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An attempt to assess the monetary value of carbon absorbed in the Polish forest sector

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Abstract

Forests and forest management play a vital role in capture and storage of carbon dioxide, which contributes to mitigation of climate change. Forests are not only a natural carbon sink. Proper forest management can enhance biomass production, providing wood to be converted into e.g. construction timber, paper and furniture as well as wood fuels and, as a result, considerably enlarge this carbon sink. Poland, being a party of the Climate Convention and Kyoto Protocol and a member of the EU is obliged to provide yearly reports on carbon emissions and sequestration, including the Land Use, Land Use Change and Forestry (LULUCF) sector, of which forestry is the leading constituent. Forests, with the sequestration rate at a level of 3.93 t $CO_2 \cdot ha^{-1}$ form practically the only important carbon sink in the LULUCF category. Unfortunately the LULUCF sector has not been yet included in the current climate policy framework. The purpose of the study was an attempt to estimate the hypothetical value of carbon stored in forestry, resulting from the reported quantities of the emitted and sequestered carbon. The calculations were based on figures included in the National Inventory Report for Poland, reported yearly to the Secretariat of the Climate Convention. Among the forestry carbon sources/sinks, reported annually, the sequestration resulting from forest management significantly exceeds the net sequestration from afforestation/deforestation activities. Average data from recent years show that forest management is a net CO_2 sink, with 12 Mt $CO_2 \cdot y^{-1}$ (above the forest management reference level, FMRL), and when combined with the carbon pool change resulting from afforestation/deforestation activities, it can be regarded as a net carbon sink sequestering nearly 15 Mt $CO_2 \cdot y^{-1}$. That value, when multiplied by the price of carbon emission allowance (e.g. EUA), could be a source of over 80 mill Euros per year, if used as a commodity on the emissions market. Due to high price volatility of CO_2 emission allowances, the calculated profits are hypothetical, and the EU Emissions Trading System does not include forestry. These potential gains can become realistic after the LULUCF sector has been included in the emissions trading system.

Key words

carbon sequestration, carbon emissions, CO_2 sink, forest management

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Introduction

One of the dominating problems of the contemporary world is the climate change resulting from human activities. This issue has been in the focus of scientists and politicians for many years. It is so important that it has been included in the main long term trends of our civilization (Lindahl and Westholm 2015), observed in today's world. Recent reports of the Intergovernmental Panel on Climate Change (IPCC) indicate the significant influence of anthropogenic factors on the changing climate. The Climate Convention and the Kyoto Protocol, which came onto force in 2005, present a result of the political action leading to mitigating the negative influence of man on the Earth's climate. The problems of environmental protection have even found their place in documents developed by moral authorities (Francis 2015; Posas 2007; Sadowski 2016).

Forest ecosystems are a substantial carbon reservoir in the world, as they contain over 80% of the carbon stored in land vegetation, and about 70% of carbon stored in soils (Post et al. 1982). In Europe, forests cover an area of 159 mill. ha, which corresponds to 37% of the continent's area. On average 75% of the annual wood increment is harvested, which leads to a yearly accumulation of 435 Mt CO_2 (Nabuurs et al. 2015). In Poland, in the most common pine forests, the general carbon pool in the ecosystem is 148 $t \cdot ha^{-1}$ (Zwoliński 1998), of which 91 tonnes is stored in plants and 57 tonnes in the soil. An assessment of the carbon balance indicates that within one year as much as 1.3 $t\ C \cdot ha^{-1}$is bound in the woody biomass and in the mineral soil, which corresponds to 13% of the primary gross production of the ecosystem (Zwoliński 1998). This means that a greater part of the carbon dioxide absorbed by the forest from the atmosphere is released back in respiratory processes.

The United Nations Framework Convention on Climate Change – UNFCCC (United Nations… 1992) not only calls for a reduction in anthropogenic GHG emissions (art. 4.1c), but it also states that countries should promote and enhance sinks and reservoirs of GHGs, including forests (art. 4.1d). The vital role of forests is stressed in the Kyoto Protocol (1998), especially in its articles 3.3 and 3.4. Article 3.3 of the Protocol states that afforestation, reforestation or deforestation activities can be included in the GHG reduction obligation. Article 3.4 enables to include forest management activities to meet obligations put on countries listed in Annex I to the Protocol.

Poland is not only a party to the Climate Convention, and not only did it ratify the Kyoto Protocol, but it actively strives to increase the absorption of greenhouse gases, through e.g. pursuing its forest policy (Forest… 1997] and increasing the forest cover to the planned 30% in 2020 and 33% in the middle of the 21 century. The Polish forest policy is focused on the sustainable and multi-functional character of the forest management, which means that it fulfils protective environmental functions, including the protection of climate. The accumulation of carbon in biomass and in soils reflects Criterion No.1 of the sustainable forest management (C1. Maintenance and appropriate enhancement of forest resources and their contribution to global carbon cycles), which was adopted at one of the ministerial conferences on forest protection in Europe (Anonym 2001).

According to the obligations resulting from the Kyoto Protocol, Poland reports the carbon dioxide quantities emitted and sequestered every year, including the activities within the category Land Use, Land Use Change and Forestry (LULUCF). This sector, from the point of view of the effects of forest management on the emission balance, is very important, because it includes the potential capabilities of forestry to reduce the greenhouse gas net emissions. This sector may also contribute to mitigating climate change not only through reductions in GHGs emissions, but also by preserving and enhancing carbon dioxide sinks and its stored pools.

The reported information on forestry includes activities in afforestation, reforestation, deforestation and in forest management. In particular, the changes in carbon stocks in the aboveground and belowground biomass, in forest litter, dead wood, forest soil and harvested wood products are reported. The detailed principles for preparing and running emissions accounts for this sector are included in the decision of the EU Parliament and the Council on accounting rules on GHG emissions and removals resulting from activities relating to land use, land-use change and forestry 539/2013/UE (Anonym 2013).

Data covering the emitted and sequestered quantities of CO_2 in the forestry sector and regularly reported

to the Secretariat of the Climate Convention make it possible to analyse the importance of the forestry sector in the LULUCF category. It also allows to assess the potential monetary gains from the sector, when it is included in the climate policy framework and if it becomes a part of the emissions trading system. The purpose of the research was to assess the position of forestry on the background of GHG emissions and removals in Poland. An attempt was made to estimate the hypothetical value of carbon stored in forestry, resulting from afforestation, reforestation, deforestation and forest management.

Moreover, the problem of potential financial gains from forestry can be seen in the context of sequestration promoting carbon forest complexes (CFC) (Drabarczyk 2016), being currently developed. These forest complexes aim at intensifying carbon sequestration in forestry and bringing the CO_2 absorbed by forestry into the EU Emissions Trading Systems and other trading schemes currently operating in the world.

Material and methods

The data on the emitted and sequestered amounts of GHG are based on the figures taken from the national inventory submissions by Poland for 2017 to the United Nations Climate Change (Anonym 2017) and Poland's National Inventory Report 2017 submitted under the UN Framework Convention on Climate Change and its Kyoto Protocol (Olecka et al. 2017). The analysis of the LULUCF sector included the emitted and absorbed quantities of carbon dioxide and other GHGs, expressed as CO_{2e}, for the period from 2010 to 2015.

The potential monetary value of the absorbed net carbon dioxide was calculated based on the data from the above mentioned documents and it covered the period from 2013 to 2015, because the second commitment period (CP2) started in 2013 and so far the data for three first years of that period have been published. For the calculation of the potential income (PI) due to carbon dioxide absorbed by the forestry sector ($PI_{CO2e\ For.}$) the following formula was adopted:

$$PI_{CO2e\ For.} = (SFM - FMRL_{POL} + AFF - DEF) \times C_{CO2e} \quad (1)$$

where:

SFM – sequestration resulting from forest management [Mt CO_{2e}],

$FMRL_{POL}$ – Forest Management Reference Level for Poland [Mt CO_{2e}],

AFF – sequestration due to afforestation [Mt CO_{2e}],

DEF – emissions due to deforestation [Mt CO_{2e}],

C_{CO2e} – adopted price of 1 tonne of CO_{2e}.

The reported sequestration from forest management (SFM) included all human-induced changes in forest cover and growth from practices applied to a forest which affected its ecological, economic or social functions.

The prices of one tonne of CO_{2e} that were adopted for the calculations were the average monthly prices of European Union Allowances (EUA) for 2013, 2014 and 2015, reported from the CO_2 market (Anonym 2017). The purpose of adopting these prices for further calculations was to assess potentially expected monetary gains, assuming that CO_2 emissions and sequestration by forestry in the near future will be similar to those in the recent past. It should be remembered however, that GHGs emitted by the LULUCF category (including forestry) are not covered by the present emission trading system. In order, however, to estimate the potential value of the GHG emissions by forestry, a monetary value of a CO_2 unit must be adopted, and that of UEA seems reasonable. The data on current CO_{2e} prices in systems trading in carbon in other countries/continents were adopted from ICAP (2018), and the information on exchange rates was taken from relevant internet resources (X-rates 2018).

According to the methods of calculating GHG emissions and sequestration due to forest management, valid for the present accounting period, the yearly sum of GHG emitted and absorbed by forest management was put against the Forest Management Reference Level (FMRL) and the net result presented the actual amount of GHG emitted or sequestered by forest management that could be put to the country's credit. The Reference Level for Poland was set at 27,133 Mt of CO_{2e}, and published in the Decision 529/2013/UE (Anonym 2013).

Results and discussion

The total reported GHG emissions for 2015 (Olecka et al. 2017) amounted to 385842,89 kt CO_{2e} without LULUCF and 356997,9 kt CO_{2e} with LULUCF. The LULUCF sector itself, responsible for the GHG removal at a level of 28844,99 kt CO_{2e} set off 7.5% of the emissions. An analysis of the data on the LULUCF sector for the last 6 years based on the data reportedby the National Centre for Emissions Management (KOBiZE) (Olecka et al. 2017) for 2015 showed that forestry, with 36813,83 kt CO_{2e} on average, presented the largest CO_{2e} net sink in the LULUCF category. Harvested Wood Products (HWP) and Grassland – other CO_{2e} sinks in this category – absorbed only 3803,71 and 384 kt CO_{2e}, respectively. They also contributed to the removal of carbon dioxide from the atmosphere, however to a much lesser degree. Considering the areas under different land use activities, it turned out that, when referred to the area, forests absorbed almost 3.9 tonnes of CO_2 per ha (Tab. 1).

The data from the period between 2013 and 2015 proved the significance of carbon dioxide quantities absorbed by forestry (Tab. 2). The average quantity of the sequestered CO_2 by forest management above the Forest Management Reference Level (27.133 Mt) was 12 Mt CO_{2e}, varying from 18.3 Mt CO_{2e} in 2013 to 6.9 Mt CO_{2e} in 2015. On average, yearly afforestation activities led to the sequestration of 2.8 Mt CO_{2e}, while deforestation was a source of emissions at a level of 0.27 Mt CO_{2e}. This confirmed the vital role of forest management (art. 3.4 of Kyoto Protocol) in the net sequestration of GHG. On average, the total forestry sector absorbed nearly 15 Mt of carbon dioxide (CO_{2e}) per year (above FMRL).

Table 1. Average CO_{2e} emissions and sequestration values for different land use categories between 2010–2015, based on Olecka *et al.* (2017)

Land Use Category	Emissions/ removals (tonnes CO_{2e})	Area (ha)	Emissions/removals per area unit (tonnes $CO_{2e} \cdot ha^{-1}$)
Forests	–36,813,830	9,355,800	–3.93
Cropland	444,000	14,112,600	0.03
Grassland	–384,490	4,168,310	–0.10
Wetlands	4,520,670	1,368,710	3.30
Settlements	1,197,990	2,165,430	0.69

(sign „–" means sequestering)

Table 2 presents amounts of carbon dioxide absorbed due to activities within the forest sector. The sequestered amounts of CO_2 due to forest management were set against the reference level adopted for Poland, added to the net afforestation/deforestation value and multiplied by the price, resulting in the potentially expected monetary gains.

Considering the fact that the system of forest carbon complexes (CFC) promoting sequestration is being developed, aiming at the inclusion of the carbon dioxide sequestered by forestry in the carbon trading schemes, the potential incomes resulting from the sale of carbon units, assuming the average CO_2 price in recent years, were calculated. The price and the potential income are presented in the two right hand columns of Table 2. As-

Table 2. Reported CO_{2e} sequestration and emissions values by the forestry sector and potential incomes from CO_{2e} sequestration between 2013 and 2015

Year	Sequestratation due to forest management SFM	Afforestation AFF	Deforestation DEF	Forestry in total SFM – $FMRL_{POL}$ * + + AFF– DEF	Price of 1 tonne CO_{2e} C_{CO2e}	Potential gains $PI_{CO2e\ For.}$
1	2	3	4	5 = 2 + 3 – 4	6	7 = 5 · 6
		(kt CO_{2e})			(EUR · tCO_{2e}^{-1})	(1000 EUR)
2013	45,448.98	2,844.38	203.67	20,956.69	4.48	93,886
2014	38,107.10	2,818.22	316.94	13,475.38	5.97	80,448
2015	33,993.79	2,851.87	301.57	9,411.09	7.68	72,277
Average	39,183.29	2,838.16	274.06	14,614.39	5.62**	82,204

* $FMRL_{POL}$ Forest Management Reference Level adopted for Poland is 27133 kt CO_{2e}; ** weighted average.

suming the average carbon dioxide price of 5.89 EUR per 1 tonne of CO_{2e}, about 88 million Euros in one year could be expected. Although, forestry is not yet covered by the EU emissions trading scheme today, the above given values can present a monetary picture of forestry as a carbon dioxide sink.

Table 3 presents the present hypothetical monetary value of carbon removals in the forestry sector that could be gained if forestry were included in emissions trading systems. The systems listed in Table 3 do not include forestry, except for the New Zealand Emissions Trading Scheme (NZ ETS). This emission trading system is unique, as it is the only ETS in the world that deals in carbon allowances related to the forestry sector. The purpose of including forestry in the emissions trading scheme was to promote planting of forests and improving forest management so that it would increase the levels of carbon sequestered in forests. The carbon prices are highly volatile, depending on the carbon trading system and time, as e.g. the EU ETS price of carbon with 7 EUR per tonne is much higher than that in Table 2.

Table 3. Hypothetical monetary values of Polish forest carbon credits, if traded worldwide

Emissions Trading System	Price* of carbon in EUR/CO_{2e}	Potential value of Polish forest carbon credits in mill. EUR
California-Quebec	12.32	179.98
China-Beijing	6.55	95.73
China-Chongqing	2.48	36.21
China-Guandong	1.77	25.81
China-Shanghai	4.51	65.85
China-Hubei	1.95	28.44
China-Shenzen	3.20	46.73
China-Tianjin	2.09	30.59
China-Fujian	2.80	40.87
EU ETS	7.00	116.77
Republic of Korea	16.89	246.90
New Zealand	12.67	185.24
Ontario	11.43	167.07
RGGI (Regional Greenhouse Gas Initiative)	3.42	49.95
Switzerland	6.37	93.10

* Prices for January 17, 2018.

The price of carbon is highly volatile, as one can gather from Tables 2 and 3, but the resulting hypothetical gains are informative about the order of magnitude. The information about the monetary value of carbon credits produced by the forestry sector can induce climate friendly investments, contributing to the protection of climate.

The mitigation effect produced by forestry in Poland amounts to 9.3% of the GHG emissions (excl. LULUCF). That is slightly less than the overall effect of the European forestry. According to Nabuurs et al. (2015) forest and the forest sectors in the EU produced a climate mitigation effect reaching 13% of the EU's emissions, however their estimate included not only the sequestration effect, but that of substitution as well.

The results of the analysis presented above show that the LULUCF category, including forestry as its leading component, presents not only a considerable CO_2 sink, but it can also make considerable financial gains. Although these gains are hypothetical today, their considerable value is clearly visible.

The idea of including forests in the carbon accounting scheme remains controversial. There are well-grounded concerns that some countries rich in forest resources might use the natural forest growth to escape from problems related to reforming their energy and industry sectors. It is extremely difficult to differentiate human-induced contributions from natural effects of storing carbon in forest ecosystems. There are still many questions in the area of climatic impacts by forestry that call for caution when including forestry practices in the GHG emissions accounting system. On the other hand, however there is still carbon sequestration potential that could go well above the present sink and provide financial gains to those who put an effort to mobilize this potential. One may argue that including forestry in the European climate policy framework and in the emissions trading mechanism can lead to beneficial developments in the forest sector, reaching far beyond the protection of the existing forest ecosystems. The complexity of the problem of accounting forestry management activities is stressed by Krug (2018) who presents the evolutionary way that the LULUCF sector accounting process has taken since the time the Kyoto Protocol came into force. Even today, with the Paris Agreement in force, with its goal to achieve a emissions/removals balance by mid-century, the approach

to the inclusion of forestry in the climate policy framework is rather cautious.

Although the formula used in the above presented analysis is simple and includes only such activities as afforestation, deforestation and forest management, there have been other attempts to estimate the mitigation effect of forests. Some older analyses (Karjalainen et al. 2003) focus on the effects of forest management and climate change on the carbon budget in the forest sector in Europe. Recently, some researchers (Nabuurs et al. 2017) have projected an additional sequestration increase of about 172 Mt CO_2/y by 2050 at the UE level, resulting from improved forest management alone. The researchers advocate the concept of climate smart forestry (CSF) to enhance the mitigation potential. No doubt, forests are a vital factor in shaping climate and have a considerable potential in mitigating its change.

The fact that on the one hand the carbon emissions/sequestration from forestry have to be reported, but on the other hand the carbon removal potential by forests is not used in the best way, nor is it incentivized, is noted by many researchers (Nabuurs et al. 2015; Ellison et al. 2014). Ellison et al. (2011) suggest a broader scope of carbon pools accounted under LULUCF (and forestry which takes the lion's share in this sector) which should include the promotion of standing forests, harvested wood products and bioenergy. They also confirm the need to reform the climate policy framework, and possibly to include the LULUCF sector in the Emissions Trading Scheme. In this context the Polish idea of Carbon Forest Complexes, aimed at enhancing forest biomass growth and carbon sequestration is interesting and worth pursuing.

At present the issues of the inclusion of LULUCF into the European climate policy framework are subjects of intensive EU-level debate, and a regulation regarding this problem is undergoing the legislative process (Erbach 2018). The provisional agreement is pending the formal approval by the European Parliament. Forestry will most probably be included in the climate policy framework 2021–2030. The technicalities of accounting carbon credits produced by the forest sector can be discussed, but the fact is that forestry is gaining its momentum. The way how land is used is becoming more and more important in tackling the climate change, as it is clearly visible that curbing the emissions by improvements in the energy and industry sectors is not enough to reduce the risk of a climate disaster.

Conclusions

The industrial human activity has brought about many negative effects, of which the climate change is perhaps one of the worst. The general scientific community agrees that the main cause of change in the climatic system of the Planet is caused by burning fossil fuels. Another important factor affecting climate is the way land is used. Hence the importance of the land use, land use change and forestry in tackling the problem. The LULUCF sector with the dominating role of forestry in the sector is becoming more and more important, especially now, with the Paris Agreement in force demanding that GHG emissions be balanced by removals, and by forests in particular. Managing forests by actively pursuing silvicultural activities leading to enhanced carbon sequestration, forest protection and utilization with a view to producing bio-energy and/or storing carbon in wood products can be perceived as an important tool in fighting climate change. In the case of Poland, carbon sequestered due to forest management activities considerably exceeds the carbon quantities removed from or delivered to the atmosphere in course of afforestation or deforestation. The above presented analysis shows that enhancing carbon sinks and pools in the forestry sector above preserving the natural forest cover and continuing the traditional business-as-usual strategy, should rather be oriented towards active management of this ecosystem. Although forestry is not included in the European climate policy framework, nor can the carbon credits earned in the forest sector be traded in, it could be a potential source of considerable monetary gains, on the order of about 80 million Euros on the yearly basis, if included in the e.g. EU Emissions Trading System. Although the calculated monetary value is still hypothetical, it may provide the public with the idea how much the forest sector is worth in the context of carbon sequestration. The activity of man, which, as it is commonly perceived, has contributed to dangerous and negative climate changes, can also lead to the mitigation of the climate change or even to some improvements in the situation. Forestry can be a good example of such activities.

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