Agroforestry can mitigate environmental problems in European agricultural deficit areas

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Abstract

Agricultural production is one of the main causes for pressure on natural resources and environment in Europe. Agroforestry is known to provide food, fodder and material while enhancing ecosystem services and environment. In this context, this study evaluates how agroforestry can help to reduce environmental pressure in Europe. In the first step, we localised environmental deficit regions in European farmland areas based on a literature review and existing digital spatial information. For the second step local agroforestry experts were consulted to propose agroforestry systems, which they recommend to farmers of those regions to mitigate the environmental deficits.

Keywords: ecosystem services; deficit regions; carbon storage; biodiversity

Introduction

In Europe, environmental pressures such as water pollution or impacts of climate change have been increasing over the last decades. With the Nitrate Directive (91/676/CEE) in 1991, the Water Framework Directive (Directive 2000/60/EC) in 2000, and the Biodiversity Strategy in 2010, the European Commission showed awareness to environmental problems and tried to mitigate undesirable effects. Nonetheless, these problems persist and are linked to or caused by (intensive) agricultural production.

In this context, agroforestry (AF) can play an important role in future agricultural policy to mitigate critical emissions: agroforestry systems are known to simultaneously provide food, fodder and material whilst generating ecosystem services such as soil protection, water regulation, landscape diversity and (functional) biodiversity (Torralba et al. 2016). Additionally they have a great potential for climate mitigation and adaption (Hart et al. 2017).

Against this background, the European AGFORWARD project (www.agforward.eu) tried to [illegible] above-mentioned environmental targets. The study presented here was conducted as part of this project and is organized in two steps: First, based on a literature review and existing digital spatial information, farmland areas with potential (overlapping) environmental deficits in Europe were localised. Secondly, local agroforestry experts were consulted to propose agroforestry systems, which they recommend to farmers of those regions to mitigate the environmental deficits.

Materials and methods

In this study, the focus was on agricultural land in Europe, both arable land and grassland (Tóth et al. 2013; BFS 2015) without the Natura 2000 areas (EEA 2015), existing Agroforestry areas (den Herder et al. 2017) and the High Nature Value Farmland (EEA 2015). We proceeded in two steps:

1. Based on literature and existing information, we identified areas with potential environmental deficits in i) soils (soil erosion by wind and water, soil organic carbon), ii) water (water pollution by nitrates, water use efficiency in irrigated land), iii) affected by climate change (e.g. rising temperature) and iv) deficits in ecological functions (pollination and pest control deficits, threats to soil biodiversity). These analyses resulted in nine continental scale maps of ecosystem service deficits. By combining the maps, we created a heat map for environmental deficits to identify priority regions for the implementation of AF.

2. Based on participatory research and development (R&D) in 40 AGFORWARD working groups across Europe, we propose specific agroforestry systems that can mitigate the above-mentioned deficits and reduce the critical loads. Those systems are tailored to the respective deficit regions and based on advice from local agroforestry specialists. This resulted in a matrix of agroforestry systems divided into arable and grassland.

Results

In total, more than half of European agricultural was in good condition and grasslands were less harmed than croplands. While e.g. climate change (temperature increase > 2°C until 2050) affected more than 80% of arable and grasslands; soil erosion by wind was almost not relevant. The worst 10 % of the area with accumulated deficits were defined as priority regions, where the implementation of AF can be particularly effective. Regional hotspot areas for environmental deficits are the north-western part of France, Denmark, the centre of Spain, the North (Po region) and the south-west (Sicily) of Italy and the eastern part of Romania.

Regional experts suggested suitable agroforestry systems for affected cropland and grassland per biogeographical region. Table 1 gives an extract of the recommended systems, the potential tree species, number of trees per hectare, tree products and suitable crops.

Table 1: Extract of expert recommendation summary of suitable agroforestry systems

Region	Type	Species	Trees ha^{-1}	System	Crops	Tree Products
Mediterranean lowlands	Silvopastural single trees	Poplar; Peduncolate oak	57	lines	grass	fodder tree, timber
Mediterranean hills	Silvoarable single trees	Fruit trees	417	lines	fodder crops	fruits
Atlantic	Silvopastural single trees	Poplar	25	boundary	grazing, hay, silage	timber
Atlantic	Silvopastural single trees	Ash and Oak	400	single tree scattered	grazing, hay, silage	fodder tree, timber

Discussion

The analysis addressed nine deficits indicators and their occurrence in European agricultural land. The best available data were used, being aware that differences in scales (100 – 1000 m), time periods (2006 - 2017) and objectives (e.g. modelled nitrate losses in EU vs. nitrate losses in Switzerland) exist and might result in spatial inaccuracies (Schulp et al. 2014).

Additionally, our results provided ideas for suitable tree and crop species and a possible composition of agroforestry systems. Nonetheless, we are aware that the systems are highly dependent on soil, water and climate conditions of a specific plot or location. The underlying hypothesis that agroforestry can mitigate the environmental deficits was verified in various studies at plot and landscape scale (e.g. Nair et al. 2007; Reisner et al. 2007; McIvor et al. 2014).

Conclusion

The study provided an indication on where and which kind of agroforestry can mitigate the environmental problems in Europe and help to reach the ambitious European policy targets.

References

BFS (2015) Arealstatistik 2004 -2009. Bundesamt für Statistik, Neuchâtel. https://www.bfs.admin.ch/bfs/de/home/statistiken/raum-umwelt/erhebungen/area.html (accessed 18/04/2018).

den Herder M, Moreno G, Mosquera-Losada RM, Palma jhn, Sidiropoulou A, Santiago-Freijanes JJ, Crous-Durán J, Paulo JA, Tomás M, Pantera A, Papanastasis VP, Mantzanas K, Pachana P, Papadopoulos A, Plieninger T, Burgess PJ (2017) Current extent and stratification of agroforestry in the European Union. Agric Ecosyst Environ 241:121–132.

EEA (2015) Natura 2000 data - the European network of protected sites.

Hart K, Allen B, Keenleyside C, et al (2017) Research for Agri Committee - the Consequences of Climate Change for Eu Agriculture. Follow-Up To the Cop21 - Un Paris Climate Change Conference.

McIvor I, Youjun H, Daoping L, et al (2014) Agroforestry: Conservation trees and erosion prevention. Encycl Agric Food Syst 1: 208–221.

Nair VD, Nair PKR, Kalmbacher RS, Ezenwa I V (2007) Reducing nutrient loss from farms through silvopastoral practices in coarse-textured soils of Florida, (USA). Ecol Eng 29: 192–199.

Reisner Y, de Filippi R, Herzog F, Palma J (2007) Target regions for silvoarable agroforestry in Europe. Ecol Eng 29:401–418.

Schulp JEC, Burkhard B, Maes J, Van Vliet J, Verburg PH (2014) Uncertainties in ecosystem service maps: A comparison on the European scale. PLoS One. doi: 10.1371/journal.pone.0109643

Torralba M, Fagerholm N, Burgess PJ, Moreno G, Plieninger T (2016) Do European agroforestry systems enhance biodiversity and ecosystem services? A meta-analysis. Agric Ecosyst Environ 230: 150–161.

Tóth G, Gardi C, Bódis K, Ivits E, Aksoy E, Jones A, Jeffrey S, Petursdottir T, Montanarella L (2013) Continental-scale assessment of provisioning soil functions in Europe. Ecol Process 2: 32.