert meeting have been discussed and compared with results from similar studies in France (Arrouays *et al.*, 2002), Switzerland (Leifeld *et al.*, 2003) and the EU (Freibauer *et al.*, 2004; Smith, *et al.*, 2004).

In this report we define several steps that are worthwhile to take in the Netherlands for a successful preparation on the commitments under the Kyoto Protocol and to comply with the requirements for preparation of the National Inventory Report on emissions of greenhouse gases whether or not they include activities to be reported under Kyoto Protocol Article 3.4.

The selection from options and a decision on implementation of such activities in land use, agriculture and forestry under the Kyoto Protocol Article 3.4 is an iterative process with the reporting of emissions of greenhouse gases. Following identification of options it is appropriate to check whether the effects show up with calculations for the national inventory in the Netherlands. If yes, to further determine effectivity and source or sink strength of execution of activities within the rules and regulations set out for Kyoto Protocol article 3.4 activities and if no, to first define and

implement adaptations to the emission inventory methodology (emission registration system) of the Netherlands (figure 1).

In consultation with SENTER NOVEM (H.H.J. Vreuls) and the ministry of Agriculture (B.J.L. Clabbers) we invited 10 experts (see appendix 1) to join in a one – day workshop in a Group Decision Room (GDR) setting at Alterra on September 2nd, 2003. All experts were facilitated with interconnected computers such that all information they provided was stored and used for a report. All participants were enabled to comment on each others input, suggestions and comments. The experts responded to successive questions on white spots in the national inventory, sink and source strength, options and effectivity for activities eligible under Kyoto Protocol Article 3.4 and relevancy and prioritization for the Netherlands (see appendix 2).

The group of experts agreed well on sources of greenhouse gases that are not included in the National Inventory Report on emissions of greenhouse gases in the Netherlands and on a series of options eligible under the Kyoto Protocol Article 3.4.. The experts felt that definition of sources or sinks was difficult and this topic remained ambiquous. Not only because of the definition issue and contrary to our expectation, the experts were not able to succesfully quantify source or sink strength's. Many experts felt they would need more time to consult specific literature sources. We had hoped that experts would draw from their own specific and sometimes unpublised data. We conclude from the workshop that limited national data and reports are available (see i.e. Smith *et al.*, 2004; Freibauer *et al.*, 2003; Watson *et al.*, 2000), and this hold for Europe and the Netherlands in particular (see i.e. Guo and Gifford, 2002).

A group of 30 international experts faced a similar challenge in an international workshop in Clermont Ferrand in France (September 4th and 5th, 2003) and they were able to identify many options for carbon sequestration. They, however, were unable or not willing to quantify the effectivity of these options and too indicated that they would have to search literature at home. As few data and papers are available chances are high that assessments are then based on very limited actual measurements (see Guo and Gifford, 2002). In our workshop and report we used the assessment by Freibauer *et al.* (2004) and Smith *et al.* (2004) as a starting point.

A comparison between the options of Kyoto Protocol Acticle 3.4 activities with the National Inventory Report for the Netherlands (Olivier *et al.*, 2003; methodology in Spakman *et al.*, 2003) reveals that the Netherlands hardly reports any emissions or removals from land use and for agriculture only reports on CH_4 and N_2O. This is for some sources incomplete while other sources are lacking (Nabuurs *et al.*, 2003); some of these omissions are currently being settled through adaptation of the protocols in 2003 and 2004.

In the GDR workshop several omissions or white spots where no reporting is done were identified: buffer strips along arable fields and grassland, organic soils including peat containing soils in lower parts, small landscape elements, im- and export of fiber (Janssens *et al.*, 2004), energy crops and management of crop residues.

The experts' top – 5 of the identified options relevant to land – use, agriculture and forestry in the Netherlands eligible under the Kyoto Protocol Article 3.4 are:

1. Land – use changes from arable land to forestry (1.1 Mton C per year)
2. Crop residues in arable land (1.1 Mton C per year)
3. Management of soil C in organic and peat soils in lower areas (0.65 Mton C per year)
4. Use of organic wastes including crop residues to replace fossil fuels (0.6 Mton C per year)
5. Establishment and management of parcel edges (*bufferstroken*) (0.25 Mton C per year)

The overall potential is estimated by the experts at 3.7 Mton C per year or 13.7 Mton CO_2 equivalents per year. The experts have identified no other options for forestry than through the use of wood for renewable energy production and replacing use of fossil fuels despite a potential bias in this group of only 2 forestry experts versus 7 from agriculture. The experts have expressed as their opinion that it would be most important to have a set of definitions which includes system boundaries for each activity and option identified. This allows for accurate quantification and avoid double counting of effects. Such definitions are not available yet.

We have included an actionlist extracted from our questions to the experts about what is logical to do next:

- Selection of options and set system boundaries in proper definitions
- Further quantify the effects and uncertainties of options on the basis of specific data or relevant data for conditions in the Netherlands
- Decide on methodology of monitoring effects of measures and of upholding the activities and costs associated with both
- Decide on whether or not to include Kyoto Protocol Article 3.4 activities in the Dutch Climate policies; here are 3 – 4 possible attitudes: (1) never, (2) no, unless, (3) yes, later and (4) yes, now. As to why 4 options: the Netherlands is committed to the international community and to the rules that apply to the Kyoto Protocol eventhough the latter are not fully clear yet. This means that it is not just a decision by the Dutch Government whether or not activities will be taken and reported on but that the international community expects countries to live up to the rules set by an international forum. As such, it would be wise policy to anticipate on future developments and are (2) no, unless and (3) yes, later relevant actions indeed.
- Formulate a protocol including QA quality assessment and QC quality control and appoint those responsible for review on transparancy, consistency and availability of data
- Exercise in quantification of effects through monitoring of activities and assessment of necessary data
- Continue and initiate capacity building in experts

Samenvatting

Dit rapport is een onderdeel van de voorbereiding van Nederland om te voldoen aan haar verplichtingen in het kader van klimaatverdragen te rapporteren over emissies van broeikasgassen als gevolg van landgebruik, landgebruiksveranderingen en bosbouw aan het klimaatsecretariaat in Bonn. Het rapport identificeert een aantal mogelijkheden om binnen de kaders van artikel 3.4 van het Kyoto Protocol (landgebruik en verandering van landgebruik) activiteiten te ontplooien die het vastleggen van koolstof in de bodem (sink) versterken of de emissie van koolstof uit de bodem verminderen en koolstof vasthouden die al in de bodem is opgeslagen. Een aantal experts is gevraagd de mogelijkheden voor KP artikel 3.4 in Nederland te concretiseren. Voor deze mogelijkheden is een schatting gemaakt van de orde van grootte die heeft geleid tot een prioriteitenvolgorde van voor Nederland relevante maatregelen.

Het rapport geeft verder een overzicht van de mogelijke omissies (witte vlekken) in de rapportage van broeikasgassen onder het klimaatverdrag (tabel 4 en 5 van het format van UNFCCC) (zie tabel 1). Het rapport is een aanvulling van de rapportage van Nabuurs *et al.* (2003) over de gevolgen van de opstelling van de Good Practice Guidance for Land Use, Land-Use Change and Forestry – IPCC Tool for Estimation of Soil Carbon Stock Changes (IPCC – GPG) voor de national inventory van broeikasgassen door Nederland. Voor deze zogenaamde witte vlekken zijn schattingen van de omvang van de emissie gemaakt en vervolgens zijn deze schattingen vergeleken met de bronnen die wel worden gerapporteerd in de national inventory (eenvoudige key source category analysis). Dit is van belang bij de overweging van mogelijke opties voor toepassingen van artikel 3.4 in Nederland.

In de rapportage worden een aantal vergelijkbare studies die zijn uitgevoerd in Frankrijk (Arrouays *et al.*, 2002) en Zwitserland (Leifeld *et al.*, 2003) en ten behoeve van de EU (Freibauer *et al.*, 2004; Smith *et al.*, 2004) aangehaald en voor zover relevant voor de Nederlandse situatie besproken.

Het rapport definieert een aantal vervolgstappen die Nederland kan overwegen ter voorbereiding op de verplichtingen die voortkomen uit het Kyoto Protocol en uit de eisen die worden gesteld aan de voorbereiding en opstelling van de National Inventory Report over emissies van broeikasgassen, al dan niet in relatie tot eventuele opties onder artikel 3.4 uit het Kyoto Protocol.

De vaststelling van opties in landgebruik, bosbouw en landbouw voor het Kyoto Protocol artikel 3.4 is een iteratief proces: na identificatie van opties is het zinvol om te toetsen in hoeverre de effecten worden meegerekend in de rapportage systematiek van emissies die Nederland hanteert en, zo ja, om vervolgens nader omvang en effectiviteit van die opties bij uitvoering te preciseren ten behoeve van de regels onder Kyoto Protocol artikel 3.4 en, zo nee, om aanpassingen te verrichten aan de Nationale Rapportage systematiek (zie figuur 1)

Binnen het project is een groep experts uit Nederland uitgenodigd voor een workshop van een dag in de vorm van een Group Decision Room. Deze groep heeft een groot aantal vragen beantwoord en de resultaten op de dag zelf in een korte bespreking bediscussieerd. De groep heeft een groot aantal witte vlekken en opties onder Kyoto Protocol artikel 3.4 geïdentificeerd. De groep bleek tegen de verwachting in niet in staat om kengetallen voor relevante activiteiten in de landbouw en landgebruik te noemen. Veel deelnemers gaven aan daartoe gegevens te moeten opzoeken in literatuur.
Bij eenzelfde procedure tijdens een internationale workshop in Clermont Ferrand (September 4 en 5, 2003) bleek een groep van 30 internationale experts weliswaar een groot aantal opties voor vastlegging van koolstof te kunnen benoemen maar ook niet de absolute vastlegging van koolstof te kunnen, durven en/of willen aangeven . Beide groepen verwijzen naar de behoefte literatuur na te slaan, hoewel er weinig bronnen beschikbaar zijn (Guo and Gifford, 2002). Dit leidt o.i. tot een hoog risico op napraten en niet tot gegevens met voldoende mate van zekerheid. In dit rapport worden getallen gebruikt die zijn gebaseerd op recente publicaties van Freibauer *et al.* (2004) en Smith *et al.* (2004) aangevuld met Nederlandse inbreng van experts.

Rapportage van veranderingen van emissies en voorraad koolstof onder het Kyoto Protocol vraagt om meer detaillering dan rapportage van emissies in de National Inventory conform de IPCC 1996 Revised Guidelines (IPCC, 1996); dit is zeker het geval als we de IPCC 1996 Revised Guidelines vergelijken met de GPG2003 (zie rapport appendix 4).

Na vergelijking van de opties voor activiteiten onder het Kyoto Protocol artikel 3.4 met de National Inventory Report van Nederland (Klein Goldewijk *et al.*, 2004; Spakman *et al.*, 2003) valt op dat Nederland nauwelijks over landgebruik en voor landbouw alleen over N_2O en CH_4 rapporteert en dit deels onvolledig doet (zie ook Nabuurs *et al.*, 2003); gedeeltelijk worden omissies via aanpassing van protocollen in 2003 en 2004 weggewerkt.

In de workshop (group decision room) werden witte vlekken (geen rapportage over emissies broeikasgassen) geïdentificeerd: bufferstroken en kleine landschapselementen (zijn sterk in opkomst), veenweidegebied in west en noordwest Nederland, import en expert van grondstoffen (Janssens *et al.*, 2004), energiegewassen (oogst) en crop residues (oogstresten).

De toppers bij geïdentificeerde opties voor Kyoto Protocol artikel 3.4 zijn, tussen haakjes is het potentieel voor Nederland aangegeven:
- landgebruikverandering van agrarisch naar bos (1.1 Mton C per jaar)
- gewas resten in akkerbouw (1.1 Mton C per jaar)
- beheer en management van bodem C in veenweidegebied en overige organische gronden (0.65 Mton C per jaar)
- energie: gebruik van reststoffen of productie voor opwekking energie ter vervanging van fossiele brandstoffen (0.6 Mton C per jaar)
- parcel edge (bufferstroken) management (0.27 Mton C per jaar)

Ondanks een mogelijke bias in de groep (2 bosbouwers, 7 niet-bosbouwers) lijken er binnen bosbeheer weinig andere mogelijkheden te zijn anders dan via aanwending van biomassa voor energie.

De experts waren verder van mening dat het wenselijk is om bij opties een goede definitie beschikbaar te hebben met systeemgrenzen ter bepaling van de omvang en ter voorkoming van dubbeltellingen. Deze definitie ontbreekt in de meeste gevallen vooralsnog.

Tot slot is een mogelijke actielijst opgesteld rond de vraag: Wat is wenselijk en logisch om nu te doen?

- Selectie van opties en deze voorzien van een definitie met vaststelling van specifieke systeemgrenzen
- (Nader) kwantificeren van de te verwachten effecten en bijhorende onzekerheid en onnauwkeurigheid liefst en zo mogelijk op basis van specifieke gegevens voor Nederland of op basis van gegevens met grote relevantie voor Nederland
- Vaststellen van de wijze van monitoren en handhaven en de kosten daarvan.
- Besluiten tot al dan niet opnemen in voorbereiding van Kyoto Protocol rapportage Nederland hier zijn 3 tot 4 opties: (1) nee, nooit, (2) nee, tenzij, (3) ja, straks en (4) ja, nu. Waarom 4 opties? Nederland verplicht zich aan de internationale gemeenschap en de regels die van toepassing zijn op activiteiten onder het Kyoto Protocol zijn nog niet allemaal in detail vastgelegd of in het geheel nog niet vastgelegd. Dit betekent dat niet alleen Nederland bepaald of en hoe rapportage plaatsvindt maar dat verwacht wordt dat deze aan internationale eisen zal voldoen. In dat opzicht is een zekere anticipatie op toekomstige veranderingen wenselijk en zijn nee, tenzij en ja, niet nu van belang voor overweging.
- Opstellen van een protocol inclusief QA/QC en aanwijzen van verantwoordelijken voor beheer en uitvoeren van een review met betrekking tot transparantie, consistentie en continue beschikbaarheid data
- Droogoefenen met kwantificeren van effect en monitoren van benodigde gegevens
- *Capacity building* in experts continueren en versterken

1 Introduction and objectives

1.1 International agreements on climate change and emissions

According to international agreements, countries including the Netherlands are required to report on emissions of greenhouse gases to the United Nations Framework Convention on Climate Change (UNFCCC). Relevant to agriculture are emissions of greenhouse gases CO_2 (carbon dioxide), N_2O (nitrous oxide) en CH_4 (methane) and stocks of carbon in soils. Such National Inventory Reports are produced annually (Olivier et al, 2003; Klein Goldewijk et al., 2004). The IPCC (Intergovernmental Panel on Climate Change) provides methodologies to produce such national inventories on the basis of generally available national statistics on land use and agriculture and forestry (IPCC, 1997).

European countries have signed the Kyoto Protocol laid out in 1997. Those countries that have signed may choose to subtract from their overall national greenhouse gas emissions any sequestration of carbon dioxide or any reduction of emissions of CO_2 and non – CO_2 greenhouse gases "induced by additional human activities" (IPCC, 2000). These activities include forestry (deforestation, afforestation and reforestation) in Kyoto Protocol article 3.3 and forest and agricultural management in Kyoto Protocol article 3.4[1].

1.2 Reporting emissions and emission reduction

It seems logic and is highly likely that the reporting on emissions in the National Inventory and the reporting of effects of activities under the Kyoto Protocol should comply with international standards and match sources and sinks that are recognized[2]. The Dutch National Inventory on greenhouse gas emissions from land use and forestry and agriculture in the Netherlands however is still incomplete: several sources may not have been identified yet and others may well be reported

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[1] IPCC has proposed a series of "additional human induced activities" that will increase terrestrial carbon stocks as being eligible under Kyoto Protocol article 3.4. This series includes management of forested and agricultural (grassland and cropland) land through organic fertilization, optimization of fertilization and improving productivity, use and application of organic waste, rotations and harvest management, pest and fire management, water management and restauration of wetlands and re - vegetation (see IPCC Special Report on Land Use, Land Use Change and Forestry (LULUCF) by Watson et al., 2000)

[2] Following the drafting of the Kyoto Protocol and the IPCC Special Report LULUCF in subsequent international meetings of countries in the Conference of Parties (COP) guidelines and rules with respect to the accounting of activities under Kyoto Protocol article 3.4 have been developed (see i.e. Marrakech Accords at CoP7) but are still not final; relevant issues concern the reference year (1990), an activity being human induced and additional to the reference year 1990 and the carbon sequestration being measurable, demonstrable and verifiable. Parties are required to account for changes in soil carbon sinks and sources on a net – net basis and compare fluxes of carbon in the commitment period with that flux of carbon in the reference year and must take into account nitrous oxide (N_2O) and methane (CH_4) as well.

incomplete. If so, this would certainly limit the use of those opportunities that are provided in the Kyoto Protocol.

The government in the Netherlands is planning to report to the UNFCCC whether and if so how it will use the opportunities set out in the Kyoto Protocol articles 3.3 and 3.4. A working group WEB sinks on "emission monitoring of greenhouse gases and sinks"[3] is
given the task to prepare and make suggestions on such communication with the UNFCCC on issues that relate to land use and soil carbon and forestry[4].

1.3 Objectives

This study was commissioned by NOVEM on behalf of WEB sinks to carry out a study and report on:

- Identification of white spots in the National Inventory with regard to land use and agriculture
- Key source category analyses including estimate on source strength, uncertainties and trend
- Identify options and assess the potential of activities that are eligible under Kyoto Protocol article 3.4 (land use and land use change)

1.4 Approach

In this report we present the results of a workshop in which 9 experts have discussed the objectives above and assess the potential of activities in the Netherlands on the basis of both expert opinion and (international) literature. This workshop was held on September 2nd, 2003 at Alterra in Wageningen. Experts had been identified in consultation with NOVEM and WEBsinks (see appendix 1). The workshop setting was in a Group Decision Room (GDR) where all participants have access to a PC. This allows participants to respond to questions, statements and lists with options all simultaneously and anonymously (see agenda and programme in Appendix 2). All results are stored. Following or during discussion of results all participants can provide comments and suggestions to all contributions and remarks made by any of the participants. The setting allows for an efficient exchange of ideas and information and eases reporting.

[3] WEB sinks (werkgroep emissiemonitoring broeikasgassen) is a joint working group from the ministries of Environment (VROM) and agriculture (LNV).
[4] This task of the WEB sinks is to prepare a national inventory system that is ready by the end of 2004 and can be used for the National Inventory Report of 2005. This system is to be implemented and used for accounting in the first commitment period 2008 – 2012 of the Kyoto Protocol.

2 Requirements for UNFCCC reporting (NIR) and reporting under Kyoto Protocol

2.1 National Inventory Reporting

Countries generally use the IPCC Revised 1996 Guidelines (IPCC, 1997) for National Greenhouse Gas Inventories (IPCC Guidelines) to estimate greenhouse gas emissions by sources and removals by sinks for reporting to the Conference of Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC). The requirement for countries to use the IPCC Guidelines for this purpose is set out in various decisions and conclusions of subsequent meeting of the Conference of Parties (COP) and its subsidiary bodies since. In 1998, the Parties to the UNFCCC invited the IPCC to develop good practice guidance (GPG) to the IPCC Guidelines. Since the Parties had already agreed to use the IPCC Guidelines for estimating greenhouse gas emissions and removals, the role of good practice guidance was not to replace the IPCC Guidelines, but rather to provide advice consistent with them.

2.2 Good Practice Guidance

IPCC finished its work for the first volume of the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (GPG2000) to be accepted at the IPCC Plenary meeting held in Montreal in May 2000. The COP subsequently endorsed GPG2000, and it is extensively referred to in the Marrakech Accords (MA), and in the decisions and conclusions of the COP and its subsidiary bodies referred to in the first paragraph of this introduction. The Marrakech Accords also invited IPCC to develop good practice guidance for land use, land-use change and forestry (LULUCF), which is not covered in GPG2000.

The first volume of good practice guidance (GPG2000) did not cover the land-use change and forestry (LUCF) activities described in chapter 5 of the IPCC Guidelines. This was due to the fact that during the time that the GPG2000 was being prepared, IPCC was also preparing a Special Report on Land-use, Land-Use Change, and Forestry (LULUCF) (Watson et al., 2000). Parallel work on good practice guidance for LULUCF would have carried a risk of inconsistency with the Special Report. Furthermore, significant negotiations on LULUCF were underway in the UNFCCC process. Thus, the IPCC recognised that it would be better to develop good practice guidance for LULUCF in the light of the outcome of these negotiations.

The LULUCF negotiations were completed during the second part of the sixth COP (COP6), and at COP7, which took place respectively in Bonn (July 2001) and Marrakech (November 2001). Paragraph 3 in the Decision 11/CP.76 agreed at COP7 contains the following requests to the IPCC:

- To elaborate methods to estimate, measure, monitor, and report changes in carbon stocks and anthropogenic greenhouse gas emissions by sources and removals by sinks resulting from land-use, land-use change and forestry activities under Article 3, paragraphs 3 and 4, and Articles 6 and 12 of the Kyoto Protocol, on the basis of the Revised 1996 Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories, taking into account the present decision (11/CP.7), and draft decision -/CMP.1 (Land use, land-use change and forestry), to be submitted for consideration and possible adoption to the Conference of Parties at its ninth session;

- To prepare a report on good practice guidance and uncertainty management relating to the measurement, estimation, assessment of uncertainties, monitoring and reporting of net carbon stock changes and anthropogenic emissions by sources and removals by sinks in land-use, land-use change and forestry sector, taking into consideration the present decision (11/CP.7) and draft decision -/CMP.1(Land use, land-use change and forestry), to be submitted for consideration and possible adoption to the Conference of Parties at its ninth session.

2.3 Good Practice Guidance for LULUCF

The good practice guidance report has elaborated the IPCC 1996 Revised Guidelines (IPCC, 1997) by a set up that has abandoned the process based set up. The latter concentrated on a limited number of processes (biomass in forest, deforestation, and soil carbon mainly) while the LULUCF GPG (IPCC, 2003) provides a consistent set up by land use type (Forest, cropland, grassland, wetland, settlement, and other land). Subdivision is suggested according to if the land use has remained in the same land use over the last 20 years or whether it was changed into a certain land use. Then, methods and data are suggested for each carbon pool (aboveground, belowground, litter, dead wood, and soil C) and for the non – CO_2 greenhouse gases nitrous oxide and methane.

Advantages are that this approach is transparent and covers the full area of managed land. By following the single processes as in IPCC 1996 Revised Guidelines, it was never very clear what happened to a piece of land if it was not under that same land use before or after. Neither did the set up of the IPCC 1996 Revised Guidelines allow for a more detailed application of methods (coupling biomass and soil dynamics on the same track of land) in a way that could be compared to the basic level of detail (*Tier 1*) of the these guidelines. Disadvantage of the current set up of the GPG LULUCF (IPCC, 2003) is that if a single process needs to be reported, then it must be traced back in all categories of land. However, this would have been the case in the IPCC 1996 Revised Guidelines as well had they been applied properly.

2.4 Reporting under the Kyoto Protocol for the Netherlands

This reporting needs to be done by Annex 1 countries 1 only. The relevant articles for the Netherlands are: 1) Article 3.3 reporting related to Afforestation, Reforestation and Deforestation (ARD,): this reporting is obligatory, 2) Article 3.4 reporting and accounting related to additional activities as selected on a voluntary basis by individual countries. Nabuurs *et al.*, 2003 give a detailed description of the current status of LULUCF greenhouse gas reporting in the Netherlands. Currently, reporting by the Netherlands is incomplete and actions are needed to comply with the recently formulated Good Practice Guidance (IPCC, 2003). Reporting under the Kyoto Protocol means that the selected activities also need to be accounted for in the national system for UNFCCC reporting. As a conseqeunce, selection from options and a decision on implementation of such activities in land use, agriculture and forestry under the Kyoto Protocol Article 3.4 is an iterative proces with updating the reporting methodology of emissions of greenhouse gases (figure 1): (1) following identification of options it is appropriate to (2) check whether the effects show up with calculations for the national inventory in the Netherlands. If yes, to (3) further determine effectivity and source or sink strength of execution of activities within the rules and regulations set out for Kyoto Protocol article 3.4 activities and if no, (4) to first define and implement adaptations to the emission inventory methodology (emission registration system) of the Netherlands. When adaptations to the National System are made both requirements derived from Kyoto Protocol and the GPG need to be taken into account simultaneously (Figure 1).

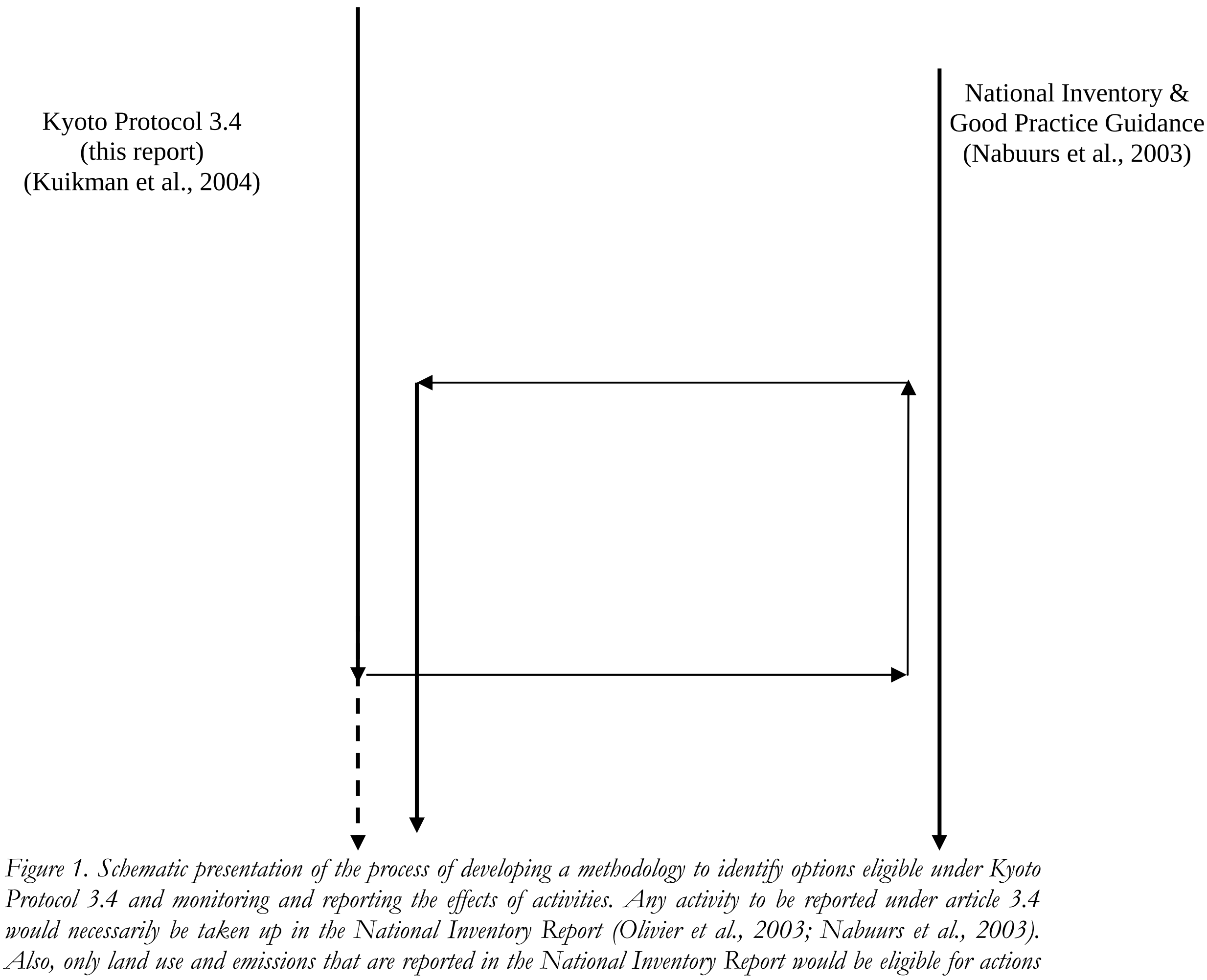

Figure 1. Schematic presentation of the process of developing a methodology to identify options eligible under Kyoto Protocol 3.4 and monitoring and reporting the effects of activities. Any activity to be reported under article 3.4 would necessarily be taken up in the National Inventory Report (Olivier et al., 2003; Nabuurs et al., 2003). Also, only land use and emissions that are reported in the National Inventory Report would be eligible for actions to reduce emissions or enhance sinks for carbon (this report).

3 White spots and key source analysis for LULUCF sector in Dutch NIR: results from experts in GDR

3.1 White spots in the Dutch NIR for the LULUCF sector

An inventory of omissions (white spots) in the Dutch National Inventory Report (NIR 2003) (Olivier et al., 2003) was made in the expert meeting. Experts identified the requirements in reporting tables for IPCC category 4 (emissions landuse agriculture with grassland and cropland) and IPCC category 5 (Land use changes and Forestry). A total of 16 so – called white spots have been identified (table 1) for IPCC category 5 and 3 white spots for category 4. None were identified for category 5C Abandonment of managed land.

Relevant white spots for the Netherlands are:

- Buffer areas ("bufferstroken") which could account for 10 – 15 % of the future national agricultural area
- Imports (and exports) of C which animal feed and wood (products)
- Land use changes and how to deal with the category settlements and other land
- C in water covered soils.

On the issue of imports and especially for animal feed, experts found it difficult to agree on definition of system boundaries and whether this is a source or sink of CO_2. The land use change and urbanization brings about removal of soil and soil C or covering of soils. Here too experts found definition of activities and areas difficult to address. Little is know about the C in soils of ditches, streams and rivers yet these could be important given the extensive area in the Netherlands and interactions with land (removing organic material from ditches and stream to land).

Source strength of emissions of white spots

On all white spots identified, experts were asked to estimate the source strength (table 1). Estimates were provided for all except for import of C in animal feed and wood (5E7) and CO_2 emissions from use of chalk in fertilization in agriculture (5D6). For a total of 7 white spots no source strength estimate could be made at the workshop. Following the workshop with experts, estimates for animal feed[5], chalk fertilization[6], forest soil C stocks[7], emissions of CO_2 and non – CO_2 greenhouse

[5] Estimates for import of animal feed are taken from Janssens et al. (2004) and Velthof (2004) and amount to approximately 10 Mton C

[6] In the Netherlands approximately 2 billion kg chalk is used. This is balanced by an annual loss of approximately 50 – 100 kg C per ha through leaching and run – off. This estimate does not include mining activities in the Netherlands and elsewhere (50% of the chalk used in the Netherlands is produced in the nationally and the remainder is imported) or processing in the sugar industry (burning of chalk). So – called "schuimaarde" is 70% of the chalk fertilizers used in the Netherlands and its production requires substantial amounts of energy and produces CO_2.

gases from managing organic soils[8] and loss of permanent grassland[9] were taken from literature.

3.2 Trends in emissions of white spots

Not only source strength but also trends that may result in changes in emissions are an important determinant of the necessity to report on emissions. Experts identified major trends that would result in changes of 10% of the area or emissions in land use and agriculture and forestry in the Netherlands (appendix 1). White spots which may lead to substantial changes of 10% or more in any year are:

5D2 Emission of greenhouse gases from management of organic soils (area and emission)
5D5 Soil C stocks in peat soils
5D4 Area changes following implementation of buffer strips
5E3 Land use changes
5E5 Energy cropping practices
5E7 Import and export of C in animal feed and wood

In addition, implementation of manure policies to comply with the EU nitrate directive has consequences for crop residues as in autumn a cover crop is required with possible effects on indirect emissions of N_2O from nitrate leaching.

A first approximation of potential emissions lies at assuming maximal rates of loss of C stocks in soil. Kuikman et al (2003) used existing soil maps and databases to arrive at a current topsoil (0-30cm) C stock in agricultural and forest soils of 264 Mton C for the Netherlands. If we assume that maximally 5% of this stock could be lost annually, we arrive at an absolute upper boundary of emissions of 13.2. Mton C /y for the whole of the Netherlands. Individual estimates in Table 1 (with grassland soils about half of the total area) can therefore never be higher than approximately 6 Mton C/y (or 24 Mton CO2/y).

Recently, inputs of organic matter to agricultural land was estimated at a total of 5.2 Mton effective organic matter; this is equivalent to 3.2 Mton organic carbon or 11.7 Mton CO_2 (Velthof, 2004). Major sources in the Netherlands are: crop residues in grass (1.1 Mton), crop residues in arable land and cover crops (0.6 Mton), manure (1.3 Mton), compost (0.1 Mton). If one assumes that on average 2% of soil organic carbon is respired each year this would total 6 Mton C or 22 Mton CO_2 per year. The far greatest part of this CO_2 would be produced from managed organic peat soils.

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[7] In the "meetnet functievervulling bos" 2001 the carbon stock is estimated at 19.5 Mton which is equivalent to 71 Mton CO_2; the annual increment in wood is estimated at 4% or 3 Mton CO_2; Schelhaas (unpublished EDI measurements) estimates another 2 – 3 Mton CO_2 equivalents in litter.

[8] Kuikman et al. (2003) see later in text

[9] Vellinga et al., (2004) estimate the area of permanent grasland lost on the basis of agricultural statistics at xxxx ha (CBS, 2004) and a loss of 1 – 2 ton C per ha for land use change from grassland to arable land; Vellinga et al. (2004) estimate the area of grassland renovation at 50 000 – 100 000 ha per year; calculations estimate an emission of 1.5 Mton CO_2 for this specific grassland management

Table 1: Overview of white spots the Dutch National Inventory Report for the LULUCF sector (IPCC category 5 en category 4D). Estimations for the carbon source are taken from the experts in the GDR (n = number of experts) and compared to available figures from literature (see text).

		Greenhouse gas source and sink categorie	Short name	Maximum source (Mton CO_2) (positive = emission to atmosphere)		
				n	range	literature
	5A.	**Changes in forest and Other Woody Biomass Stocks**				
1	5A1	Soil C stock change	Forest soil C stocks	2	-3 to -1	-
2	5A2	Changes in biomass C stock in trees outside forests (single trees, hedgerows etc)	Trees in non-forest locations	2	-1 to -0.5	-
		Improved estimate for other treee compartments (branches etc)	BEF improvement	1	-0.2	-
	5B.	**Forest and grassland conversion**				
3	5B1	Conversion of permanent grasland to arable land or rotational grassland	Conversion grassland	1	+5	(Vellinga et al., 2004)
	5B2		Conversion forest	1	+0.1	
		Restoration of wetland – changing water management in areas with peat soils	Wetland restoration			Van der Born et al. (2003)
	5D.	**CO_2 Emmissions and Removals from Soil**				
4	5D1	Emission of land and water management (drainage organid soils) and emissions of nitrous oxide (N_2O) and methane (CH_4)	Emission from drained soils	1	+6	Kuikman et al., (2003), Burgerhart (2002) and van der Born (2003)
5	5D2	Emission of land use and organic soils and and emissions of nitrous oxide (N_2O) and methane (CH_4)	Emission from organic soils	1	+1[1]	-
6	5D3	Soil cultivation and crop management in agriculture	Soil- and crop management	0	-	Vleeshouwers and Verhagen (2001)
7	5D4	Buffer strips, riparian zones and management of borders of ditches and streams, sinks (carbon stocks and emissions of nitrous oxide (N_2O) and methane (CH_4)	Sinks in bufferstrips and ditch and stream management	1	-1	-
8	5D5	Soil C stock changes in peat soils (regrowth of peat and biomass crops for energy)	Stocks of C in peat soils	1	+3[2]	-
9	5D6	CO_2 emissie bij kalkbemesting	CO_2 emissie bij kalkbemesting	2	0	Statline (CBS, 2004)
	5E.	**Other**				
10	5E1	Emissions from burning plant residues (wood, forest management, organic wast, reed, desease management in fruit cropping)	Burning of residues; waste, disease management	0	-	-
11	5E2	Emissions from composting crop residues (may not be required due to displacement of emissions)	Composting of residues	0	-	-

12	5E3	Landgebruik veranderingen (landbouw -> bos, natuur, stedelijk gebied)	Land use changes	1	+13	-
13	5E4	Emissions from waste management of organic and crop residues	Emissions from residues	1	-3	-
14	5E5	Energy crops	Energie gewassen	1	-2.4[3]	-
15	5E6	C in soils under water (ditches, streams)	C in soils under water	1	0	-
16	5E7	Import and export of C in animal feed and wood	Import and export of C	2	-10 to +15	Janssens et al. (in prep) and Wolters (pers. Comm.)
	4D.	**N_2O emissions from agricultural soils**				
17	4D1	Indirect emission of nitrous oxide – incomplete (concept of) reporting in National Inventory Report (Olivier et al., 2003)	Indirect N_2O from NO_3	0	-	Denier van der Gon et al. (2004)
18	4D2	Indirect emission of nitrous oxide – no reporting of emissions yet specific manuring techniques to prevent ammonia volatilization are accounted for by higher emission factor for direct emission of nitrous oxide from application of animal	Indirect N_2O from NH_3	0	-	Denier van der Gon et al. (2004)
19	4D3	Emission of nitrous oxide from crop residues	N_2O from crop residues	0	-	-

Notes: 1: assumption relevant area of organic soils 100,000 ha and rate 10 ton/ha y; 2: compare with 5D2 for budget; 3: assumption 25% of area arable land 200,000 ha and rate 12 ton/ha y, category is sink under assumption that biomass vegetation is replacing fossil fuel

Soussana et al. (2004) estimates 20 year averaged C sequestration from changes in grassland management in France at 0.1 – 0.5 t C per ha per hear for increases in the duration of grass leys on arable land, at 0.3 – 0.4 t C per ha per year for change of rotational grassland to permanent grassland and at -0.9 - -1.1 t C per ha per year for intensification of organic soils with permanent grassland.

Pulleman et al. (2003) compare organic matter dynamics for organic versus conventional arable farming in marine loam soil in the Netherlands. More than 70 years of different management has resulted in soil organic matter (top 20 cm) contents in organic farmed arable soils (24 g C per kg soil) to be greater than in conventionally farmed arable soils (15 g C per kg soil). However, soil organic matter contents in permanent grassland was highest with 46 g C per kg soil.

Lettens et al. (2004) assessed the soil organic matter contents of belgium soils derived from a series of soil and geographical data from the Belgian national Soil Survey project in the periode 1950 – 1970. The average soil organic carbon contents for the upper 30 cm of arable land, pasture and forest are 51 t C per ha, 70 t C per ha and 60 – 70 t C per ha, respectively. These values compare well with numbers presented by other authors, i.e. Batjes (1996) on global scale, Arrouays et al. (2001) for France or Smith et al. (2000) for Europe and Kuikman et al. (2003) for land use in the Netherlands. Sleutel et al. (2003) conclude that Belgian cropland (appr. 600 000 ha) is a net source of 2.2 Mton CO_2 per year in the period from 1990 till today on the basis of over 210 000 topsoil measurements in the period 1989 – 1999.

Grassland management including ploughing up permanent grassland or ploughing of grass in leys significantly impacts emissions of CO_2 and N_2O. Grassland renovation and land use change converting permanent grassland to arable land and leys in the Netherlands likely yields emissions of 1.7 Mton CO_2 equivalents in 2000 of which 0.65 Mton from N_2O on the basis of calculations using a simple model (Vellinga et al., 2004; Andrén et al., 2004).

Sofar we have not considered peat soils. These soils with peat layers are part of the organic soils and have a special position in the national balance of soil organic carbon and emissions of greenhouse gases. In the Netherlands relatively large areas of 200 000 to 300 000 ha are classified as peat soils with layes of peat varying from 0.4 to more than 10 m. The water management as currently practiced is crucial for agriculture and settlements in this region but is cause of losses of carbon and emissions of CO_2 and N_2O. The oxidation of peat produces 5 – 15 Mton CO_2 which is approximately 5% of the total CO_2 emissions in the Netherlands; this emission is not reported in the National Inventory (Burgerhart, 2001; Van der Born et al., 2002; Kuikman et al., 2003).

For some categories significant trends are expected:

- **developments in 'Veenweide' area** are important for the future: both large in magnitude (Table 1: **5D2** Emission from organic soils and **5D5** Soil C stock changes in peat soils) and a clear change in trend (van der Born et al., 2002; Kuikman et al., 2003; pers. comm. v/d Akker). Also in combination with the growth of bioenergy crops (category **5E5**);
- **5D4 Bufferzones**: relatively small based on individual surface areas, but it is expected that in due time 10% of the Dutch agricultural area is managed as land edge, bufferzone or riparian zone. Effect on rate of carbon sequestration unknown, while determination of small areas for individual zones is problematic;
- **5E3 Land-use change**: consists of several developments: urbanization, extensivation in agriculture, change in function of countryside, and function change from agriculture to nature (river floodplains). How to deal with land use category Other land in GPG
- **5E7 Import and export of C**: in very densely populated countries (Benelux), where consumption of food, feed and wood products exceeds production, carbon fluxes originating from trade are even larger than the terrestrial carbon stock changes (figure 2, Janssens et al., 2004).

Although a formal key source analysis has not been carried out yet in this report, the first results give an indication of the aspects that are specific for the Netherlands. Because of its unique biosphere combined with a high land use intensity, the Netherlands has specific qualities (and opportunities?) but also specific problems.

3.3 Discussion of the results from the expert workshop

The group of experts that joined the workshop at Alterra on September 2nd, 2003 agreed well on sources of greenhouse gases that are not included in the National Inventory Report of emissions of greenhouse gases in the Netherlands. The experts felt that definition of sources or sinks was difficult and this remained ambiquous. Also quantification of source strength's was difficult. Many experts would need more time to consult specific literature sources. We conclude from this experience that most likely limited data and reports are available (see i.e. Smith et al., 2004; Freibauer et al., 2003; Watson et al., 2000) and this holds for Europe and the Netherlands in particular (Guo and Gifford, 2002)[10].

In an international workshop held in Clermont Ferrand (France) on September 4th and 5th, 2003 more than 30 experts met for a similar purpose. The result is strikingly similar to the results at the workshop in Wageningen for this project: experts were not able or willing or both to quantify emissions or changes in emissions of greenhouse gases following specific management actions in land use and agriculture (see Smith et al., 2004 in prep).

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[10] Guo and Gifford (2002) present a meta analysis on effects of land use change on soil carbon stocks on the basis of a literature review of 74 published studies; of these studies most refer to USA or New Zealand or Australia and only 3 are from Europe. The authors conclude that available data are limited and methodologies remain highly diverse. As a consequence their conclusions are working hypotheses only.

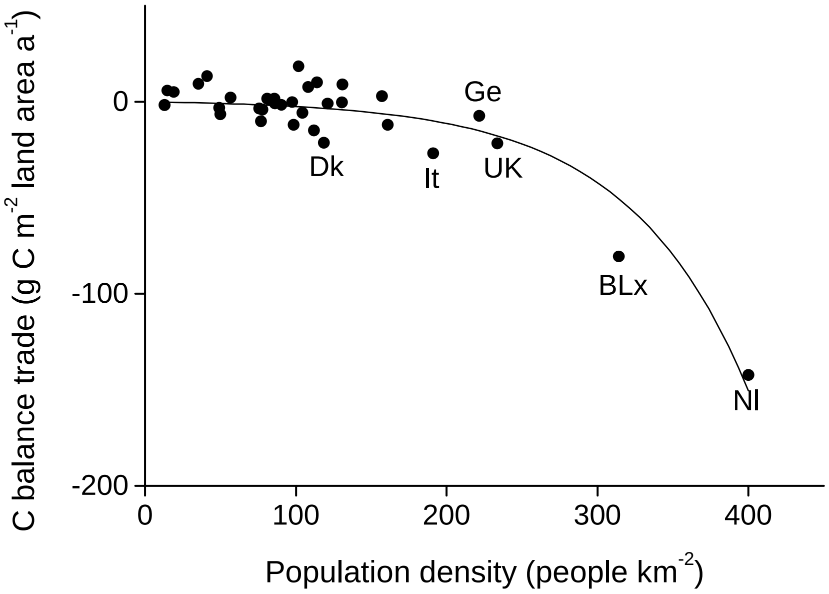

Figure 2: Negative correlation between population density in European countries and carbon flows via trade (from Janssens et al., 2004).

Experts felt that definition of activities and systems borders would be helpful to identify and quantify emissions of greenhouse gases for white spots and for options in Kyoto Protocol article 3.4. This holds for trade – offs between emissions of different greenhouse gases and for displacement of emissions to elsewhere within a sector, production systems or nations as well. For example: import or export of animal feed within the Netherlands is considered neutral for C but what about international trade of organic material for animal feed[11].
Experts felt that discrepancies may exist on information from statistics that is needed to define the base line or reference conditions such as 1990 statistics as most statistics have been aggregated at national levels or scale and necessary information on the whole period of 1990 – 2010 for specific conditions may not be available. For example: the level of resolution if identifying area of buffer strips and other small landscape elements that are kept under specific management or activities that are relevant and eligible for Kyoto Protocol article 3.4 may be insufficient.

[11] Janssens et al. (2004) report that (citation) "Import and export of organic matter via trade will decouple the photosynthetic uptake of C from its subsequent decomposition/combustion, because C that is taken up in one country returns to the atmosphere in another country. Hence, the net C exchange between the terrestrial biosphere and the atmosphere can differ substantially from the observed changes in terrestrial C stocks and we therefore accounted for these trade-related C fluxes in our estimates of the C exchanges between the terrestrial biosphere and the atmosphere. We observed a negative correlation between the density of C flows via trade (export – import of food- feed- and wood C) and the population density (Fig. 1). In very densely populated countries (Benelux), where consumption of food, feed, and wood products exceeds production, these C fluxes originating from trade are even larger than the terrestrial C stock changes.

4 Options and potential for activities in the Netherlands under Kyoto Protocol Article 3.4: results from an expert meeting

For the upcoming first evaluation period of the Kyoto Protocol (2008-2012), activities related to Land Use, Land-Use Change and Forestry (LULUCF) are accountable under Article 3.4 of the Kyoto Protocol. Changes in agricultural policy and developments in the rural landscape (urbanization, (re-)development of wetlands, water retention areas) have important consequences for the dimensions of the agricultural activities (area, number of animals and farms) and possibly also for the emission of greenhouse gases. As such, the emission of greenhouse gases in the Netherlands is influenced and could both increase or decrease. However, it is also possible to direct agricultural activities in such a way that reduction of emission is achieved. These activities can then be accounted for under Article 3.4. A system for inventory, monitoring and reporting will then be required according to the Good Practice Guidance (GPG) and rules for reporting of Kyoto Protocol article 3.4 activities (see chapter 2).

In this section the options and potential for the Netherlands to implement LULUCF activities under Article 3.4 to reduce greenhouse gas emissions are evaluated. On the basis of expert judgment relevant activities for the Netherlands are listed, prioritized and estimations for emissions and emission factors are made. Information from recent reports and articles is used to interpret and clarify results. Ongoing and new activities are evaluated for the sequestration of carbon through the input and output of soil organic matter. But also possible changes in emission for other greenhouse gases (N_2O, CH_4) are assessed in order to the determine the overall greenhouse gas mitigation effect of an activity. Finally, in this chapter we propose a list of most promising activities for the Netherlands.

4.1 Options for activities in the Netherlands

Starting-point for the inventory of options for activities under Article 3.4 in the Netherlands is a recent study carried out by Freibauer *et al.* (2004). This paper presents a long-list of activities relevant for the European situation. The paper concentrates on grassland and cropland management both in mineral and organic soils. Management changes within a single land-use (e.g., reduced tillage on cropland) as well as transitions between land-uses are considered (cropland to grassland conversion). Increasing the soil carbon content is achieved through higher carbon input, decreasing carbon output or a combination of the two through improved management. Carbon sequestration can also occur through a reduction in soil disturbance (Freibauer *et al.*, 2004).

An overview of the activities that were used as a starting-point for the GDR is given in Appendix 5. First, the participating experts were asked if any activities specific for the Dutch situation should be added to the list and what relevance the listed activities have for the Dutch situation. Second, identified activities were prioritized into three classes: high priority, low priority and no priority for the Netherlands. Experts motivated their choice on the basis of relevance for the Netherlands, sequestration potential and available area for such activities. In two voting rounds, all activities were directed into either of three categories with at least 10 activities in the class of high priority and related to land – use types according to GPG2003 (Table 2). Furthermore, for every measure the descriptions from the experts in the GDR workshop and additional comments given by the experts are summarized. Three activities were later added to the high priority class (pers. comm. Gert-Jan Nabuurs).

An first observation is that the experts have a high degree of agreement on which measures under KP 3.4 should get a high priority. Based on the typology of GPG2003, high priority measures for all land-use types were proposed in Table 2. However, all measures related to grassland management in fact are suggested to be implemented for organic soils, viz. Veenweidegebied. Measures for grassland on other than organic soils (17, 18, 19 and 20) were given no or low priority only. The main reason for this is that the margins for alternative management practices is relatively small related to socio-economic aspects (e.g. milk quota). Comparison of the high priority activities for the Netherlands (Table 2) with the most promising measures identified for Europe (Freibauer *et al.*, 2004) shows both similarities and clear differences. The activities related to *crop residue managements*, *land-use change* (agricultural land to forest or nature), *bio-energy crops* and *shallow water tables for farmed organic soils* are promising both at the Dutch and European level. Main differences are related to *organic farming* and *zero tillage* that are important only at the European level. For the Netherlands specifically *composting* and *parcel edge management* were considered important.

Several activities categorized as high priority (Table 2) are interrelated and feedback mechanisms between the measures exists that need to be accounted for:

- **Organic soils**: The activities Bio-energy crops (12), Grassland management (21), More shallow water table (22) and Change in animal stocks (24) all deal with possibilities of carbon sequestration and emission reduction in organic soils. Implementation of a more shallow water table has direct consequences for grassland management and the stocking rate of cattle. Therefore these measures need a combined evaluation for example through evaluation of future land-use scenarios for these areas. A good example of this is given in a recent study by Van den Born *et al.* (2002) for the so – called wet area *Veenweidegebied*;
- **Land-use change**: Several activities are related to different forms of land use change. In Table 2 a distinction is made between several types of land-use change: (15): agricultural land to forest or nature, (23): forest to other land use, and (34): conversion to settlements. Through separate definition of the land-use change measures overlap between measures is excluded;
- **Forest measures**: In Forest protection, taking exploitable forest out of production (31) abandones production completely, while the measure Longer rotations or developing nature oriented forest management (27) refers to a change of forest management wher production is still possible.

Table 2: Overview of priorities for activities under Kyoto Protocol Article 3.4 in the Netherlands

Activity[1]	**Land use type**[2]	**Description**[3]
High priority		
Crop residues (7)	Cropland management	measure includes removal of crop residues from the field and use in energy conversion (bio – energy) or as fiber material (bio–degradable materials) if possible in cascades – risks are for loss of nutrients and organic matter in cropland and necessity to replace lost nutrients by fertilizer (CO_2 and N_2O during production and transport) – alternatives are feed for animal production and use of animal manure (cascade)
Composting (9)	Cropland management	fermentation of manure with crop residues as alternative for traditional composting may replace fossil fuels (CH4 from manure and crop residues) and keep nutrients cycling within agricultural systems (Cropland management in combination with intensive animal production i.e. pig manure – cattle manure is already fermented) (reduces CH4, reduces CO2 from fossil fuel, reduces N2O from field application of pig slurries, maintains organic matter in soils) (difficult in terms of legislation and implementation).
Bio-energy crops (12)	Cropland management	cropland management or under land use change (i.e. grassland in organic soils of 'veenweide' to forested land or to Phragmites – riet; both agriculture and forestry, no technical or agronomic limitations – dilemma is how to categorize in either forest (trees and woody material) or cropland (annual crops) or cropland (perennial crops i.e. riet) (account for soil preparation, fertilization and soil and water management).
Land use change (15): agricultural land to forest or nature	Cropland, Grassland (ARD)	category cropland and grazing land management as deals with agricultural land; deals with soil C; removing cropland from agriculture to establish nature or extensification of former cropland to low density stocks of grazing (C sequestration for limited time period, possible higher N2O emissions from past fertilizer application or CH4 from necessary water table management); reforestation of cropland; cropland to grassland not very likely in the Netherlands as long as current milk quotum policy is maintained (generally less nitrous oxide as fertilization practice is halted).
Land use change (23): Intensive to extensive use of organic soils	Grassland management	See report Van der Born (2002)
Grassland management (21)	Grassland management	grazing land management on organic soils – continuing permanent grassland to conserve existing soil organic matter pools or less frequent or no grassland renovation including soil tillage or removing the (living) sod (conserves soil C or increase soil C pool size)
More shallow water table (22)	Grassland management wetlands	either wetland or grazing land management on organic soils – conserves existing soil organic matter pools probably at the expense of higher CH4 if high water tables are maintained (less frequent or intensive grazing reduces N2O from manure or fertilisation); if high water tables are maintained throughout the year, peat will be formed and sequester carbon dioxide in soil organic matter; process may continue long and store high amount of C if practice is continued.
Change in animal stocks (24)	Grassland management	grazing land management on organic soils; combine with more shallow water table in lower areas of the Netherlands; this will produce less manure and nitrous oxide and likely not increase methane, carbon stores in soil will be conserved.
Parcel edge management (33)	Cropland management grassland management	cropland or grassland management; practice is clearly agricultural and may affect up to 10% of the total area of agricultural land and lead to lower production, less losses of nutrients to water and lower nitrous oxide (direct and indirect) emissions; though production may be re-located; difficult to identify spatially and quantify effects and difficult to monitor.
Longer rotations or in general: nature oriented forest management (27)	Forest management	Forestry in The Netherlands is changing from a production orientation to nature orientation. This leads to older forests, other tree species, more dead wood, less soil disturbance, and more litter, to name some aspects. We can expect that this leads to higher average carbon stocks in forest biomass. An additional carbon sequestration in the forest of between 0.1 and 0.8 Mg C/ha.y can be expected.
Longer life wood	Forest	If society chooses to use wood based products instead of concrete,

products (28)		plastics or aluminium, then fossil fuels are saved. Through this material substitution wood based products have an emission reduction effect that lasts indefinitely, and it is an effect that is outside the political discussions concerning carbon stocks in wood based products.
Forest protection: taking exploitable forest out of production (31)	Forest management	This is a measure that fits in current trends in Dutch and European forestry. It is expected that this may be practice on 30 to 40% of Dutch forests in the future. It may yield an extra sequestration in the forest biomass between 0.2 to 1.4 Mg C/ha.y. Wood products not produced from Dutch forests will be imported. Gradual decrease of forest area has never been systematically assessed, but several statistics that partially cover the Netherlands exist. It can be a slow process (degradation of hedgerows). Category likely KP 3.3 (ARD) as it deals with mostly woody biomass and its use after harvest or through management practices . such as thinning; re- and afforestation has major effects Measures should aim at slowing down or even a turn around of the process.
Low priority		
Livestock management in grassland (19)	Grassland	Comparable to activity 24, but here more specific for grassland in general and not organic soils only
Restoration of degraded forests (32)	Forest	forest management; integrated forest management is current forest practice and effects difficult to detect and quantify.
Extensification (13)	Cropland	
Reduced tillage (2)	Cropland	
Land use change (34): conversion to settlements	Settlements	Large areas are or will change to build up areas (settlements or roads). This is often a sudden proces (urban sprawl). What happens to carbon in the soil (sink or source?), also land use or crops and trees in built environment may contribute significantly.
No priority		
1. Zero-tillage	Cropland	Developments only small scale, no significant effect. In contradiction with crop protection policy and ambitions to realize high yields
30. Pest management	Forest	not current practice
29. Fire management	Forest	Hardly occurring at the moment
20. Protection and restoration	Grassland	Organic soils
25. Fertilization	Forest	Some liming is still practice. This will not have a growth stimulating effect.
26. Thinning	Forest	Through thinnings the growth is concentrated on fewer trees. However, thinnings hardly have an effect on total NPP or NEP. Thinnings allow for a stand to grow longer. Thus eventually, higher carbon stocks may be reached.
17. Change from short duration to permanent grasslands	Grassland	Comparable to activity 21, but here more specific for grassland in general and not organic soils only
11. Irrigation/drainage	Cropland	
10. Improved rotations	Cropland	
8. Sewage sludge	Cropland	Low potential. Not allowed in the Netherlands for its high metal concentrations.
3. Set-aside	Cropland	Not clear how C sequestration will take place. Choice for different crops
4. Perennial grasses and permanent crops	Cropland	Comparable to activity 12, but here not limited to bio-energy crops
5. Deep-rooting crops	Cropland	
6. Animal manure	Cropland	Large manure stocks in NL, but C is easy decomposed. Earlier applied 'stalmest' resulted in C sequestration.
14. Organic farming	Cropland	Only relatively small area under production
16. Increase the duration of grass leys	Grassland	Comparable to activity 21, but here more specific for grassland in general and not organic soils only
18. Extensification of organic soils with permanent grassland	Grassland	

[1] adapted from Freibauer *et al.*, 2004;
[2] taken from GPG2003 and 96GL
[3] comments from GDR + additional comments by experts

In the discussion experts concluded that they were surprised by the low priority assigned to some activities, i.e.:

- **animal manure**: the Netherlands has relatively large manure stocks within agriculture of which the carbon is often easily decomposed. However, this may well depend on the application method for the manure; for example, the use of farmyard manure has led to sequestration of carbon in the soil though crop residues from other land may be required to produce the farmyard manure;
- **organic farming**: in several european countries organic farming has been introduced on relatively large areas of up to 20% (Freibauer *et al.*, 2004). However, it is expected that organic farming will be less relevant for the Netherlands and it remains questionable whether changing from intensive to organic agriculture allways does increase carbon sequestration rates indeed;
- **perennial grasses and permanent crops**: this category is closely related to bio-energy cropping. Otherwise, the main objective for this activity is improvement of soil fertility and structure. This could lead to soil carbon sequestration though it is expected that only a limited area will be available.

Experts felt that not only innovative activities should be searched for but also less obvious options should not be overlooked. The boundaries and the definitions within the GPG2003 need to be assessed carefully to identify the degrees of freedom for implementation of activities under Kyoto Protocol article 3.4 in the Netherlands. The following principles are leading:

1. maintain current carbon stocks in agricultural soils
2. promote soil carbon sequestration
3. avoid carbon emissions from soils managed for agriculture.

4.2 Potential for activities in the Netherlands

To evaluate the potential and feasibility for activities under Article 3.4 of the Kyoto Protocol in the Netherlands several factors have to be taken into account. The following main factors can be distinguished (Arrouays *et al.*, 2002; ECCP, 2003):

- **Sequestration rate:** this is expressed as the amount of carbon that is stored in the soil within a certain time period often per year. The carbon sequestration rate depends on climate, weather, soil type and land management: high decomposition rates occur in regions where high temperatures in summer coincide with moist conditions whereas low decomposition rates occur in areas with low temperatures and wet conditions. In addition, sequestration rates will change over time: initially rates will be high and will decrease until a constant equilibrium level is reached (Figure 3). Therefore, it is important to be specific as to how the sequestration rate is expressed and calculated; many reports use a mean sequestration rate over a longer period. National or local sequestration rates are scarce and the available rates have a high uncertainty;
- **Available area:** the most important factor for activities under KP article 3.4 is the area of land for which the activity (potentially) can be applied. In a recent study, Nabuurs *et al.* (2003) have evaluated the available monitoring systems for quantifying land-use change in the Netherlands. Important attention points are: the required and available scale for monitoring land-use changes, and the

availability of this information from the Kyoto Protocol base-year 1990 and onwards;

- **Environmental impact**: this aspect relates both to other greenhouse gases (N_2O of CH_4) and to i.e. the impact on biodiversity, landscape. Within the research program 'Reduction plan non-CO_2 Greenhouse Gases' (ROB; see www.robklimaat.nl) efforts are underway for inventory methodologies of other greenhouse gases;
- **Socio-economic impact**: this aspect mainly relates to effects on farm income and farm profitability. In general it is difficult to assess impact of measures on farm profitability and/or costs, and many measures have positive and negative effects. Through the implementation of new policy, certain activities can be stimulated (compensation) or discouraged.

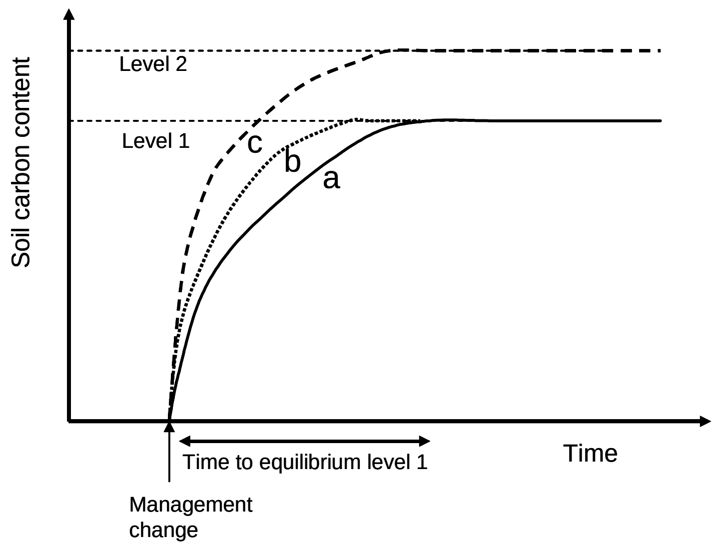

Figure 3: Illustration of possible scenarios of the effect of a management change on the soil carbon content. The three presented scenarios show a difference the required time to reach equilibrium (scenario a vs b) and in efficiency concerning the equilibrium level that can be achieved (scenario a vs c). Differences can be explained by factors like treatment, soil type, or climate (Taken from Kooistra and Kuikman., 2003).

In the assessment below the main focus is on sequestration rate, surface area and the resulting sequestration potential, but also the environmental factors are described.

For those high priority activities for the Netherlands described in Table 2 an estimation was given for the soil carbon sequestration potential by the experts in the GDR. The resulting estimations for sequestration potential the Netherlands are presented in Table 3. The estimations are compared with potentials based on sequestration rates taken from Freibauer *et al.* (2004). The sequestration rates are multiplied with surface areas for different types of land-use in the Netherlands to calculate the sequestration potential. Based on the estimation of the experts in the GDR a total potential of 4.9 Mton C can be sequestrated in soils of the Netherlands each year (longer life wood products not taken into account). Based on Freibauer *et al.* (2003), 3,5 Mton C y^{-1} can be sequestrated. This still is an over-estimation as cropland and grassland areas may have been counted for different activities twice.

Table 3: High priority measures for increasing soil carbon stocks in agricultural soils under KP 3.3 and 3.4 in the Netherlands and potential for yearly soil carbon sequestration rates based on estimation from experts in GDR (column 3with n (number of experts), mean and std) compared with estimations taken from Freibauer et al. (2004) (column 4 – 6).

	Activity	**Estimation for total C sequestration potential from emissionfactor x area of measure in Mton C y^{-1} (CO_2-eq in brackets) (from GDR workshop)**			**Potential soil C sequestration rate (t C ha^{-1} y^{-1})[1] (Freibauer et al., 2004))**	**Uncertainity[1] s.d. (Freibauer et al., 2004)**	**Total soil carbon sequestration potential[1] if all land within land use type[2] is used (Mt C y^{-})**	**Limitations**	**Literature for Dutch situation**
		n	*mean*	*std*					
7.	Crop residues	5	1.06 (3.92)	3.85	0.7	> 50%; -0.3 to 0.3	0.65	Surplus resisdue not available	Anonymus, 1987
9.	Composting	3	0.3 (1.2)	0.98	0.4	>> 50%	0.37	Available material	
12	Bioenergy crops	3	0.6[3] (2.13)	1.03	0.6	>> 50 %	0.55	Available area	Londo, 2002
15	Land use change: agricultural land to forest or nature	4	1.08 (4.02)	4.1	0.3 – 0.6	>> 50 %	0.27 – 0.55	Available area	
21	Grassland management (OS)	2	0.2 (0.75)	0.92	1.4	> 50 %	0.3	Adoption by farmers	Born et al., 2002
22.	More shallow water table (OS)	3	0.65 (2.4)	1.04	1.4 – 4.1	> 50 %	0.3 – 0.86	Adoption by farmers	Born et al., 2002 + vd Akker
23.	Land use change (OS): Intensive to extensive use of organic soils [5]	3	1.1 (4)	2.65	0.8 – 3.3	> 50 %	?	Available area	Born et al., 2002
24	Change in animal stocks (OS)	2	0.3 (1.05)	1.34	?	?	?		Born et al., 2002
33	Parcel edge management [4]	1	0.27 (1.0)	-	> 2.2	>> 50 %	2 (lower limit: 0.2)	10% of available cropland	
27	Longer rotations or in general: nature oriented forest management		0.16		0.1 – 0.8	> 50%	(360 000 ha * 0.1 Mg C)	Area, willingness of owners	MFV: forest inventory
28	Longer life wood products		3[6]		-	>> 50%	-	Limitations in import, limitations in acceptance by society.	
31	Forest protection: taking exploitable forest out of production		0.29		0.2 – 1.4	> 50%	(360 000 ha * 0.1 Mg C)	Area, willingness of owners[7]	MFV: forest inventory

Notes: [1] Taken from Freibauer et al., 2004: Table 2; [2] Areas for land use types taken from LGN4: grassland in NL = 1252261 ha; cropland in NL (mais, aardappelen, bieten, granen, overige landbouwgewassen) = 921494 ha; veenweidegebied in NL (from table vd Akker) = 210962 ha. [3] This excludes the avoided emissions from fossil fuel; [4] In Freibauer et al. (2004) described as extensification in cropland; [5] No estimations available; [6] Pers. comm. Gertjan Nabuurs: Based on assumed doubling of wood based products use i.e. from 15 million m3 /y now to 30 million m3 . every m3 avoids 0.2 Mg C emissions. Main uncertainty is whether the assumed goal can be reached. Emission factor is far less uncertain; [7] C flux reaches new equilibrium after 4 to 5 decades.

A realistic estimation excluding area overlap would be 1,5 Mton C y^{-1} (5.5 Mton CO_2 equivalents). Freibauer *et al.* (2003) estimates that in EU-15 16-19 Mt C y^{-1} (59 – 70 Mton CO_2 equivalents) can be sequestered during the first Kyoto commitment period (2008-2012). Forestation and forest growth in the Netherlands as reported in the National Inventory Report (Olivier *et al.*, 2003) is calculated at 1.4 Mton CO_2 equivalents.

For the high priority activities in Table 3 the following comments can be made:

- **Crop residues:** In literature contrasting views can be found on the use of crop residues for carbon sequestration which is reflected in results of the GDR. Although five experts give an estimation for the sequestration potential of crop residues, the high value for the standard deviation reflects a high degree of uncertainty of the achievable potential. Freibauer *et al.* (2004) describes the promotion of organic input on arable land (crop residues, cover crops, farm yard manure, compost, sewage sludge). Arrouays *et al.* (2002) concludes that the use of crop residues for energy valorization may more interesting in terms of the CO_2 budget than the accumulations induced by their return to the soil. For 7 tons of straw, the soil carbon accumulation is estimated at 0.15 tC/ha/year, while combustion allow returns of 2.4 tC from replacement of fossil fuel. However, material needs to be collected and transported and it may result in less soil organic matter. Additional research is required to evaluate the Dutch situation;
- **Composting:** recent results from the research program ROB have shown that based on improved techniques fermentation of manure with crop residues as alternative for traditional composting may replace fossil fuels (CH_4 from manure and crop residues) and keep nutrients cycling within agricultural systems;
- **Bio-energy crops**: This measure has a high potential also in relation to developments in the Veenweidegebied, and potential will mainly depend on the surface area that will be adopted for this activity. However, competition for expensive land may limit expansion;
- **Land-use change**: the experts within GDR have high expectations for land-use change of agricultural land to forest and nature, but also with high degree of uncertainty as reflected in the standard deviation. For the other identified land-use change categories no estimations were made by the experts;
- **Organic soils**: several measures are available for the organic soils: grassland management (21), more shallow water table (22) and change in animal stocks (24). The sum of these measures results in an estimate of 1.15 Mton C y^{-1}. A detailed study for different land-use scenario's has been made by van der Born et al., 2002. Within literature large differences for estimation of the surface area of organic soils in the Netherlands: estimated surface area for Veenweidegebied: see Kuikman *et al.*, 2003: estimation Hendriks, 1991: 294000 ha; Hensen *et al.*, 1995: 450000 ha; further van den Born *et al.*, 2002: 400000 ha and table by van der Akker (personal communication, in preparation): 210962 ha. In addition, protection of peat soils to reduce emission of greenhouse gases will result in less CO_2 and N_2O originally emitted through peat oxidation but likely more CH_4;
- **Parcel edge management**: during the discussions within the GDR, this activity was mentioned as an important future development that has a clear relation with carbon sequestration. However, no clear value for the sequestration rate is

available, while the potential area was estimated as 10% from the total area of arable land. Clearly for this activity additional information, definition and research is required to establish good estimates for potential of C sequestration;

- **Forest management**: Recently, a literature review has been made within the framework of the EU-project AFFOREST on building knowledge and capacity to provide support for decisions regarding afforestation in respect to changes in C, N and H_2O pools and fluxes (Hansen, 2002). This report provides insight and figures on the effect of forest management on soil carbon sequestration in several European countries.

Efficient carbon sequestration in agricultural soils demands a permanent management change and implementation concepts adjusted to local soil, climate and management features in order to allow selection of areas with high carbon sequestering potential (Freibauer *et al.*, 2004).

4.3 Impacts of activities: environmental side effects and socio-economic aspects

In addition to the carbon sequestration potential of the activities also the impact of the activities on other greenhouse gases (CH_4 and N_2O) need to be accounted for. Given the potential that organic matter contains nitrogen as well as carbon, increasing the soil carbon content also provides more substrate for N loss by leaching and N_2O emission. For the high priority activities of Table 3, the experts estimated the potential impact on the emission on other greenhouse gases (Table 4). The following symbols are used in Table 4: + positive impact (decreasing emission), 0 no impact, and - negative impact (increasing emission).

Table 4: Impact on emission of greenhouse gases for defined high priority activities within GDR. The following symbols are used: + positive impact (decreasing emission), 0 no impact, and - negative impact (increasing emission).

	Activity	**CH_4**	**N_2O**	**Other (NO_3, NH_3)**
7.	Crop residues	+	+	0
9.	Composting	0	+–	–+
12	Bioenergy crops	+–	–+	–+
15	Land use change: agricultural land to forest or nature	0	+	+
21	Grassland management (OS)	0	+	+
22.	More shallow water table (OS)	– –	0	0
23.	Land use change (OS): Intensive to extensive use of organic soils			
24	Change in animal stocks (OS)	0	–+	+–
33	Parcel edge management	+ +	+ +	+
27	Longer rotations or in general: nature oriented forest management	+–	+–	+
28	Longer life wood products[1]			
31	Forest protection: taking exploitable forest out of production[1]			

Notes: [1] No estimations available

Based on the results form the experts in the GDR clear positive effects can be expected from crop residues, parcel edge management and to a somewhat lesser extent for land use change from agricultural land to forest and nature and grassland management. A more shallow water table will result in a increased emission of CH_4 and this may off set some but not all of the C sequestration.

The socio-economic effects of the identified high priority activities are divers (Freibauer *et al.*, 2004). A general effect for several activities is improved long term fertility. The possible implementation of bio-energy crops will mainly depend on the price of other fuels, while it will result in less flexibility to market changes. Land use change to forest and nature will depend on possible subsidies to improved leisure value of the land, however land is taken out of production. In general it is difficult to assess impact of measures on farm profitability and/or costs, and many measures have both a positive as a negative effect. Socio-economic effects of the activities under Article 3.4 need to be specified for the Dutch situation.

4.4 Inventory and monitoring of activities

Implementation of Article 3.4 activities in the Netherlands during the first evaluation of the Kyoto Protocol will require the design and operationalisation of a national system for inventory and monitoring. In section 3.1 of this report an analysis was made for the white spots of the current LULUCF greenhouse gas reporting by the Netherlands. Current LULUCF greenhouse gas reporting by the Netherlands is incomplete. The few sections that are included are done at lower tiers. In addition to the identified white spots from this inventory also sinks and emissions from the activities that will be implemented in the future need to be included in the national system.

Recently, Nabuurs *et al.* (2003) prepared a report on the readiness of the Dutch National System for greenhouse gas reporting of the LULUCF sector. Discrepancies between the ongoing reporting and current monitoring systems and the requirements as set out by the Marrakesh Accords and the Good Practice Guidance now prepared by the IPCC (2004). An important item for the road map to reporting under Tier 2 and 3 is the choice for land use changes and emission factors to be improved (Nabuurs *et al.*, 2003). Currently general emission factors on the European scale are available (Smith *et al.*, 2004), however emission factors specific for conditions and practices in the Netherlands would preferable but are in many cases not available. In this report a priority set of activities (Table 2) has been defined for which emission factors should be improved. For C changes, relevant closed and ongoing long term experimental measurements can be adopted to derive emission factors for C (CO_2 and possibly CH_4) (Kooistra and Kuikman, 2003). However, a systematic evaluation and analysis of available hardcopy documentation (for example in TAGA) or digitally stored databases will be required to derive representative and verifiable emission factors.

Data availability on areas of land use and land cover are well available for the Netherlands (Nabuurs *et al.*, 2003), although consistent time series may be a problem due to differences in classifications. Also data on practices in agriculture are well covered, however for management of nature reserves this is currently less developed but requirements under the bird and habitat directives will improve this situation. The databases that will be developed need to be maintained in such a way that re-calculation is possible for the 1990 to present period at least and if possible for the period 1970-90 (Nabuurs *et al.*, 2003). This could result in friction between statistics that have been reported in the past and information that is required for future reporting for example differences in spatial support.

4.5 National carbon sequestration potential

On the basis of the expert judgment within the GDR a short-list of most promising carbon sequestration activities for the Netherlands has been defined (Table 5). The option Longer life wood products (Table 3) could be promising but is still under international political debate (Janssens et al., 2004) and therefore has not been included in the current short-list. Based on the activities in Table 5, total potential carbon sequestration adds up to 3.72 Mton each year. Figure 4 shows how this value refers to other sinks and emissions for other categories in the LULUCF sector in the Netherlands (1990 figures taken from Olivier et al., 2003).

Table 5: Most promising carbon sequestration activities for the Netherlands based on expert judgment from GDR

	Activity	Carbon sequestration rate per unit area ($t\ C\ ha^{-1}\ y^{-1}$)	Potential in NL during first commitment period ($Mt\ C\ y^{-1}$)	Environmental side effects	Requirements for monitoring and reporting system
1	Land use change: agricultural land to forest or nature	0.3 – 0.6	1.1	Benefits for wildlife, biodiversity and leisure	System for monitoring land-use changes; join running EU and national projects for emission factors
2	Crop residues	0.7	1.1		Management-specific emission factors required
3	More shallow water table (organic soils)	1.4 – 4.1	0.65	Increased emission of CH_4, close relation with other activities for organic soils; benefits for wildlife, biodiversity and leisure	System for areal assessment (currently several estimations); integrate ongoing research to define proper emission factors
4	Bioenergy crops	0.6	0.6	Much greater additional benefit from substitution of fossil fuels by bioenergy	System for monitoring area under bioenergy crops; emission factors
5	Parcel edge management	> 2.2	0.27	Promotion of activity through different policy measures, benefits for wildlife, biodiversity	System for monitoring parcel edges areas; additional research on emission factors

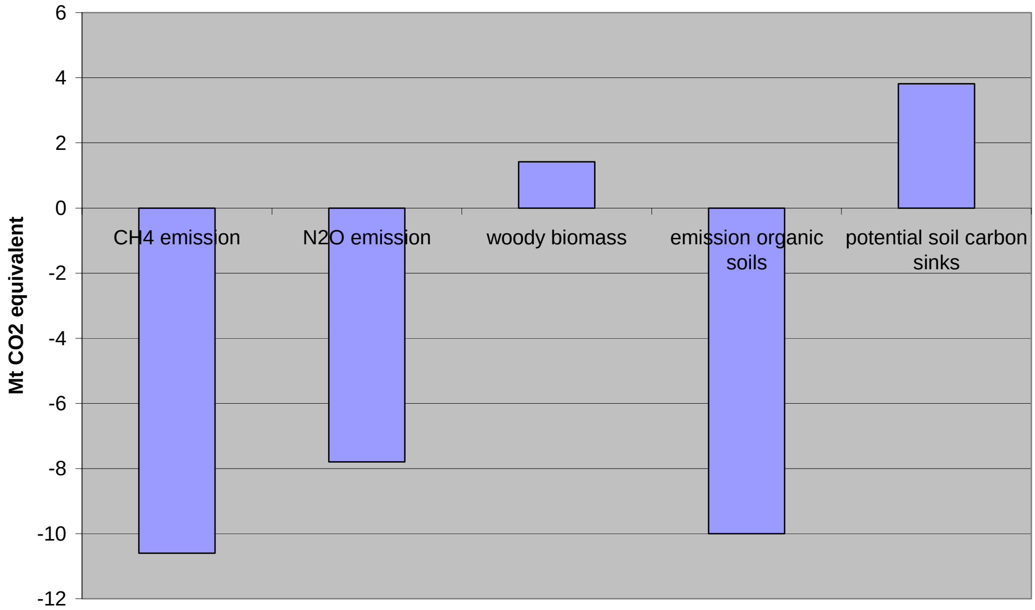

Figure 4: Comparison of most important GHG emissions for methane (CH_4), nitrous oxide (N_2O) and sinks for the LULUCF sector in the Netherlands (1990 figures from Olivier et al., 2003) and emission of CO_2 from organic soils and potential sink strength taken from GDR expert opinion.

5 Carbon sequestration potential in an international context

Recently several efforts have been made in other European countries (Arrouays *et al.*, 2002; Leifeld *et a*l., 2003) and at the European level (Freibauer *et al.*, 2004; Smith *et al.*, 2004) to identify the potential of carbon sequestration under article 3.4 of the Kyoto Protocol. In this section we would like to compare the most promising measures for the Netherlands (Table 3 and 5) with options that are identified in other countries. This shows were overlap exists with other countries and which measures are more a specific option for the Netherlands.

In Table 6 the results of a quick scan of recent studies on carbon sequestration in other European countries or the total of Europe are presented. Comparison of table 3 and 6 shows that the choice for measures is dependent on differences in soil, climate and land-use between the countries. Only one measure is seen as promising for all countries (including the Netherlands) and the EU level: afforestation or land-use change from arable land to forest with a comparable range for the sequestration rate. Zero-tillage or conversion tillage and conversion to permanent grassland were seen as important measures in France and Switzerland (Table 6), but in the GDR these measures have not been given a high priority for the Netherlands (Table 2). Possibly because both measures require significant changes in the farmers management practices. Compared to the other countries organic soils play a significant role for the Netherlands: both because of their large area and the large amounts of carbon stored per hectare. In contrast to France and Switzerland, experts in the GDR identify for the Netherlands use of crop residues and growing of bioenergy crops as promising activities. However, the activity of crop residues needs additional definition of the land management that is included.

Arrouays *et al.* (2002) indicate that after a critical review of literature they identified gaps in knowledge and impossibility for quantifications. Generally, the studies indicate that limited quantitative information is available on regional sequestration rates. Mostly widely-used figures (Smith *et al.*, 2000; Freibauer *et al.*, 2004) or standard IPCC rates (IPCC, 2000) are used for calculating sequestration potentials. In addition, trade-offs with other GHGs are described qualitatively (e.g. increase of N_2O emission) rather than quantifying actual emission. Also in a recent international workshop (Smith *et al.*, 2004), experts at the European level identified a whole list of possible activities under KP article 3.4 but could not quantify the sequestration rate for these activities. Resulting in the definition of research priorities: soil process studies in agriculture and data inventory and collection and meta-analysis.

Table 6: Quick scan of studies on carbon sequestration measures in EU-15 and EU-countries.

Source	**National sequestration potential**	**Most promising measures**	**Rate or potential per measure (tC $ha^{-1} y^{-1}$)**	**Environmental side-effects**	**Requirements for reporting**	**Identified risks**
France (Arrouays et al., 2002)	max. 3-5 Mton carbon y^{-1} over 20 years; realistic 1-3 Mton carbon y^{-1}	Based on high flux: [1] • Afforestation of arable land, • increase in permanent grasslands Based on surface area: • suppression of tillage, shallow ploughing • planting of green manures between crops • sowing grass within vines and orchards	0.44±0.24 (p.11) 0.5±0.25 (p.14) 0.20±0.13 (p.14) 0.15 (p. 13) 0.4 (p. 13)	Estimates in report do not account for emissions of other greenhouse gasses (notably N_2O); Use compatibility of activities with other environmental benefits (erosion, biodiversity)	Will require costly and complicated system for verification; Determination of baseline difficult; Observation system for demonstration of increase in additional storage	Critical review of literature underlined gaps in knowledge in impossibility for quantifications; Required changes are contrary to current evolutions; Assume commitment of farmers for long period
Switzerland (Leifeld et al., 2003)	Total stored in agr. soils 170 Mton carbon (p.61) Mean theoretical[2] 0.3 Mton carbon y^{-1} (p. 102)	Mineral soils: • Expand area under no till • Converting temporary set-asides to permanent grassland • Conversion of arable land to grassland Organic soils: • Reduce oxidative peat losses • Restoration of cultivated peatlands	0.34 (p. 72) 0.6 (p. 83) 0.19 (p. 81)	Agriculture will remain net GHG source even when all potential realized	Enhance quality of Swiss soil map Process-oriented studies of influence of management practices on GHG fluxes	Findings rely on a weak data base of soil properties and land-use types Arable land to grassland requires significant change in agricultural structure
EU-15 (Freibauer et al., 2004)	Realistic potential 16-19 Mton C y^{-1} in agricultural soils	Most promising policy measures: Promote organic input on arable land instead of grassland Afforestation of arable land Biofuel production Promote organic farming Permanently shallow water table in farmed peatland Zero tillage/ conservation tillage	See table 5 0.3 – 0.8 0.6 0.6 >0 – 0.5 1.4 – 4.1 >0 – 0.8	In general risk of more N_2O Benefits for wildlife, biodiversity etc.	Regional specific data on soil, climate, land cover etc. are not readily available and quality varies strongly	

Notes: [1] table 1 (p. 16) of Arrouays et al. (2002) gives an evaluation of assessed measures; [2] used recalculation 1 t C * 3.67 = t CO_2

6 How to proceed?

In this report we have summarized our current knowledge on optional activities under Kyoto Protocol Article 3.4 in the Netherlands, their effectivity, the opportunities and likelyhood for implementation and implications for reporting the results within the National Inventory Report on Greenhouse Gas Emissions.

The following has been achieved:
- Identification of white spots in reporting for LULUCF sector in the NIR
- First onset for quantification of white spots
- Identification and prioritization of activities eligible under the Kyoto Protocol Article 3.4 and relevant for the Netherlands
- First onset for quantification of the activities labelled with high priority
- Description of missing information and requirements for reporting system

Experts met in a workshop within a Group Decision Room facility and identified two main problems that need to be addressed before an implementation could be effective: 1) develop clear and recognized definitions of system – boundaries for the identified activities including both the spatio-temporal scale and boundaries within and between sectors, and 2) additional data collection and sometimes research is required to characterize soil processes and extract or develop emission factors or respons curves for both C sequestration and emissions of non – CO_2 greenhouse gases methane (CH_4) and nitrous oxide (N_2O) at the national, regional and farm scale for specific activities in the Netherlands.

Based on these findings a roadmap to prepare the implementation of KP Article 3.4 in the Netherlands is proposed:
- Selection of (priority) activities and establishment of definition and system-boundaries[12]
- Quantification of potential effects and related uncertainty and accuracy
- Definition of system for monitoring and management including estimation of costs
- Decision on go-no go for Article 3.4 activities to be included in Kyoto Protocol reporting for the Netherlands, here 3 or 4 options are available[13]: (1) no, never; (2) no, unless; (3) yes, later; and (4) yes, now.

[12] This definition could prepared by a small group of experts based on formats as described in IPCC Good Practice Guidance (2003)

[13] Why 4 options? The Netherlands commits itself to the international community and the rules that are applicable to the activities under the Kyoto Protocol, however, part of these rules have not been described in detail or haven't been described at all. This means that not only the Netherlands decides or and how the reporting will take place but it also has to comply with international standards. In this way a certain anticipation to future changes is required and are the options no, unless and yes, later important to consider.

- Formulation of monitoring protocols including QA/QC and appointment of organization responsible for management and execution of review (transparency, consistency, continues availability of data)
- Practice with quantification of effects and monitoring of required data
- Continue and strengthen capacity building of experts

Currently there is still debate if KP Article 3.4 activities should be reported for the Netherlands. However, activities in the category land-use change will already be reported in the NIR based on the new guidelines as described in the Good Practice Guidance. Activities defined by land management (crop residues, energy crops) are not covered yet in the reporting set-up for the NIR as described by Good Practice Guidance.

Within this report a quick-scan has been made for the developments in other European countries (chapter 5). Based on extended analysis this information can be used as a benchmark for the Dutch situation. However the specific conditions that apply to the Benelux countries have to be kept in mind (Janssens et al., 2004). Another direction that needs to be exploited deals with the development of future land-use and land management scenarios. Based on these scenarios the choice for certain activities and trade-offs with other aspects can be explored.

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Appendix 1 List of experts for Group Decision Room workshop of September 2nd, 2003

The following experts were present during the Group Decision Room, 2 September, Alterra Wageningen[14]:

- Jan Verhagen (PRI – carbon sinks and agriculture)
- Oene Oenema (Alterra – agriculture and emissions greenhouse gases)
- Kor Zwart (Alterra – soil science)
- Wim Daamen (Bureau Daamen – agriculture and forestry)
- Gert Jan van den Born (RIVM – organic soils and "*Veenweidegebied*")
- Jaap Paasman (Stichting Bosdata – forestry and sinks)
- Klaas van der Hoek (RIVM – emission registration)
- Philip Ehlert (Alterra – soil science and agriculture)
- Andre van Amstel (MSA – NIR and protocols agriculture)

Auditors:

- Harry Vreuls (NOVEM)
- Ronald Hutjes (Programmaleader P421 Climate Change of the ministry of agriculture, fisheries and nature management)

Chairman: Peter Kuikman (Alterra)
GDR facilitator: Annelies Bruinsma (Alterra)
Reporting: Lammert Kooistra (Alterra)

[14] Reviews following the GDR workshop were provided by Gert Jan Nabuurs (Alterra – forestry) and Jan van den Akker (Alterra – organic soils)

Appendix 2 Agenda Group Decision Room workshop September 2nd, 2003, Alterra, Wageningen

10:15 – 10:30 Introduction

10:30 – 12:30 White spots and key source analysis for LULUCF sector in Dutch National Inventory report

1. Review of current categories for agriculture in Dutch NIR:
   - Give comments on current categories in NIR (see appendix 3)
   - Add categories: identification of white spots and omissions
2. Give an estimate of the carbon source for the identified categories in point 2.
3. Preliminary Key source analysis: evaluation of the estimated sources for the identified categories
4. Trend analysis
5. Writing concept text for addition in NIR
6. Due to lack of time this point has not been carried out

12:30 – 13:30 Lunch

13:30 – 15:30 Options and potential for activities under KP article 3.4 in the Netherlands

7. Which categories have potential for the Netherlands: Forest Management, Cropland Management, Grassland Management, Revegetation, Farmed organic soils
8. Assessment of potential activities for the Netherlands, a first list with activities was provided based on the assessment made by Freibauer *et al.* (2004):

- give comments per activity in the list (see appendix 5)
- Add relevant activities that are not included in the list

9. Determine for identified activities relevance for the Dutch situation
10. Prioritize the potential for the identified activities: high priority, low priority, no priority
11. For the high priority activities give an estimate of the carbon sequestration potential, emission factor, potential area, range of uncertainty
12. Give an estimate of the potential side-effects that can be expected for other GHG
13. Give additional comments to the identified high priority activities

15:30 – 16:00 Evaluation and closing

Appendix 3 White spots and omissions in the Dutch National Inventory (in Dutch)

An overview is given of the comments from the GDR (see point 1 in appendix 2).

Emission from drained soils

1. drainage zal worden terug gedrongen als anti-verdrogingsmaatregel.

Emission from organic soils

1. veenweide gebieden zullen de komende decennia, om reden van behoud/beheer/management mogelijkheden drastisch gaan veranderen. Een zeer substantieel deel van het huidige areaal (ongeveer 20%) zal mogelijk anders worden beheerd. Daarbij zal de huidige sources van co2 veranderen in neutraal
2. bufferstroken zullen meer en meer een 'nuttige' functie verkrijgen (bijv. biomassa tbv energie) en natuur
3. energie transitie omvat ook het op termijn inzetten van grote hoeveelheden biomassa, daarbij zal de land en bosbouw een substantiële bijdrage leveren

Bodem&gewasbescherming landbouw

1. bewerking niet bescherming
2. kan worden ingezet directe link met duurzaam landgebruik (link met landgebruik veranderingen)
3. deel van de landbouw is ah extensiveren

Forest soil C stocks

1. strooisellaag/humus neemt bij gelijkblijvend beheer toe op de zandgronden
2. huidige staande voorraad ca 200 m3/ha met toenemende tendens. maximale hoeveelheid hout per ha 300 in 50-100 jaar?
3. toenemend volume in bos heeft gevolgen bij catastrofes: bosbrand of ziekten/plagen in bosareaal
4. langzame verschuiving van toename c in houtvoorrraad naar toename in strooisel en bodem voorspelling van blijvende toename de komende dertig jaar van minimaal 1 % per jaar

Trees in non-forest locations

1. toenemende bebouwing in landelijk gebied levert toenemende begroeiing in landelijk gebied
2. Met afname van het landbouwareaal zal de omvang van kleinschalige landschapselement toenemen zowel als agr natuurbeheer of stedelijk groen

Voorraadveranderingen CO2 veengebieden

1. over een decade of meer veel toename verwacht, om het voordeel dan te incasseren nu huidige toestand als nulsituatie vastleggen
orde van grootte meer dan 10%
2. Voorraadverandering voor bossen blijft de komende tijd onveranderd groot of als hout, dood hout, strooisel of c in bodem elke tien jaar tien procent erbij

Conversion grasslands

1. Steeds meer wordt maagdelijk grasland gebuikt voor de teelt van aardappelen, en bloembollenteelt. Dit heeft te maken met (afwenteling) met het gewasbeschermingsbeleid. Naar verwachting gaat per ker dat maagdelijk grasland wordt omgeploegd circa 10 ton C de lucht in. Bij een areaal van 20.000 ha zou dat 0,2 Mton CO2-C zijn of globaal 1 Mton CO2 equivalent.
2. Bulkproductie akkerbouw (zetmeelaardappelen) zal afnemen en overgaan in een deel extensief beheerd grasland en een deel intensief beheerd grasland
3. verzilting kan ertoe leiden dat grasland toeneemt ten koste van landbouwgrond en intensief beheert grasland wordt meer extensief gebruikt.

Burning of residues

1. Verbranding van organische afvalstoffen wordt aangemerkt als een noodzakelijke alternatieve vorm van energiewinning. Op termijn zou enkele tientallen procenten van de energiewinning uit deze alternatieve vorm afkomstig moeten zijn. Als dit doel gehaald wordt, dan kan reductie verkregen worden van benutting van fossiele brandstof. Er wordt echter onvoldoende stil gestaan bij hergebruik van assen. Dit zal echter beperkingen aan deze ontwikkeling opleggen

Composting of residues

1. verplicht aanbieden van snoei- en afvalhout aan afvalverwerking ipv zelf opstoken. vermoedelijk zelfde resultaat met een omweg ONZIN

Indirect N20 from NO3

1. Neemt fors af (is fors afgenomen) (circa 20-50%) door mestbeleid
2. Is fors afgenomen maar in de huidige methode is dat nog niet goed te kwantificeren (default 30% uitspoeling en afspoeling en 2,5% uit oppervlaktewater)

Indirect N2O from NH3

1. Neemt fors af (is fors afgenomen (20-50%) door mestbeleid
2. Is fors afgenomen maar wordt nog niet goed gerapporteerd door gebruik van default waarden

N2O from crop residues

Bufferstroken e.a.

1. Akkerranden en bufferstroken zijn vooral vanaf 1992 ingevoerd (McSharry - regelingen van de EU). Verwacht wordt dat over niet al te lange tijd 10% van het areaal beheerd wordt als akkerrand, bufferstrook, riparian zone. Deze stroken hebben potentie op koolstof vast te leggen (circa 1 Mgton CO2 equivalent per jaar).
2. valt braak hier ook onder? is dit per def. een rand?
3. Recreatieschappen beheren ook grote arealen in de stadsranden. Horen die hieronder? Kunnen bij extensief en op natuur gericht beheer bijdragen aan emissievermindering
4. grote veranderingen verwacht in emissie. terugbrengen van riviertjes zoals dommel enz, in oude loopbaan brengt veel afbraak van c in de bodem mee
5. met name waar de dynamiek in landgebruik plaats vindt, is het moeilijk aan te tonen omdat de statistieken achter de feite aan lopen. Ook modellen zijn daarin veelal beperkend. Dit is een wezenlijk probleem bij het duidelijke maken van de ontwikkeling

Landgebruik veranderingen (landbouw -> bos, natuur, stedelijk gebied etc.)

1. verstedingelijking, extensivering, afname aantal bedrijven, functie verschuiving oh platteland , conversie naar natuur zal doorzetten
2. veel meer areaal zal verdwijnen in ' overhoekjes' , kleine elementen met beplantingen, wegbegeleidende beplantingen. open landschap verdwijnt
3. verandering in 10% van het landbouwareaal is zeer wel denkbaar, denk aan aanpassingen in de EHS waardoor wellicht per categorie landuse het totale areaal gelijk blijft, maar de landuse vormen worden vaak wel op een andere locatie uitgeoefend
4. verschuiving van locatie van grasland, bouwland, bos, plas geeft ook aanleiding tot toename/afname van emissies en vastlegging

Emissies uit het dumpen van biomassa op de bodem

1. Aanscherping door EU richtlijnen voor afvalstoffen zal leiden tot een grotere druk op de landbouw om biomassa van de samenleving anders dan compost, zuiveringsslib of zwarte grond af te nemen. Deze afvalstromen zijn nu nog diffuus en waren in 1990 niet zichtbaar. " Grijze afvalstromen" als groenafval, bermgras, snoeiafval, reststromen die niet meer toegepast kunnen worden als veevoeder (inkrimpende veestapel, scherpere veevoedingsnormen) geven nu al een extra druk. De aanvoer van organische stof neemt toe. Daarbij komt dat de landsgrenzen voor transport van afvalstoffen zullen worden gesloten. Stort van afval in het oosten van Duitsland zal - als voorbeeld - vanaf 2008 niet meer mogelijk zijn. De consequenties daarvan zijn niet duidelijk.

CO2 emissie bij kalkbemesting

energie gewassen

1. Over 30 jaar moet 1/3 deel (1700 PJ) van onze energieconsumptie uit renewable bronnen komen. Dit heeft een geweldige impact op landgebruik, import van grondstoffen.
2. ambitie niveau (EZ) is hoog. zal belangrijk worden
3. biomassa als basismateriaal voor productie van - bioplastics, en ander constructie materiaal zal toenemen.

C in waterbodems

1. weinig verandering
2. effect terug dringen eutrofiering onduidelijk

Import/export van C (in veevoer, hout)

1. Houttoepassingen zullen de komende tijd duurzamer worden, houtimport groeit nog, stedelijke en luxe functies nemen toe. Inschatting 10% in ca tien jaar
2. afname import? netto effect onduidelijk
3. Intensieve veehouderij zal afnemen, alle directe en indirecte emissies zullen dalen
4. Deze importen van hout en veevoer zijn al heel lang een probleem. Bij gericht beleid kan wellicht 10% verandering optreden
5. NL is op dit moment voor zowel hout als veevoer een zeer grote importeur. Op termijn veronderstel ik een daling a.g.v. afname intensieve veehouderij in NL en inzet alternatieven voor hout, duurzamere toepassing of beperkte inzet eigen houtteelt

Appendix 4 Relation of identified omissions in NIR to IPCC Good Practice Guidance

The table below gives the reporting format for the Kyoto Protocol land-use categories as described in GPG (IPCC, 2004) and relates it to the identified white spots for the LULUCF sector in the Dutch NIR (Table 1). The table has not been completed yet, but shows the implications for reporting Kyoto Protocol Article 3.4 activities under the GPG.

Land-use Category		Relation to 96 GL [4]	White spot in current reporting See table 1	Biomass, Gg				Soils, Gg		Total, Gg	
				CO_2 Emissions		CO_2 Removals		CO_2 Emissions	CO_2 Removals	CO_2 Emissions	CO_2 Removals
Initial Land-use	Land-use during reporting Year			Living biomass	Dead organic matter	Living biomass	Dead organic matter				
Forest Land	Forest Land	5A	- Forest soils - Forest biomass in small patches - Emission from drained soils - Non-CO2 emissions from organic soils - Biomass allocation								
Cropland	Forest Land	5A, 5C, 5D	Abandonment of managed lands afforestation								
Grassland	Forest Land	5A, 5C, 5D	Abandonment of managed lands afforestation								
Wetland	Forest Land	5A, 5C, 5D	-Emission from drained soils -Non-CO_2 emissions from organic soils								
Settlement	Forest Land	5A, 5C, 5D	Abandonment of managed lands								
Other Land	Forest Land	5A, 5C, 5D	Abandonment of managed lands								
Cropland	Cropland	5A, 5D	-Emission from drained soils -Non-CO_2 emissions from organic soils -Soil management in agriculture - Parcel edge management - Liming								
Forest Land	Cropland	5B, 5D	Deforestation								
Grassland	Cropland	5B, 5D	Grassland conversion								
Wetland	Cropland	5D									
Settlement	Cropland	5D									
Other Land	Cropland	5D									
Grassland	Grassland	5A, 5D	Rejuvenation of grassland Emission from drained soils Soil management in agriculture - Parcel edge management - Liming								
Forest Land	Grassland	5B, 5D	Deforestation								
Cropland	Grassland	5C, 5D									

Wetland	Grassland	5C, 5D									
Settlement	Grassland	5C, 5D									
Other Land	Grassland	5C, 5D									
Wetland	Wetland	5A, 5E	Emission from drained soils Non-CO2 emissions from organic soils Carbon stock changes in wetland areas Emissions from water surfaces Emissions from water soils								
Forest Land	Wetland	5B									
Cropland	Wetland	5E									
Grassland	Wetland	5B									
Settlement	Wetland	5E									
Other Land	Wetland	5E									
Settlement	Settlement	5A	Emission from drained soils Non-CO2 emissions from organic soils								
Forest Land	Settlement	5B									
Cropland	Settlement	5E									
Grassland	Settlement	5B									
Wetland	Settlement	5E									
Other Land	Settlement	5E									
Other Land	Other Land	5A									
Forest Land	Other Land	5B									
Cropland	Other Land	5E									
Grassland	Other Land	5B									
Wetland	Other Land	5E									
Settlement	Other Land	5E									

[1] All units should be reported in gigagram (Gg). To convert unit from "tonnes C" to Gg CO2, multiply the value (from the worksheets) by 44/12 and 10^{-3}. Similar to the convention used in the worksheets, the sign for removal (uptake) is positive (+) and for emission is negative (-).

[2] Land-use may be further divided according to forest type or tree species, climatic zones (e.g. boreal, temperate, tropical wet or tropical dry), or ecological zones.

[3] May include other non-specified sources or sinks such as HWP, etc.

[4]: 5-A Changes in Forest and Other Woody Biomass Stocks; 5–B Forest and Grassland Conversion; 5-C Abandonment of Managed Lands; 5–D Emissions and Removals from soils, and 5-E Other.

Appendix 5 Options for the Netherlands on relevant Kyoto Protocol article 3.4 activities (in Dutch)

An overview is given of the comments from the GDR (see point 7 in appendix 2).

Consider the realism with respect to adoption of farmers, agricultural culture, legal context, ecological constraints.

1. Zero-tillage
Beperkte ontwikkeling in Nederland. Vooral van belang in een klein deel van de biologische landbouw. Geen wezenlijke bijdrage aan reductie aan uitstoot.
Beperkt perspectief, vanwege de vele (en toename in) hakvruchten en bloembollen.
Verder botst deze maatregel met het gewasbeschermingsbeleid en de ambitie om hoge opbrengsten te realisern. Resultaat verrwaarloosbare emissie.
Meer perspectief biedt het telen van een tussengewas, nagewas bij maisland en andere gewassen.
2. Reduced-tillage
3. Set-aside
Biedt perspectief, maar dan wel kiezen voor een braak die koolstof kan vastleggen. Er is een gigantisch verschil tussen gewassen. Van die potentie kan veel gebruik worden gemaakt dan dat nu wordt gedaan
hier wordt weinig van verwacht als er geen NL plan achter zit
m.a.w. plan van aanpak
alleen zinvol als het nut heeft (energiegewas, vlinderbloemigen onderwerken)
Hangt van het landgebruik af in welke mate koolstof wordt opgeslagen. Naarmate de zuurgraad toeneemt door achterwege laten van bekalking kan het effect toenemen.
4. Perennial grasses and permant crops
hoog, toename
5. Deep-rooting crops
Dit geldt vooral voor keuze van voedergewassen en nagewassen (catch crops).
De uitdaging is om een prikkel te verzinnen om de boer zo ver te krijgen dat hij deze gewassen gaat telen.
ook van belang voor mineralenefficientie van dierlijke mest en kunstmest
6. Animal manure
We hebben veel mest in NL, maar deze mest is bevat hoofdzakelijk gemakkelijk afbreekbare koolstof en draagt weinig bij aan vastlegging. De vroegere stalmest droeg wel bij aan koolstofvastlegging. Hoe zorg je dat de huidige dunne mest de karakteristieken krijgt van de vroegere stalmest
7. Crop residues
inzet in reststromen (bioenergie) is zinvoller dan inwerken
hoog, ander gebruik waardoor cascadering
is een afweging, tussen zinvolle afzet in eind of tussenprodukt of t.b.v. toename org. matter in bodem
8. Sewage sludge
Laag potentieel. Mag niet in Nederland vanwege hoog gehalte aan zware metalen
9. Composting
Een alternatieve vorm van compostering is anaeroob composteren (vergisting). Indien daarvoor gewasresten worden gebruikt kan dat door besparing van fossiele brandstoffen een aanzienlijke besparing opleveren. Co-vergisting met dierlijke mest is een vorm. Raming besparing 1-3 Mton?
Dit is een onderschatte potentie. Er kan hier veel meer met vergisting
10. Improved rotations
11. Irrigation/drainage
12. Bioenergy crops
hoog, maar vooral door veranederende importstromen
liggen mogenlijkheden voor landbouw
hoge potentie, maar economisch nog erg kostbaar a.g.v. zeer hoge grondprijzen
technologisch gezien geen grote beperkingen meer
zowel bosbouw als landbouw zijn potentiele spelers
13. Extensification
zal leiden tot minder produktie, indien gelijke produktie gehandhaafd wordt tot toename areaal landbouwgrond en dus afname natuurlijk (bebost) gebied
14. Organic farming
kan bijdrage aan toename hh koolstof in bodem, mits gebruik gecontinueerd.
Gering ten opzichte van huidig landgebruik

15. Land use change
functie verschuivingen zullen ruimte voor landbouw bepalen.
kortstondig extra vastlegging als landbouwgrond naar natuur wordt overgebracht. daarna indifferent
16. Increase the duration of grass leys
17. Change from short duration to permanent grasslands
18. Extensification of organic soils with permanent grassland
Omhoog brengen van waterspiegel
Omzetten in natuur
19. Livestock management on grassland
20. Protection and restoration
21. Grassland management
22. More shallow water table
ik neem aan dat primaire productie in pioniervegetatie wordt verhoogd. met verlanding is dit een een goede sink (moerasbouw)
zal ook nodig zijn ivm verzilting.
combinatie met andere gewassen bv riet is mogenlijk
23. Land use change: other (bioenergy) crops
Zeer hoog, bosareaal uitbreiding heeft zeer groot effect
bioenergie crops (bv riet) geeft nieuwe kansen.
Vergeet ook niet stedelijk groen
24. Change in animal stocks
onvermijdelijk bij verhoging grondwaterspiegel
25. Fertilization
26. Thinning
Alles wat je hier niet oogst komt uit het buitenland. Geen effect
27. Longer rotations
Marginaal, je moet het bekijken op bosecosysteem niveau, of bedrijsniveau. Eindkap in Nederland is al minimaal
Langere rotatie op akkerbouwland betekent een lagere frequentie van de verbouw van hakvruchten. Dit geeft minder grondbewerking en een wat hogere aanvoer van organische stof.
28. Longer life wood products
29. Fire management
30. Pest management
worden al niet meer gebruikt
31. Forest protection taking exploitable forest out of production
alles wat we zelf niet produceren komt uit het buitenland marginaal effect. We gebruiken ongeveer 6 milj ha bos in het buitenland dat is 20 X wat we hier exploiteren.
32. Restoration of degraded forests
Gebeurt via geintergreerd bosbeheer, effecten nauwelijk meetbaar
33. Bufferstroken