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Environmental and economic assessment of biomass sourcing from extensively cultivated buffer strips along water bodies

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ABSTRACT

Buffer strips represent oblong land elements along water bodies playing an important role for the water quality management of the surface water. In the policy context buffer strips are referred to as land with defined farming restrictions aiming at protecting the water course. In the current EU agricultural policy framework the majority of the decisions regarding subsidy schemes for buffer strips is taken on the member country level, which results in great differences between the EU members with regard to this water protection measure. If incentives for farmers for establishing and maintaining buffer strips are in place, they are usually linked to the harvest ban on the buffer strip. Such protection model can be endangered by volatile and rising prices for agricultural products. However, buffer strip can represent a valuable source of different ecosystem services, including biomass provision. If harvesting under certain restrictions would be allowed, the biomass could generate additional revenue that might contribute to securing buffer strips existence and consequently maintaining their protection function.

This study aimed at assessing the costs and environmental consequences of biomass mobilizing from buffer strips. It dealt with different scenarios of biomass sourcing from extensively cultivated buffer strips in the Netherlands. In 12 scenarios, the cultivation of grass or cereal mixes (including multiple harvesting or perennial cultivation) for different valorisation chains (ensiling or fodder & bedding) was assessed. Both total net cultivation costs as well as the hectare based environmental performance (using the Life Cycle Assessment methodology) were evaluated. Additionally, the environmental impact of electricity production through anaerobic digestion of biomass from buffer strips was compared with the impact from digestion of classic grass silage and the impact profile of Dutch electricity mix.

The results indicate ensiling as the scenario generating more net costs and higher environmental impacts as compared to fodder & bedding. In the latter, the cereal cultivation represents a better solution from economic perspective, while grass shows lower environmental impacts. Moreover, optimizing grass cultivation through switching to perennial mode contributes to strong improvements of the economic performance and contributes to additional reduction of environmental impacts, and consequently delivers the best environmental and economic solution. Moreover, the comparison with the Dutch electricity mix shows that biomass from buffer strips, if used in anaerobic digestion, can, in terms of environmental performance, compete with classic silages and contribute to reduced environmental damage.

1. Introduction

Buffer strips (BS) represent oblong land elements along water bodies playing an important role for the water quality management of the surface water. In the policy context BS are referred to as land with defined farming restrictions aiming at protecting the water course (Stutter et al., 2012; Hauck et al., 2014). The introduction of agriculture limiting measures on BS allows reducing nutrients and pesticides runoffs from the agricultural fields, which could otherwise more easily enter the local surface waters (Arora et al., 2010; Weissteiner et al., 2014; Reungsang et al., 2001; Osborne and Kovacic, 1993). The sustained vegetation, through its root system, helps preventing soil erosion and stabilizes water body banks (Verstraeten et al., 2003, 2006), but can also moderate flood damage, enhance carbon sequestration effects and support groundwater

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recharge (Xue et al., 2014). For arable land, depending on the width and the distance from the water body, the BS linked measures usually concern limitations or total abolition for application of pesticides, herbicides, mineral and (or) organic fertilizers. Additionally, for BS included in particular subsidy schemes the type of cultures allowed to be grown or even the cultivation mode including harvest abolition might be pre-defined. Moreover, the restrictions can also concern other types of land use, such as livestock grazing.

In the EU some of the above mentioned measures resulting from the Cross Compliance (EC, 2009a,b) are mandatory for the farmers receiving direct EU payments and the payments forming part of the rural development policy (EC, 2015a,b). Nevertheless, the policy interpretation and implementation, and the pre-defined financial support for BS in Europe differ from country to country (EC, 2013). In the Common Agricultural Policy (CAP) after 2014, the special function of BS for the environment and biodiversity has been recognized and the BS understood as areas without regular farming regime have been included in the greening measures as so called ''ecological focus areas (EFAs)'' with the hope of encouraging farmers to implement these measures. However, the choice of BS as a reported EFA measure is voluntary and depends on the individual farmer's perspective. In general, for the majority of national schemes in the EU, if the BS is a subject of subsidy then the cultivation (even in an extensive way) or harvesting and use of biomass from BS are either entirely prohibited or only conditionally permitted. This means that the only profit of the farmer from land defined/declared as a BS in these schemes is that generated through the subsidies. Such situation makes the land owner not only entirely dependent on the financial support but might also create risk for sustaining of the BS as environmental protection measure. Thus, the potential food price increase could make maintaining BS less profitable to a farmer, than regular crop cultivation (even if underlying certain environmental restrictions). If some of the existing BS would be shifted to regular crop production, it could have a strongly negative effect on the water quality of the water bodies protected through the BS. Therefore, on one hand there is a clear need to search for a profitable but low-impact use concepts for BS to ensure continuity for the water protection and to reduce the dependency of farmers on subsidies, while on the other hand the European policy should be more standardized and harmonized to overall allow involving BS as an important water protection measure including an option of biomass sourcing. In this context, DLV Plant, in the framework of the ARBOR project (ARBOR, 2015), has launched a pilot study in the Netherlands aiming at finding new concepts of extensive BS use. Such concepts are based on the minimisation of environmental impacts and maximisation of economic revenues and should allow for (i) sustaining the water and soil protection function of the BS, (ii) generating additional profit for the farmers to prevent them from reuse of their BS for conventional farming and (iii) mobilizing locally sourced biomass streams to supply regional demand.

The majority of available studies related to BS focus on the analysis of BS in the context of the supply of ecosystem services (Farmer et al., 2008; Lyons et al., 2000; Christen and Dalgaard, 2013; Hauck et al., 2014), e.g. water protection, increase of biodiversity and habitat quality, increase of carbon sequestration and other ecosystem services like nutrients cycling, noise buffering, etc. Since in the common understanding BS are not perceived as biomass provisioning systems, the literature on evaluations of production costs and benefits and assessment of environmental impacts associated with biomass production provided through BS, is very scarce (Gopalakrishnan et al., 2009; Eranki et al., 2013; Ferrarini et al., 2014). This paper presents the results of an environmental and economic assessment for different extensive BS use concepts for the Dutch demonstration sites established in the framework of the ARBOR project. To broaden the analysis and interpretation of the environmental implications associated with the BS concept, two supply chains for the BS biomass were investigated (production of silage, which could be further used as a fodder or for energy production via anaerobic co-digestion (AD), and production of hay, grain and straw which could be overtaken by agricultural production systems) and modelled according to data from existing life cycle inventory databases. These two possible functions were then compared to the 'business as usual' scenario (in which the biomass from BS is not used and no cultivation practices are allowed) and to the scenario in which the BS area is instead dedicated to intensive cultivation of agricultural crops for food production. The rationale behind the choice of the intensive cultivation on BS as one of possible scenarios is explained more in detail in Section 2.2.

2. Material and methods

2.1. Demonstration site and primary data sourcing

The analysed demonstration sites have been established on land formerly used for regular agricultural activities, such as conventional cultivation of potatoes, onions, sugar beet, wheat, etc. The three parcels are 9 m wide and 493 m, 658 m and 518 m long BS (in total 1.5 ha), located along important water canals in Pannekeet, Waesberghe and Schaapstal (the Netherlands). The BS consisted of a 6 m wide strip along the water bank on which grass mixes were grown, and a 3 m wide parcel part between the grassy strip and the crop producing field, on which cereal mixes (wheat, barley and rye) were planted. Neither pesticides nor fertilising agents were applied during cultivation. During the investigation period, the planted cereal and grass mixes were mown once a year, but the crops were left on the fields mainly due to the current policy in the Netherlands (MEA, 2014), which does not allow harvesting biomass from BS. In general, due to this policy related harvest ban, no valorisation concepts currently exist for the biomass from BS. Consequently, different macro scenarios of biomass sourcing have been developed within the study (see Section 2.2) to investigate potentials of biomass provisioning.

Based on the data from the demonstration sites, the economic and environmental assessments have been conducted. Since the BS was cultivated in an extensive way, the potential yields are not comparable with the conventional farming outputs. Due to above mentioned policy related constrains no primary data with regard to the biomass yields were available for the BS. Hence, the estimated yield data was based on expert's judgment (DLV Plant and buffer strip owner) and literature (KTBL, 2006; Eurostat, 2015). Depending on the analysed scenario (see Section 2.2), the following yields were estimated per harvest and ha: 7.5 t of grass silage, 17 t of cereal whole plant silage, 3 t of hay, 3 t of grain and 2 t of straw. For the comparison with classic agriculture the average yield values for field production of onions (47 t/ha), potatoes (44 t/ha), wheat (8.5 t/ha) and sugar beets (74 t/ha) for the Netherlands were used based on data from Eurostat (2015) and Nielsen et al. (2003).

2.2. Analysed scenarios

Four alternative scenarios were elaborated to compare current to previous BS cultivations, as well as the different final products that could be generated for the uptake in alternative valorisation chains.

2.2.1. Greening scenario (SC_GRE)

Greening Scenario (SC_GRE) reflects the current use of BS, i.e., establishing vegetative cover of the strips (grass or cereal mix), mowing after the end of summer and leaving the mown crop on the