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Potential of land use activities to offset road traffic greenhouse gas emissions in Central Spain

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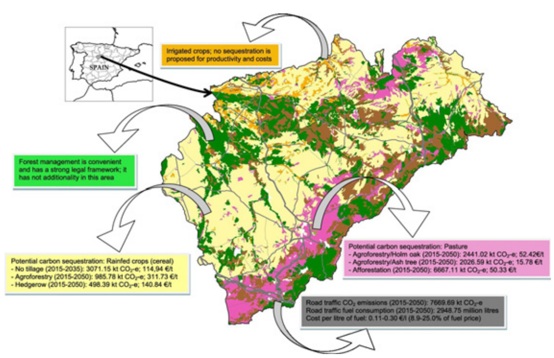
HIGHLIGHTS

- Offsetting road carbon emissions through land use activities is possible in Spain.
- It is possible to link carbon sequestration, biodiversity and rural development.
- The challenge to offset carbon emissions is funding.
- It is possible to apply a fuel tax, in accordance with the polluter-pays principle.

GRAPHICAL ABSTRACT



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ABSTRACT

The transport sector is one of the main sources of greenhouse gases, adding in Spain near a quarter of the total national emissions, the majority in road transport. Therefore, road contribution to climate change should be mitigated to achieve the proposed goals in the fight against climate change. Policies and strategies suggest several preventive mitigation options, but have paid little attention to compensatory mitigation. We have conducted a theoretical case study in a Spanish province, Segovia, estimating the carbon dioxide emissions in the road network between 2015 and 2050, and analysing different compensation possibilities through conservation agriculture, agroforestry, afforestation and hedgerow plantation. We have calculated carbon sequestration in the reference period and costs per tonne for each option, estimating the budget range of offsetting road carbon emission, and funding possibilities, especially through fuel taxes. The paper demonstrates that offsetting carbon emissions produced by roads in this area is technically possible and highly desirable, unifying carbon sequestration, biodiversity improvement and rural development. The main challenge is funding, which depends largely on the political will and the awareness of the citizens.

1. Introduction

Climate change is a major global problem, caused by the emission of greenhouse gases (GHG) and, with significant but smaller importance, by the destruction of sinks; both aspects increase the atmospheric concentration of GHG, exacerbating the natural greenhouse effect.

Numerous activities contribute to GHG emission, and only a few can act as sinks. Transport sector is a key emitter activity, representing almost a quarter of Europe's GHG emissions. Although GHG emissions in the EU-28 were down by 22.9% in 2014 compared with 1990 levels (EUROSTAT, 2016), transport has not seen the same gradual decline as

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other sectors; emissions only started to decrease in 2007 and still remain higher than in 1990 (EC, 2016). Within the transport sector, the contribution to GHG emissions of road transport is especially remarkable; according to the Spanish 2014 GHG inventory, road transport emits 75,652 kt CO_2-e, 23% of the GHG national emissions (MAPAMA, 2016).

The European Strategy for Low-Emission Mobility (EC, 2016) proposes that GHG emissions from transport will be at least 60% lower than in 1990 by midcentury, identifying three priority areas for action: increasing the efficiency of the transport system, speeding up the deployment of low-emission alternative energy for transport, and moving towards zero-emission vehicles. To achieve these objectives, there are already some regulations, such as those aimed at reducing emissions from new passenger cars (EU, 2014). In road transport specifically, climate change mitigation is proposed through: improvement in vehicle efficiency; low carbon fuels; reduction of road traffic; intermodal connections; public transport; non-motorized mobility; modal shift to railway; behavioural changes (avoidance of unnecessary trips, efficient driving); fuel taxes; sustainable mobility in urban planning; greater occupancy of vehicles; or environmental criteria in urban parking management (MMA, 2007; Sims et al., 2014; MAGRAMA, 2015).

The effects of climate change are tangible and demand actions; climate change mitigation is necessary, and urgent, to achieve the goals of the climate agenda. According to the mitigation hierarchy, negative environmental impacts should be avoided, if this is not possible then corrected and, as a last option, compensated. The current approach on climate change mitigation in the transport sector places emphasis on preventive mitigation, undoubtedly the best strategy to avoid GHG emission. In addition, the regulatory framework for GHG emissions pays particular attention to regulated sectors such as industry and energy, subject to carbon trading according to the Kyoto Protocol (UN, 1998) and the EU Directive 2003/87/EC (EU, 2003), but these schemes leave out diffuse sectors such as transport. However, in order to support the path towards reducing emissions, compensatory mitigation should not be undervalued as a complementary strategy, which would allow a reduction in the short or medium term of atmospheric concentrations of GHG while achieving the main mitigation objectives.

Offsetting GHG emissions is not attracting much attention. Some papers have related urban green areas with offsetting carbon emissions (Jo, 2002; Zhao et al., 2010). Martin and Point (2012) analyse the budget for financing GHG emissions offsetting projects in roads based on the opportunity costs. There are not case studies on direct offsetting of road GHG emissions, probably due to the dissociation between the impact, GHG emission, and the possible compensation.

Compensatory mitigation for climate change may be done through a reduction in atmospheric GHG concentration, with natural sinks or artificial capture and storage. Land Use, Land Use Changes and Forestry (LULUCF) activities have an enormous potential for carbon sequestration, with associated advantages as landscape and biodiversity improvement, especially forest-based measures, which merits consideration as cost-effective actions in the climate change policies (Galik and Jackson, 2009; Lubowski et al., 2006). LULUCF is the only net sink sector, and although traditionally excluded from GHG accounting, the 2030 EU Climate and Energy Framework (EC, 2015) will include it, which would imply a boost to these activities as a means to contribute to the achievement of the countries' climate goals.

In biodiversity compensation it is usually preferable using on-site measures (Cuperus et al., 1999; Rajvanshi, 2008), but in GHG compensation there is no such need, and can be off-site. This has led to numerous carbon offset projects being shifted to developing countries, where their implementation is cheaper and it is possible to use avoided deforestation schemes not applicable to developed countries. This has advantages, such as mobilizing capital from developed to developing countries, but also disadvantages, such as not to assume locally the impacts associated with development and minimizing the costs offshoring the compensation. Although it is possible, and probably necessary, to compensate in third countries, it would be also desirable to implement local GHG offsetting projects, so that compensation is assumed where the emissions are produced. This may have several advantages. On the one hand, the concepts of impact and compensation, which are otherwise dissociated, are linked. On the other hand, the cost of compensation is more real; if the impact occurs in a developed country and compensation in a developing country, the economic measurement scale is different. The benefits of climate change mitigation are global, but usually not tangible at the local level (Wilbanks et al., 2007; Klein, 2011), which can reduce social acceptance; in local compensation the investments are locally tangible. Finally, emission targets are set at the country level, so local actions through LULUCF activities have a positive influence in the nations' GHG balance, aiding to achieve emission targets.

Compensatory mitigation through LULUCF activities is effective to reduce atmospheric CO_2 concentration only in a short span of time on geologic scale, but no permanently, because the carbon is fixed in lignocellulosic products, with a variable but limited duration before decomposing and releasing back into the atmosphere. Consequently, sequestration is not an alternative to reducing GHG emissions. However, although technological advances are progressively faster, the urgency to reduce atmospheric concentrations of GHGs is even greater, so it is highly advisable to adopt all kinds of complementary strategies, including compensatory mitigation, which, moreover, have other induced benefits, ecological, social and landscape, if they are well designed.

The aim of this paper is to analyse the feasibility of offsetting locally the GHG emissions generated by a road network through LULUCF activities under a Mediterranean climate, without environmental or social impacts, determining the costs and funding possibilities.

2. Methods

2.1. Research questions

There are two research questions: (i) Is it technically possible to offset locally the GHG emissions of a road network through LULUCF activities under a Mediterranean climate, without environmental or social impacts? (ii) If possible, what are the costs, how they are compared to the current carbon markets, and how could be funded?

To answer these questions, first we made a forecast of the CO_2 emissions in a spatial and temporal scope, to determine the amount of compensation that must be provided. Then, we have proposed compensation possibilities based on LULUCF activities, following a triple objective: carbon sequestration, biodiversity and landscape improvement and rural development. For each measure, we have analysed the technical feasibility and costs, discussing their potential and funding possibilities. The future trends discussed on this paper are based on existing

Table 1
Land uses in Segovia province in 2013.

Land use				Area (ha)	Percentage (%)
Arable land	Herbaceous crops	Rainfed	Cereal	167,365	24.18
			Other	35,823	5.17
		Irrigated		17,416	2.52
	Fallows			2756	0.40
	Woody crops			43,645	6.30
Meadows and pastures	Natural meadows			6139	0.89
	Pastures			129,511	18.71
Forest land	Timber woods			119,302	17.23
	Open wood			33,913	4.90
	Shrub wood			35,236	5.09
Other areas	Wasteland pasture			54,783	7.91
	Unproductive land			4832	0.70
	No agricultural area			34,602	5.00
	Rivers and lakes			6929	1.00
				692,252	100.00