The Role of Forests in Climate Change: Nordic Experience

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Preface

Forests play an important role in the global carbon cycles and climate change mitigation. They absorb atmospheric carbon through photosynthesis and sequester it in biomass and thus create a natural storage of carbon. Forests are also an important source of biomass which is regarded as an important possibility to reduce greenhouse gas emissions. Land-use, land-use change and Forestry (LULUCF) has gained an increasing role on the agenda of the international climate change negotiations.

This report discusses the role of forests in the Nordic countries from a climate change policy perspective. The report aims to provide a comprehensive understanding of the issue and to present the results in an easily digestible way.

The report focuses especially on the role of forests in enhancing carbon stocks and carbon sinks in the Nordic countries. The boreal and temperate forests in the Nordic region are a globally important reserve of carbon. The main geographical scope of the report covers the five Nordic countries. The use of wood in products, buildings and as bioenergy is examined.

The report also discusses the role of forests in the context of market-based mechanism for emission reductions. There is an ongoing debate whether the forest sector should be included in market-based schemes such as emissions trading. The conclusion at this point is that there is little scope of including Nordic forests in a so called compliance scheme.

A number of policy recommendations are included in the report. The authors present recommendations related to sustainable forests management, the use of wood for construction purposes and for forest-based products and use of biomass in the Nordic countries. The development of a bioeconomy is considered to offer a great opportunity for the Nordic forest sector.

A handwritten signature in dark ink, reading "Magnus Cederlöf". The signature is fluid and cursive, with the first name "Magnus" and the last name "Cederlöf" clearly distinguishable.

Magnus Cederlöf
Chair the Working Group on
Environment and Economy (MEG)
under the Nordic Council of Ministers

Abbreviations

ARD	Afforestation, Reforestation and Deforestation
AWG	Ad hoc Working Group
CCEMA	Alberta Climate Change and Emission Management Act
CDM	Clean Development Mechanism
CEE	Center for Energy and Environment
CHP	Combined Heat and Power
CO ₂	Carbon dioxide
COP	Conference of Parties
CPA	Climate and Pollution Agency
EDDP	Energy Technology Development and Demonstration Program
EEA	European Economic Area
EFTA	European Free Trade Association
EPA	Environmental Protection Agency
EU	European Union
FMRL	Forest Management Removal
GDP	Gross Domestic Product
GGAS	New South Wales Greenhouse Gas Reduction Scheme
GHG	Green House Gas
GtC	Giga tonne of carbon
HWP	Harvested Wood Products
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
KWh	Kilo Watt
LULUCF	Land Use Land Use Change and Forestry
MFA	Ministry for Foreign Affairs of Finland
MRV	Monitoring, Reporting and Verification
Mt	Million tonnes
MWh	Mega Watt
NAMA	Nationally Appropriate Mitigation Action
NAPA	National Adaptation Program of Action
NGO	Non-Governmental Organization
NIR	National Inventory Report
NOK	Norwegian Krone
NREAP	National Renewable Energy Action Plan

NZ ETS	New Zealand Emission Trading Scheme
PLA	Polylactic Acid
PSO	Public Service Obligation
RD&D	Research, Development and Demonstration
REDD	Reducing Emissions from Deforestation and Degradation
RGGI	Regional Greenhouse Gas Initiative
RMU	Removal Unit
SEF	State of Europe's Forests
tCO ₂	Tonne of carbon dioxide
UNFCCC	United Nations Convention on Climate Change
WCI	Western Climate Initiative

Glossary

Carbon stock

Carbon stock is the total amount of carbon stored in a system such as forests.

Carbon sink

A carbon sink can be defined as a natural or artificial system that accumulates and stores atmospheric carbon. A forest can act as a carbon sink when it accumulates more carbon than it releases at a certain period of time.

Carbon sequestration

The carbon sequestration refers to the physical or biological processes such as photosynthesis that remove and store atmospheric carbon in carbon sinks such as oceans, forests or soils.

Carbon source

A carbon source is a system that releases more carbon to the atmosphere than it accumulates at a certain period of time.

Summary

Background, objectives and scope

Forests play an important role in the global carbon cycle and climate change mitigation. They absorb atmospheric carbon through photosynthesis and sequester it in living and dead biomass and soil, and thus create a natural storage of carbon. The boreal and temperate forests in the Nordic region are a globally important reserve of carbon.

The key objective of the project is to discuss the role of forests in the Nordic region in climate change mitigation. This report discusses the feasibility of a Nordic scheme for trading forest carbon. The main geographical scope of the report covers five Nordic countries: Denmark, Finland, Iceland, Norway and Sweden. Information and discussion on three Nordic territories – Åland Island, Faroe Island and Greenland are also presented whenever relevant.

International climate policy negotiation and Nordic forests

The Kyoto Protocol, an international climate agreement, allows the parties to include land use, land-use change and forestry (LULUCF) activities as a part of their effort to mitigate the climate change. The protocol has provisions for all Annex I parties (including the Nordic countries) to report emissions and removal of greenhouse gases (GHGs) from LULUCF activities. The Articles 3.3 and 3.4 of the protocol regulate the national LULUCF GHG accounting. It is mandatory for the Annex I parties to account for the emissions and removal from afforestation, reforestation and deforestation, forest management and use of harvested wood products (HWPs) in the second Kyoto commitment period (2013–2020). Cropland and grazing land management, revegetation, wetland drainage and re-wetting are the voluntary LULUCF activities. The net removal of GHGs by LULUCF activities in an Annex I party is rewarded by granting the party with the right to issue removal units (RMUs). For the first commitment period (2008–2012), each party is assigned with a cap for RMUs. Among the Nordic countries, Iceland's cap is zero and other countries' are above zero. For the second commitment period (2013–2020) the issuing of RMUs is based on a country-specific forest management reference level (FMRL) and a cap of 3.5% of emissions in 1990. All forest carbon sequestration exceeding the FMRL but below or equal to the cap

constitutes the RMUs for a party. The RMUs can be used by the party to meet its GHG emissions reduction targets or sold to other parties to meet their targets set under the Kyoto Protocol. Reducing emissions from deforestation and forest degradation, conservation, the sustainable management of forests and enhancement of forest carbon stocks (REDD+), an international forest-based climate policy framework, is aimed to be implemented in developing countries and has direct relevance to tropical forests. It does not have any direct implication for forests in the Nordic countries.

Nordic forest resources and carbon sinks

The Nordic region, with over 61 million ha of forests, is rich in forest resources. The region has just under one-third of forests in Europe excluding Russia. Sweden, Finland and Norway are the most forested Nordic countries together covering about 99% of the forests in the region. Most forests in the region are of the boreal type. Private ownership is the dominant form of forest ownership in the region. Most private forest-owners are ordinary Nordic citizens. States also own considerable shares of forests particularly in Finland, Denmark and Sweden. On average, the contribution of the forest sector to GDP and employment in the Nordic region is higher than that in Europe as a whole. The sector plays a prominent role in the economy of particularly Finland and Sweden.

In the Nordic countries, especially in Finland, Sweden and Norway, the total growing and biomass stocks have been growing as a result of practicing sustainable forest management and investing in forestry for the last six to seven decades. The total biomass stock is expected to grow and the net annual increment is expected to remain positive in coming decades as well.

Trend in forest biomass in the Nordic countries

In the current decade, the forest sink in the Nordic region is expected to further increase in size to reach about 140 million tonnes of CO₂ (tCO₂) in 2020. Forest management practices such as fertilizing, thinning in an optimised way, lengthening rotation are clearly having a positive effect on the growth of biomass and carbon sinks in forests. However, collecting harvesting residues for bioenergy use may have negative effects on growth and carbon stock of forests. Old-growth forests protected by strict conservation are conducive to both increasing carbon stock and biodiversity conservation. However, the carbon uptake will diminish and be zero as they reach the climax phase.

Net CO₂ removal by forests in the Nordic region

The use of wood and emission reductions

Wood is widely used for construction, energy production, and making products such as furniture, paper and packaging. Wood in construction and products stores carbon as well as avoids GHG emissions through substitution of more energy intensive materials such as concrete and steel. Studies show that, on average, the use of one cubic meter of wood in products or construction reduces about two tCO₂e of emissions (including the substitution effect). However, it is good to recognise that the climate benefits of wood use are highly case-specific and depend mainly on carbon-storage capacity of the product, its full life-cycle, as well as the properties of the material that has been substituted. Many countries have already taken national-level initiatives to promote the use of wood in construction.

The Nordic countries have long traditions using wood energy. The extent of forest resources and development of the forest industry has led to various types and scales of wood energy utilization. In Finland and Sweden, wood accounts for a major part of renewable energy sources. Similar development can be observed in Norway as well but on a much smaller scale. In these countries, the use of wood as fuel is now becoming more forest industry independent, much due to policies enhancing the increasing use of biofuels. In Denmark the use of wood fuels is mainly based on combustion of imported wood pellets in energy production.

Different Nordic countries are bound by the requirements of the same renewable energy directive; however they have different approaches in building policies supporting the increasing use of wood energy. Sweden established the carbon dioxide tax as one of the first countries in the world. Taxation of the fossil fuels has become the central element in Swedish renewable energy policies in steering the use of fuels towards renewable alternatives already long before the international negotiations on this topic. The Finnish policy system involves mainly a feed-in tariff system for power plants fuelled with wind, biogas, forest chips and wood-based fuels. However private forest owner can apply for state subsidies for harvesting of energywood from young forest stands, EUR7/m³. The support system is called KEMERA-“Fund for sustainable forest management”-scheme which is targeted to fund forest improvement operations and conservation of valuable biotopes. Within the same fund, subsidies used to be provided to chipping of energywood but this stopped in the end of 2012.

Over the years, the national policies have naturally been developed to meet the requirements of particular country's operational environment.

The bioeconomy has a great potential for enhancing the contribution of the Nordic forest sector to the economy and climate change mitiga-

tion. It enlarges the range of forest-based products and the scope of bio-based materials for emission reductions. Cellulose, hemicellulose, lignin and other nano materials collected from wood and bark are being used as raw materials for producing plastic, fabrics, pharmaceutical and beverage products. These raw materials, on the one hand, store carbon and avoid carbon emissions by substituting emission intensive materials such as oil. In addition, they also open up new business opportunities for forest-based products.

Market-based mechanisms

There are a number of emissions trading schemes or systems around the world currently under operation or at an advanced stage of development, and come in the form of cap-and-trade systems or baseline crediting systems. Cap-and-trade systems impose a limit on overall emissions that can be traded, while baseline crediting mechanisms incentivise emission reductions through rewarding reducing emissions (crediting) below a business as usual baseline.

Established in 2005, the EU Emission Trading System (EU ETS) continues to be the largest scheme for trading greenhouse gas (GHG) emissions. In 2009, Iceland and Norway joined the EU ETS and it was recently announced that the EU had, in principle, agreed to link the EU ETS with the Australian emissions trading scheme.

The EU ETS does not allow the trading of land-based certified emission reductions. However, a growing number of compliance and voluntary emission trading schemes and market based mechanisms, have evolved over the past few years that do allow land based offsets to be traded. The New Zealand Emissions Trading Scheme (NZ ETS) established in 2008, was one of the first schemes to include the forestry sector. The Australian Carbon Farming Initiative has been designed to cover all land-based sector emissions and sinks, the Republic of Korea passed the Carbon Sink Act in 2012, which integrates the forestry sector into its scheme.

Reforestation, improved forest management and avoided conversion projects are allowed under the Regional Greenhouse Gas Initiative (RGGI) in nine states in the north-eastern USA, and forest offsets are included in California's cap-and-trade program. Forest sector offsets are also under consideration in the Japanese Bilateral Crediting Offset Mechanism (BCOM), and emissions trading schemes in Chile and China. Green Bond issues have raised over USD 4 billion since 2008, and forestry projects that reduce GHG emissions are eligible. Given the number of compliance and voluntary market mechanisms that have been developed and are under development, the trend is clear – market mecha-

nisms that include forestry are increasing in volume, size and liquidity, and the range of instruments is diverse.

Establishing a compliance scheme for trading carbon sequestered in the Nordic forests is not foreseeable for a number of reasons. Firstly, the Linking Directive to the EU ETS, through which the Nordic countries already participate in, provides an already available Kyoto compliant scheme. Furthermore, the EU ETS also specifically excludes Certified Emission Reductions (CERs) and Emission Reduction Units (ERUs) from land use, land use change and forestry (Directive 2004/101/EC). Therefore the current reality is that carbon from Nordic forests cannot be traded on a compliance scheme.

Secondly, the current forest policy and regulation framework, within the Nordic region promotes sustainable forest management. The reality is that there is not much more that Nordic countries and their forest owners can do in specifically Denmark, Finland, Sweden and Norway, outside the regulatory framework, to conserve and sustainably manage forest carbon stocks.

Voluntary carbon market projects under the Verified Carbon Standard (VCS) in Iceland could become a reality if there were interested investors and the projects were feasible; however Iceland is constrained by limited human and financial resources to meet its current afforestation objectives, and the current price of Verified Emission Reductions (VERs) for forest carbon projects on the voluntary carbon market, would not make such projects financially attractive at the moment.

Key policy recommendations

- The Nordic region is rich in forest resources. The forest biomass stock is growing and the net annual increment is positive. As a result, the Nordic forests sequester a large amount of carbon. The Nordic countries should continue with the sustainable forest management practices, investing in forestry and the current policies of increasing forest stock.
- The use of wood for construction and products such as furniture, paper and packaging reduces GHG emissions indirectly. Nordic countries could learn from existing examples and strengthen national policies or schemes to promote the use of wood, for instance, in building and construction. Such policies could be developed at the national level. In addition, the Nordic Member States of the EU could advocate such policies on the EU level.
- The bioeconomy enhances the contribution of the Nordic forest sector to the national economy as well as enlarges the range of forest-

based products and the scope of bio-based materials for emission reductions. Therefore, research and development in the bioeconomy should be strengthened, and public policies related to forestry and economic development should be more focused on the bioeconomy in the Nordic countries.

- National policies and approaches for increasing the use of wood energy are different in different Nordic countries. Nevertheless, the possibility of combining policies and integrating approaches at the Nordic level should be investigated as this could further enhance the wood energy use. A common Nordic fund could be established for providing financial support to the development and pilot projects of new and innovative wood energy systems. Co-operation in this regard should be done with The Working Group for Renewable Energy as well as with Nordic Energy Research, both under the Nordic Council of Ministers.
- As the Nordic countries have the potential for increasing both the volume in forests as well as the use of wood, they should continue with a balanced approach. The failure to encourage growth in forest sink might ultimately lead to limited future potential share of biomass available for bioenergy purposes.
- Moreover, they need to have a careful consideration regarding the possible detailed negotiations on the use of harvested wood products.

1. Context

1.1 Objectives and scope

The objective of this project is to discuss the role of forests in Nordic countries in climate change mitigation.¹ The outcome of the project is this report which provides an input for the Nordic countries on the possible roles of forests as a part of a cost-effective climate policy. The report aims to provide in a comprehensive and easily digestible way a better platform for the Nordic countries in forming their positions for the future negotiations within UNFCCC. The main target audience of the report is the Nordic society.

The report includes discussion on the role of forests as carbon stock and carbon sinks in the Nordic countries. The above- and below-ground carbon sink in Nordic forests is discussed and relevant data and projections are presented. The forest policy as well as policies on conservation and how these affect the role of forests in carbon sequestration and climate change mitigation are analysed. Also the use of wood in products, buildings and as bioenergy is discussed. The main geographical focus of the paper is five Nordic countries: Denmark, Finland, Iceland, Norway and Sweden. Moreover, information and discussion on three Nordic territories, namely, Åland Island, Faroe Islands and Greenland are presented whenever relevant. Hereafter in this report, the terms “forests in the Nordic region” and “Nordic forests” are used interchangeably.

The remainder of the report proceeds as follows. Background to the report and overview to the Nordic forest resources are given in Sections 1.2 and 1.3, respectively. Chapter 2 discusses the international climate policy dialogues that have relevance to the Nordic forests. Forest carbon sink and the effects of management practices on that sink in the Nordic countries are analysed in Chapter 3 followed by a discussion on the role of wood biomass use in climate change mitigation in Chapter 4. Chapter 5 first presents emissions trading schemes around the globe that allows forest activities and then analyse the feasibility of such a scheme

¹ The climate change adaptation aspects of the Nordic forests are not included in this report.

for the Nordic region. Conclusions and recommendations are presented in Chapter 6.

1.2 Background

Forests are a very important player in global carbon cycle. They absorb carbon from the atmosphere through photosynthesis and sequester it in biomass, and thus create a natural storage of carbon. Forests have great potential to mitigate the climate change by reducing the net emission of carbon dioxide (CO₂), the main culprit greenhouse gas (GHG) for this phenomenon. The Global Forest Resource Assessment 2010 of FAO (i.e. FAO 2010) reported that the world's forests, with an area just over 4 billion hectares (ha), store 652 giga tonnes of carbon (GtC).² Boreal forests found in Nordic countries, USA, Canada and Russia house more than half of this carbon stock (Carlson *et al.* 2009). Therefore, conserving and sustainably managing boreal forests to keep this vast amount of carbon in place is an equally important part of the climate change solution as conserving tropical or temperate forests.

The global policy fora, however, has mainly been focused on tropical forests.³ The UN Conference on Environment and Development in Rio de Janeiro in 1992 and many subsequent UN Conferences and climate negotiations highlighted the importance of combating tropical deforestation. Following the trend, the Bali conference in 2007 endorsed Reducing Emissions from Deforestation and Degradation in developing countries (REDD) as a means of combating global warming and climate change. The Copenhagen Conference in 2009 strongly hints REDD as a likely component, while it was adopted as a component of a post-Kyoto climate regime in Cancun in 2010.

Unlike the tropical forests, the boreal and temperate forests in the Nordic region are not under anthropogenic threat of disappearance. Instead, the area of these forests has either been stabilized or increasing, and likewise are not on the focus in the post-Kyoto climate negotiation. However, these forests offer a great opportunity to apply forest conservation and sustainable forest management as a climate change strategy with avoiding the loss of carbon stored in them, and thereby to avoid

² 1 Gt equals to 1 billion tonnes.

³ This is because tropical forests have suffered from high rate of disappearance contributing to the most of about 17.4% of global GHG emissions that comes deforestation and forest degradation.

further acceleration of climate change. Therefore, side by side the tropical forests, the potential contributions of Nordic forests are essential to be fully considered in any future climate regime.

During the last couple of years Land Use, Land Use Change and Forestry (LULUCF) in Annex I countries of the Kyoto Protocol has gained an increasing role on the agenda of the international climate debate. For the Nordic forests this is the part of the negotiations that affect the rules for how these forests will be included in the outcome of the negotiations. Therefore, the negotiations also included the carbon storage in Harvested Wood Products (HWPs) has also got attention in the negotiations during the last few years.

The forests in Nordic countries are a very important source of timber, especially for the traditional forest industries and recreation as well as for fulfilling the emissions reduction targets set forth by different national and international climate agreements of these countries. Especially, Finland, Sweden and Norway, which all have vast forest resources, will have to rely on the forest sector even much more heavily than others countries in trying to meet with the climate policy requirements. Thus the potential contributions of forest sector in Nordic countries in climate change mitigation have to be analysed carefully.

1.3 Overview of forests in Nordic region

1.3.1 *Forest resources*

The Nordic region comprises of five sovereign countries and three territories. The sovereign countries are Denmark, Finland, Iceland, Norway and Sweden. The territories are Åland Island, Faroe Islands and Greenland. The first territory is a part of Finland and the last two are parts of Denmark. The region is rich in forest resources. It has over 61 million hectare (mha) of forests which constitute just under one-third (i.e. 31.42%) of forests in Europe excluding Russian Federation and 89% of forests in North Europe.⁴ A clear lion-part of the forests in the Nordic countries is practically in Finland, Norway and Sweden. Sweden holds about half and Finland more than one-third of the forests in the region.

⁴ The forests in the Nordic region constitute 1.51% of world's forests. The North Europe comprises of the Nordic countries and territories and Estonia, Latvia and Lithuania (see State of Europe's Forests 2011).

Both per capita forest holding and forest cover are the highest in Finland, while Sweden is the second in terms of both variables. Generally, the Nordic countries have gained significant proportions of forest cover between 1990 and 2010.

Distribution of forests in the Nordic region

Forest area and cover in the Nordic region

Country/ Territory	Forest area (ha)		Forest cover (%)	Net forest-cover change per year (%)		
	Total (1000 ha)	Per capita (ha)		1990–2000	2000–2005	2005–2010
Denmark	587	0.11	13.84	0.89	2.57	1.25
Finland	22,084	4.11	72.63	0.25	-0.27	-0.07
Iceland	30	0.10	0.30	7.78	6.66	3.32
Norway	10,250	2.11	33.69	0.19	0.81	1.14
Sweden	28,605	3.04	69.72	0.00	0.00	0.07
Åland Island*	61.7	2.20	40.43	-	-	-
Faroe Islands	0.1	NS	0.08	0	0	0
Greenland	0.22	NS	< 0.01	0	0	0
Total/average in Nordic region	61,556	2.44	40.27 (53.1)±			

± Excluding Faroe Islands and Greenland; * Included in Finland; NS = not significant.

Sources: State of Europe's Forests [SEF] 2011 (for Denmark, Finland, Sweden, Norway and Iceland), FAO FRA 2010 (for Faroe Islands and Greenland) and http://www.regeringen.ax/naringsavd/skogsbruksbyran/Alands_skogstillgangar.pbs (for Åland Island).

Forests in the Nordic countries store vast amount of carbon. The size of forest carbon sink in these countries is also significant in comparison to their total emissions. For example, in Norway the forest sink can offset just over two-third of total emissions in 2010.

Forest carbon stock and sink, and total emissions in Nordic countries in 2010

Country	Forest carbon stock Million tonnes of CO ₂ (tCO ₂)	Forest carbon sink Million tCO ₂	Total emissions Million tCO ₂ equivalent
Denmark	162.21 [#]	5.69	62.62
Finland	18,200.63	32.70	74.55
Iceland	11.74	0.27	5.27
Norway	1,152.38 [*]	35.87	53.90
Sweden	15,833.85	38.10	66.27

[#] Does not include soil carbon.

^{*} Does not include soil and litter carbon.

Source: Adapted from FAO FRA 2010 Country Reports and National Greenhousegas Inventory Reports [NIRs] (2012) of respective countries.

Most of the forests in the Nordic region are under private ownership. Individual ownership is the most prominent form of private ownership in this region. For example, 80% of Norway's forests are owned by the country's ordinary citizens. Significant portions of forests are also owned by states or by other public entities in the Nordic countries.

Forest ownership structure (%) in the Nordic region

Country/Territory	Private				State and/or other public	Others*
	Individual	Private industry	Other private	Private total		
Denmark	65	-	4	69	31	-
Finland	52	8	-	60	35	5
Iceland	-	-	-	70	30	-
Norway	80	4	4	88	12	-
Sweden	50	25	-	75	25	-
Åland	-	-	-	96	4	-
Faroe Islands	-	-	-	-	-	-
Greenland	-	-	-	-	100	-

Source: Nordic Family Forestry (NFF) 2013 and FAO FRA 2010.

* Communities, churches and so on.

1.3.2 Biodiversity and socio-economic importance

Nordic countries are not very diverse in terms of forest types. Finland, Norway and Sweden are located in boreal zone and most forests in these countries fall into the category of boreal forests. The forests in Denmark, which has less than 1% of the forests in the region, fall into the central European temperate forest category. Since Finland, Norway, Sweden and Åland are abundantly forested, forests are the key component of landscape diversity in these countries. Forests are also one of the important features of landscape in Denmark. However, in Iceland, Faroe Islands

and Greenland, being very sparsely forested, forests are not the most common feature in their typical landscape.

The Centre of Advanced Research on Environmental Services from Nordic forest ecosystems reported that the forests in the Nordic region are home to about 25,000 floral and faunal species.⁵ These constitute approximately half of all species found in the region. The Nordic forest species diversity consists of colourful wildlives such as moose (*Alces alces*) and brown bear (*Ursus arctos*). It also consists of 54 tree species (Stokland *et al.* 2003). However, most commonly found and most commercially exploited tree species are just a few. Norway spruce (*Picea abies*), scots pine (*Pinus sylvestris*), silver birch (*Betula pendula*) and downy birch (*B. pubescens*) are the most common and commercially important tree species in Finland, Norway and Sweden. For example, in Finland and Sweden these four species constitute nearly 95% and 92%, respectively, of the volume and the annual increment of the growing stock (Statistics Finland 2012, Environmental Protection Agency [EPA] of Sweden 2012). In Denmark, in addition to these four species, beech and oak are common (NFF 2013).

The contribution of the forest sector to the gross domestic product (GDP) in Nordic countries is decreasing as other sectors of the economy are growing faster, and pulp and paper industry has been experiencing a steep decline over the past decade. Nevertheless, the contribution of the forest sector (forest activities, wood processing and the pulp and paper industry) to GDP and employment in Nordic countries on average is higher than that in Europe as a whole. However, the significance varies considerably among the countries in the region. The contributions of the forests sector to GDP and employment in Finland and Sweden are above those of their Nordic neighbours and Europe's average. In fact, Finland's forest sector's contribution to GDP is the highest in Europe. The figures of forest sector GDP and employment presented in the table do not capture the contributions of forest-based tourism, wood energy, furniture and wood processing equipment manufacturing and trade in forest products. Environmental benefits of forests such as carbon sequestration, watershed and pollination services are also not captured. If all these have been accounted for, the contribution of forest sector especially to GDP in Nordic countries would have been much higher than current.

⁵ Web address: <http://www.nordicforestry-cares.org/index.htm>

Contribution of forest sector to economy

Country/Territory	GDP (%)	Employment (%)
Denmark	0.8	1.5
Finland	5.0	3.6
Iceland	0.2	-
Norway	1.0	1.1
Sweden	3.4	2.0

2. The international policy dialogue on climate change

2.1 Background

The UNFCCC deals with five economic sectors that are the sources of anthropogenic GHG in the atmosphere: energy, industrial processes, agriculture, land use, land-use change and forestry (LULUCF) and waste. As the sectors are defined, GHG removals from the atmosphere occur only in LULUCF, because of biomass growth. This results in specific accounting characteristics, which make the LULUCF sector distinct from the rest.

Issues related to LULUCF have been discussed under the UNFCCC since the third Conference of the Parties (COP) that took place in 1997 in Kyoto. From the start, the subject has been considered confusing with limited reliable estimates of how much the forest sector was contributing to climate change, and how much it would actually help mitigate the problem. These uncertainties fuelled intensive debates which resulted in a complex set of rules adopted in 2001 and 2003 – COP 7 in Marrakech and COP 9 in Milan.

Aside from scientific uncertainty on accounting, there are several other problems with the current system. These include, for instance, the complex and expensive tasks of accounting, monitoring, and reporting, and the fact that emissions from deforestation in developing countries are not covered by the agreement. Negotiations on a new agreement are under way, so there is still room for improvement.

2.2 The Convention

Article 4 of the Convention defines the commitments by Parties to mitigate climate. These take into account Parties' common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances. The same Article 4 makes references to commitments relating to the land use, land-use change and forestry sector as quoted below:

“Article 4, paragraph 1(a): Develop, periodically update, publish and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties.⁶

Article 4, paragraph 1(d): Promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all GHGs not controlled by the Montreal Protocol, including biomass, forests and oceans as well as other terrestrial, coastal and marine ecosystems.”

2.3 The Kyoto Protocol

The Kyoto Protocol is an international agreement linked to the UNFCCC, which commits its Parties by setting internationally binding emission reduction targets. The Protocol determines that Parties shall include land use, land-use change and forestry activities as part of their efforts to contribute to the mitigation of climate change.⁷ It has clear provisions for Annex I Parties to report emissions by sources and removals by sinks of GHGs resulting from LULUCF activities (Articles 3 and 4), but it also determines that land-use activities may be included in the flexible mechanisms of Joint Implementation (JI), which is addressed in Article 6, and the Clean Development Mechanism (CDM) in Article 12.

There are two main provisions under the Protocol that regulates LULUCF national accounting: Articles 3.3 and 3.4. Article 3.3 is mandatory for all Annex I Parties. It requires that countries account for direct human induced afforestation, reforestation, and deforestation (ARD), which have occurred since 1990.⁸ It stipulates that an Annex I country's assigned amount, i.e. the quota it can emit during the first commitment period from 2008 to 2012, will be credited (or debited) with any increase (or decrease) in carbon stocks between 2008 and 2012 that results from afforestation, reforestation or deforestation activities.

⁶ These include the inventories of GHG emissions and removals from the LULUCF sector.

⁷ In Article 2, sub-paragraphs 1(a) (ii) and (iii), Annex I Parties, in meeting their emission reduction commitments under Article 3, shall implement and/or further elaborate policies and measures to protect and enhance sinks and reservoirs of GHGs not controlled by the Montreal Protocol, promote sustainable forest management, afforestation and reforestation and sustainable forms of agriculture.

⁸ For the definition of these terms, refer to Decision 16/CMP.: Land use, land-use change and forestry (2005), available at <http://unfccc.int/resource/docs/2005/cmp1/eng/08a03.pdf#page=3>

Under Article 3.4, countries may elect additional human-induced activities related to LULUCF to be included in their accounting of anthropogenic GHG emissions and removals for the first commitment period. These are: forest management, cropland management, grazing land management and revegetation.

Activities under Articles 3.3 and 3.4 of the Kyoto Protocol

Mandatory activities (3.3)	Voluntary activities (3.4)
Afforestation-reforestation	forest management (FM)
deforestation	cropland management
	grazing land management
	revegetation

When LULUCF activities under Articles 3.3 and 3.4 result in a net removal of GHGs, an Annex I Party can issue removal units (RMUs) on the basis of these activities as part of meeting its commitment under Article 3.1.⁹ However, for the first commitment period (2008–2012), Parties have decided to cap the amount of RMU's, assigning different values for different countries. For many countries, though, the cap reduces the incentive to increase net uptake in the Forest Management sink. The table below details the amounts.

⁹ RMUs represent the same compliance value as other Kyoto flexibility mechanisms and can be traded among parties.

RMUs assigned to different Annex I parties of the Kyoto Protocol

Party	Million tonne (Mt) C/yr
Australia	0.00
Austria	0.63
Belarus	-
Belgium	0.03
Bulgaria	0.37
Canada	12.00
Croatia	0.265 ¹⁰
Czech Republic	0.32
Denmark	0.05
Estonia	0.10
Finland	0.16
France	0.88
Germany	1.24
Greece	0.09
Hungary	0.29
Iceland	0.00
Ireland	0.05
Italy	0.18
Japan	13.00
Latvia	0.34
Liechtenstein	0.01
Lithuania	0.28
Luxembourg	0.01
Monaco	0.00
Netherlands	0.01
New Zealand	0.20
Norway	0.40
Poland	0.82
Portugal	0.22
Romania	1.10
Russian Federation	33.00 ¹¹
Slovakia	0.50
Slovenia	0.36
Spain	0.67
Sweden	0.58
Switzerland	0.50
Ukraine	1.11
United Kingdom	0.37

Source: UNFCCC Decision 16/CMP.: Land use, land-use change and forestry (2005), available at <http://unfccc.int/resource/docs/2005/cmp1/eng/08a03.pdf#page=3>

From the table, it is evident that Canada, Japan and Russia have significant higher caps compared to other countries. These figures were not solely based on a scientific calculation, but on intensive negotiations.

¹⁰ This figure has been added by decision 22/CP.9.

¹¹ This figure is changed from 17.63 to 33.00 by decision 12/CP.7.

Article 25 of the Protocol establishes that:

“This Protocol shall enter into force on the ninetieth day after the date on which not less than 55 Parties to the Convention, incorporating Parties included in Annex I which accounted in total for at least 55% of the total carbon dioxide emissions for 1990 of the Parties included in Annex I, have deposited their instruments of ratification, acceptance, approval or accession” (our italic).

After the withdrawn of the United States,¹² there was a threat that the “55” target was not going to be achieved. At the time, Japan, Canada, and Russia were still considering if they should ratify the instrument. Therefore, to ensure that the Protocol entered into force, generous caps on the crediting of GHG emission reductions and removals from forest management were established for these countries.¹³

2.4 Issuance of RMUs

RMUs can be used by countries to meet their commitment under the Protocol, or sold to another party.

The first RMUs were issued in 2011, in the National Registries of France, Australia, Russia, and Hungary. At the end of 2011, both France and Australia held 23 million RMUs in their National registries. Russia held 4 million RMUs at the end of 2011, and was issued 462 million RMUs in February 2012 (Ecosystem Marketplace 2012).

In 2011, we also witnessed the first sale of Removal Units (RMUs), coming from Hungary. The country announced that the revenue from the sale of the units would be used to support environmentally friendly investments. Hungary, along with Denmark, France, and Switzerland, has opted to print RMUs annually, while other Kyoto signatories will receive RMUs in 2014, two years after emissions data for the entire 2008–2012 Kyoto period is finalized.

¹² The United States is part of the Convention, but decided not to ratify the Kyoto Protocol.

¹³ See Decision 16/CMP.: Land use, land-use change and forestry (2005), available at <http://unfccc.int/resource/docs/2005/cmp1/eng/08a03.pdf#page=3>

2.5 LULUCF decisions in Durban (COP 17, 2011)

The Ad hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP) has been carrying discussions on how to revise carbon accounting rules for LULUCF since 2008. There were several proposals on the table, but the two main issues being considered were i) accounting options for forest management (Art. 3.4 explained above) and if this activity should become mandatory; and ii) if the cap listed in Table 2.2 should be revised or substituted by an alternative rule. After two weeks of negotiations in Durban, the following was agreed upon.

2.5.1 *Forest management*

Forest management reporting under article 3.4 of the Protocol has now become mandatory for all Annex I countries during the second commitment period.

The accounting will be calculated relative to a baseline reference level plus a new cap of 3.5%. Just like the rules were set out before, Parties will gain credits if reported removals are higher than the baseline reference level net removal, but respecting the new cap. On the contrary, i.e. in case removals are lower than the baseline reference level, Parties will be debited. According to experts, this represents an important step forward as:

- forest management became a mandatory reporting activity.
- there are no longer countries with significant higher caps as a product of negotiations (only) – like it happened with Canada, Japan and Russia.
- there is now incentive to pursue increased carbon sequestration in the context of the forest management sector as the new approach using reference levels is significantly different from previous rules.

According to experts (Ellisson 2012), the new calculation will allow all countries to see a significant increase in cap – except for Slovenia, Latvia, Russia, Japan and Canada.¹⁴ For Hungary, the “new cap” represents a 276% increase over the previous cap, while the Netherlands’ cap was increased by a factor of 200. The figure below shows a comparison of old and new cap with average FM Removals (above Reference Line, FMRL).

¹⁴ Although Russia, Japan, Canada will not be part of the second commitment period.

Comparison of Old and New cap with Average FM Removals (Above Reference Line, FMRL)

Source: Elisson 2011, available at <http://www.vki.hu/~ellison/Durban%20and%20LULUCF.pdf>

As explained, countries decided to keep a cap during the first commitment period (see previous section). For some countries, this cap reduced the incentive to increase net uptake in the Forest Management sink. With the Durban decision to increase the cap, countries that are reducing emissions which are not being accounted for (refer to section 3.1.5 for further debate) will be able to issue more RMUs to either be used for compliance, or transacted with other countries. However, experts highlight that, for countries such as Poland, Slovakia, Croatia, Latvia and Slovenia, the new cap may not be large enough to encourage significant additional growth in the net forest sink.

In addition, the previous rule on the potential for offsetting net emissions under Article 3.3 (Afforestation-reforestation and deforestation) with excess carbon sequestration under Article 3.4 (forest management) has been eliminated. Experts argue that this is an advantage as it strengthens the force of incentives to increase carbon sequestration outside of forest management.

2.5.2 Disturbance mechanism

The debate over turning forest management into a mandatory activity was facilitated by the inclusion of a new mechanism for adjusting accounting for natural disturbances. The idea was to exclude areas affected by forest fires or other natural disturbances from accounting, which is an important issue for parties with large disturbances, such as Canada and Australia.

According to the official definition, natural disturbances are “non-anthropogenic events or non-anthropogenic circumstances. For the purposes of this decision, these events or circumstances are those that cause significant emissions in forests and are beyond the control of, and not materially influenced by, a Party. These may include wildfires, insect and disease infestations, extreme weather events and/or geological disturbances, beyond the control of, and not materially influenced by, a Party. These exclude harvesting and prescribed burning”.

The approved mechanism will allow Parties to withdraw emissions from land areas associated with natural disturbances from accounting when they exceed a set background level. The background level is set based on historical information on disturbances.

2.5.3 *New activities*

Wetland drainage and re-wetting represents a new electable activity, but it is still included in the list of voluntary activities. SBSTA has been granted a mandate to further consider a more inclusive activity-based approach.

2.5.4 *Harvested Wood Products (HWP)*

The accounting rules for harvested wood products under the Protocol will no longer assume, in certain circumstances, that all of the carbon sequestered during the life of the tree was lost on harvesting, but rather would capture that some of the carbon is stored. Liability for harvested trees would depend on the use of the harvested wood (e.g. use for paper, or wood panels, or as sawn wood).

The potential to include HWP in carbon accounting has also been intensively discussed, and has finally become mandatory. It can now be accounted based on the current instant oxidation approach, or based on the production approach. However HWP leading to deforestation will be counted as instant oxidation.

The decision also stresses that Emissions from harvested wood products removed from forests which are accounted for by a Party under Article 3, paragraphs 3 and 4, shall be accounted for by that Party only. Imported harvested wood products, irrespective of their origin, shall not be accounted for by the importing Party.

2.6 Further improvements needed

2.6.1 *Accounting for LULUCF*

But experts are arguing for further improvements. Future Forest researchers, for instance, have come forward with The Incentive Gap model, which proposes the merging of carbon reporting across all activities into one, all-inclusive framework (collapsing Arts. 3.3 and 3.4). The goal is to encourage a more balanced and efficient use of forest-based resources for the purposes of climate change mitigation and adaptation. According to experts, current approaches to forest resource-based carbon accounting consider only a fraction of its potential and fail to adequately mobilize the LULUCF sector for the successful stabilization of GHG concentrations.

Country submissions

In October 2012, the UNFCCC Secretariat has released a document containing Parties' views on issues relating to a more comprehensive accounting of anthropogenic emissions by sources and removals by sinks from LULUCF, including through a more inclusive activity-based approach or a land-based approach.

Australia's argues that the consideration of a more comprehensive framework could inform land sector discussions under the UNFCCC broadly, including as parties cooperate to develop a post-2020 framework. It supports retaining the provision on natural disturbance; the reference level approach for forest management; and improved accounting for HWPs.

The EU's submission calls for a more comprehensive accounting framework to be considered in the context of the negotiations of a future post-2020 framework and include consideration of non-Kyoto parties' views. The EU underscores aspects for developing a more comprehensive approach and possible options to do it, addressing advantages and shortcomings of the land-based and activity-based accounting approaches, as well as a possible combined approach.

Switzerland emphasises that accounting methodology for the land-use sector should be fully compatible with accounting for other sectors and programmes within a future reporting context, including developing country nationally appropriate mitigation actions (NAMAs), REDD+ (reducing emissions from deforestation and degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries), and national adaptation programmes of action (NAPAs).

2.6.2 REDD+

A new mechanism entitled REDD+ has been discussed under the international negotiations since 2005. The issue gained momentum in 2007 when the IPCC (2007) highlighted that land-use changes account for approximately 20% of today's total GHG emissions, which is more than the total transportation sector worldwide. Most of these emissions come from deforestation in developing countries where forests are being cleared for agriculture and timber. Additionally, after an extensive analysis of the economics of climate change, the Stern Review concluded that "curbing deforestation is a highly cost-effective way of reducing greenhouse gas emissions and has the potential to offer significant reductions fairly quickly" (Stern 2007, 537).

REDD+ stands for reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries. As the definition puts it, the mechanism is aimed to be implemented in developing countries therefore it is not under the scope of this study.

2.6.3 Civil society voices concerns

Side-line of the official governmental negotiations, civil society actors have been voicing their concerns.¹⁵ Below is a summary of the main issues being discussed.

Mandatory activities

The issue of expanding the array of land management emissions that are covered by countries' commitments continues to be discussed. Some NGO's have been pledging for a more encompassing approach to mandatory LULUCF accounting, arguing that climate accounting regime should be as inclusive and complete as possible. They defend that comprehensive accounting is key to providing the signals and incentives for all countries with land-based emissions to move to more sustainable land uses. The argument is that the current system which only requires that certain activities are accounted for does not reflect the true climate impact of anthropogenic activities, and, therefore, fails to create real rewards for mitigation.

¹⁵ Examples: EDF: <http://unfccc.int/resource/docs/2012/smsn/ngo/266.pdf>, CAN: <http://unfccc.int/resource/docs/2012/smsn/ngo/257.pdf>

Bioenergy: emissions unaccounted for

The use of biomass for energy is not mentioned as a land-use activity in the Kyoto Protocol and Marrakech Accords, but it is recognized through the reduction in fossil fuel emissions, e.g., when biomass fuels are substituted for fossil fuels in the energy sector. There has been intensive criticism on the unaccountable emissions from biomass being used as energy source. Some consider it as a perverse incentive. And if it is not accounted under LULUCF, it should be captured in the energy sector at the point of use.

The IPCC considers that the CO₂ emissions from the combustion of biomass for energy are not accounted for in the energy sector – meaning zero emissions. However, they are included as a change of stock in the agriculture, forestry and other land use (AFOLU) sector. Bioenergy was considered a zero emission activity in the energy sector for many reasons: (i) “the net release of carbon should be evident in the calculation of CO₂ emissions described in the Land Use Change and Forestry chapter” (IPCC 1996); (ii) “of the sustainable nature of biofuels” (IPCC 1996); (iii) “the accounting system should be as simple as possible, but not simpler” (Apps *et al.* 1997); (iv) “net emissions or removals of CO₂ are estimated in the AFOLU sector and take account of these emissions” (IPCC 2006); (v) “biomass data are generally more uncertain than other data in national energy statistics” (IPCC 2006); (vi) “a large fraction of the biomass, used for energy, may be part of the informal economy, and the trade is not registered in the national energy statistics and balances” (IPCC 2006); (vii) ‘it avoids any double counting’ (IPCC 2006).

From the 1996 and 2006 IPCC guidelines, it is clear that bioenergy was considered to have zero CO₂ emissions in the energy sector only, but not zero emissions overall.

Forest management reference levels

In accordance with the Footnote 1 to Paragraph 4 of the UNFCCC Decision 2/CMP.6,¹⁶ Annex I countries of the Kyoto Protocol have set their

¹⁶ The decision is available at <http://unfccc.int/resource/docs/2010/cmp6/eng/12a01.pdf#page=5>

own forest management reference levels (FMRLs). Each party has the flexibility regarding the choice of data, methodologies and procedures for constructing its FMRL.¹⁷

NGOs are arguing that this flexibility might lead to problems with consistency. Additionally, the country-specific models to generate the baselines could potentially create a lack of transparency and completeness, making it difficult to assess overall accuracy.

A few developing countries are working on proposing an alternative text that does not let countries use projected reference levels. Their argument is that the REDD+ and LULUCF negotiations should be more consistent and follow the same line of thought. Under REDD+ negotiations, developed countries like Norway have been demanding that REDD+ MRV is subject to third-party “international” verification; while developing countries, like Brazil, argue that verification should be conducted domestically. Conversely, under LULUCF negotiations, developed countries seem to have a different opinion regarding domestic “control” of the process.

All in all, NGO’s are aware that compromises must be reached in order for us to reach an international agreement: “what is the worse of two evils? Having no Kyoto Protocol, or having a Kyoto Protocol that lacks environmental integrity?”

¹⁷ Each party has also submitted, as requested in the Decision 2/CMP.6, to the UNFCCC Secretariat in 2011 the information on the FMRL following the Guidelines for Submissions of Information on Forest Management Reference Levels given in Part I, Appendix II of the Decision. Each submission has gone through the Technical Assessment (TA) performed by an Expert Review Team (ERT) following the Guidelines for Review of Submissions of Information on Forest Management Reference Levels given in Part II, Appendix II of the Decision. An ERT has six land use, land-use change and forestry experts selected from the UNFCCC roster of experts.

3. Nordic forests and carbon

3.1 Forests and carbon

3.1.1 Role of forests in carbon cycle

Forests are an important component of global carbon cycle. Forest vegetation absorbs CO_2 from the atmosphere during the photosynthesis and accumulates in plant biomass as solid carbon in the process of growth. A significant portion of this accumulated carbon re-enters the atmosphere through plant respiration, forest fire and decay of biomass (Apps *et al.* 2006, Broadmeadow and Mathews 2003). Burning of plant biomass for energy also releases carbon back to the atmosphere. The carbon removed from forests through cutting also comes back to the atmosphere either in short or long term depending on where the forest products are put to use. In general, accumulation of carbon in forest growth exceeds the total release from it, and thus forests globally act as a carbon sink (see, e.g. IPCC 2007).

Trees and the carbon cycle

According to FAO FRA (2010), global forests store just over 652 GtC. Living forest biomass accounts for 44% of this carbon stock, forest soil 45% and deadwood and litter account for 11%. Globally the carbon stock has been on constant decline between 1990 and 2010. However,

during the same period, the stock has increased in Europe (excluding Russia) in the northern part of which the Nordic countries are located. Forests and other terrestrial ecosystems annually absorb about 2.6 GtC (i.e. equivalent to 9.53 Gt of CO₂),^{18,19} 1.6 GtC of which re-enters the atmosphere due mainly to forest clearing and degradation, and thus the rate of carbon sequestration is 1 GtC per year (IPCC 2007). Therefore, forest ecosystems act as both sink and source in global carbon cycle.

Due to the increasing concentration of CO₂ and other GHGs in the atmosphere, global temperature is rising and climate is changing. Anthropogenic disturbances are mainly responsible for these. Combustion of fossil fuels and deforestation and forest degradation are the two main causes. The latter contributes to 17.4% of total anthropogenic GHGs emissions (IPCC 2007). These emissions mainly come from tropics as most deforestation and forest degradation occur in forests of this region. However, both area and carbon stock in temperate and boreal forests is increasing (see FAO FRA 2010).²⁰

Boreal forests, the category which most forests in Nordic countries belong to, cover more than 10% of world's land surface (Carlson *et al.* 2009) and form the largest terrestrial biome by area in the world (Melillo *et al.* 1993). This forest biome stores a vast amount of carbon which is equal to approximately 50% carbon in the atmosphere (Chapin *et al.* 2000 and Gower *et al.* 2001). In fact, the carbon stored in boreal forests is twice as much in tropical forests and 40% more than that in tropical and temperate forests combined (Carlson *et al.* 2009). Moreover, because forest growth exceeds biomass removal, boreal forests act as carbon sink. For example, Shvidenko and Nilsson (2002) reported that Russian forests have been carbon sink for past decades. Likewise, Nordic countries particularly Finland, Norway and Sweden have vast area of forests which store a large stock of carbon. Biomass and carbon stock in forests in all countries of this region have been growing constantly. Disturbance will cause release of this carbon, and thus global attention and policy mechanisms needed to incentivize the carbon sequestration in the Nordic countries.

¹⁸ Between 1990 and 2010, carbon stock has also increased in the forests of East Asia, West and Central Asia, Caribbean and North America. In other sub-regions it has decreased in that period (see FAO FRA 2010).

¹⁹ 1 tC = 3.67 tCO₂.

²⁰ Temperate forests are mainly found in Europe, North America and East Asia.

Net annual rate of increment (%) in forest growing stock in the Nordic countries between 1990 and 2010

Country	Net annual rate of increment (%)		
	1990–2000	2000–2005	2005–2010
Denmark	1.36	7.96	0.76
Finland	1.03	0.90	0.24
Iceland	3.03	3.71	3.88
Norway	1.44	2.11	2.11
Sweden	0.92	0.81	0.17

Source: Adapted from SEF 2011.

3.1.2 Forest biomass

Between 1925 and 2010, forest biomass stock increased in Sweden and Norway, while in Finland the stock decreased slightly until the middle of 1970ies and then increased steadily until the end of the period.^{21,22} In all five Nordic countries and thus in the whole Nordic region the forest biomass have constantly increased between 1990 and 2010. The forests in the region consisted about 4,500 million tonnes of biomass in 1990 which increased to just over 5,100 million tonnes in 2010. This can be explained by the fact that in the Nordic countries, the net annual increment of forest growing stock has been positive over last two decades and before. In Sweden, Norway, Denmark and Iceland, the increase in forest cover also has contributed to the increase in forest biomass stock. In Finland, even though forest cover decreased slightly between 1990 and 2010, annual increment in growing stock was far greater than annual harvest and thus the net annual increment was positive and overweighed the biomass removal due to decrease in forest cover. It is projected that in all Nordic countries and thus in the whole Nordic region, the forest biomass will continue to increase steadily until 2050.²³ This corresponds to the fact that the net annual increment in forest growing stock will be positive in the Nordic countries in coming decades.

²¹ Forest biomass includes above- and below-ground live biomass and deadwood.

²² For Sweden, Finland and Norway forest growing stock data are available already from mid 1920ies corresponding to the beginning of forest inventory in these countries. These data make it possible to provide biomass estimates for these countries from 1925. Denmark and Iceland have started their national forest inventories only recently, and naturally long-term inventory data are not available for them and thus their biomass estimates are for shorter time series.

²³ The biomass trend is not applicable for LULUCF accounting required under Kyoto Protocol.

Trend in forest biomass in the Nordic countries

Source: 1990–2010 values are adapted from FAO FRA (2010), 1925–1989 and 2011–2050 values are Indufor's own estimates.

3.1.3 Net removal of CO₂ by forests

A negative net removal of atmospheric CO₂ by forests means that forests are a sink of carbon, while a positive net removal means the emissions and thus forests are a carbon source. The net removals in the Nordic countries for 1990 to 2020 are reported below.²⁴ The net removals between 1990 and 2010 are taken from the respective country's latest (2012) national inventory report (NIR) for GHGs submitted to the United Nations Framework Convention on Climate Change (UNFCCC) and between 2011 and 2020 are based on Indufor's own projection. The net removal of atmospheric CO₂ by forests presented in the NIR of a Nordic country can be considered the biological maximum of forest sink in that country and is practically indifferent from the net removal reported under the Kyoto Protocol.²⁵

²⁴ The justification for choosing this time period is that in climate negotiations that have implications on the Nordic forests the reference year for emissions accounting is often 1990, while 2020 marks the end of horizon for the most of already adapted climate policies, for example, the second commitment period of the Kyoto Protocol ends in 2017 or 2020. Thus reporting forestry removal or emissions for years before 1990 and after 2020 would not add any value to the report.

²⁵ In this report, the NIRs of the Nordic countries are referred to after the agencies responsible for preparing and submitting the respective NIRs, i.e. Sweden – Swedish Environmental Protection Agency [Swedish EPA] (2012); Finland – Statistics Finland (2012); Norway – Norwegian Climate and Pollution Agency [Norwegian CPA] (2012); Denmark – Danish Center for Environment and Energy [Danish CEE] (2012); Iceland – Icelandic Environment Agency [Icelandic EA] (2012).

Reporting of emissions under the Kyoto Protocol and to UNFCCC²⁶

The reporting of LULUCF net CO₂ emissions regarding forests by the Nordic countries for the Kyoto Protocol and to UNFCCC is usually very consistent with each other. However, for the Kyoto reporting, the areas under each sub-category or activity are accumulated from the base year and onward, and do not leave the LULUCF class. On the other hand, for the UNFCCC reporting, a converted land is usually reported under the land-use class it was converted to (Swedish EPA 2012). The implication of this is that in the Kyoto reporting the deforested land still remains under the forest class and thus the net emissions from this class accounts for the emissions due to deforestation, while in the UNFCCC reporting such emissions are not accounted for under forests (see table below).

Despite the difference in the accounting systems, the net emissions from forests under the Kyoto and UNFCCC reporting are only marginally different. This is because deforestation is quite rare in the Nordic countries in recent decades. Rather these countries have been able to either stabilize or increase their forest cover, and keep the level of forest growing stock above the total drain consisting of harvesting and mortality.

Corresponding sub-categories/activities related to forests in UNFCCC and Kyoto Protocol reporting

UNFCCC	Kyoto Protocol
Forest land remaining forest land (5.A.1)	Forest management (Article 3.4)
Land converted to forestland (5.A.2)	Afforestation/reforestation (Article 3.3)
Land converted to	Deforestation (Article 3.3)
-Cropland (5.B.2)	
-Grassland (5.C.2)	
-Wetlands (5.D.2)	
-Settlements (5.E.2)	

Source: adapted from Statistics Finland 2012.

²⁶ As explained in chapter 2, the rules have changed for the second commitment period. Refer to this chapter to understand the new rules on accounting and reporting for forest management, HWP, natural disturbances, and wetland drainage. As a consequence, countries will have to acknowledge these changes and reflect them on their national communication in the future.

Sweden

Between 1990 and 2010, as Figure 3.3 demonstrates, forests in Sweden have been a sink of carbon. However, the size of the sink, i.e. the amount of CO₂ removal by forests has fluctuated with a decreasing trend. In 1990, the total CO₂ removal by Swedish forests was just over 44 million tonnes, but in 2010 it reduced to 37 million tonnes. Both forest biomass and soil have acted as the sink during that period. The removal by forest soils have increased marginally over the period from just over 7 million tonnes in 1990 to about 9 million tonnes in 2010. On the other hand, the removal in forest biomass generally decreased with the lowest removal in 2005. Both the quantity and decrease in rate of removal by forest biomass have been much higher than the quantity and increase of rate of removal by forest soil and thus trend in total removal by forests is practically determined by the trend in removal by biomass.

In Sweden, for the entire period between 1990 and 2010, the increment of forest growing stock has been larger than the drain of it due to harvesting and natural mortality and thus biomass acted as a sink. However, the rate of increment in growing stock has been slower than the rate of increase in drain and thus size of forest biomass sink decreased gradually. The increase in the rate of drain has mainly been due to the increase in harvesting rate which is led by increased demand for forest products (EPA 2012). The drain peaked in 2005 as a result of wind throws originating from a severe storm which corresponded to the lowest quantity of CO₂ removal by forests in Sweden.

Net CO₂ removal by forests in Sweden

Source: Net removal for 1990–2010 are adapted from Swedish EPA (2012) and for 2011–2020 are Indufor's estimate.

It is projected that the forests in Sweden will remain as sink until the end of the decade of 2010s. The soil sink will increase. However, the biomass and thus the total forest sink will decrease. This is because demand for forests products will continue to increase leading to increase rate of forest harvesting. The rate of drain will be more than that of biomass growth and thus the forest sink will decrease.

Finland

The forests in Finland have been a carbon sink for the entire period between 1990 and 2010. The quantity of atmospheric CO₂ removal by the Finnish forests in 1990 was 23.4 million tonnes which fluctuated with an increasing trend to reach 32.7 million tonnes in 2010. This means the forest sink has increased in 2010 by 41% since 1990. The forest soils have generally been a source with a constant rate of emissions and the enormous removal by forest biomass practically determine the size and trend of the forest sink in Finland between 1990 and 2010.

The removal by forest biomass fluctuated to increase from just over 28 million tonnes of CO₂ in 1990 to nearly 34.5 million tonnes in 2010. There were dips in early 1990ies and late 2000s linked to poor economic growth and thus lower demand for forest products by industry. Overall, the removal of CO₂ between 1990 and 2010 has been governed by the annual increment and the drain of growing stock. Due to effective and sustainable forest management practices in past decades, the annual increment of growing stock in Finland has increased steadily. It increased from 77.7 million m³ in 8th National Forest Inventory (1986–1994) to 103.7 million m³ in 2011 (Finnish Statistical Yearbook of Forestry 2011). The drain due to harvesting and natural mortality of trees has also increased, but always remained below the increment of growing stock. This means the increased CO₂ emissions due to the drain is more than compensated by the removal by growing stock increment and thus forest biomass has acted as a sink. The fluctuation in the biomass sink can be explained by the roundwood harvesting which constitutes the main part of the drain. The roundwood harvesting in Finland fluctuated a lot due to the changes in international forest-product market situation over past few decades (Statistics Finland 2012).

Net CO₂ removal by forests in Finland

Source: Net removal for 1990–2010 are adapted from Statistics Finland (2012) and for 2011–2020 are Indufor's estimate.

The dead organic matter and soil in forests have released CO₂ in most years during the period mentioned above with the release of 4.7 million tonnes in 1990 and 1.6 million tonnes in 2010. This is because the mineral soils have been a sink, but the organic soils have been a source due to drainage of peatland. Organic soils have released more CO₂ than what mineral soils removed in most years between 1990 and 2010. It is projected that forest soils will become, and the forest biomass will remain a sink with increasing rates of removal for 2013–2020. Thus forests will remain a sink in Finland with the net removal exceeding 45 million tonnes of CO₂ in 2020.

Norway

Between 1990 and 2010, as Figure 3.5 shows, the forest biomass in Norway removed atmospheric CO₂ at an increasing rate in general. In 1990, the quantity of removal was approximately 6 million tonnes which increased to over 27 million tonnes in 2010. The removal by dead organic matter and soil in forests also increased over the same period, but at much slower rate than that by biomass. As a result, the total CO₂ removal by forests in Norway followed almost the same increasing trend as the biomass.

The increasing demand for timber, combined with visionary policy initiatives to rebuild Norway after the Second World War, led the country to invest heavily in forestry and adopt active forest management policy over last six to seven decades. Massive area, especially on the west coast of Norway, was brought under plantation each year and harvested forestland was replanted. The planted forests currently are at the most productive stage contributing to the increase in biomass and thus carbon stock in forests (CPA 2012). In 1990, the carbon stock in Nor-

way's living forest biomass was just over 300 million tonnes which steadily increased to near 400 million tonnes in 2010. On the other hand, the level of annual drain have followed a flat trend and remained below the level of annual increment that followed a gradual upward trend (Norwegian Forest and Landscape Institute [NFLI] 2012). As a result, biomass and thus carbon have accumulated in forest at an increasing rate in Norway over last few decades. This increasing trend is expected to continue in the future as well and thus the atmospheric CO₂ removal by forest biomass and soil is also expected to increase.

Net CO₂ removal by forests in Norway

Source: Net removal for 1990–2010 are adapted from Norwegian CPA (2012) and for 2011–2020 are Indufor's estimate.

Denmark

As demonstrates, the forests in Denmark acted as carbon sink removing approximately 1 million tonnes of CO₂ per year in the decade of 1990ies. Growth in forest biomass exceeding drain due to harvesting and natural mortality explains this removal. However, between 2000 and 2005, the Danish forests were a carbon source releasing between 1 and 2 million tonnes of CO₂ each year. During that period the age distribution became skewed towards mature forests, which were eventually harvested and the cleared land was regenerated with saplings (Danish CEE 2012). This resulted in negative net increment in forest biomass and thus turned the Danish forests as a net source of carbon. Forests acted as a carbon sink again between 2006 and 2010 with a fluctuating level of CO₂ removal. Over the decade of 2010s, the forests in Denmark is expected to grow in biomass volume with the harvesting rate staying below the biomass

growth rate and thus sequestering carbon in forest biomass and soil (Johannsen *et al.* 2011). As a result, Danish forests are expected to remain as a carbon sink with a constantly increasing rate of CO₂ removal.

Net CO₂ removal by forests in Denmark*

Source: Net removal for 1990–2010 are adapted from Danish CEE (2012) and for 2011–2020 are Indufor's estimate.

*The removal by forest biomass and soils are not available separately.

Iceland

As the area of forests in Iceland is far less than that in other Nordic countries, the net removal of atmospheric CO₂ by Icelandic forests is also very low comparatively. While the removal in other Nordic countries is in millions of tonnes, in Iceland it is still in a few hundred thousand tons. In 1990, the Icelandic forests removed about 30,000 tonnes of CO₂ which increased steadily to reach just over 270,000 tonnes in 2010. Continuous growth in forests, but minimal level of harvesting is the reason for this increase in CO₂ removal. Indeed, according to Iceland's reference level submission for the Kyoto Protocol compliance (Snorrason 2011), between 1990 and 2010, the annual commercial harvesting in Iceland was only about 1,000 m³ on average. In addition, only limited amount of fuelwood is collected from natural birch forests which constitute about 90% of Iceland's forests. Clearcutting is not usually practiced and timber comes from commercial thinning of planted forests which cover about 10% of forest in the country. The situation with forest management is not expected to change in near future. The demand for commercial timber may increase slightly which is expected to be met by plantation for-

ests. As a result, the CO₂ removal by the forests in Iceland is expected to increase at a constant rate till the end of current decade.

Net CO₂ removal by forests in Iceland*

Source: Net removal for 1990–2010 are adapted from Environment Agency of Iceland [EAI] (2012) and for 2011–2020 are Indufor's estimate.

*The removal by forest biomass and soils are not available separately.

The Nordic region

Following the trend in increasing forest biomass, the total removal of CO₂ by Nordic forests increased between 1990 and 2010. In 1990, the removal was about 80 million tonnes of CO₂ which increased to just over 120 million tonnes in 2010. It is projected that in the rest of the current decade, the total removal will continue to increase steadily to reach near 140 million tonnes of CO₂ in 2020 for the monetary value of the CO₂ removal). This is mainly because annual removal of growing stock and biomass from forests is expected to be less than the annual increment and thus the net annual change in biomass will always be positive which will result in increasing biomass in the Nordic forest.

Net CO₂ removal by forests in the Nordic region, Canada and Russia

Source: Net removal for 1990–2010 of the Nordic region is the summation of all Nordic countries' net removals, of Canada is adapted from Environment Canada (2012), of Russia from Russia's NIR (2012) submission, and for 2011–2020 is Indufor's estimate.

However, compared with CO₂ removal by the forests in Russia, the removal by the Nordic forests is low and the trend is flat. In 1990, the Russian forests removed about 232 million tCO₂ and the removal amount increased steadily to reach just over 700 million tCO₂ in 2010. The reason for this is that Russia has huge forest area of 809 million ha (SEF 2011) and the drain of forest biomass through harvesting and decay is far less than the growth. Moreover, initiatives to suppress wild forest fires, on the one hand, helped in maintaining forest growth and increasing carbon stock in living biomass. On the other hand, catastrophic forest fires like in Siberia and the Russian Far East contributed to increasing dead organic matter and carbon stock in soil (Shvidenko and Nilsson 2002). The trend in net forest biomass growth is expected to continue resulting in increasing amount of CO₂ removal by the Russian forests (see Figure 3.8). The forests in Canada, on the other hand, have been a net source of carbon for most of years between 1990 and 2010. This attributed to the fact that most forests in Canada are at old-growth stage with declined growth but high rate of decay of organic matter. Therefore, at the country level, despite having a large share of forests protected, the release of atmospheric CO₂ from the Canadian forests due mainly to decay of organic matter and harvesting exceeds the removal due to forest growth (Environment Canada 2012). If this trend continues, the Canadian forests will act as a carbon source in this decade.

Monetary value of forest carbon sink in Nordic region

The present value of forest carbon sink in the Nordic region is presented below. Even though it is rather a theoretic estimation, the value gives a good approximation of what the Nordic forest carbon sink worth monetarily and the theoretical size of a possible Nordic sink market. With a constant price of €5/tCO₂ and 3% annual market interest rate, the present value is estimated to be just under 900 million Euros in the beginning of 1990ies. The value follows a declining trend to reach about 600 million Euros in 2010 and just above 500 million Euros in 2020 even though the carbon sink has increased. This means that under the assumed market conditions, the rate of decrease in the value is faster than the rate of increase in the sink.

Present value of forest carbon sink in the Nordic region (at €5/tCO₂ & 3% interest rate per year)

As can be seen from the Figure 3.9 on the left, the present values for Denmark and Iceland, corresponding to the size of their respective forest sinks, are far lower than that in Sweden, Finland and Norway. It can be noted here that the present value of the sink increases both with the increase of CO₂ price and the decrease of market interest rate. With the former one, the present value still follows the declining path and the rate of decline increases over time, while with the latter the rate of decline decreases or the present value increase over time.

The total CO₂ removal by the forests of Denmark and Iceland combined is negligible compared with that in Sweden, Finland and Norway. The last three countries together practically constitute the whole forest carbon sink in the Nordic region. This is unsurprising since these three countries have more than 99% of forests in the region. The biomass and soil carbon sinks in these three countries together have increased between 1990 and 2010 and are also projected to increase until 2020. This implies that the decrease of forest biomass sink in Sweden is more than compensated by the increase in Finland and Norway together. Similarly, the CO₂ emissions from forest soil in Finland are more than offset by forest soil sink in Sweden and Norway combined.

Net CO₂ removal by forests in Sweden, Finland and Norway

Source: Net removal for 1990–2010 is the summation of respective countries' net removals, and for 2011–2020 is Indufor's estimate.

3.1.4 Net removal of CO₂ by harvested wood products

Harvested wood products (HWPs) remove considerable amount of CO₂ in the Nordic region as a whole. Between 1990 and 2010, the net removal in Sweden has been the biggest among the Nordic countries and is expected to remain so until 2020 and basically sets the trend of net re-

removal for the whole Nordic region.²⁷ Larger size of economy and population and thus higher consumption of wood products might be a reason for this.²⁸ HWPs have been CO₂ sink in Finland and Norway, while CO₂ source in Denmark for most years between 1990 and 2010 and trend is expected to continue until 2020 for these countries. The sink size fluctuated over 1990 and 2000s especially in Sweden and Finland due to the fluctuating level of use of HWPs in longer lasting purposes such as construction and furniture with a dip in Sweden in 2008.

Net removal of CO₂ by harvested wood products in Nordic countries

Source: Net removals for Finland, Sweden and Denmark are adapted from the respective countries submission of information on forest management reference level to the Kyoto Protocol. For Norway, net removal in 1990–2010 is adapted from Norwegian CPA (2012) and in 2011–2020 is Indufor's estimate.

3.1.5 Forestry credits

We can consider each tonne of atmospheric CO₂ removed or sequestered by forests as one forestry credit. Depending on whether or not a Nordic country's forestry credits can be used to meet its emissions reduction target set by the Kyoto Protocol, we can divide the forestry credits into: (i) RMUs and (ii) Non-RMUs.²⁹

²⁷ The data on CO₂ removal by HWPs in Iceland is not available. Nevertheless, it is realistic to assume that the removal amount in the country is negligible compared with other four Nordic countries as Iceland's forest harvesting and timber import are little.

²⁸ Differences in methodologies used by the countries could also a reason for this.

²⁹ RMUs are introduced in Section 2.1 of this report.

RMUs

For the first commitment period of the Protocol (2008–2012), all the Nordic countries except Iceland are allocated with RMUs for the activities under Article 3.3 (afforestation, reforestation, deforestation) and Article 3.4 (forest management). As pointed out in Section 2.4, these RMUs can be used to meet a country's commitment under the protocol of reducing emissions from the sectors or sources listed in Annex A, i.e. energy, industrial processes, solvent and other product use, agriculture and waste. Denmark has already issued its RMUs, while Finland, Sweden and Norway are planning to issue those in the near future.³⁰ Indeed, Finland is expected to issue RMUs in the end of 2014 or early 2015. The maximum amount of RMUs or the Kyoto forestry credits all Nordic countries together can issue for the first commitment period is 21.81 million tCO₂ (Table 3.2).

For the second Kyoto commitment period, which starts in 2013 and is most likely to end in 2020, the issuance of RMUs is based on a country-specific baseline, and a cap of 3.5% of emissions in 1990. The baseline represents the forest management reference level (FMRL). All forest carbon sequestration exceeding the FMRL but below or equal to the cap constitutes the RMUs for a country. If the forest carbon sequestration in a country falls below the reference level, then the country receives negative carbon credits. The table below shows the FMRLs proposed by the Nordic countries.

The forest management reference levels proposed by the Nordic countries

Country	Proposed reference level (million tCO ₂ per year)
Sweden	41.34 [#]
Finland	20.10 [#]
Norway	11.40
Denmark	0.36 [#]
Iceland	0.15

[#] Including net-emissions from HWPs with first order decay function.

Source: Each country's *submission of information on forest management reference level* to UNFCCC.

According to the estimate by Indufor, the RMUs for the entire Nordic region for the second commitment period will be just over 71 million tCO₂ if the period ends in 2020.

³⁰ Denmark's accounting frequency is annual, while for other Nordic countries it is the *end of the commitment period*.

Total RMUs (million tCO₂) in the Nordic countries

Country	1 st commitment period (2008–2012) [±]	2 nd commitment period (2013–2020) ^{#§}
Sweden	10.63	15.30
Finland	2.93	19.70
Norway	7.33	13.95
Denmark	0.92	20.83
Iceland	0.00	1.27
Nordic region	21.81	71.05

[±] Based on assigned RMUs under UNFCCC Decision 16/CMP.: Land use, land-use change and forestry (2005) as presented in Chapter 2 of this report.

[§] Indufor projection.

[#] Sweden, Finland, Norway and Denmark include net emissions in HWP.

Non-RMUs

We define the non-RMUs as the credits or the part of the forestry sink that cannot be used to meet Kyoto target, even though they are the real removal of atmospheric CO₂. Therefore, for the first commitment period (2008–2012), the part of the sink in excess of the assigned RMUs forms the non-Kyoto forestry credits. For the second commitment period (2013–2020), a country's forest carbon sequestration between zero and FMRL, and above FMRL plus the cap (i.e. 3.5% of 1990 emissions) cannot be used to meet the Kyoto targets and thus are the non-RMUs. Indufor estimate shows that the non-RMUs for the Nordic region will be 605 million tCO₂ in the first commitment period and about 1,039 million tCO₂ if the second commitment period ends in 2020.

Non-RMUs (million tCO₂) in the Nordic countries

Country	1 st commitment period (2008–2012) [±]	2 nd commitment period (2013–2020) ^{#§}
Sweden	215.43	331.92
Finland	197.03	328.19
Norway	172.20	346.83
Denmark	19.01	30.40
Iceland	1.36	1.37
Nordic region	605.03	1,038.70

[±] Based on assigned RMUs under UNFCCC Decision 16/CMP.: Land use, land-use change and forestry (2005) as presented in Chapter 2 of this report.

[§] Indufor projection.

[#] Sweden, Finland, Norway and Denmark include net emissions in HWP.

3.2 Impacts of management practices on carbon stock in Nordic forests

Management practices affect the carbon stock in forests by regulating the forest growth and soil processes. Limited availability of nitrogen, along with relatively low summer temperature and short growing season, acts as a limiting factor for the growth of Nordic forests (Linder 1987, Kellomäki *et al.* 1997). Thus nitrogen fertilization is considered an important forest management practice in the Nordic regions. It enhances the forest growth and thus increases the carbon sequestration particularly in less fertile sites (Norden 2013, Hyvönen *et al.* 2007). In 1960ies and 1970ies, fertilization indeed played an important role in Finland in enhancing timber production by increasing forest growth especially in upland area (Kukkola and Nöjd 2000). Nitrogen addition to forests may also affect the pool of soil organic carbon as enhanced growth in foliage and leaf area result in increased litterfall (Hyvönen *et al.* 2007). Johnsson and Curtis (2001) showed that fertilization indeed increase soil carbon storage.

Stand density also affects the growth and thus carbon stock in forests. Routa *et al.* (2011, 2012) showed that high stand density at pre-commercial stage increase the wood production in Finnish boreal forests. This actually implies that high stand density enhances forests growth and carbon sequestration. Natural regeneration in addition to planting and delaying or not doing tendering makes the stand density high and thus indirectly help in enhancing carbon stock in forests. Silvicultural practices such as clearing make more space and nutrients available for the remaining saplings or trees in young stands, and thus enhance timber production in the long run. The drainage of peatland, on the one hand, enhances the forest growth and thus carbon sequestration in forest biomass, releases carbon from peatland itself on the other hand.

For maximizing forest carbon stock, low thinning can be considered as an effective forest management measure (Lasch *et al.* 2005). However, increasing thinning thresholds may also enhance timber production from and carbon stock in boreal forests in Finland (Alam *et al.* 2012). Increasing the rotation length also increases carbon sequestration in forests (Liski *et al.* 2001, Ericsson 2003). Applying higher rotation length in forest landscape initially dominated by young stands gives higher wood productivity and thus ensures higher carbon sequestration. Multi-objective forest management also enhances the carbon stock. Optimal rotation for maximizing carbon sequestration often varies from the economically optimal rotation. Thus economic incentives such as payments

for carbon sequestration are needed to persuade the forest-owners to lengthen the rotation for maximizing carbon sequestration. Combining energy wood production with timber production into forest management objective not only enhances higher carbon sequestration but also reduces CO₂ emissions from forest management (Routa *et al.* 2012) and thus ensures higher removal of atmospheric CO₂.³¹

Forest management with prolonged rotation period and less thinning has an increasing effect on carbon stock. However, much of the carbon stock especially that in above ground biomass – as clear-cutting is the common harvesting practice in the Nordic countries – is removed from the forests when they are harvested. This carbon goes back to the atmosphere quickly if the HWPs are used for bioenergy and products with short life span such as paper. The carbon stock in soil may also be reduced for several decades after harvesting (Norden 2013). These imply that the positive carbon stocking impact of forest management practices is short lived under current forest harvesting practices in the Nordic region. Moreover, intensive forest management is not beneficial for biodiversity richness. Forest management practices are in fact the main threat for a large portion of species that are threatened to be extinct, i.e. red-listed species in the Nordic region (Birdlife Europe 2011). Continuous cover-harvesting combined with prolonged rotation, retention of old trees and dead wood, and keeping buffer zones against wetlands have positive effect on both biodiversity and carbon stock. Forest biodiversity usually benefits from extensive areas of old-growth forests under natural ecosystem dynamics ensured by strict conservation. The total carbon stock also continues to increase in such forests, but with a decreasing rate of carbon sequestration as the stand age increases (Norden 2013). The flip side of enhancing biodiversity benefits and carbon stock through strict conservation is that the forests under such conservation become unavailable for harvesting reducing the timber supply in both in the short and long run.

The demand for forest bioenergy is increasing. To meet this increasing demand, whole tree harvesting that involves removing branches, treetops and stumps with merchantable timber is becoming a popular practice especially in Nordic countries. This harvesting approach results in increased biomass removal (Poudel *et al.* 2012) from forests com-

³¹ From CO₂ removal point of view, how harvested wood products (HWPs) are used and what materials they substitute are also important alongside forest management. These issues are discussed in Chapter 4 of this report.

pared with conventional harvesting approach in which only merchantable timber is removed. The increased biomass removal implies the nutrient loss and thus growth reduction and decrease of carbon stock in forests in the long-run (see, e.g. Kallio and Salminen 2012). However, the extraction of stump and root is reported not to have any effect on forest carbon sink (Alam *et al.* 2012).

4. Use of wood biomass as a tool to mitigate climate change

Wood is one of the essential primary materials for construction, furnishing, printing, packaging, as well as energy production. In terms of environmental impacts it is often considered as more environmentally friendly as most of the competing materials, especially when accounting for the whole product lifecycle.³² However, it is important to acknowledge that the validity of such statement depends largely on the assumption that the wood raw material procurement is based on sustainable practices. This chapter discusses the argumentation behind the goal of using forest products as a tool in climate change mitigation.

4.1 Use of wood-based products

One of the most extensive studies on GHG impacts of wood products was carried out by Sathre & O'Connor (2010). They examined 66 studies (in English, Swedish and Finnish) of which 49 presented original data and analysis. Although the studies differed e.g. in scope and methodology, an exercise of this magnitude can be seen to provide clear overall trends on the potential of climate change mitigation through increased wood product use. 21 of the reviewed studies provided sufficient information to calculate the displacement factor of at least one wood product substituted for a non-wood product.³³ The results ranged between -2.3 and 15 with most in the range of 1.0 to 3.0. The average displacement factor was 2.1. According to Sathre & O'Connor (2010) the few cases of negative displacement factors were the result of inappropriate disposal of

³² Lifecycle accounting considers every input (energy, materials etc.) and every output (emissions, waste, product and co-products) for every stage of processing from extraction or regeneration through processing, ultimate use, maintenance and disposal.

³³ According to Sathre & O'Connor (2010), a displacement factor is an index of the efficiency with which the use of biomass reduces net GHG emission. It quantifies the amount of emission reduction achieved per unit of wood use. A higher displacement factor indicates that more GHG emission is reduced; a negative displacement factor means that emission is greater when using the wood product.

wood products. The average result means that for each tonne of carbon (tC) in wood products substituted for non-wood products, GHG emissions are reduced by approximately two tC. This figure corresponds with 3.9 tCO₂e emission reduction for each tonne of oven dry wood used or 2 tCO₂e per m³ of wood product (Sathre & O'Connor, 2010).

Total CO₂ saving from combined carbon store and substitution effect

Source: Reproduced from CEI-Bois: European wood factsheets: 3. Wood products as carbon stores.

From their extensive review, Sathre & O'Connor (2010) identify several mechanisms by which wood product substitution affects GHG balances. These mechanisms will be discussed below.

Manufacturing wood products consumes relatively little fossil energy

Vast majority of publications agree that manufacturing wood-based products requires less total energy than manufacturing of most alternative materials. This is especially true in terms of consumed fossil energy. Many wood-based industries dealing with primary material produce significant share of their required energy from wood processing residues. Sometimes even in quantities that allow distribution of energy to local grids. Production of composite wood products consumes larger amounts of fossil energy than production of solid wood products (Werner & Richter, 2007). However, this is still commonly less than that needed for non-wood products.

Avoided process emissions due to product substitution

Certain materials, such as cement, steel and many plastics, generally consume large quantities of fossil energy in their production. For example, cement production itself has been estimated to result in 5–8% of global CO₂ emissions (MFA, 2011). These materials are used extensively by the construction sector which is responsible for 33–50% of global

raw material consumption depending on the publication (MFA, 2011).³⁴ Consequently, wood substitution in the construction sector provides numerous opportunities for emission reductions. This statement is supported by a mass of research, review papers and reports (e.g. Eriksson *et al.*, 2012; Eriksson *et al.*, 2007; Gustavsson *et al.*, 2006; MFA, 2011; Pingoud *et al.*, 2010; Reid *et al.*, 2004; Sathre & O'Connor, 2010; Koskela *et al.*, 2011; Bribián *et al.*, 2011; Cei-Bois, 2011; DG ENT, 2004). Regardless the vast agreement on the environmental benefits of wood as raw material, substitution should never result in lower quality, safety or operability of the end product. Indeed, each material has its strengths and therefore favouring wood-based products in terms of their environmental benefits should occur only when it can be clearly justified through a cost-benefit analysis.

Carbon storage in wood-based products

50% of the dry weight of wood is carbon that has been captured through photosynthesis from atmospheric CO₂. Hence, wood products provide a physical storage of carbon that would otherwise act as a GHG. The significance of such storage depends mainly on the sustainability of forestry practices and whether the products pool as a whole is increasing. Longer product lifecycle translates lengthier carbon storage. Therefore, products such as solid wood furniture and wood used in construction structures play a more important role than e.g. paper products that have a relatively short lifecycle. In general, aiming to enhance the size of the wood-based product pool, as well as increasing the share of longer lifespan products, has a potential to lower atmospheric CO₂-levels in a short- to medium-term. This issue is being increasingly acknowledged globally which is visible by numerous initiatives that target increasing the usage of wood in products. However, it is good to note that substitution effects of avoided emissions become increasingly important in the long-term when the saturation point of carbon storage is reached.³⁵

According to Sathre & O'Connor (2010), some of the wood substitution studies covering relatively short time frames have considered carbon storage to be as influential to climate change mitigations as avoided

³⁴ In Finland, production of construction products results in approximately 5% of energy consumption and GHG emissions (MFA, 2011). The results can be assumed to be similar in other Nordic countries.

³⁵ Saturation point in this case refers to a situation when there is equal amount of wood-based material leaving the product pool than enters it. Also chances to meaningfully increase the use of wood-based products within that specific context have been exhausted.

emissions. On the other hand, studies examining long term carbon dynamics of wood products have shown that avoiding fossil emissions is eventually far more significant (Sathre & O'Connor, 2010). Considering the housing sector, which is a major energy consumer globally, most of the emissions originate from the usage-phase of the house (when compared to building and demolition). This is especially evident in the Northern countries where cold winters result in high energy demand for heating. However, the current policies and housing regulations aim towards zero-energy houses, thus increasing the importance of the construction phase emission reductions.

Average lifetime of wood products in Germany

Source: Reproduced from CEI-Bois: European wood factsheets: 3. Wood products as carbon stores.

Examples of initiatives to increase the usage of wood in products

Sweden – Trästad 2012-project

Trästad 2012 is a project that aims to change the country's architectural history by developing the architecture, technology and business model for timber structures. The project is an investment in rational and climate friendly construction. The objective is to develop Swedish expertise and technology, and in time create a European and global market for Swedish industrial wood construction technology. Trästad 2012 aims to provide an inspiration to local builders, architects, planners and politicians. The project allows municipalities to take on and develop areas of concern for the future of timber construction, such as architecture, engineering, and business models. There are 17 municipalities in the country participating in the project. The project started in 2009 and ended in the end of December 2012. It strengthened and acted as a natural extension of the 2005–2008 “National Strategy for wood-based building” (*Nationella träbyggnadsstrategin*). This, in turn, was based on the 2004 study on the advancement of wood-based building (*Mer Trä i byggandet*).

France – Decree on the use of wooden materials in certain buildings

In 2010, France passed a Decree on the use of wooden materials in certain buildings (Official title of the decree: Décret no 2010–273 du 15 mars 2010 relatif à l'utilisation du bois dans certaines constructions). The legislation is aimed at promoting the use of wood in construction. Under the new law, French builders are required to use a certain portion of wood in the construction of new buildings. The required amount is proportionate to floor area and the minimum requirement varies according to the intended use of the building. The largest wood use requirement is placed on residential buildings. The law also stipulates that the wood used in buildings has to be sourced from sustainably managed forests. The main driver behind the legislation is climate change mitigation.

Source: Compiled from MFA (2011), News article from the Finnish Forest Industries Federation.³⁶

Avoided fossil fuel emissions due to biofuel substitution from biomass by-products

Forest thinning and harvest operations generate significant amounts of biomass residues. Even more is produced during primary and secondary wood processing. In addition, unless of course recycled, wood-based

³⁶ <http://www.forestindustries.fi/juurinyt2/Uutiset/Pages/woodconstructioninfrance.aspx>

products can be often used as combustible residue in the end of their lifecycle. All these by-products can be used as biofuel to replace more polluting fossil fuels, thus creating a more environmentally friendly energy alternative. The CO₂ emitted during direct combustion of sustainably produced biofuel is largely balanced by CO₂ uptake in renewing forests (Macqueen *et al.*, 2004; Sathre & O'Connor, 2010). Many studies indicate that the recovery and combustion of the biomass by-products associated with the lifecycle of wood-based products is the single most significant contributor to the lifecycle GHG benefits of wood-based product use (Gustavsson *et al.*, 2006; Sathre & O'Connor, 2010). Macqueen *et al.* (2004) consider this as one of the quickest and lowest-cost options for reducing CO₂ emissions. However, the magnitude of the benefit depends largely on the qualities of the fossil fuel being replaced.

Carbon dynamics in landfills

In some cases wood products are landfilled in the end of their lifecycle (instead of recycling or combustion as biofuel). Carbon dynamics of the landfills differ considerably across the regions depending on e.g. climate, soil composition, microbial activity and the characteristics of wood material. In certain situations the decay of wood may be so slow that the landfill can be considered as semi-permanent carbon storage. However, cases of methane emissions from landfills have also been reported (Börjesson & Gustavsson, 2000; Petersen & Solberg, 2002). Consequently, the landfilling option for post-use wood-based products carries great uncertainties and should be considered case specifically (Sathre & O'Connor, 2010).

4.2 Bioenergy from forests

As members of the European Union, Denmark, Finland and Sweden, are obligated to adopt the EU target of 20% final energy consumption from renewable energy by 2020. Based on this, the EU institutions adopted the Directive 2009/28/EC on the promotion of the use of energy from Renewable Energy Sources (RES Directive) which contains a series of elements to create the necessary legislative framework for concretising the 20% renewable energy targets. The RES Directive entered into force in June 2009 and can be considered as the main political driver of renewable energy development in the EU. Norway and Iceland are members of the EFTA, and the RES directive is applied by incorporating of the directive to the European Economic Area (EEA) agreement.

The Directive 2009/28/EC in its articles 17, 18 and 19 sets out sustainability criteria for biofuels. The criteria are related to greenhouse gas savings,

land with high biodiversity value, land with high carbon stock and agro-environmental practices. The criteria apply since December 2010. The European Commission has adopted a number of Decisions and Communications to assist the implementation of the EU's sustainability criteria.

Production of Energy from Wood and Wood Wastes in Nordic Countries

Source: Eurostat (2013).

The figure above illustrates the general trend of wood energy production in the Nordic countries during 2000–2010. The values are presented in equivalents of cubic meters of wood. In this study the underlying assumption is that one cubic meter of wood equals 2 MWh of energy. In the Eurostat statistics the covered countries include Denmark, Finland, Sweden and Norway. The effect of adopting the policies aiming at increasing the amount of renewable energy can be seen in the development of wood energy production. The general trend in all Nordic countries has been increasing, however scale and rate varies depending on the preconditions in each country.

In Finland and Sweden the high level of utilization of wood as energy source is based on the existing large forest industry sector and common use of forest industry by-products in energy production. Majority of wood energy in Finland and Sweden is produced by using black liquor, bark and sawmilling by-products as fuel. Also both countries have long and vast traditions in using traditional firewood in energy production in small-sized dwellings. The recent increase can be explained in the growing use of forestry residues and wood pellets in energy production.

In Denmark and Norway the use of wood as energy source has been traditionally at a lower level, about 5–10 million m³ of wood per year. In

Denmark the increase of wood fuel consumption has been slightly faster than in Norway because of notable increase of wood pellet consumption in energy production.

There are no comprehensive statistics of wood energy use in Iceland. The reason for this is mainly that the use of wood in energy production is very minor. According to Iceland Forest Service, in Iceland the vast majority of forest products consumed in Iceland are imported due to the country's very small forest resource. Niche market exists for fuelwood which is supplied with wood from selection felling in the largest birch forests and thinning in plantations. Annual fuelwood consumption in Iceland has been only about 200–300 tonnes.

4.2.1 National Renewable Energy Action Plans (NREAPs)

Article 4 of the Directive 2009/28/EC obligates all Member States to submit a national renewable energy action plan (NREAP), which includes a detailed explanation on the adopted measures for respective country to reach the legally binding goals set for the share of renewable energy production in the total net energy consumption 2020. In the NREAPs Member States set out the targets, the technology mix they expect to use, the trajectory they will follow and the actions and reforms the countries will implement to overcome the barriers to developing renewable energy.

Commission Decision of 30 June 2009 establishes a template for National Renewable Energy Action Plan under the Directive 2009/28/EC. The Nordic countries Denmark, Finland and Sweden have, as well as the other EU countries, submitted the NREAPs.

Denmark is expected to be among the countries that fulfils its renewable energy share up to 2020. In the Renewable Energy Directive, Denmark has committed to a target of 30% corresponding about 16,000 ktoe of renewable energy by 2020. Wood energy is planned to constitute about 1,200 ktoe of the total amount, equaling 8% of the total target.

Finland has committed to a target of 38% corresponding about 10,700 ktoe of renewable energy by 2020. Wood energy is planned to constitute majority, about 8,000 ktoe of the total amount, equaling 75% of the total target.

In Sweden a target of 50% corresponding about 19,000 ktoe of renewable energy by 2020 share of renewable energy has been set. Wood energy is planned to constitute majority, about 8,200 ktoe of the total amount, equaling 43% of the total target.

In Norway no NREAP or any other overall and integrated biomass strategy has been developed so far. Currently in Norway the share of renewable energy of total net domestic energy consumption is about 50% constituting mainly of electricity from hydropower. The role of bioenergy in energy production is minor, about 5% of total.

According to the Nordic Energy Research & IEA (2013) bioenergy will become the single most important energy source in the Nordic region. It is also expected to become a net importer of bioenergy. Ensuring the sustainability of the bioenergy supply will be a central challenge for the policy makers not only in Nordic countries but globally. Continuous policy support is necessary to bring the costs down to competitive levels as well as reduce the risk associated to investments in immature technologies. Also public research and development can be accelerated with correct policy and subsidy instruments. The following chapter describes in detail the key policies and support mechanisms in the Nordic countries that are aimed to increase the share of wood biomass in energy production.

4.2.2 Denmark

In 2007 the Danish Ministry of Climate and Energy launched an Energy Technology Development and Demonstration Program. The programme aims to support the energy policy objectives of security, respect for the global climate and a cleaner environment and cost effectiveness. The law should also encourage the use and development of business potentials in the area for growth and employment.

The Energy Technology Development and Demonstration Program (EDDP) is aimed at the development, demonstration and market introduction of new energy. The main goals of the programme are:

- Subsidize primary development and demonstration
- Actively promote cooperation between public and private actors
- Strengthen interaction with international activities and programs related to energy technology.

In Denmark, electricity from renewable sources including wood fuels is mostly promoted through a premium tariff. Also renewable energy sources for heating purposes such as wood are exempt from the tax obligations on the production, supply and use of energy sources. The main incentive for renewable energy use in transport is a quota system. In addition there are 2 training programmes for RES-installers, a certification scheme for wind energy plants, two different research, development and demonstration

(RD&D) programmes and an obligation to use renewable heating in new and renovated buildings. However policies aiming specifically in increasing the wood fuel use do not exist. (RES LEGAL Europe 2013)

Premium tariff system

In the premium tariff system the operators receive a variable bonus on the market price of electricity. The sum of the bonus and the market price shall not exceed a legally set maximum, which depends on the date of connection of a given system and the source of energy used. In certain cases, system operators are granted a guaranteed bonus on top of the market price.

Tax exemptions

In Denmark the government provides also tax exemptions for the use of biofuels including wood. In Denmark, different taxes are levied on the production, processing, possession, receipt and dispatch of fossil fuels for heating purposes, for example the energy tax on mineral oil products, taxes on coal, lignite and coke or the carbon dioxide tax on certain energy products. Renewable energy sources are exempt from these taxes, as they are not classed as taxable in the specific regulations.

Net Metering

The Regulation on net-metering for the producers of electricity for own needs is based on the Act on Electricity Supply and authorises the exemption of certain system operators from Public Service Obligation (PSO). Electricity producers using all or part of the electricity produced for their own needs are exempt from paying Public Service Obligation on this electricity. The Public Service Obligation is a charge levied to support renewable energy. Biomass systems such as ones using wood are eligible for the support but the system capacity must not exceed 6 kW per household or per 100 m². Only systems in non-commercial buildings are eligible and systems must be connected to a private supply system.

Subsidy for small scale renewable energy technologies

Energinet.dk provides funding to promote the deployment of small electricity generation installations using renewable energy sources or technologies deemed to be of strategic importance by the competent ministry, including PV-installations, wave power plants and special installations using biogas and biomass as electricity source. The subsidy may be rewarded for the coverage of several types of costs:

- Investment, preparation or installation costs into the plant in order to enable the production of electricity.

- Costs of commissioning of the plant into a proving phase, including the cost of the necessary consultancy.
- Expenses for preparing of results concerning its finance and operations for a period after commissioning.

Energienet.dk has provided and manages a budget, which amounts to 25 million DKK per year (EUR 3 million) until the end of 2015.

Access of renewable energy to the grid

Access of electricity from renewable energy sources to the grid shall be granted according to the principle of non-discrimination. With regard to the use of the grid renewable energy shall be given priority. The connection of a heat generation plant to a district heating network in Denmark always involves grid development, since the construction of a plant must occur simultaneously with the development of the district heating grid.

4.2.3 Finland

In Finland, electricity from renewable energy sources is mainly promoted through a premium feed-in-tariff. The tariff applies to electricity produced from biomass, biogas and wind. In Finland state grants are made available to support research and development in the field of renewable energies. Development of renewable heat production infrastructure is supported through available investment subsidies. In other areas, such as the building sector and certification and training programmes, the development of specific regulatory measures is still in the process. (RES LEGAL Europe 2013)

Feed-in tariff system

The generators of renewable electricity including wood receive a variable premium feed-in tariff on top of the wholesale electricity price for a period of 12 years. This means that the generators get a fixed target price for their electricity. Biomass systems that fail to meet certain requirements of the premium feed-in tariff scheme are eligible for a fixed but reduced feed-in tariff. Wood fuel plants are eligible if they meet the following conditions:

- The plant must not have received the premium feed-in tariff before.
- The plant must not have received other state grants.
- The plant must be built entirely from new parts.
- The nominal capacity of the generator must be at least 100 kWh and must not exceed 8 MVA.
- The plant must produce both electricity and usable heat.

- The plant must achieve an efficiency rate of at least 50%, or even 75% if the capacity of the generators is equal to or exceeds 1 MWh.

Energy taxation on fuel for heat and power plants

In Finland the energy taxation is one of the main instruments in mitigation of climate change and environmental policy. The aim is to reduce energy consumption and guide the energy generation and use to alternatives that cause lower GHG emissions. The taxation takes into consideration the energy content, GHG emissions and local/particle emissions that have adverse health effects. For fossil fuels, the GHG emission values are based on the values used in the national fuel classification of Statistics Finland. The evaluation of the CO₂ content of biofuels is based on their treatment in the RES Directive. A flat rate tax reduction of 50% is applied to all biofuels that meet the sustainability criteria of the RES Directive. The taxation system does not directly subsidize wood fuels in energy production, but make them more attractive alternatives in comparison to fossil fuels because of their tax free status.

Other subsidies

The state of Finland provides subsidies for investment and research projects in the field of sustainable energy generation. The so-called "energy aid" is a state grant for investments in RES. Grants are available for investment and research projects that involve the use of renewable energy. According to the Ministry of Employment and the Economy, all technologies are eligible for grants for research and investment projects that involve the generation of renewable energy or the application of RES technologies. Among other costs, the costs for preparation, planning costs and materials are eligible for subsidies.

Subsidy for harvesting of small diameter trees for energy production

Currently the harvesting of energywood is supported by KEMERA-fund, EUR 7/m³ of harvested energywood from thinning of young forest stands. However, a new subsidy system replacing this is under development. A proposal of a subsidy system for small diameter energywood is currently being processed in the European Commission. The new system will be applied earliest from the beginning of 2014.

Heat Bonus in CHP production

In Finland the combined production of heat and electricity is promoted by giving CHP plants working on biogas and wood fuel the right for an increased fixed "heat bonus". The granting of the support is subject to

certain conditions. For CHP plants working on wood fuels the bonus fixed EUR 20/MWh.

Investment Support for Small Scale Renewable Energy Production

Farmers constructing heat plants working on renewable energy can apply investment support. The support can be allocated for the construction, expansion or renovation of heating facilities used for agricultural production. The applied operation needs to be based on either biomass, such as wood, waste, solar energy, or any other renewable source. The aid can be in the form of either a state investment subsidy, lowered interest rates for loans or state acting as a guarantee for a loan. The exact amount of subsidy varies from the action supported.

Access of renewable energy to the grid

Access to the grid by electricity produced from renewable energy sources follows the principle of non-discrimination and electricity produced from RES is not given priority. The main support mechanism for heat produced from RES, is a “heat bonus” allocated to CHP plants working on biogas and wood fuel. The connection of a heat generation plant to the grid is market oriented and priority is not granted to heat produced from RES. In transport, the main incentive for renewable energy use is a quota system.

4.2.4 Iceland

In Iceland, the generation of electricity from renewable energy sources is promoted by subsidies granted for the design and construction of original tools and equipment for research on and the exploitation of energy resources as well as for special projects in the field of economical energy use.

The state-owned National Energy Fund grants subsidies for measures that aim to reduce the use of fossil fuels. Among other aims, it supports the exploitation of domestic energy sources instead of fossil fuels. All energy production based on biomass including wood is eligible to apply for the grant. Grants shall not exceed 50% of the estimated costs of a given project.

Access of renewable energy plants to the grid is subject to the general legislation on energy. As 100% of electricity consumption in Iceland is generated from renewable energy sources, RES are not given priority grid connection.

4.2.5 Norway

In 2001 The Norwegian government established Enova a public agency owned by the Ministry of Petroleum and Energy. Enova has become the most crucial instrument for reaching the goals related to renewable energy production and energy efficiency. Enova administers a group of programmes and support schemes using money from public and funding. Enova has published three main objectives:

- More efficient use of energy.
- Increased use of energy carriers other than electricity, natural gas and fuel oil for heating.
- Increased production of energy from renewable sources.

In 2008 Norway adopted the Strategy for Increased Expansion of Bioenergy. Its main purpose is to increase the utilization of bioenergy for heating, followed by an increase in the supply of wood fuels. Energi 21 is an initiative that was launched by Ministry of Petroleum and Energy. Its purpose is to set out desired course for research, development and demonstration of new energy technology including wood biomass.

Grid operators are obliged to connect renewable energy plants to their grids without discriminating against certain (groups of) plant operators. This obligation also applies if the realization of the new connection requires the development of the grid.

The main promotion system for renewable energy in Norway is a quota system including a certificate trading scheme.

Quota system

Norway and Sweden operate a common quota system for renewable electricity. The Electricity Certificates Act obliges electricity suppliers and certain electricity consumers to prove that a certain quota of the electricity supplied by them was generated from renewable sources including wood biomass. Proof of quota is provided using tradable certificates allocated to renewable energy producers. Sweden and Norway introduced a common electricity certificate market on 1st January 2012. One certificate is issued for every MWh of produced renewable electricity, and applies to all types of generation technology. Entities that fail to fulfil their quota obligation have to pay a fine. For every certificate failed to fulfil carries a fine of 150% of the weighted average certificate value in Sweden and Norway during the period between 1st April of the previous year and 31st March of the given year.

Special Taxes

The Norwegian Parliament has levied “special taxes” on fossil fuels. The level of tax is set in the annual budget negotiation every year. There are two types of special taxes: the energy tax is levied based on volume of fuel and the CO₂ tax is based on the GHG emission level of fuels. The companies that participate in the quota system do not pay the CO₂ tax. The taxation system does not directly subsidize wood fuels in energy production, but make them more attractive alternatives in comparison to fossil fuels because of their tax free status.

Regulations relating to subsidies in forestry

Ministry of Agriculture and Food have defined a system for subsidy for forest biomass for energy purposes. The subsidy scheme is managed by the Norwegian Agricultural Authority. Subsidy is granted for the following forestry activities:

- Pre-commercial thinning
- Harvest of broadleaved trees
- Tending of young stands
- Collecting harvest residues
- Tending of the cultural landscape
- Clearance along roads

The subsidy is paid for NOK 20/m³ (about EUR 3/m³) of roundwood from pre-commercial thinnings, NOK 35/loose-m³ (about EUR 5/loose-m³) of chips from harvest residues, and NOK 70/loose-m³ (about EUR 9/loose-m³) of chips for the others whole trees. The subsidies are financed from the state budget.

4.2.6 Sweden

The legislation is in many cases supporting the use of bioenergy by taxing and thus making the alternative energy sources, such as fossil fuels, more expensive, or for example forcing the buyers of electricity to buy a certain quota of electricity from renewable energy sources.

In Sweden, there are also training programmes that are not subject to legal regulation. There are several voluntary training programmes with certification schemes for installers of RES installations. Regarding wood energy a scheme called “Pellsam” provides a voluntary 2-day training programme with a certification scheme for the installers of pellet devices.

Fossil fuel tax

In 1991 Sweden established one of the earliest forms of general CO₂ tax on fossil fuels. The carbon dioxide tax is imposed on the emitted quantities of carbon dioxide from all fuels except biofuels and peat. Energy and carbon dioxide tax rates are indexed to track price developments. Energy tax is an umbrella name for spot taxes on fuels and electricity. They can be roughly divided up into fiscal taxes and those intended to achieve environmental objectives. This latter group of taxes includes the carbon dioxide and sulphur taxes, while the general energy tax is essentially a fiscal tax. However, there is no hard and firm boundary between the types, as both groups have an environmental effect as well as a fiscal function. The taxation system does not directly subsidize wood fuels in energy production, but make them more attractive alternatives in comparison to fossil fuels because of their tax free status. For example, heavy taxation of fossil fuels has worked as an incentive to invest on pellet boilers. The result is that the use of wood pellets in private households has increased 20-fold over 13 years.

Quota system

Sweden and Norway operate a common quota system for renewable electricity. Currently the main incentive for the use of renewable energy sources is a quota system in terms of quota obligations and a certificate trading system. The Electricity Certificates Act obliges energy suppliers to prove that a certain quota of the electricity supplied by them is generated from renewable energy sources. Energy suppliers shall provide this evidence by presenting tradable certificates allocated to the producers of electricity from renewable sources. The conditions of the issue of certificates are the same as described for Norway.

4.2.7 Key issues on wood energy in the Nordic countries

The use of wood as energy source has long traditions in the Nordic countries. However the extent of forest resources and development of forest industry has led to various types and scales of wood energy utilization in the Nordic countries. In Finland and Sweden wood accounts for major part of renewable energy sources mainly, because it is connected to the wood use of forest industry and diverting the side streams to energy production. Similar development can be observed in Norway as well but in much smaller scale. In these countries the use of wood as fuel is now becoming more forest industry independent, much due to policies enhancing the increasing use of biofuels. In Denmark the use of wood fuels is mainly based on combustion of imported wood pellets in energy production.

Different Nordic countries are bound by the requirements of the same renewable energy directive, however they have different approaches in building policies supporting the increasing use of wood energy. Sweden established the carbon dioxide tax as one of the first countries in the world. Taxation of the fossil fuels has become the central element in Swedish renewable energy policies in steering the use of fuels towards renewable alternatives. Finnish policy system involves mainly support both to investments and direct operational subsidies paid for every cubic meter of produced energywood.

Norway and Sweden operate a common quota system for renewable electricity. The quota system has been recently started and the results of its efficiency will be seen in the future. Functionality of this kind of common quota system should be investigated on the whole Nordic region level.

Another good benchmark to be expanded from country level to whole Nordic region would be a common fund which could administer financial support money to development and pilot projects of new wood energy systems from publicly and privately funded sources. This kind of system has been used successfully in Norway over a decade.

4.3 Bioeconomy

The climate change mitigation potential of forests has been acknowledged in many forested countries. As trees grow they continuously sequester carbon from the atmosphere. HWPs also store carbon in them for long periods of time – up until they are burnt or disposed of in some other way.

In the era of bioeconomy the much-favoured climate change mitigation potential of forests increases as the range of forest-based products and the scope of bio-based raw materials storing carbon enlarges significantly. As cellulose, hemicellulose, lignin and other wood and bark components will be used for new purposes carbon can be stored for longer times in plastics and fabrics, and for shorter times in pharmaceutical products, chemicals, food and beverages, and so on. This postulates that many fossil-based raw materials (like oil) should be replaced by bio-based raw materials. Research and development in bioeconomy has advanced considerably in the past years and bio-based products are reaching both the technical and commercial readiness. All in all, replacing fossil-based products with bio-based products would make forests an even more important brake for the adverse effects of climate change. Consequently, there are more business options for the forest industry and forest-based raw materials than ever before. As shows, the value-added and sophistication in the use of forests

increases as it moves from level one to level four. It still needs to be remembered that all four levels must be able to co-exist also in the future, even if their shares may change.

Business levels of forest-based bioeconomy

Source: Adapted from a presentation by Olli Hietanen (Future Research Centre, University of Turku).

The first business level is *services* which encompass all that can be produced without felling trees. This level includes carbon sequestration, non-timber forest products, nature-based tourism, pollination services, watershed regulation and various other environmental services of forests. The second level is *wood products*, i.e. the first utilisation level of a felled tree. The third level is *fibres and biomass*. This third level has been the economic growth engine especially in Finland and Sweden for the past six decades, but is now decreasing in importance due to the ongoing large-scale restructuring of the industry (new pulp and paper facilities being built in the global south rather than north) and digitalization of societies worldwide. One increasingly important business level is *renewable energy* that is produced from the residues of levels 2, 3 and 4. Both solid biomass (e.g. wood chips and pellets) and liquids (e.g. bio-oil) are used as raw material for bioenergy.

The fourth and most novel business level – that comes with the highest value-added – is *chemicals and plastics*. This level breaks the confines of traditional industry sectors and makes them part of a larger bio-business sector. In fact, this partly means returning to the track in which

sulphite pulp mills produced different chemicals as by-products. Most of the sulphite pulp mills have been closed as the fashion “core business only” gained ground in industries preventing the implementation of ideas related to special chemical products. The point is that, in many cases, we are not talking about chemically brand new products or processes. The new thing is the green drivers that allow the development and implementation of bio-products and bio-business lines.

The potential for new forest-based innovations and business concepts is boundless. For instance, the market potential and future prospects of ligno-cellulosic (i.e. non-food) plastics and textiles is very promising. The industries currently have many environmental and social challenges as they are dependent on fossil oil, and thus create a large carbon footprint. Textiles industry, in turn, is highly dependent on cotton that requires large areas of land and water; which is away from food production. Bio-based material, whether biodegradable or non-biodegradable, is sustainable in nature, carbon sequestration is inborn in its DNA, does not compete for land needed for food and feed, does not create tension for food prices, and significantly increases the value-added of forest residues (when not burnt but dissolved for further use). The recognition and market for environmental services of forests are widening.

As natural resources become increasingly scarce and competed over, and as environmentally conscious consumers prefer natural products over fossil materials, the future outlook for new bio-based and carbon smart products is very positive. This is especially true for the Nordic countries, where forests grow much more than they are used.

5. Market driven instruments for carbon sequestration in forests

5.1 EU on LULUCF accounting rules: encouraging landowners to implement effective measures

Until now, the efforts of farmers and forest owners, and their good practice aimed at securing carbon stored in forests and soils, have not been properly recognised. The reason for this has been the challenges that come with collecting robust carbon data from forests and soils and the lack of common rules on how to account for emissions and removals. Recently, following the decision of the UNFCCC on revised accounting rules from soils and forests adopted in December 2011, the EU is determined to close the gap in common accounting in its climate policy.

Therefore, in March 2012, the European Commission took a first step towards incorporating removals and emissions from forests and agriculture into the EU climate policy by adopting a proposal “on accounting rules and action plans on greenhouse gas emissions and removals resulting from activities related to land use, land use change and forestry”.³⁷

The LULUCF-proposal – which aims to be compatible with the UNFCCC context – establishes accounting rules for greenhouse gas emissions and removals in the forest and agriculture sectors – the last major sectors without common EU-wide rules.

Currently, the LULUCF sector do not count towards the EU's 20% greenhouse gas emission reduction target for 2020, even though they do

³⁷ COM(2012) 93 final. The proposal also addresses other important issues such as of HWP's. In terms of HWP's, the EU has been very positive for their role in the framework of climate change policy. Consequently, Article 7 of the LULUCF-proposal details accounting rules for HWP's (paper, wood panels and sawn wood). Accordingly, “Member States shall reflect in their accounts pursuant to Article 3(1) emissions from harvested wood products containing carbon on 1st January 2013 even where such harvested wood products were harvested prior to this date.” The proposal has been well received among forest industries as it strengthens the role of wood as a climate friendly material. This is discussed in further detail in Chapter 4.

in part count towards the Union's quantified emissions limits and reduction targets under Article 3(3) of the Kyoto Protocol – as explained in chapter 2. Therefore, it is imperative to establish common calculations methods in order to precisely quantify both emissions quantities and removals and incorporate these in the EU's reporting obligations.

The European Economic and Social Committee,³⁸ recently commenting on the proposal, stated that it is important to stimulate the climate change mitigation potential of the LULUCF sector and increase the visibility of the mitigation effort of farmers. The idea is to create framework conditions that enable landowners and land managers to implement effective LULUCF measures in a way that makes economic sense and not only at their own cost. The Committee highlights that the EU should “encourage EU producers to achieve the goals set, just as the emissions trading system aims to do”.

The Committee stresses the multifunctional role of forests in society and therefore emphasizes the importance to take a holistic approach to the issue by embracing both climate and sustainable forest management practices in the EU – “Forests are much more than carbon reservoirs and this should be acknowledged in climate-related policies”.

Consequently, the Committee concludes that, even though the proposal does not provide for the inclusion of the LULUCF sector in the EU's climate commitments at this stage, it can be considered a strong first step towards this by establishing the appropriate policy context.

But is it feasible for the EU to create an internal framework that brings landowners closer to the international efforts to address climate change? Can a Nordic framework on encouraging and compensating farmers for their contribution towards mitigating climate change through the promotion of LULUCF activities be successfully created? Could the benefits compensate the potential high transaction costs associated with the political and technical barriers of setting up and running such system?

The next section will explore some existing schemes set up in different countries and explore some ideas for the Nordic context.

³⁸ <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2012:351:0085:0088:EN:PDF>

5.2 Incentives and mechanisms internationally

There are a growing number of emission trading schemes and initiatives around the world that allow emission reductions from forestry to be traded. Emission trading schemes can use a number of mechanisms to ensure emissions are reduced over time. The most well-known is the cap and trade mechanism. The cap sets a limit on emissions, which is lowered over time to provide real emission reductions, and can be applied on a variety of levels, from various jurisdictions, to sectors, industries and companies. Trading allowances determined by the cap is meant to provide an economic incentive to emit less. Lower emissions mean that emitting entities pay less and when they go below their cap, they can sell their surplus allowances, on the other hand, higher emissions mean that emitting entities will need to pay more when they go above the assigned cap, and will therefore need to buy their deficit allowances from those with surplus allowances.

The baseline – crediting emissions trading systems are those in which entities are rewarded for reducing emissions below a baseline. These reductions become credits, which can be traded. Entities liable under the scheme will purchase credits and then surrender them within a defined period to meet to a target applied to a jurisdiction or sector. In a baseline-crediting system, emitters that are not under an aggregate cap can create credits, usually called offsets, by reducing their emissions below a baseline level of emissions. Such credits can be purchased by emitters that have a regulatory limit.

The key features of how forestry is considered under a variety of different emission trading schemes are presented below in sub-sections 5.2.1–5.2.6.

5.2.1 *New Zealand Emissions Trading Scheme (NZ ETS)*

While some consider the NZ ETS as a cap-and-trade-scheme, there is debate on whether the NZ ETS should be classified in this category because there are no caps, only trading. This is because the NZ ETS is internationally linked and can import additional emission reduction units from other schemes. Furthermore, there is no certainty to the volume of emissions with which the national economy must operate and therefore no hard emission budget constraints in the form of a cap, see Terry & Bertran (2010).

The NZ ETS was legislated through New Zealand's Climate Response Act (2002) and enacted through the Climate Change Response (Emissions Trading) Amendment Act in September 2008. The scheme currently includes

forestry, energy, fishing, industry, liquid fossil fuels, synthetic gases and waste, by either allocating or requiring the surrender of New Zealand units (NZUs). By 2013, the scheme will apply to all greenhouse gases specified in the Kyoto Protocol and it will apply to all sectors of the economy that emit these gases including electricity generation,³⁹ industrial heat and power, transport, industrial processes forestry, agriculture and waste.

Forestry was the first sector to enter the NZ ETS, and its priority inclusion is because forestry is New Zealand's largest potential carbon sink. It is expected that new planting initiatives will expand the forest area in New Zealand supporting her obligations under the Kyoto Protocol. The amount of carbon stored in forests depends on factors such as species, site conditions, and the rotation period. Currently, all harvested wood products are conservatively assumed to be immediately released back into the atmosphere and harvest residues are assumed to decay over a 10 year period. In addition, the New Zealand government expects deforestation of pre-1990 forests to reduce considerably under the ETS.

The NZ classifies forests differently: (i) pre-1990 forests and post-1989 forests. Key features of these forests are given below.

Pre-1990 forests

- Pre-1990 forests are areas that were forested as at 31st December 1989 and remained forested on 31st December 2007.
- Deforestation for pre-1990 forests apply only to exotic forests, not indigenous forests.
- Landowners of pre-1990 forests that deforest are required to pay units equivalent to the emissions from their forests. However, owners of pre-1990 forest land have the option to offset their deforestation liability. As of January 2013, forestry offsetting became an option for pre-1990 forestland owners and provides the opportunity to landowners to convert forest to another land use without deforestation liabilities, provided that they plant an equivalent new forest elsewhere.

³⁹ Carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆).

Post-1989 forests

- The post-1989 forests are forests established on land that was not forest land as at 31st December 1989 or was forest land on 31st December 1989 but was deforested between 1st January 1990 and 31st December 2007.
- For the owners of post-1989 forests, the participation in the NZ ETS is voluntary. The Government retains the responsibility for the credits and liabilities of post-1989 forests whose owners do not join the ETS.
- By joining the scheme, the owners of these forests can earn carbon credits for the increase in carbon stock from 1st January 2008. However, they must surrender the equivalent credits or pay in cash for the decreases in carbon stock in their forests from harvesting or natural causes or if they withdraw the forests from the scheme (MAF 2011).

5.2.2 *Clean Energy Future (CEF) and Carbon Farming Initiative (CFI)*

Australia enacted the Clean Energy Future (CEF) legislation on 1st July 2012. The legislation is designed as a fixed price emissions trading scheme. The CEF is enacted in three stages. It commenced on 1st July 2012 with a fixed price of AUD 23, rising 4% per annum until 30th June 2015. From July 2015 until June 2018, the CEF will operate as a floating price emissions trading scheme with a maximum price of AUD 20 above the international price per certificate. From July 2015, the intention is that the CEF will become an emissions trading scheme linked to international markets with a floating price and minimal restrictions. An independent review board will set an emissions cap 5 years in advance, see IETA (2012). It is expected that eventually the scheme will transition into a flexible price internationally linked cap-and-trade emissions trading scheme.

Supporting the CEF legislation is the Carbon Farming Initiative (CFI), which is designed to reward the landowners for undertaking land-based activities that either reduce emissions or sequester atmospheric carbon. These activities will generate offset credits called the Australia Carbon Credit Units (ACCUs) which can be used as compliance certificate under the CEF. The CFI has been designed to cover all land based emissions and sinks, including: soil carbon sequestration, afforestation and reforestation, improved forest management, agriculture emissions management and more (IETA 2012).

5.2.3 *Regional Greenhouse Gas Initiative (RGGI)*

The RGGI is a cooperative effort among nine Northeast and Mid-Atlantic States of USA which started operations in 2009 and is classified as a mandatory cap-and-trade scheme.⁴⁰ RGGI is composed of individual carbon dioxide (CO₂) Budget Trading Programs in each participating state. Through independent regulations based on the RGGI model Rule, each states CO₂ budget trading program limits CO₂ emissions from electric power plants, issues CO₂ allowances and establishes participation in regional CO₂ allowance auctions. CO₂ offsets are generated from project based GHG emission reduction projects from outside the capped electricity sector. The RGGI Offset Protocol for US Forest Projects includes requirements for forest projects that create CO₂ Offset Allowances under the regulatory requirements of a RGGI participating state. The following forest projects are eligible:

- Reforestation
- Improved Forest Management
- Avoided Conversion

The RGGI Offset Protocol for US Forest Projects was updated recently, see RGGI (2013).

5.2.4 *Alberta-based Greenhouse Gas Reduction Program and Offset Crediting System*

Alberta's offset credit system is a compliance baseline-crediting mechanism for entities regulated under Alberta's mandatory GHG emissions intensity-based regulatory system. As part of the Climate Change and Emissions Management Act (CCEMA) (2002) and Specified Gas Emitters Regulation (2007), companies in Alberta, Canada, that emit more than 100,000 tonnes of CO₂ per year are required to be part of the program. Initially it targeted 100 facilities that contribute to about 70% of industrial GHG emissions in Alberta. The act requires companies to reduce their emissions by 12% each year. There are a number of offset protocols for project types under implementation and under development. One of these current protocols allows companies can use credits generated from affor-

⁴⁰ The states in RGGI are Connecticut, Delaware, Maine, New Hampshire, New York, Vermont, Massachusetts, Rhode Island and Maryland.

estation projects to offset their emissions. The eligible afforestation projects must be established in areas where there was no tree cover prior to 31st December 1989. A protocol for emission reductions from changes in forest harvesting practices is currently under review.

5.2.5 *California's Cap-and-Trade Program*

In 2006, the State of California passed the Global Warming Solutions Act known as Assembly Bill 32 (AB 32) which requires California to reduce economy wide emissions to 1990 levels by 2020. The California Air Resource Board (ARB) is the regulatory agency, and has already developed protocols supporting the creation of offsets in US forestry and urban environments. The final cap-and-trade regulation under AB 32 specifically recognises reducing emissions from deforestation and degradation (REDD) as a sector based offset credit, see TGC (2012).

5.2.6 *Other schemes under development*

There are a number of other market mechanisms under planning, development or piloting and these will provide increased opportunities for capitalising on the forest sector's climate change mitigation role, and several countries have announced their intentions for allowing forest offsets on their schemes – specifically, Japan Bilateral Crediting Offset Mechanism (BCOM), Chile and China. Other emission trading schemes currently under planning include Ukraine, Kazakhstan, Turkey, Mexico, Brazil.

5.3 Nordic forests and the carbon market

5.3.1 *Compliance markets*

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) established emissions trading as a mechanism to meet binding GHG emission targets through implementing national caps on the greenhouse gas emissions of developed countries (Annex I) that have ratified the Kyoto Protocol. Established in 2005, the EU Emission Trading System (EU ETS) continues to be the largest compliance scheme for trading greenhouse gas (GHG) emissions, and of the Nordic countries, covered Denmark, Finland and Sweden. In 2009, Iceland and Norway were linked to the EU ETS through the incorporation of the EU

ETS directive (Directive 2003/87/EC as amended) into the European Economic Area (EEA) agreement.

However, establishing a compliance scheme for trading carbon sequestered in the Nordic forests is not foreseeable for a number of reasons. Firstly, the Linking Directive to the EU ETS, through which the Nordic countries already participate in, provides an already available Kyoto compliant scheme, however, the EU ETS also specifically excludes Certified Emission Reductions (CERs) and Emission Reduction Units (ERUs) from land use,^{41,42} land use change and forestry (Directive 2004/101/EC). This is largely because there were concerns over the permanence of emission reductions in afforestation/reforestation projects, and flooding the market with cheap surplus emission reductions. Previous to 2012, common rules on how to account for emissions and removals from the LULUCF sector were also an impediment, which has recently been overcome. The third phase of the EU ETS (2013–2020) saw changes, such as sectoral enlargement and the inclusion of new greenhouse gases, which could give hope to the inclusion of land based emission reductions being traded on the scheme, however, if such a concept was ever politically feasible, it would be post 2020.

5.3.2 Voluntary carbon market

The voluntary carbon market is much more flexible than the compliance market and uses a number of different mechanisms, standards and methodologies for greenhouse gas accounting and selling Verified Emission Reductions (VERs). There are a number of standards that facilitate the sale of VERs on the voluntary carbon market from land based projects and programmes, these are; the Verified Carbon Standard (VCS), and Plan Vivo. Recently the Carbon Fix Standard teamed up with the Gold standard in the hope to facilitate the generation of VERs from land based projects. However, like the compliance markets, all these standards for the voluntary carbon market require and apply strict additionality criteria, which means that only those projects that would not have happened without carbon finance are eligible, in other words, if the land based project will occur without the voluntary carbon market financing,

⁴¹ CERs are generated from Clean Development Mechanism (CDM) projects implemented in non-Annex I countries (mainly developing countries).

⁴² ERUs are generated from Joint Implementation (JI) projects implemented in Annex I countries falling under Annex B (mainly economies in transition) in the Kyoto Protocol.

usually because it is commercially profitable, then it is not eligible for validation under the standards for the voluntary carbon market.

The voluntary carbon market does not limit its boundaries to developing countries, which constitute the majority of voluntary land-based carbon projects, and there are examples of VERs in developed countries that have ratified the Kyoto Protocol and host voluntary carbon market projects, see the Native Forest Protection Project in Tasmania, Australia, which was verified under the verified carbon standard.

Similarly, Nordic countries are not excluded from the voluntary carbon market, however, the current forest policy and regulation framework, within the Nordic region promotes sustainable forest management, and therefore developing projects for climate mitigation through the voluntary carbon market, is very limited. In other words, there is not much more that Nordic countries and their forest owners can do in specifically Denmark, Finland, Sweden and Norway, outside the regulatory framework, to conserve and sustainably manage forest carbon stocks.

That being said, Iceland has a situation that could give it eligibility for the voluntary carbon market. Afforestation through planting increased through the 1990ies to roughly 4 million seedlings annually and public financing for forestry reached a maximum in 2005. However after the financial crisis in which Iceland was hit (2008–2009), funding for forestry was cut drastically, and in real terms, public funding for forestry in 2013 was only half of what it was in 2005. This caused a drastic reduction in afforestation efforts, and consequences included tree nurseries going out of business and educated foresters moved abroad.

Approximately 40% (approx. 400,000 ha) of the land area in Iceland can be potentially afforested, however afforestation efforts have been slow, at about 1,000–1,500 ha per year. At this rate, it will take 70 years to reach an afforestation goal of 1% of the land area (Skogrækt ríkisins, 2013). Given the recent turn of events in Iceland, and the implications it has had on its forest programmes, carbon finance for afforestation from the voluntary carbon market could be used to increase afforestation efforts, if the circumstances for the formulation of a voluntary carbon market project are feasible.⁴³

Denmark has the potential to also provide VERs from the forest sector on the voluntary carbon market, as the current forest area in Den-

⁴³ The feasibility of voluntary carbon market projects is affected by the price of their verified emission reduction units (t CO₂), which is currently very low, and could affect the financial feasibility of a project.

mark is 11%, however, according to the Danish national forest programme, there is the objective to increase forest area to somewhere between 20–25% after one tree generation (80–100 years). Application of the Verified Carbon Standard (VCS) additionality criterion would need to show that such afforestation efforts would not occur without finance from the voluntary carbon market, and this may be more difficult to prove in Denmark's case, compared with Iceland's clear financial predicament and its impact on the forest sector.

6. Conclusions and Recommendations

Conclusions	Recommendations
<p>The most important way of mitigating climate change is to diminish the emissions from transport, industry, housing etc. However, forests do play a significant role since 17.4% of the global emissions are from deforestation, mainly in tropical countries.</p>	<p>Even though REDD+ does not have any direct implication for the Nordic forests, the Nordic countries could still participate and contribute significantly to the REDD+ activities and discussion at the global level.</p>
<p>The Nordic region as a whole is rich in forest resources. The forest growing and biomass stock in the Nordic countries has been increasing in the last few decades because of forest growth exceeding drain consisting of harvesting and decomposition. Likewise, the forest carbon sink has increased in last few decades in these countries. Particularly, the forests in Finland, Sweden and Norway have sequestered a large amount of carbon each year as a result of practicing sustainable forest management and investing in forestry in last five to six decades. In the coming decades the carbon stock and carbon sink in the Nordic forests is expected to further increase in size given that current management and investment practices continue.</p> <p>The current forest policies in the Nordic countries aiming at more forests and multifunctionality including economic, environmental and social values have resulted in more forests and more wood. This is beneficial also from a climate point of view.</p>	<p>Continue to keep current targets and policies of increasing forest production.</p>
<p>If a forest is not harvested it will sequester and store more carbon for a certain time. However, after a certain amount of time the rate is declining and less than in a managed forest.</p>	
<p>Increasing the use of wood-based products has potential to mitigate climate change. Manufacturing of these products consumes generally relatively little fossil energy. Moreover, biomass by-products and end-of-life wood waste utilization provide an opportunity to avoid fossil fuel emissions due to biofuel substitution. Significant amount of process emissions can be avoided by substituting high energy intensive materials with less energy intensive wood-based materials. Further benefit is achieved through the sink effect. Especially wood-based products that have a long life-time, such as high quality furniture and wood used in building structures, store carbon for extensive periods of time.</p> <p>There are examples of promotion, based on climate mitigation purposes, of the use of wood for example in building.</p>	<p>Nordic countries could learn from existing examples and strengthen national policies or schemes to promote the use of climate smart solutions and raw-materials in for instance building. Such policies could be developed on the national level. In addition those countries that are Member States of the EU could advocate such policies on the EU level.</p>

Conclusions	Recommendations
<p>In the era of bioeconomy the climate change mitigation potential of forests increases as the range of forest-based products and the scope of bio-based raw materials storing carbon enlarges significantly. As cellulose, hemicellulose, lignin and other wood and bark components will be used for new purposes carbon can be stored for longer times in for instance plastics and fabrics. This postulates that many fossil-based raw materials (like oil) should be replaced by bio-based raw materials such as wood.</p> <p>The use of wood as energy source has long traditions in the Nordic countries. However the extent of forest resources and development of forest industry has led to various types and scales of wood energy utilization in the Nordic countries. In Finland and Sweden wood accounts for major part of renewable energy sources mainly, because it is connected to the wood use of forest industry and diverting the side streams to energy production. Similar development can be observed in Norway as well but in much smaller scale. In these countries the use of wood as fuel is now becoming more forest industry independent, much due to policies enhancing the increasing use of biofuels. In Denmark the use of wood fuels is mainly based on combustion of imported wood pellets in energy production.</p> <p>Different Nordic countries are bound by the requirements of the same renewable energy directive; however they have different approaches in building policies supporting the increasing use of wood energy. Sweden established the carbon dioxide tax as one of the first countries in the world. Taxation of the fossil fuels has become the central element in Swedish renewable energy policies in steering the use of fuels towards renewable alternatives. Finnish policy system involves mainly support both to investments and direct operational subsidies paid for every cubic meter of produced energy-wood.</p> <p>There are basically three ways in which forests contribute to climate change mitigation: i) carbon stock in forests; ii) carbon sequestration in harvested wood product; and iii) substitution of non-renewable energies and substitution of more carbon intensive materials. Carbon which is sequestered in the forest cannot simultaneously substitute for non-renewable energies or raw materials. Therefore, a choice must be made: should a country increase its area and volume of forest as much as possible or should the</p>	<p>Research and development in bioeconomy should be strengthened now when bio-based products are reaching both the technical and commercial readiness.</p> <p>Over the years, the national policies have naturally been developed to meet the requirements of particular country's operative environment. However, in the future the possibility of combining policies and integrating the elements suitable to support the use of wood fuel on Nordic level should be investigated. Following examples could be used on the level of whole Nordic region. Norway and Sweden operate a common quota system for renewable electricity. The quota system has been recently started and the results of its efficiency will be seen in the future. Functionality of this kind of common quota system should be investigated on the whole Nordic region level. A common Nordic fund which could administer financial support money to development and pilot projects of new wood energy systems from publicly and privately funded sources. This kind of system has been used successfully in Norway over a decade. There could be opportunities to develop such incentives in collaboration with the Working Group for Renewable Energy or with Nordic Energy Research, both under the Nordic Council of Ministers.</p> <p>As there is potential for both increasing the volume in the forests as well as to increase the use of wood the Nordic countries should continue with a balanced approach – as failure to encourage growth in forest sink (through e.g. further promoting forest management) might ultimately lead to limited future potential share of biomass available for bioenergy purposes.</p>

Conclusions	Recommendations
same country focus on increasing its supply of wood for products and as biomass for energy generation.	
A carbon credit scheme for harvested wood products would have to include also the release of carbon at the end of the life-cycle. This would mean that the end user has to pay for releasing the carbon. In the end this would probably be an incentive against the use of wood.	The Nordic countries need to have careful consideration regarding possible detailed negotiations on the use of harvested wood. In fact mechanisms, if not designed carefully, might have an adverse effect on the use of renewable materials.
There are an increasing number of market mechanisms and schemes developing around the world that allow emission reductions from the forest sector within the scheme. The largest compliance market is the EU ETS, however it does not allow land based emission reductions on its scheme. The voluntary carbon market provides opportunities for the forest sector to incentivise carbon forestry. Iceland and Denmark have the most conducive circumstances for incentivising their forest sectors from the voluntary carbon market.	Further study on the feasibility of the voluntary carbon market and its potential contribution to Iceland's afforestation objectives should be considered.

7. Sammandrag

Bakgrund och målsättning

Skogen spelar en stor roll i det globala kretsloppet av kol och i att minska klimatförändringen. Skogen absorberar genom fotosyntesen kol från atmosfären och binder det i levande och död biomassa och i marken. På det sättet skapas ett naturligt lager av kol. De boreala skogarna i Norden är ett globalt sett viktigt kollager.

Avsikten med projektet är att diskutera den nordiska skogens roll då det gäller att minska klimatförändringen. I rapporten diskuteras också ifall det skulle vara genomförbart med en nordisk mekanism för handel med skogarnas roll som kolsänkor. Rapportens huvudsakliga geografiska område är de Nordiska länderna (Danmark, Finland, Island, Norge och Sverige) samt de självstyrande områdena (Åland, Färöarna och Grönland).

De internationella klimatförhandlingarna och skogarna i Norden

Kyoto-avtalet tillåter länderna att inkludera aktiviteter gällande "Markanvändning, förändrad markanvändning och skogsbruk" (LULUCF, *Land Use, Land Use Change and Forestry*) som en del av sina åtgärder för att bekämpa klimatförändringen. Protokollet ger alla Annex I länder, till vilka alla de Nordiska länderna hör, möjligheter att rapportera om emissioner och bindning av klimatgaser till följd av LULUCF aktiviteter. Artiklarna 3.3 och 3.4 i protokollet reglerar hur den nationella LULUCF bokföringen skall göras. Det är under den andra avtalsperioden (2013–2020) obligatoriskt för Annex I länderna att upprätta ett bokföringssystem för redovisning av emissioner och bindning från nybeskogning, återbeskogning och avskogning samt skogsskötsel och träprodukter. Skötsel av odlad och betad mark, återodling, dikning samt återställning av våtmarker är frivilliga LULUCF aktiviteter. Nettoupptaget av växthusgaser genom LULUCF-aktiviteter för en Annex I avtalspart ger parten rätt att utfärda s.k. removal units (RMU). För den första avtalsperioden (2008–2012), har varje avtalspart ett tak för RMU. För de nordiska länderna har Island ett tak som är noll medan alla de övriga länderna har ett högre tak. För den andra avtalsperioden (2013–2017 eller 2020) är utfärdandet av RMU baserat på landsspecifika referensnivåer för skogsskötsel (FMRL, *Forest Management Reference level*) och ett tak på 3,5 % av emissionerna år 1990. All kolbindning som är över FMRL-nivån

men under eller samma som taket utgör avtalspartens RMU. Dessa RMU:n kan användas av parten själv för att uppnå målen gällande en minskning av utsläpp av klimatgaser. Alternativt kan parten sälja dessa till andra avtalsparter så att de uppnår sina mål under Kyoto protokollet. Minskningen av utsläpp av klimatgaser som en följd av avskogning, eller REDD+ (Reducing emissions from deforestation and forest degradation) är en allt viktigare del av de internationella klimatsamtalerna. REDD+ är avsett att tillämpas i utvecklingsländer och har en direkt relevans för tropiska skogar. REDD+ inverkar inte direkt på de nordiska skogarna.

Nordiska skogar som resurs och som kolsänkor

Norden har rika skogstillgångar, mer än 61 miljoner ha, vilket motsvarar ca en tredjedel av skogarna i Europa (fråntagit Ryssland). Av skogarna i Norden finns 99 % i Sverige, Finland och Norge. Merparten av skogarna är boreala och privatskogsbruket, där vanliga medborgare äger skogen, är den dominerande ägoformen. Även staten har betydande skogsinnehav speciellt i Finland, Danmark och Sverige. I Norden är skogssektorns bidrag till BNP och antalet arbetstillfällen i medeltal högre än vad den är i Europa i övrigt. Speciellt i Sverige och Finland har sektorn en stor betydelse.

I Norden, speciellt i Finland, Sverige och Norge, har den totala mängden virke och biomassa ökat som ett resultat av långsiktig skogsvård och investering i skogstillväxt under de senaste sextio till sjuttio åren. Den årliga ökningen av biomassa har varit positiv eftersom tillväxten överstigit uttaget i form av avverkning och naturlig avgång. Den totala ökningen av mängden biomassa samt den årliga tillväxten förväntas vara positiv också under de kommande årtiondena.

Trenden för skogsbiomassans tillväxt i Norden

Som en följd av den årliga ökningen av skogens biomassa har skogens roll som kolsänka ökat under de senaste årtiondena. Skogarna i Finland, Sverige och Norge har bundit en avsevärd mängd kol varje år. Under innevarande decennium kommer skogen som kolsänka att öka och nå 140 miljoner ton CO₂ (tCO₂) år 2020. Skogsvårdsåtgärder såsom gödsling, lättare gallringar, förlängd omloppstid och röjning har en positiv inverkan på tillväxten och därmed på skogen som kolsänka. Nyttjande av hyggesrester för bioenergi kan ha en negativ inverkan på tillväxten och på det sättet för kolupptagningsförmågan. Gammelskogar som är strikt skyddade t.ex. på grund av mångfalden är till en början bra för att öka kolnivån, men upptagningsförmågan avtar senare och blir noll i klimaxskedet.

De nordiska skogarnas årliga kolbindning

Användningen av trä ger minskade utsläpp

Trä används i hög grad i konstruktioner, för att framställa olika produkter såsom möbler, papper och förpackningsmaterial samt för energiproduktion. Användningen av trä minskar utsläppen av klimatgaser. Trä i konstruktioner eller i produkter lagrar kol och dessutom undviker man övriga utsläpp genom att trä används som substitut i stället för t.ex. betong och stål vilka kräver mera energi i produktionsskedet. Studier visar att användningen av en kubikmeter virke i produkter eller i konstruktioner minskar utsläppen med ca 2 tCO₂, då substituteffekten är medräknad. Flera länder har redan vidtagit åtgärder och tagit initiativ för att främja användningen av trä i konstruktioner.

De nordiska länderna har långa traditioner i att använda trä för energi. Utvecklingen har emellertid lett till olika omfång och olika former av träenergi i de olika länderna beroende på hur rikliga skogstillgångarna är eller hur skogsindustrin utformat sig. I Finland och Sverige står trä för mer än hälften av den förnybara energin men även i Norge är andelen betydande. Speciellt i Finland och Sverige är bioenergin mycket beroende av skogsindustrin. Danmark är mera beroende av importerade pellets.

De olika nordiska länderna är kraftigt beroende av målen i EUs direktiv för förnybar energi, trots att de har väldigt olika utformning av de politiska styrmedel som skall öka användningen av träenergi. Sverige skapade en koldioxidskatt som ett av de första länderna i världen. Beskattning av fossila bränslen har blivit ett av de centrala elementen i Sveriges politik för att styra landets energiproduktion i en förnybar riktning. Den finländska politiken innehåller i första hand stöd för direkta investeringar och direkta stöd för varje producerad kubikmeter energived. Under årenas lopp har den nationella politiken naturligtvis utvecklats för att bäst möta de förutsättningar respektive land har.

Bioekonomin har stora möjligheter att bidra till att skogssektorn i Norden får en större ekonomisk betydelse och betydelse för att bekämpa klimatförändringen. Bioekonomi ger ökade möjligheter att använda ved för nya och allt mera diversifierade produkter och på det sättet för biobaserade material att binda kol. Cellulosa, hemicellulosa, lignin och nanomaterial från ved och bark kan användas som råvara för att producera plaster, tyger, läkemedel och ämnen för läskedrycksindustrin. De här ämnena lagrar å ena sidan kol och man undviker emission av koldioxid pga att man kan ersätta material som olja och å andra sidan öppnar de nya affärsmöjligheter för skogsbaserade produkter.

En marknadsbaserad mekanism för kolbindning i skogen

Globalt finns det en rad olika system och mekanismer för utsläppshandel antingen redan nu i funktion eller i ett avancerat utvecklingsskede. Det finns två huvudmodeller, s.k. cap-and-tradesystem eller baseline-system. I cap-and-trade systemet finns ett utsläppstak över hur mycket av emissionerna som kan säljas, medan baseline-system belönar åtgärder vilka sänker emissionerna under en referensnivå som baserar sig på att inget görs (business as usual).

EU:s utsläppshandel (EU ETS, EU Emission Trading System) som grundades år 2005 är fortfarande den största mekanismen för handel med växthusgaser. Norge och Island anslöt sig till EU ETS år 2009 och nyligen meddelades att EU har gjort ett principbeslut att koppla samman EU ETS och det Australiska systemet för handel med växthusgaser med varandra.

EU:s utsläppshandel tillåter emellertid inte handel med landbaserade certifierade utsläppsminskningar. Ett ökande antal frivilliga utsläppshandelssystem och marknadsbaserade mekanismer, vilka tillåter handel med landbaserade kolsänkor, har utvecklats under de senaste åren. Nya Zeelands utsläppshandel (NZ ETS) bildades år 2008 och var ett av de första systemen som inkluderar skogssektorn. Carbon Farming Initiative i Australien har utvecklats för att täcka alla landbaserade utsläpp och kolsänkor, och Sydkorea godkände en lag om kolsänkor (Carbon Sink Act) år 2012 vilken integrerar skogssektorn i systemet.

Återbeskogning, förbättrad skogsvård och projekt för att undvika förändring av markanvändningen är godkända i RGGI (Regional Greenhouse Gas Initiative) i nio delstater i nordvästra delarna av USA och kolsänkor i skog är med i Kaliforniens handelssystem. Diskussionerna om kompensations för skogliga kolsänkor övervägs också i Japan (Japanese Bilateral Crediting Offset Mechanism, BCOM) och inom utsläppshandeln i Chile och Kina. Miljöinriktade obligationer (Green Bond) har samlat mera än 4 miljarder US dollar sedan år 2008 och skogsprojekt vilka minskar växthusgaserna kan inkluderas. Med tanke på antalet frivilliga marknadsmekanismer som har utvecklats eller håller på att utvecklas så är trenden klar – marknadsmekanismer vilka inkluderar skog och skogsbruk växer i volym, storlek samt likviditet och det finns en lång rad olika instrument.

Det finns en rad orsaker till att det inte i Norden är troligt att det lönar sig att bilda en marknadsmekanism där skogen ingår. För det första är det sammanlänkande direktiv (Linking Directive) för EU ETS, där de Nordiska länderna redan deltar, redan i sig ett existerande system för överensstämmelse med Kyoto-besluten. Men samtidigt utesluter EU ETS också specifikt certifierade utsläppsminskningar CER (Certified Emission Reductions) och utsläppsminskningenheter ERU (Emission Reduct-

ion Units) från markanvändning, förändrad markanvändning och skogsbruk (Direktiv 2004/101/EC).

För det andra främjar skogspolitiken och den skogliga lagstiftningen i Norden i sig ett bärkraftigt skogsbruk. Med andra ord är det ytterst lite, utöver den redan gällande lagstiftningen, de Nordiska länderna, speciellt Danmark, Finland, Norge och Sverige, samt skogsägarna kan göra för att öka och bevara kollagret i skogarna.

Island däremot kan möta kriteriet för kompletterande åtgärder och därmed kan frivilliga mekanismer för kolbindning under Verified Carbon Standard (VCS) vara en möjlighet på Island ifall det finns intresserade investerare och lönsamma projekt. Island har emellertid begränsade mänskliga och finansiella resurser att möta sina nuvarande beskogningsmål och det nuvarande priset för VER (Verified Emission Reductions) för skogliga projekt på den frivilliga kolmarknaden gör inte sådana projekt ekonomiskt sett attraktiva.

De viktigaste rekommendationerna

- Norden har rikliga skogsresurser. Skogsbiomassan växer och den årliga virkestillväxten är positiv. Som ett resultat av detta binder de nordiska skogarna rikligt med kol. För att upprätthålla detta kollager och för att fortsatt fungera som kolsänka bör de nordiska länderna fortsätta med ett bärkraftigt nyttjande av skogen, med att investera i skog och med nuvarande politik att öka virkesförrådet.
- Användningen av trä i konstruktioner och produkter såsom möbler, papper och kartong minskar klimatgaserna. De nordiska länderna kunde fortsatt nyttja bra exempel då de utvecklar sin nationella politik och incitament för att främja användningen av virke som t.ex. byggnadsmaterial eller i konstruktioner. Sådana politiska styrmedel kunde utvecklas på nationell nivå, men de länder som är medlemmar av EU kunde också föra fram frågan på EU-nivå.
- Bioekonomin ger ökade möjligheter för Nordens skogssektor ekonomiskt sett men ger också ökade möjligheter att använda ved för nya och allt mera diversifierade produkter och på det sättet för biobaserade material att binda kol. Därför borde de nordiska länderna stärka forskning och utveckling i bioekonomi och skogspolitiken och den ekonomiska politiken borde allt mera fokuseras på bioekonomi.
- Den nationella politiken och styrmedlen för att öka användningen av träenergi varierar mellan de nordiska länderna. Det vore emellertid viktigt att undersöka om politiska styrmedel och exempel kunde användas bredare i hela Norden och på så sätt ytterligare öka

användningen av trä för energiproduktion. En samnordisk fond kunde grundas för att ge finansiellt stöd för försöksprojekt och för utvecklingen av nya och innovativa metoder för träenergi. Samarbete gällande detta borde ske med Arbetsgruppen för förnybar energi samt med Nordisk Energi Forskning, båda under Nordiska Ministerrådet.

- Eftersom Norden har potential såväl att öka volymen i skogarna som användningen av virke är det viktigt att detta görs på ett balanserat sätt. Ett tillkortakommande i att främja tillväxten i skogens roll som kolsänka kan i framtiden leda till en minskad möjlighet att öka andelen biomassa i produktionen av bioenergi. Norden bör även ha gemensamma diskussioner vad gäller träets roll i produkter (Harvested Wood Products, HWP) i de detaljerade diskussionerna på det internationella planet.

8. Tiivistelmä

Tutkimuksen tausta, tavoite ja kohdealue

Metsillä on tärkeä rooli maailmanlaajuisessa hiilenkierrossa ja ilmastomuutoksen lieventämisessä. Ne sitovat ilmakehän hiiltä yhteyttämissen kautta ja säilövät sitä elävään ja kuolleeseen biomassaansa sekä maaperään. Tämän johdosta metsät toimivat hiilen luonnollisena reservinä. Pohjoismaiset boreaalisen ja lauhkean vyöhykkeen metsät ovat globaalisti tärkeitä hiilivarastoja.

Tämän toimeksiannon päätavoitteena on käsitellä pohjoismaisten metsien roolia ilmastomuutoksen hillinnässä. Raportissa pohditaan myös metsien hiilensidontaan liittyvien pohjoismaisten markkinamekanismien soveltuvuutta. Maantieteellisenä kohdealueena toimivat viisi Pohjoismaata: Islanti, Norja, Ruotsi, Suomi ja Tanska. Ahvenanmaata, Färsaaria ja Grönlantia koskevaa tietoa käsitellään silloin kun se on katsottu relevantiksi.

Kansainväliset ilmastopoliittiset keskustelut ja pohjoismaiset metsät

Kioton pöytäkirja on kansainvälinen ilmastopoliittinen sopimus, jonka puitteissa asianomaiset valtiot voivat sisällyttää maankäytöstä, maankäytön muutoksista ja metsätaloudesta (land use, land-use change and forestry, LULUCF) johtuvat päästöt osaksi ilmastomuutosta hillitsevää toimintaohjelmaansa. Pöytäkirja määrittää velvoitteita kaikille kehittyneille maille (Annex I-maat), mukaan lukien Pohjoismaat. Yksi näistä velvoitteista on raportoida LULUCF toimiin liittyvistä kasvihuonekaasujen päästöistä ja nieluista. Pöytäkirjan artikkelit 3.3 ja 3.4 säätelevät LULUCF päästöjen laskentaa. Toisella sitoumuskaudella (2013–2020) Annex I maille on pakollista ilmoittaa päästöt ja nielujen aikaansaamat poistumat, jotka ovat peräisin metsittämisestä, uudelleen metsittämisestä ja metsänhävityksestä, metsänhoidosta sekä puutuotteiden käytöstä. Maatalousmaan hoito, kasvillisuuden palauttaminen sekä kosteikkojen kuivatus ja palauttaminen ovat vapaaehtoisesti ilmoitettavia LULUCF toimia. Mikäli Annex I-maan LULUCF toimenpiteet luovat laskennallisen nettonielun, saa tällainen maa oikeuden päästövähennyksiin kaupattavien poistoyksiköiden kautta. Ensimmäisen sitoumuskauden (2008–2012) aikana, jokaiselle osapuolelle on määritetty myönnettävien poistoyksiköiden yläraja. Pohjoismaista Islannin yläraja on nolla ja muilla tätä suurempi.

Toisella sitoumuskaudella (2013–2020) poistoyksiköiden määrittäminen perustuu maakohtaiseen metsänhoidon viitearvoon ja 3,5 prosentin ylärajaan 1990 vuoden päästöistä. Täten viitearvon ylittävä hiilensidonta tuottaa asianomaiselle valtiolle poistoyksiköitä aina määritettyyn ylärajaan asti. Kyseinen valtio voi käyttää ansaitsemiaan poistoyksiköitä saavuttaakseen sille asetetut kasvihuonekaasupäästötavoitteet. Vaihtoehtoisesti poistoyksiköt voidaan myydä toisille pöytäkirjan alaisille Annex I osapuolille, jotka vuorostaan hyödyntävät ne päästövähennystavoitteisiinsa. REDD+ on kansainvälinen metsiä koskeva ilmastonmuutoksen ehkäisymekanismi, joka keskittyy kehitysmaiden metsäkadon ja metsien tilan heikkenemisestä aiheutuvien päästöjen vähentämiseen, metsien suojeluun ja kestävään hoitoon sekä metsähiilivarastojen kasvattamiseen (Reducing Emissions from Deforestation and Forest Degradation in developing countries, as well as the conservation of forest carbon stocks, sustainable management of forests, and enhancement of forest carbon stocks, REDD+). Kehityksmaapainotuksen johdosta REDD+ mekanismilla ei ole suoraa vaikutusta pohjoismaisia metsiä koskevassa päätöksenteossa.

Pohjoismaiset metsävarannot ja hiilinielu

Pohjoismaiset metsävarannot ovat mittavat ja ylittävät 61 miljoonaa hehtaaria. Tämä vastaa vähän alle kolmasosaa Euroopan metsistä (lukuun ottamatta Venäjää). Pohjoismaisista metsistä 99 % sijaitsee Ruotsissa, Suomessa ja Norjassa. Suurin osa metsästä on boreaalista ja kuuluu yksityisille omistajille, jotka ovat pääasiassa tavallisia kansalaisia. Valtio omistaa myös merkittävän osuuden metsää erityisesti Suomessa, Tanskassa ja Ruotsissa. Keskimääräisesti metsäsektorin vaikutus bruttokansantuotteeseen ja työllisyyteen on Pohjoismaissa suurempi kuin muualla Euroopassa. Varsinkin Suomessa ja Ruotsissa metsäsektorilla on vahva asema maan taloudessa.

Viimeisen kuuden-seitsemän vuosikymmenen aikana harjoitettu kestävä metsänhoito ja metsäinvestoinnit ovat johtaneet puuston ja biomassavarantojen kasvuun Pohjoismaissa, erityisesti Suomessa, Ruotsissa ja Norjassa. Kokonaismääräisten biomassavarantojen voidaan olettaa kasvavan tulevina vuosikymmeninä positiivisen vuosittaisen nettokasvun johdosta.

Pohjoismaiden maakohtainen metsäbiomassan kehityssennuste

Pohjoismaisen metsänielun odotetaan jatkavan kasvuaan tällä vuosikymmenellä ja saavuttavan 140 miljoonan hiilidioksiditonnin rajan vuonna 2020. Metsänhoitotoimenpiteet, kuten lannoitus, lievempien harvennusvoimakkuuksien suosiminen sekä hakkuukierron pidentäminen vaikuttavat positiivisesti metsiin sitoutuneen biomassan kasvuun. Toisaalta metsänkorjuujätteen keräämisellä bioenergian tuotantoon saattaa olla negatiivinen vaikutus hiilinieluihin. Tarkasti suojellut vanhat metsät taas edistävät ensin hiilivaraston kasvua ja ovat lisäksi tärkeitä luonnon monimuotoisuuden säilyttämisen kannalta. Näiden metsien hiilensidontakyky tosin tyrehtyy ajan kuluessa, kun metsä saavuttaa päätemetsävaiheen (kliimaksin).

Pohjoismaisten metsänielujen netto hiilidioksidipoistot 1990–2020

Puunkäyttö ja päästöjen vähentäminen

Puuta käytetään paljon rakentamisessa, energiantuotannossa sekä erilaisten tuotteiden (esim. huonekalut, paperi ja pakkausmateriaalit) valmistuksessa. Puurakenteet ja -tuotteet varastoivat hiiltä. Puuta käyttämällä voidaan myös välttää kasvihuonekaasupäästöjä, mikäli puulla korvataan enemmän energiaa valmistuksessa kuluttavia materiaaleja kuten betonia ja terästä. Keskiarvoisesti yksi kuutiometri (kuivaa) puuta käytettynä puurakenteissa tai -tuotteissa vähentää hiilidioksidipäästöjä kahdella tonnilla (hiilivarasto + substituuatio). On kuitenkin hyvä tiedostaa, että puutuotteiden päästövähennyspotentialiaali on liukuva käsite, joka määrittyy niihin varastoidun hiilen, tuotteen elinkaarianalyysin ja korvatus materiaalin substituuatiohyödyn yhtälöstä (saattaa olla joissain tapauksissa myös negatiivinen). Monet maat ovat jo käynnistäneet ohjelmia ja aloitteita puurakentamisen edistämiseksi.

Laajat metsävarannot ja metsäteollisuuden kehitys ovat johtaneet monimuotoiseen ja perinteikkääseen puuenergian käyttöön pohjoismaissa. Ruotsissa ja Suomessa suurin osa uusiutuvasta energiasta on puuperäistä. Myös Norjassa on ollut nähtävissä samansuuntaista kehitystä, mutta paljon pienemmässä mittakaavassa. Biopolttoaineiden käyttöä tukevien linjausten johdosta puunkäyttö polttoaineena on muuttumassa vähemmän riippuvaiseksi metsäteollisuudesta näissä kolmessa maassa. Tanskassa puuperäistä energiaa tuotetaan pääasiassa maahan-tuoduista puupelleteistä.

Kaikki pohjoismaat ovat saman uusiutuvan energian direktiivin alaisuudessa. Tästä huolimatta kullakin maalla on erilainen lähestymistapa rakentaessaan puuenergian käyttöä tukevia linjauksia. Ruotsi otti käyttöön hiilidioksidiveron yhtenä ensimmäisistä maista maailmassa. Fossii-listen polttoaineiden verotuksesta on tullut keskeinen tekijä Ruotsin uusiutuvan energian käyttöä edistävässä politiikassa. Toisaalta Suomessa uusiutuvan energian käyttöönottoa edistetään esimerkiksi tukemalla investointeja sekä myöntämällä tuotannollisia kannustimia jokaista tuotettua energiapuukuutiometriä kohden. Vuosien saatossa eri maiden kansalliset linjaukset ovat kehittyneet vastaamaan kyseisen maan toimintaympäristön vaatimuksia.

Biotalous on hyvä mahdollisuus kasvattaa pohjoismaisen metsäsektorin asemaa ilmastomuutoksen hillinnässä sekä tärkeänä osatekijänä kokonaistaloudessa. Biotalous laajentaa metsistä saatavaa tuotevalikoimaa ja bioperäisten materiaalien mahdollisuuksia tuottaa päästövähennyksiä. Puusta ja kaarnasta tuotettua selluloosaa, hemiselluloosaa, ligniinia ja muita nanomateriaaleja käytetään raaka-aineina, kun tuotetaan esimerkiksi muoveja, kankaita, lääkeaineita ja juomateollisuuden

tuotteita. Nämä raaka-aineet varastoivat hiiltä sekä välttävät hiilipäästöjä korvaamalla saastuttavampia raaka-aineita, kuten öljyä. Tämän lisäksi uusien raaka-aineiden käyttö avaa uusia liiketoimintamahdollisuuksia metsätaloudessa.

Markkinapohjaiset mekanismit

Maailmanlaajuisesti on toiminnassa tai edistyneessä kehitysvaiheessa useita päästökauppajärjestelmiä. Nämä järjestelmät toimivat joko katto ja kauppaperiaatteella (cap and trade) tai pohjautuvat tiettyyn määritettyyn perustasoon (baseline). Katto- ja kauppajärjestelmä asettaa rajan kokonaispäästöille ja käy kauppaa päästöoikeuksilla. Toisaalta perustasoon pohjautuvat hyvitysmekanismit tuottavat kaupattavia päästöhvytyksiä oletetun perustason alittavista päästövähennyksistä.

Vuonna 2005 perustettu Euroopan päästökauppajärjestelmä (EU ETS) on toistaiseksi suurin päästökauppajärjestelmä. Islanti ja Norja liittyivät myös tähän järjestelmään vuonna 2009. EU on ilmoittanut viime aikoina, että se pyrkii yhdistämään omat päästömarkkinansa Australian vastaavan kanssa.

EU ETS ei salli kaupankäyntiä maankäyttöön liittyvillä päästövähennyksillä. Tästä huolimatta viime vuosina on perustettu kasvava määrä sitovia sekä vapaaehtoisia päästömarkkinoita, joiden puitteissa myös maankäyttöön liittyviä hyvityksiä voidaan kaupata. Uuden-Seelannin päästökauppajärjestelmä (New Zealand Emissions Trading Scheme) perustettiin vuonna 2008 ja se oli yksi ensimmäisistä, joka sisällytti piiriinsä metsäsektorin. Metsän- ja maanomistajille suunnattu hyvitysjärjestelmä Australiassa (Australian Carbon Farming Initiative) on suunniteltu huomioimaan kaikki maankäytön päästöt ja nielut. Tämän lisäksi mm. Etelä-Korean hiilinieluasetus (Carbon Sink Act) vuodelta 2012 mahdollistaa metsäsektorin huomioimisen päästölaskennassa.

USA:n koillisosan yhdeksän osavaltion alueellinen kasvihuonekaasualoite (Regional Greenhouse Gas Initiative, RGGI) hyväksyy hankkeet, jotka edistävät uudelleen metsitystä, parannettua metsänhoitoa ja metsämaiden muuntamisen ehkäisyä. Metsien tuottamat hiilihyvitykset ovat mukana Kalifornian kiintiö- ja kauppaohjelmassa (cap-and-trade). Tämän lisäksi metsäsektorin tuottamien hyvitysten mukaan ottamista harkitaan Chilen ja Kiinan päästökauppajärjestelmissä sekä myös Japanin kahdenvälisessä hyvityskorvausten mekanismissa (Japanese Bilateral Crediting Offset Mechanism, BCOM). Vihreät velkakirjat (green bonds) ovat tuottaneet yli neljä miljardia US dollaria vuodesta 2008 lähtien ja kelpuuttavat myös kasvihuonekaasupäästöjä vähentäviä metsäprojekteja. Viime vuosien kehityssuunta, niin sitovien kuin vapaaehtoisten päästökauppajärjestelmien suhteen, tukee vahvasti metsäsektorin asemaa osana kokonaisval-

taisempia hiilimarkkinoita. Metsät huomioivat markkinajärjestelmät ovat kasvaneet kaikissa suhteissa (mukaanlukien vaihdetut päästöyksiköt, rahavirta ja markkinamekanismien monimuotoisuus).

Sitovan päästökauppajärjestelmän perustaminen Pohjoismaiden metsiin sitoutunutta hiiltä varten ei näytä todennäköiseltä useastakin syystä. Ensinnäkin, Pohjoismaat osallistuvat jo sitovasti Kioton tavoitteisiin, sillä Euroopan linkkidirektiivi (Linking Directive) kytkee Kioton mekanismit EU ETS:ään. Koska EU ETS ei sisällytä piiriinsä LULUCF-lähtöisiä poistoyksiköitä (Direktiivi 2004/101/EC), ei pohjoismaista metsäperäistä hiiltä voida kaupata osana tätä sitovaa päästökauppajärjestelmää.

Toiseksi, nykyinen pohjoismainen metsäpolitiikka- ja lakikehys pyrkii edistämään kestävä metsänhoitoa. Täten varsinkin Norjassa, Ruotsissa, Suomessa ja Tanskassa ei todellisuudessa ole tämän kehityksen ulkopuolella moniakaan mahdollisuuksia suojella tai kestävästi hoitaa metsähiilivarantoja.

Mahdollisuuksia löytyy kuitenkin Islannissa esimerkiksi vapaaehtoisilla hiilimarkkinoilla. Tämä vaatisi kuitenkin kiinnostuneita sijoittajia ja taloudellisesti toteutuskelpoisia hankkeita, mikä on nykyisellään epätodennäköistä Islannin rajallisten henkilö- ja talousresurssien sekä hiilen alhaisen hinnan johdosta.

Suosituks

- Pohjoismaissa on runsaat metsävarannot, joiden sitoma biomassa kasvaa vuosittain. Näin ollen pohjoiset metsät sitovat mittavia määriä hiiltä. Pohjoismaiden tulisi jatkaa metsävarantojen kasvua suosivaa politiikkaa sekä rohkaista kestävä metsänhoidon periaatteita ja metsätalouden investointeja.
- Kasvihuonekaasupäästöjä voidaan vähentää paikoittain merkittävästi käyttämällä puuta erityisesti rakentamisessa ja pitkäikäisissä tuotteissa. Tämä potentiaali on jo tiedostettu, mikä on ilmeistä useista puun ja muiden vihreiden materiaalien käyttöä edistävästä aloitteista ja toimista niin Pohjoismaissa, Euroopassa kun maailmanlaajuisestikin. Pohjoismaille olisi luonnollista ottaa näkyvämpi rooli tässä edistämistyössä kansallisesti sekä Euroopan tasolla.
- Pohjoismaisen metsäsektorin taloudellinen merkitys sekä tuotekirjo kasvavat kehittyvän biotalouden myötä. Uudet biomateriaalit ovat usein myös verrattain vähäpäästöisiä. Näin ollen biotalouden tutkimusta ja kehittämistä tulee vahvistaa. Pohjoismaiden metsätalouteen ja yleiseen taloudelliseen kehitykseen liittyvien julkisten linjausten tulisi tukea tätä kehitystä.

- Puuenergiaa koskevat kansalliset linjaukset ja lähestymistavat vaihtelevat Pohjoismaiden välillä. Puuenergian käytön optimoimiseksi olisi hyvä tutkia mahdollisuuksia puuenergiapolitiikan yhtenäistämiseksi. Esimerkiksi voitaisiin perustaa yhteinen pohjoismainen rahasto, joka tukisi taloudellisesti uusien ja innovatiivisten puuenergiajärjestelmien koehankkeita. Yhteistyötä tässä asiassa tulisi tehdä Pohjoismaiden Ministerineuvoston alaisten Uusiutuvien energialähteiden työryhmän sekä Pohjoismaisen energiatutkimuksen kanssa.
- Pohjoismailla on potentiaalia lisätä sekä metsien hiilinielun kokoa että korjatun puun määrää. Tästä johtuen niiden tulisi jatkaa kummankin osa-alueen edistämistä. Epäonnistuminen metsien hiilinielun kasvattamisessa saattaa johtaa tulevaisuuden ongelmiin biomassan saatavuudessa mm. bioenergiatarpeisiin.
- Tämän lisäksi Pohjoismaiden tulee tarkoin harkita kantaansa puutuotteisiin liittyvissä neuvotteluissa ilmastositomuksen alla.

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The Role of Forests in Climate Change: Nordic Experience

The objective of this project is to discuss the role of forests in Nordic countries in climate change mitigation and discuss the possible roles of forests as a part of a cost-effective climate policy. The report aims to provide a comprehensive and easily digestible way to better understand the issue.

The report includes a discussion on the role of forests for enhancing carbon stocks and carbon sinks in the Nordic countries. The extent of above- and below-ground biomass and their role as forests carbon sinks in Nordic forests is analysed. The use of wood in products, buildings and as bioenergy is examined. Finally the report presents emissions trading schemes from around the globe that allow offsets and credits from forest projects on them and provides an analysis on the feasibility of such a scheme for the Nordic region.

The report has been commissioned by the Working Group on Environment and Economics under the Nordic Council of Ministers. The study was carried out by Indufor.

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