EIP-AGRI Focus Group Agroforestry

MINIPAPER 8: Important considerations and alternative approaches to assess ecosystem services in agroforestry systems
26 April 2017

Authors:

María Eugenia Ramos Font (Coord.), Fabien Balaguer, Martijn Boosten, Paul Burguess, William Consedine, María Rosa Mosquera Losada, Ralf Pecenka, Bert Reubens

funded by European Commission

1. Introduction and objectives

Ecosystem services represent the benefits human population derive, directly or indirectly, from ecosystem functions (Costanza et al. 1997), and they can be classified as provisioning, regulating, cultural and supporting services[1]. They have become the most widely used framework to study the relations between ecosystems (including natural and human-modified ecosystems) and people (Fagerholm et al. 2016). Agroforestry has been demonstrated to combine production with multiple ecosystem services and goods (McAdam et al., 2009); in fact it provides multiple ecosystem services, combining the provision of agricultural, livestock and forestry products with regulating services (climate regulation, pollination, disease regulation, water regulation and purification), cultural services (recreation, aesthetic, inspirational, educational, cultural heritage…) and supporting services (soil formation, nutrient cycling, primary production…).[1] In this context, there is a general need to gain more insight into the overall, total functioning of an agroforestry system (or any agroecosystem), i.e. a broad picture of the simultaneous and multiple services provided by such a system. This is necessary both to correctly valuate these systems, and to optimize their management (not focusing on only one function but rather on the overall best functioning). However, the assessment of the trade-off between production and other (regulating, cultural and supporting) ecosystem services provided by agroforestry systems can be challenging, as found in literature reviews (Torralba et al. 2016, Fagerholm et al. 2016). But also, the value attributed to specific functions might differ from situation to situation (for example sometimes erosion control in a local context is really a priority while in another context biodiversity increase is the most important), therefore, different weights might be attributed to different functions and as such this kind of assessments might contribute to decision making processes, policy incentives, etc. For example, it has been demonstrated that agroforestry systems have a greater potential of carbon sequestration (above and below ground) than traditional farming systems; and this carbon could be sold in carbon credits markets (Jose 2009). Additionally, the assessment of ecosystem services will allow not only to decide if agroforestry systems are to be stimulated in a certain context, but also which type of agroforestry systems, and where exactly.

In this context, this minipaper aims to i) make a short review of the state of the art of ecosystem services assessment in agroforestry systems, ii) provide a general framework for assessing ecosystems services, iii) make some recommendations for this assessment. Starting from there (but not further elaborated upon in this paper), one could tackle the challenges of (1) how farmers could better benefit (economically) from the ES and environmental benefits delivered (Payment for Ecosystem Services, carbon credits, etc.), and (2) how farmers themselves can further enhance the actual delivery of ES through management of their AF sites.

2. State of the art: which ES are studied and what effects of AF systems are found?

According to a recent review of methodologies used in ES studies in AF systems (Fagerholm et al. 2016), most of the studies related to agroforestry and ecosystem services are located in Spain, the UK and France, whereas agroforestry systems in the Nordic Countries and Eastern Europe were understudied. Regarding types of agroforestry systems, ES assessment is currently focused on spatially extensive wood pastures whereas forest lands and mosaics of different intensities received little attention. Regarding methodologies, stakeholder involvement, especially farmers, in ES assessment in AF systems needs to be increased. A small number of ecosystem services are usually assessed, the most common were provision of habitat and biodiversity, food, climate regulation, fibre, and fuel; however the consideration of cultural services has been largely limited to aesthetic value. Furthermore, biophysical measurement need to be complemented with monetary and socio-cultural valuation at the spatial and temporal scales, and social factors underpinning ecosystem services should also be considered. There is a need to develop mapping approaches to create spatially explicit models of service supply and demand across spatial and temporal scales, in fact, long-term studies are scarce. The majority of the studies focus on quantitative methods and biophysical field measurements addressing the assessment of only one or two services (Fagerholm et al. 2016). For example, climate regulation is usually assessed through C sequestration evaluations (Kirby and Potvin 2007; Ramachandran Nair et al. 2009); biodiversity can be evaluated be means of a wide range of indicators such as species and number of insects, birds, mammals, plants, etc. (Johnson and Beck 1988; Moguel and Toledo

[1] http://www.millenniumassessment.org/documents/document.300.aspx.pdf

funded by European Commission

1999; Harvey et al. 2006); nutrient cycling can be assessed by different soil microbial analysis (Lee and Jose 2003)

Torralba et al. (2016), who assessed in their review the actual effects of AF systems on ES delivery, showed that European agroforestry systems (both silvoarable and silvopastoral) generally promote the provision of biodiversity and ecosystem services compared to conventional agriculture. However, results were heterogeneous, with differences among the types of agroforestry practices and ecosystem services assessed. Erosion control, biodiversity, soil fertility, water quality, aesthetics and C sequestration are enhanced by agroforestry (Jose 2009) while there is no clear effect on provisioning services (Torralba et al. 2016) . Surprisingly, they also conclude that the effect of agroforestry on biomass production is negative. The positive effects of agroforestry on ecosystem services were evident apparent at a landscape and regional-scale than at a farm-scale. Additionally, most of the studies are short-term and address a small number of ecosystem services, as mentioned before, and stakeholder participation in agroforestry studies was very low. Therefore we are faced with the challenge how a more holistic evaluation of a wider range of ES could be performed, including how to deal with trade-offs. In conclusion, the role of agroforestry practices in the enhancement of the ecosystem services needs to be fully explored (Jose, 2009).

3. Relevant points for assessing ecosystem services on agroforestry

The second MAES (Mapping and Assessment of Ecosystem Services) report presents indicators that can be used as the main framework to assess ecosystem services in agroforestry systems. Four ecosystem pilots (agro-ecosystems (i.e. cropland and grassland), forest ecosystems, freshwater ecosystems and marine ecosystems) were considered in this document; and for each one a number of indicators for the three main sections of ecosystem services (provisioning, regulating/maintenance and cultural) were collected. This approach is becoming universally accepted, and therefore we propose to work within this framework and to select and/or adapt those indicators from two ecosystems pilots: agroecosystems and forest ecosystems that fit within the different types of agroforestry systems. For biodiversity, the document Biodiversity Indicators on Silvopastoralism across Europe[2] could also be useful.

In this section we want to raise some relevant, constructively critical thoughts and points with regard to such assessments of ES. First, the type of ES assessed and the way in which these ES are assessed, depends upon at least (i) the objective of the assessment, (ii) the scale considered (field, farm, landscape-catchment, region, states…), (iii) the stakeholders (farmers, landowners, citizens, farmers and agrarian organizations, extensionists, researchers, governments, etc.) involved in the assessment and (iv) the AF system and local context considered. For example, if the objective is to make the farmer (or a direct customer of products from the farm) more aware of biodiversity increase in AF systems, a visual observation of some species (birds, pollinators, plants, natural enemies using existing field guides with pictures) at plot level through the time might be a suitable option. If the objective is at the level of policy makers to assess what could be the potential impact of AF promotion in a specific region on carbon storage, a more detailed and quantitative approach (taking into account, e.g. prior land use, soil conditions, AF system and design, evolution through time, soil carbon changes in terms of distance from the tree, etc.) is needed as well as an upscaling to regional level.

There is a clear and continuous trade-off in practice between the need to have, on the one hand, a broad view on a wide range of ES and, on the other hand, the feasibility to perform such broad assessments *in situ*. Therefore, it is important to consider for example (i) the opportunities offered by modelling approaches (link with the "tools" Minipaper 3); (ii) quick estimates (cheap, fast and easy to perform measurements) of indicators for ES (potentially combined with a more in-depth assessment for a limited set of other ES), (iii) involvement a wide range of stakeholders/volunteers in ES assessments (farmers, but e.g. also nature organisations, hunting organisations, citizens, …). In fact, voluntary networks of people gathering data and monitoring, as a part of a participatory monitoring and diagnosis, will help to boost the amount of information on ES in AF systems. Data could be efficiently stored and processed by means of repositories (such as InVEST

[2] http://www.efi.int/files/attachments/publications/tr_21.pd

funded by European Commission

[3]) to be shared with stakeholders, and different APPS could be developed, through which farmers could share info/observations on their farms.
Some ecosystem services are quite easy/straightforward to assess (such as productivity) and others are quite difficult to "grasp" or tricky to directly link to the AF system under study (e.g. functional biodiversity related ES, or ES related to air and water quality, which are rather affected by the landscape as a whole).
Especially important, is the ability to assess changes over time, therefore, long term monitoring sites are needed. A network of such sites, for different AF systems and under different agro-ecological conditions, might provide us with a sound scientific basis for ES delivery calculations /simulations for similar situations. Finally stakeholder workshops (as proposed by AGFORWARD[4]) should be promoted to share information and experiences on ES assessment.

4. Conclusions and proposed activities

According to what we have mentioned in the above sections we conclude that:
1) The **MAES report could be a valuable framework** to approach the ecosystem services assessment in agroforestry systems by choosing and gathering the most suitable indicators for agro-ecosystems and forestry ecosystems.
2) The **type** of ES assessed and the **way** in which these **ES are assessed**, **depends** upon (i) the **objective** of the assessment, (ii) the **scale** considered (plot, farm, landscape-catchment, region, states…), (iii) the **stakeholders** involved in the assessment and (iv) the **AF system and local context** considered.
3) **Participatory monitoring and voluntary networks** could help to increase the number of ES assessed involving different stakeholders, complemented with farmer-to-farmer meetings, advisory services by experts, to develop a real network.
4) **Implementation of all the information** gathered at the different scales could be implemented in **existing platforms such as InVest and APPS for farmers** could be developed, to share info/observations on their farms.
5) Especially important, is the ability to assess changes over time, therefore**, long term monitoring sites** are needed. A network of such sites, for different AF systems and under different agro-ecological conditions, might provide us with a sound scientific basis for ES delivery calculations and simulations.
5) **Mapping and modelling all the information** obtained from regional scale surveys will allow to incorporate ES information to policies and land use decisions, and might help to further develop of **protocols for "Payment for Ecosystem Services".**

5. Links to other minipapers

Minipaper 9: payment for ecosystem services.

6. References

Fagerholm, Nora, Mario Torralba, Paul J. Burgess, and Tobias Plieninger. 2016. «A systematic map of ecosystem services assessments around European agroforestry». *Ecological Indicators* 62: 47–65. http://www.sciencedirect.com/science/article/pii/S1470160X15006482.

Harvey, Celia A., Jorge Gonzalez, and Eduardo Somarriba. 2006. «Dung beetle and terrestrial mammal diversity in forests, indigenous agroforestry systems and plantain monocultures in Talamanca, Costa Rica». *Biodiversity & Conservation* 15 (2): 555–585. http://link.springer.com/article/10.1007/s10531-005-2088-2.

Jose, Shibu. 2009. «Agroforestry for ecosystem services and environmental benefits: an overview». *Agroforestry systems* 76 (1): 1–10. http://link.springer.com/article/10.1007/s10457-009-9229-7.

[3] http://www.naturalcapitalproject.org/invest/
[4] https://www.agforward.eu/index.php/es/

funded by European Commission

Kirby, Kathryn R., and Catherine Potvin. 2007. «Variation in carbon storage among tree species: implications for the management of a small-scale carbon sink project». *Forest Ecology and Management* 246 (2): 208–221. http://www.sciencedirect.com/science/article/pii/S0378112707002903.

Lee, K.-H., and S. Jose. 2003. «Soil respiration and microbial biomass in a pecan—cotton alley cropping system in Southern USA». *Agroforestry systems* 58 (1): 45–54. http://www.springerlink.com/index/V2155L4W131G1414.pdf.

Moguel, Patricia, and Victor M. Toledo. 1999. «Biodiversity conservation in traditional coffee systems of Mexico». *Conservation biology* 13 (1): 11–21. http://onlinelibrary.wiley.com/doi/10.1046/j.1523-1739.1999.97153.x/full.

Ramachandran Nair, P. K., B. Mohan Kumar, and Vimala D. Nair. 2009. «Agroforestry as a strategy for carbon sequestration». *Journal of plant nutrition and soil science* 172 (1): 10–23. http://onlinelibrary.wiley.com/doi/10.1002/jpln.200800030/full.

Torralba, Mario, Nora Fagerholm, Paul J. Burgess, Gerardo Moreno, and Tobias Plieninger. 2016. «Do European agroforestry systems enhance biodiversity and ecosystem services? A meta-analysis». *Agriculture, Ecosystems & Environment* 230: 150–161. http://www.sciencedirect.com/science/article/pii/S0167880916303097.

funded by European Commission