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Framework for integrated Ecosystem Services assessment of the costs and benefits of large scale landscape restoration illustrated with a case study in Mediterranean Spain

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ABSTRACT

To prevent landscape degradation and the continuing loss of biodiversity and ecosystem services, decisions regarding landscape restoration should be based on their 'true' costs and benefits (i.e. broader welfare effects), including all externalities (positive and negative). In this paper, we present a framework consisting of nine steps to analyze, quantify and, where possible, monetize and capture the effects of changes in land use and management on the true costs and benefits. To illustrate this framework we applied it to large scale landscape restoration in a dryland region in SE Spain that is facing serious land degradation. Based on fieldwork involving several farms and expert interviews between 2017 and 2019, and additional literature review, we compared the costs and benefits, using the so-called Social- or Integrated Cost-Benefit Analyses (i-CBA) approach, of three land use systems: a multi-functional sustainable land use system (MFU) with those of almond monoculture under conventional management (CM) and under sustainable land management (SLM). Our study demonstrates that conventional financial CBA favors short-term, usually non-sustainable, land use. Using i-CBA gives a more realistic insight in the true welfare effects of landscape restoration. Our analysis also shows that a transition from conventional monoculture to multi-functional sustainable land use at the farm-level is only financially feasible when all externalities are accounted for and compensated. Our integrated approach enables the identification of opportunities and mechanisms to optimize multifunctional land use and capture the 'full value' of landscape restoration through so-called blended financing mechanisms. Eventually, sustainable land management can then become the norm rather than the exception because it is both financially more profitable for the private land owner and economically, environmentally and socially more beneficial to the community and society as a whole.

1. Introduction

As we are entering the UN Decade of Ecosystem Restoration (2021–2030) (UN, 2020), there is a new momentum for scaling up existing ecosystem restoration efforts, raising awareness of the importance of nature conservation and landscape restoration. Science-based projections of what may happen in the coming decades as a result of the combined environmental impacts of climate change, biodiversity loss and land degradation are essential to develop effective responses, including restoration efforts, in concert with the key players from governments, local communities, policy and business (UNCCD, 2017; IPBES, 2018; IPCC, 2019).

To scale up landscape restoration, the private sector and business community need to be engaged in catalyzing the implementation of sustainable land use and management (Ding et al., 2017). Although the economic benefits of landscape restoration are often clear (De Groot

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et al., 2013, Crookes & Blignaut, 2019), investments in restoration activities still fall well short of the need for several reasons (after Ding et al., 2017):

- Environmental and social benefits are usually not translated into a market value. Evaluated strictly in terms of financial gains, most restoration projects generate too low returns to attract private investors.
- Incentives to degrade land outweigh incentives to restore it. Agricultural subsidies and poor enforcement of laws banning unsustainable practices encourage harmful practices.
- Many restoration projects are too small to be attractive to institutional investors. They may require only $1–10 million in capital, while institutional investors look for minimum investment or 'ticket' sizes of at least $50–100 million.
- Many restoration projects have long investment horizons of 10–20 years because restoration is a multi-year process. This long time frame significantly limits investor and policymaker interest.
- Restoration is considered risky as there is no investment track record, and countries where restoration is needed most may have governance and land tenure issues.

One of the obstacles to attract funding for landscape restoration is that money spent on nature conservation, landscape restoration and sustainable land management is still seen as a *cost* and not as an *investment* with a high return in benefits (de Groot et al., 2013, Crookes & Blignaut, 2019). This perception is due to the neglect of a range of externalities (positive and negative) associated with land use and land use change. Money spent on converting a forest into a plantation, grassland into farmland or a wetland into a shrimpfarm is seen as an investment using the projected, usually exclusively private, profits of the plantation or farm as the main indicator. Negative environmental effects (externalities) such as erosion, flooding, loss of water quality, pollution, biodiversity loss, and public health impacts result in high public costs that are usually not taken into account. More balanced and better informed decisions require more inclusive, so-called Social- or Integrated Cost-Benefit Analyses (iCBA). Case studies applying iCBA consistently show that the true welfare effects of sustainable land (ecosystem) use are higher than those of the non-sustainable alternative (e.g. Balmford et al., 2002; Giger et al., 2015) but only when all positive and negative externalities are accounted for.

To determine the true benefits of investing in landscape restoration, we developed a Framework to analyze, quantify and, where possible, monetize and capture the effects of all externalities (positive and negative) of land use and management change in a systematic way (De Groot et al., 2019, see also: https://www.es-partnership.org/esp-guidelines/). The integrated ecosystem services assessment Framework (see Fig. 1) is linked to four different types of benefits or so-called 'returns' that are expected from landscape restoration: return of natural, social and financial capital and return of inspiration (Ferwerda, 2015).

The Framework consists of nine steps that help to quantify different aspects of the 4 returns: steps 1–6 aim to quantify and value the impacts of land use change, while the last three steps (7–9) aim to capture the value and develop long-term sustainable financing mechanisms to support capacity building and institutional change necessary for upscaling.

The objective of this paper is to explain this Framework and illustrate how the nine steps can be used for a systematic, integrated analysis of the economic and monetary costs and benefits of large-scale landscape restoration activities. We use a dryland region in SE Spain that is facing serious land degradation as a case study to illustrate the Framework by comparing the welfare effects of implementing a multi-functional sustainable land use system with those of almond monoculture applying conventional and sustainable land management practices.

2. Case study area

Southeastern Spain is one of the largest production areas in the world for rainfed organic almonds. Like many other areas in the Mediterranean Basin, the region suffers from large scale rural abandonment. Few employment alternatives and continuous changes in land use conditioned by changes in market demands, national policies (e.g. promotion

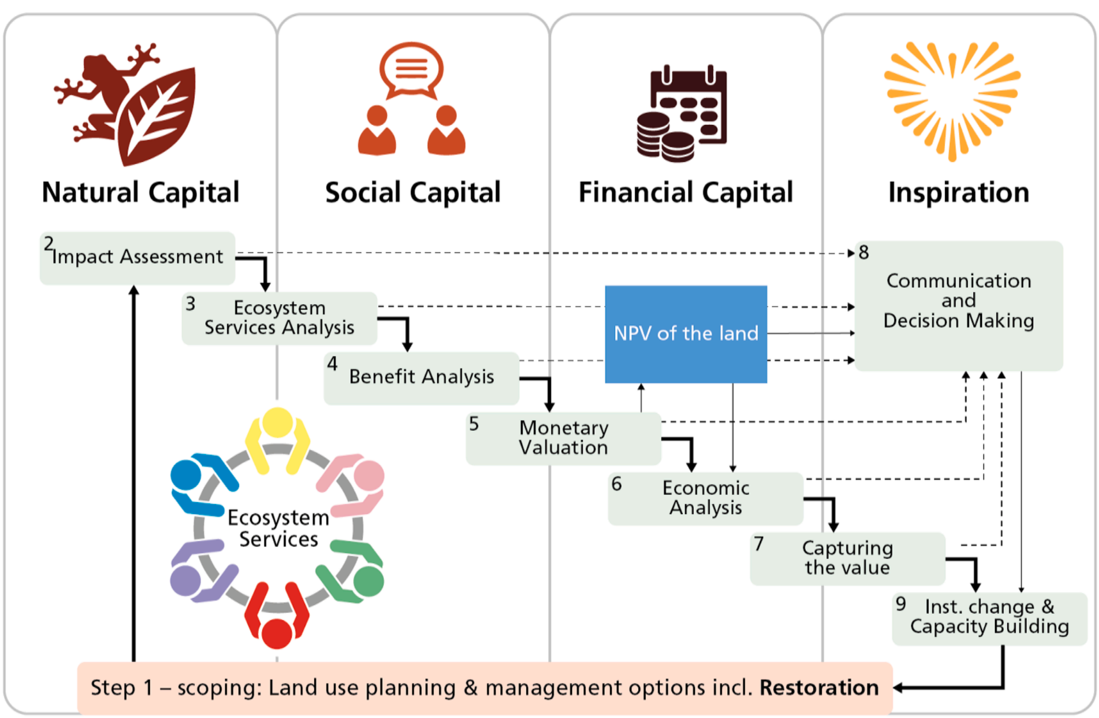


Fig. 1. Integrated Ecosystem Services Assessment Framework to value and capture the benefits of landscape restoration, nature conservation and sustainable land management.

of non-profitable cereal crops and use of heavy machinery), and the EU Common Agricultural Policy (CAP) subsidies have led to over-exploitation and severe problems of land degradation since the mid-20th century. Ongoing climate change has aggravated the situation, and the region has become even less attractive for younger generations and for many entrepreneurs due to the low agricultural production potential of rainfed farming. Together with other societal changes, this has resulted in land abandonment and people migrating from the rural areas towards the coast and cities in search of a better living (Van Leeuwen et al., 2019).

In 2016 *Commonland* initiated, and since then supported, a large-scale and business-driven landscape restoration initiative in the region in close collaboration with the local AlVelAl association (https://www.alvelal.net). AlVelAl is named after the three counties involved from the beginning: Altiplano, Los Vélez and Alto Almanzora. Together with Guadix and the northwest of Murcia, AlVelal now covers approximately 1 millon ha (see Fig. A1 in Appendix A). It contains about 100,000 ha of almond groves, of which approx. 45,000 ha are certified organic.

In order to catalyze the transition to a multi-functional sustainable land use system, AlVelAl follows the ‘four returns approach’ coined by Commonland, and supports businesses and farms to establish the so-called Almendrehesa concept: an integrated production system combining almond and other woody crops (e.g. olive, pistachio, grapes) with aromatic herbs, bee-hiving and lamb farming, complemented by joint processing and marketing and implementation of Sustainable Land Management (SLM) practices (see Fig. 2). SLM practices refer to integrated management of soil, water and biodiversity to adequately maintain and improve ecosystem services. Typical SLM practices include conservation agriculture, use of cover crops, organic amendments, crop diversification, water harvesting, and integrated nutrient management (Sanz et al., 2017). The implementation of the ‘Almendrehesa’ concept aims to create a mosaic of different multi-functional land-use types (MFU) which, in combination with organic farming and SLM practices, promotes soil restoration, erosion control, water balance regulation, and enhances biodiversity and the aesthetic value of the landscape. The definition of the Almendrehesa concept forms part of the first step of the Framework in Fig. 1 and is expected to strengthen the environment and the local economy while promoting pride and inspiration among local communities, strengthening social coherence.

3. Operationalizing the framework: methods and outline

The starting point (step 1) of the integrated Ecosystem Services Assessment Framework (Fig. 1) is to define the scope of the assessment and relevant management options. In our case study, the aim is to illustrate the Framework (Fig. 1) by conducting an integrated CBA comparing three land use types: conventional almond monoculture (CM), sustainable almond monoculture (SLM) and multi-functional land use (MFU) in the context of landscape restoration in the Alvelal territory (Table 1).

For each of these land use types, we went through steps 2–6 of the Framework to quantify the revenues (e.g. crops and other ‘returns’) and associated positive and negative environmental externalities (section 4), monetize these externalities, and calculate the net revenues (‘welfare effect’) of each land use type by an integrated Cost Benefit Analysis (iCBA) (section 5). Note that we assumed these three land use types to be fully ‘operational’ so we did not take the transition period into account to move from, for example, conventional management to multi-functional use. Data on the environmental and economic costs and benefits of each of the different land use and management types (i.e. CM, SLM and MFU) was collected in the period 2017 – 2019, partly by 13 MSc students through semi-structured interviews with 8 farmers and 6 local experts, and one PhD student (see Appendix A for details). In addition, some data are derived from previously published field research (De Leijster et al., 2019; De Leijster et al., 2020; Luján Soto et al., 2021a; Luján Soto et al., 2021b), long term experiments (e.g. Martín and Rovira, 2010), and impact modelling (e.g. Eekhout & de Vente 2019) carried out

Table 1
List of land use types and management regimes used in this study.

Land use		Management characteristics/ measures
Almond monoculture	Conventional Management (CM)	Almond monoculture with intensive ploughing (3–5 times/ year), use of chemical fertiliser and pesticides, no green cover or compost.
Almond monoculture	Sustainable Land Management (SLM)	Almond monoculture with multiple SLM practices consisting of organic agriculture (i.e. no use of chemical fertiliser and pesticides), green cover, compost and reduced tillage (max 2 times/year). Part of the land is kept under natural vegetation (mainly shrubs).
Multi-Functional (‘Almendrehesa’)	Multi-Functional Use (MFU)	Multi-functional land use consisting of a mixture of almonds, cereals, legumes and natural vegetation with application of multiple SLM practices (i.e. green cover, compost, reduced tillage), integrated with additional types of land use (i.e. sheep grazing, bees, aromatics).

Fig. 2. The Almendrehesa concept of a multi functional land use system as promoted by the Alvelal association in SE Spain.

in the local context. All results were compared to, and when needed, adjusted or complemented by literature data. See Appendix A for further details about data collection.

The farms where data were collected (see Fig. A1 in Appendix A) vary in size and in terms of land use and management types within the farm. To allow for comparison of the total ('true') costs and benefits of different land use and management regimes, we re-calculated the costs and benefits to a hypothetical 'standard farm' of 100 ha.

The farms were all producing rainfed almonds. *Conventional management (CM)* means applying tillage between 3–5 times per year and using artificial NPK fertilizer (average 150 kg ha^{-1} y^{-1}) and chemical pest control measures. *Sustainable Land Management (SLM)* involves a lower tillage frequency of maximum twice per year, annual application of green covers and compost, and no use of chemical fertilizers and pesticides. For the conventional farm, we assumed 100% of the farm was used for almond production, while under SLM 15% of the land was kept under (semi) natural conditions (see Fig. 3). To determine the net-benefits of investments in landscape restoration, the 'end-goal' of the restoration efforts should be defined. In this case, we assume that the long-term goal is the development of a multi-functional (combined) land use system based on the Almendrehesa-concept and using sustainable land management practices (SLM). For SLM and Multi-Functional (MFU) land use systems it needs to be defined which part of the farm area is actually providing the service. For our SLM farm, we assumed that the almonds are produced on 85 ha (=85%) of the total surface area of the farm. The other 15% is natural habitat, providing other services. For the MFU farm, we assumed that 35% consists of almond production, 35% cereals, 15% legumes and 15% natural habitat. These percentages are based on the current land uses of one of the visited farms and reflect the main land uses in the region. Some crops could be mixed with aromatics at field boundaries or by intercropping, which, in addition to marketable products, provide other services such as soil protection, habitat for pollinators and improve the aesthetic quality of the landscape (Duran Zuazo et al., 2008).

In the next sections, we compare the costs and benefits including positive and negative externalities of the three land use alternatives (i.e. CM, SLM, and MFU (Fig. 3). To enable this comparison, we first describe and quantify the bundle of ecosystem services provided by each land use type in section 4 (step 2 & 3). In section 5, the benefits (monetary and non-monetary) of these ecosystem services are estimated (step 4 & 5). The welfare effect (i.e. the sum of all benefits and costs) of investing in landscape restoration is then derived from the differences in Net Present Value (NPV) between the three land use alternatives (section 6). For the calculation of the NPV we did not take the investment costs into account but only considered the annual operation costs, and the net-benefits of the total bundle of ES, because we aim to show the difference in welfare effect between the three land use options as input into the decision-making process regarding restoration investments.

As proxy for the degree to which investments generate positive returns, the NPV can then be compared with the (discounted) costs of the restoration activities. In our assessment of costs and benefits, we include as much as possible both local (on-site) and regional (off-site) costs and benefits of each land use alternative. Finally, in section 7, we describe the broader socio-economic effects (step 6), and in section 8, we discuss how to capture and communicate the value to obtain institutional and financial support for large scale landscape restoration (step 7, 8 and 9).

4. Ecosystem services analysis (steps 2 and 3 in Fig. 1)

Once the scope and management options are defined (step 1), the direct (step 2) and indirect environmental effects (step 3) should be determined. A central element in this phase of the assessment is the concept of ecosystem services: the direct and indirect contributions of ecosystems to human wellbeing, such as provisioning services (resources such as food, feed, fibre, drinking water), regulating services (benefits of ecological processes such as carbon-sequestration and pollination), habitat provisioning (to maintain biodiversity) and cultural services (the non-material benefits such as recreational and inspirational benefits) (de Groot et al., 2010). For our study, we used the typology of ecosystem services developed in the TEEB study (de Groot et al., 2010). For each land use type and management regime (see Table 1), the main ecosystem services are identified, along with their actual and potential uses as well as the positive and negative externalities of each management regime, both onsite and offsite.

As mentioned in section 3, data for ecosystem services provision was used from several farms and re-calculated on a per hectare basis. To compare two farms of the same size, the total bundle of ecosystem services provided should be added proportionally to the area covered by each part of the farm (i.e. almonds, cereals, legumes, and natural habitat), and then divided by the total surface area (100 ha). We use the term Service Providing Unit (SPU), sometimes also called Service Providing Area (SPA) (Luck et al., 2003; Syrbe and Walz, 2012) when quantities relate to the actual area that is providing the service. For example, under SLM, the almond yield per SPU is thus 312 kg ha^{-1}, but for the entire farm, on average 265 kg ha^{-1} (see Table B1 in Appendix B). For provisioning and habitat services, the SPU can usually be determined in a straightforward manner, for regulating and cultural services this is often more complicated due to the dispersed nature of the service. Detailed descriptions of the services and their quantification are provided in Appendix B.

Table 2 gives a summary of the data collected on the services

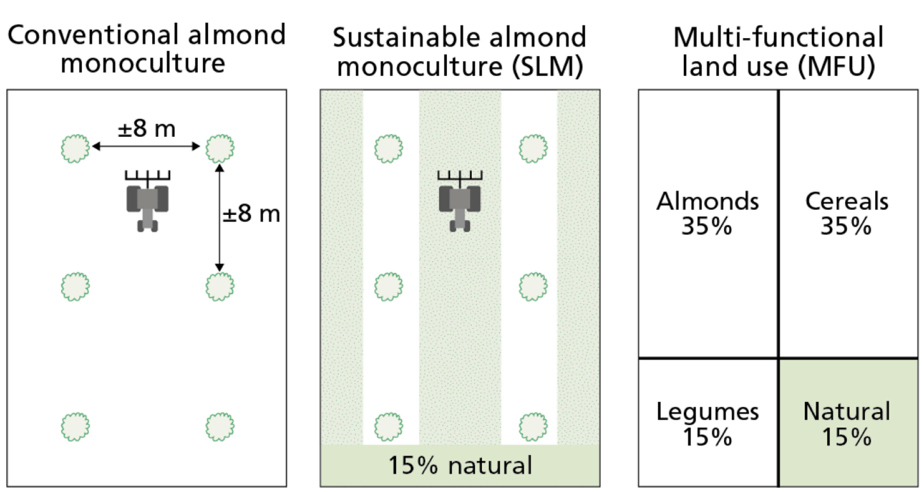


Fig. 3. Schematic representation of the three land use alternatives.

Table 2
Summary of ecosystem service provision at the farm level (100 ha) for three land use types: Almond monoculture under Conventional Management (CM) or Sustainable Land management (SLM), and Multi-functional land Use (MFU). Values are presented in units per 100 ha per year (Details see Appendix B).

	Almond Monoculture		Multi-functional Use (MFU)	Externalities (on & off site)
	Conventional Management (CM) 100% almonds	Sustainable Land Management (SLM) 85% almonds, 15% natural habitat	35% almonds, 35% cereals, 15% legumes, 15% natural habitat	Some examples (can be positive or negative)
PROVISIONING SERVICES				
Almonds (kernel)	35 t	26.5 t	10.9 t	Waste (eg shells) can be used for other purposes like heating & compost
Cereals	-	-	45.5 t	Maintenance of crop genetic diversity
Legumes	-	-	12 t	Increase soil fertility
Aromatics	-	-	3 t	Increase land-scape aesthetics
Honey	-	-	0.5 t	Bees support pollination
Segureña sheep				
-for meat	-	-	1.1 t	
-for manure	-	-	25 t	Heritage value, reduction of fire risk, reduced use of chemical fertilizer
REGULATING SERVICES				
Erosion control: loss of topsoil				
-by Almonds	-300 t	-72 t	-30 t	
-by cereals	-	-	-33 t	
-by natural habitat	-	-4.5 t	-4.5 t	SLM & MFU reduce topsoil loss (on average 76% at farm level)
Maintenance of soil fertility: Nutrient loss				
-under all crops	-5,2 t	-1.7 t	-1.5 t	
-under natural habitat	-		0	SLM & MFU reduce nutrient loss (on average 69%)
Water quantity regulation: Soil water storage				
-under all crops	11,800 m^3	11,645 m^3	11,645 m^3	SLM & MFU increase soil water storage (on average 17%)
-under natural habitat	-	2,145 m^3	2,145 m^3	
Runoff				
-under all crops	40,000 m^3	17,000 m^3	17,000 m^3	SLM & MFU reduce runoff (on average 54%)
-under natural habitat	-	1,500 m^3	1,500 m^3	
Carbon sequestration				
-by almonds	300 t	357 t	147 t	
-by cereals	-	-	88 t	
-by legumes	-	-	12 t	
-by natural habitat	-	87 t	87 t	Effect on climate change: 48% more carbon stored under SLM and 11% under MFU
Pollination (increase almond prod. due to bee pollination)	2.8 t (8%)	10 t (39%)	4.2 t (39%)	Other crops also benefit from wild pollinators
Pest control (decrease in insect pests)	-	30%	30%	Also positive effect on surrounding farms
HABITAT SERVICES				
Biodiversity protection	-	Plant diversity increase ca 15%	Plant diversity increase ca 100%	Also positive effect on landscape level
CULTURAL & AMENITY				
Recreation	-	-	50 visitors	Off-site effect on employment
Cultural heritage/identity	little	somewhat	considerable	Less land abandonment
Education & Science projects	-	potentially	20 participants, 3 projects	Inspiration and engagement

provided by the three land use systems on a hypothetical farm of 100 ha. For simplicity, only the total service provision at the farm level is shown in this table to be able to compare the results for the three land use systems. This means that the values in the SLM and MFU columns do NOT reflect the service provision per ha but have been adjusted for the total farm area. More detailed tables, including the service provision per SPU, are included in Appendix B.

5. Benefit analysis: Monetary and non-monetary values of ecosystem services provided by different land uses (Steps 4 & 5 in Fig. 1)

Once the actual and potential services and the associated externalities (positive and negative) provided by a given land use type and management regime are known and quantified (see section 4), the monetary and non-monetary effects can be analysed, taking into account both private and public benefits and costs (including direct, indirect, and non-market values). In this section 5, we focus on the monetary valuation. Non-monetary benefits are described in Appendices B and D.

To compare the total monetary value of different land uses or ecosystems, the concept of Total Economic Value (TEV) is used, which refers to the sum of all benefits derived from a natural resource or ecosystem (or man-made infrastructure). Different definitions and interpretations of the TEV-concept exist in literature. Our study uses the TEV concept as representing the net-benefit, or welfare effect, calculated as the sum of all the benefits minus costs (negative effects) of ecosystem services of a given type of ecosystem or land use. Another aspect we included in our TEV calculation is that we subtracted the costs involved in providing or managing the service from the benefit (or value). Thus, the values included in our TEV represent the net-benefits (welfare effect) of the sum of the Ecosystem Services provided by a particular ecosystem or land use type.

The economic literature recognizes two broad kinds of values: use value and non-use value (see Fig. 4). Use values encompass direct and indirect use values. Non-use value is the importance attributed to an aspect of the environment (species, ecosystem) in addition to, or irrespective of its use values. In between use and non-use is the value we place on keeping the option open to use ecosystem services in the future, either within our own lifetime or for future generations, called the option or the bequest value, respectively.

The actual measurement of these values can be done in many different ways that are usually split in Direct Market Value (DMV), Indirect Market Value (IMV) or shadow prices (see below), and Non Market Value (NMV), which shows the revealed Willingness to Pay (WTP) of individuals (through donations) or by the community (through subsidies) to express the importance they place on a given service.

Shadow prices are the estimated 'price' (or estimated value expressed) of something that is not normally priced or sold in the market and are usually applied to externalities. Mishan and Quah (2020) define it as "…the price economists attribute to a good or [production] factor on the argument that it is more appropriate for the purpose of economic calcuation than its exsiting [market] price". Methods to determine shadow prices (or indirect market values) include, for example, (avoided) damage costs (ADC), to estimate the welfare effect of sustainable land management to prevent or reduce soil erosion and water loss on farms, or the benefits from reforestation for carbon sequestration and thus, reduce damage-costs from climate change. Shadow prices provide a promising possibility to include some of the benefits (or costs) of different land use options in so-called 'blended financing mechanisms' to compensate farmers or other land owners for the public services they provide (see section 8).

Allocating direct costs (e.g. for management, resources or other external inputs) and indirect costs (e.g. due to negative externalities) to individual services is often difficult. Whether something is a cost or benefit depends very much on the context. For example, providing employment is a private cost to the farmer but a public benefit to the community (see section 7). Being well aware of these difficulties, we attempt in this paper to distinguish direct and indirect costs and benefits, both from a private (the landowner in this case) and public perspective (e.g. the municipality), in order to approximate the true welfare effect of investing in SLM and MFU as part of (large scale) landscape restoration efforts.

gives a detailed description of the calculation of the TEV of the three land use alternatives investigated in this study. Table 3 summarizes the results presented in Appendix C to allow for comparison of the TEV of the three land use options.

Some interesting conclusions can be drawn from this table, keeping in mind the rather large margin of uncertainty related to each value due to assumptions, lack of data and market uncertainties (see also Discussion). The financial value (DMV) for conventional almond monoculture (887 €/ha/y) is the highest of all three land use types, although only marginally so compared to SLM-almond production (794 €/ha/y). The DMV shows the financial value of the ecosystem services involved in a particular type of land use, mainly derived from market prices. Most of this value represents the net-benefits for the farmer (i.e. revenues minus costs). The explanation for the higher DMV for conventional farming is that 100% of the conventional farm can be used for producing almonds, while only 85 ha of the SLM-farm is used for that purpose; the rest is set aside as natural habitat. In a MFU farm only 35% of the land is used for almond production, while the revenues from the other crops (cereals, legumes and aromatics) apparently cannot compensate for the lower almond revenues.

However, the 'picture' becomes different when we include the regulating services or environmental externalities (positive and negative) of the three land use types. These externalities can be relevant either on-site (e.g. effects on soil fertility, water availability, pollination) or off-site (e.g. effects of erosion, runoff, Carbon sequestration). The net-benefits of regulating services are lowest for the CM system (329 €/ha/y) and highest for the SLM system (662 €/ha/y). For the most part, these regulating services are calculated through Indirect Market Values (IMV) or shadow prices using several different methods (see Fig. 4). Although these values are called 'shadow prices' they do represent 'real money', i.e. the costs (or benefits) of these 'externalities' are paid (or received) by someone, somewhere at some point in time and ideally should be internalised in the market value to arrive at more fair market prices. Usually regulating services are related to public benefits (e.g. prevention or mitigation of off-site effects of erosion, runoff and climate change) and our analysis shows that the higher DMV of conventional almond

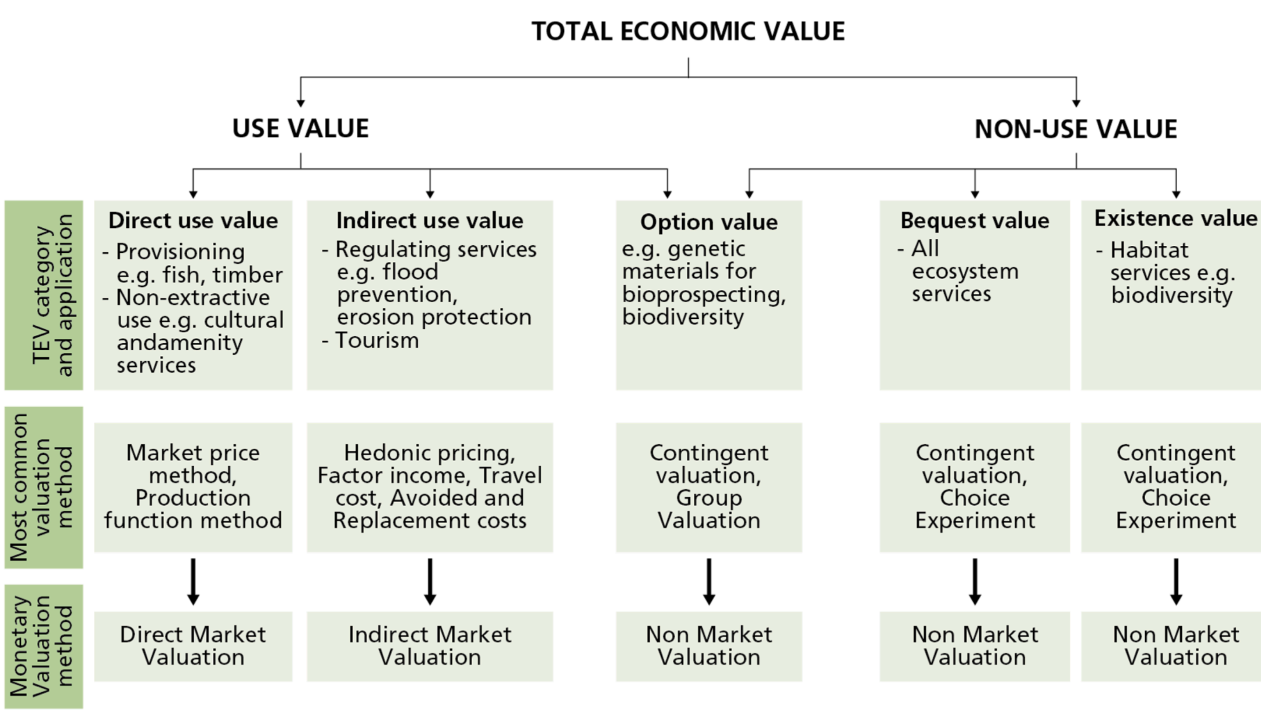


Fig. 4. The Total Economic Value (TEV) Framework Source: Ding et al., 2017.

Table 3
TEV of the three land use types: almond monoculture under Conventional Management (CM), under SLM, and Multi-Functional land Use (MFU)) (in €/year for a hypothetical farm of 100 ha 1)).

	Conventional almond monoculture (CM)	Almond monoculture under SLM	Multi-Functional Land Use (MFU)
TEV [2)]	**144,000**	**179,035**	**150,469**
DMV [3)]	88,700	79,390	69,949
IMV [4) 5)]	43,800	78,970	64,360
NMV [6) 7)]	11,500	20,675	16,160
Provisioning services	**111,100**	**111,690**	**75,499**
Almonds - net revenue	99,600 [3)]	92,140 [3)]	37,940 [3)]
- subsidies	11,500 [6)]	19,550 [6)]	8,050 [6)]
Cereals - net revenue			7,560 [3)]
- subsidies			2,450 [6)]
Legumes			2,670 [3)]
Aromatics			1,209 [3)]
Honey			7,800 [3)]
Sheep - lamb meat			5,270 [3)]
- manure			2,550 [5)]
Regulating services	**32,900**	**66,220**	**56,470**
Erosion control (cost topsoil loss)	-11,200 [4)]	-2,380 [4)]	-980 [4)]
Soil fertility maintenance (cost fertilizer/compost)	-4,500 [3)]	-8,925 [3)]	-3,500 [3)]
Water regulation	No data	No data	No data
C-sequestration - by crops	55,000 [4)]	65,450 [4)]	45,050 [4)]
- by natural habitat		15,900 [4)]	15,900 [4)]
Pollination	N/A [7)]	(33,150) [7)]	(13,650) [7)]
Pest control	-6,400 [3)]	-3,825 [3)]	N/A [8)]
Habitat services		**1,125**	**7,500**
Especially steppe bird protection		1,125 [6)]	7,500 [6)]
Cultural & amenity			**11,000**
Recreation			6,000 [3)]
Cultural heritage			No data
Education/science			5,000 [3)]

monoculture is achieved at the expense of the loss of these regulating services. This represents the classical dilemma between private benefits versus public costs.

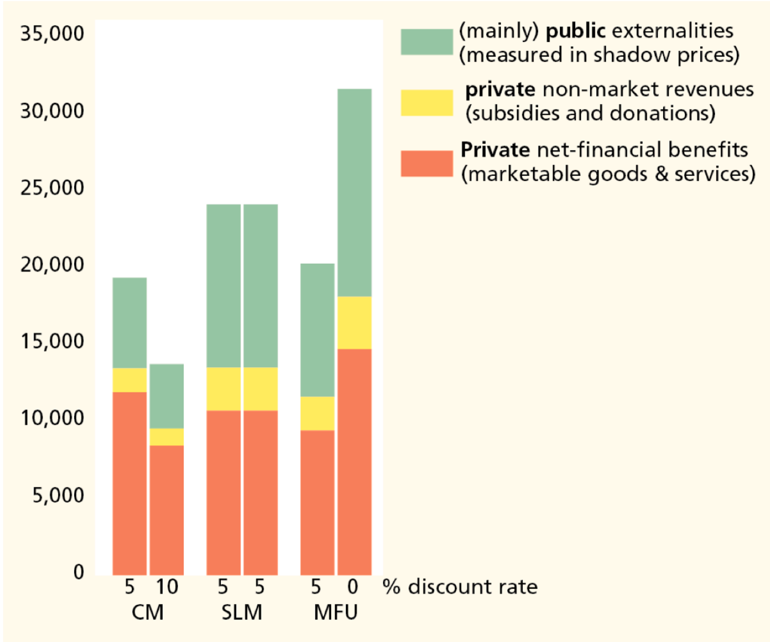
If we include all services, the TEV for CM is 1,440 €/ha/year, for SLM-monoculture 1,790 €/ha/year and for MFU 1,504 (€/ha/year). This means that by reducing almond-production from 100 ha to 85 ha under SLM, the farmer receives lower private benefits (93 €/ha/y) but provides substantially higher public benefits, which are almost completely compensated for by higher subsidies (92 €/ha/y). If other public services would also be internalised in the almond price, switching from conventional to SLM almond production would generate net-benefits of 350 €/ha/y. The TEV for MFU turns out lower than SLM (1,504 versus 1,790 €/ha/y respectively) because the much lower income from almonds cannot be fully compensated by the other crops (cereals, legumes and aromatics). Also, the public benefits are slightly lower, mainly due to the relatively high value of carbon sequestration provided by almonds with SLM (SLM has 2.4x more almond trees than MFU). Yet, due to income diversification from additional activities (such as recreation and education) and subsidies for habitat protection, the TEV of MFU is slightly higher than for conventional monoculture (1,504 versus 1,440 €/ha/y).

6. Effect of landscape restoration on (social) net present value (NPV)

The TEV only shows the *annual* net-benefits (or welfare effects) of a given land use type. Since investments in restoration, and most land use changes, only generate their full potential after several – sometimes many – years, the TEV needs to be translated into a Net Present Value (NPV). NPV accounts for the time value of money: the present value of future costs and benefits depends on the time horizon and the discount rate. The discount rate expresses the preference between the value of money today and in the future. Usually, a time horizon of 20 years and a discount rate of 5% is used (in mainstream finance even 10%). A high discount rate means we place less value on future costs and benefits. Since benefits from landscape restoration usually accrue quite some time after investment, it is appropriate to use a low or even negative discount rate: restoration enhances the capacity of the land to provide services and benefits and thus increases the value of the land (Crookes & Blignaut, 2019).

We kept the TEV constant over time because of the many uncertainties involved in the future development of the region and assumptions regarding the type of crop involved and associated market uncertainties. Keeping the TEV constant basically means an underestimate of the NPV we calculated for the MFU scenario, and an overestimate of the value for CM for which decreasing yields can be expected under ongoing land degradation.

The private 'financial or conventional NPV' for the three land use types analysed in this article (for a 20-year time horizon and 5% discount rate) is roughly represented by the DMV shown in Table 3. Discounted over 20 years, this represents a NPV of 11,941 €/ha for conventional almond monoculture (CM), 10,689 €/ha for almond monoculture under sustainable land management (SLM) and 9424 €/ha for Multi-Functional land use (MFU) (see red shaded bars in Fig. 5). If we only add non-market values (e.g. subsidies), the NPV increases to 13,489 €/ha for CM, 13,476 €/ha for SLM and 11,605 €/ha for MFU. This explains why shifting from conventional management to SLM is not very attractive in the current economic system based only on DMV and subsidies. However, if we include IMV, using shadow prices for externalities (representing mainly public net-benefits from among others C-sequestration and erosion control), the results are quite different: the



NPV of Conventional Almond Production (CM), Almond production under Sustainable Land Management (SLM) and Multi-Functional Use (MFU) during 20 years and differentiated discount rates for CM and MFU. See Table 3 for details

Fig. 5.

NPV then equals 19,385 €/ha for CM, 24,111 €/ha for SLM and 20,275 €/ha for MFU.

Thus, limiting our CBA to financial values only, and using 5% discount rate for all 3 land use options, would place CM as the economically best option. If we apply an integrated-CBA approach, including externalities, SLM comes out best and also MFU has a slightly higher NPV than conventional land use (see Fig. 5, left bars within each land use option). However, it can be rightly argued that one should use a higher discount rate for CM due to the higher fluctuations in crop revenues and degrading effect on the landscape, an intermediate discount rate for SLM-farms which have a slightly lower crop-failure risk and less negative externalities and the lowest discount rate for MFU because of the lower risk to revenues due to higher income diversification and positive effects on the landscape. If we apply these differentiated discount rates (see right bars within each land use option in Fig. 5), using 0% for MFU, 5% for SLM and 10% for CM, the NPV becomes 31,626 €/ha for MFU, remains 24,111 €/ha for SLM and becomes 13,700 €/ha for CM.

To reflect our integrated approach, we use the term ‘Social NPV’ (in analogy to s-CBA or i-CBA) as opposed to a conventional NPV which is usually limited to direct market values only.

The social NPV can be seen as a proxy of the ‘true value of the land’ which, in this somewhat hypothetical case, shows that converting conventional almond production (CM) into sustainable land management (i.e. applying SLM practises and leaving 15% of the farm under natural conditions) increases the NPV by 4,726 €/ha or 472,600 € for the entire farm of 100 ha. Switching from CM to MFU would increase the social NPV by only 890 €/ha (or 89,000 € for a farm of 100 ha), assuming the same discount rate of 5% for all three land use options (left bars within each land use option in Fig. 5).

This last result is mainly because we used rather low value crops in the MFU-farm (cereals and legumes) replacing the high-value almond crop in the CM and SLM farms for our calculations. The reason for our focus on these low value crops is that they are traditionally widespread in the area and can therefore easily be adopted. However, alternative higher value crops like pistachio are also potentially suited for the environmental conditions and, while still at a relatively small scale, are increasingly taken up by farmers. Moreover, here we looked at intercropping of aromatics in relatively small areas between almonds, while different types of aromatics for use in cosmetics, food and medicine, might also be used at a larger scale instead of cereals or legumes, resulting in higher yields and lower production costs.

Another way of looking at these figures is that for a farm of 100 ha this means that an investment (or ‘transaction cost’) of 472,600 € to switch from CM to SLM would have ‘paid itself back’ (i.e. generated higher welfare effects than the investment costs) after 20 years at a 5% discount rate, provided we acknowledge both private and public benefits. If we use differentiated discount rates, the return on investment would be much quicker, especially for MFU (right bars with each land use option if Fig. 5).

Of course these are al very rough numbers, based on many assumptions, but they do give a more realistic ‘picture’ of the true welfare effect of the different land use options than conventional CBA that only includes financial (DMV) values, which also are based on many assumptions i.r.t market development, societal preferences and other uncertainties. See section 9 for further discussion.

7. Broader socio-economic implications (step 6 in Fig. 1)

An important benefit of the ecosystem services-approach is that it enables a systematic analysis of the financial (i.e. cashflow), economic (e.g. employment) and other values (e.g. inspiration and cultural identity) of services involved in any type of land use. This integrated approach helps to identify positive and negative socio-economic implications beyond monetary values for a diverse range of stakeholders, like farmers, local communities, entrepreneurs, tourists, governmental organizations and investors.

In the context of the landscape restoration work in SE-Spain, the following broader socio-economic implications (public and private, financial and non-market) have been observed:

- MFU provides more employment than conventional monoculture (both on farm and in the wider region). This includes jobs created at the farmers cooperatives and other secondary jobs (transport and elaboration of products like aromatic oils, honey, etc).

- More employment provides direct economic benefits to the community in terms of income tax and business tax revenues, and lower unemployment payments.
- MFU helps to diversify farm income and make it more resilient to environmental variability (e.g. climate change and variability, water stress, erosion), social changes, and fluctuations in crop prices.
- More employment and social stability lead to improved social cohesion and sense of community, leading to fewer social problems, less land abandonment and possibly even the return of inhabitants.
- Improvement of the social and environmental conditions leads to better mental and physical health (lower health care costs) and increased cultural values and inspiration.

In our study, we only observed anecdotical evidence for the above effects. Obtaining better quantitative data on these socio-economic effects, including their monetary and financial implications, is essential to develop blended financing mechanisms, including payment for ecosystem services schemes (PES), subsidy reforms (CAP), specific price premiums and risk-reduction compensation to de-risk investments, or investments from insurance companies (see section 8).

8. Capturing and communicating the value to obtain institutional and financial support for landscape restoration (steps 7, 8 and 9 in Fig. 1)

Putting a monetary and economic value on the ecosystem services provided by more sustainable, multi-functional land use provides essential insight into the so-called 'true returns' of landscape restoration (steps 1–6) and helps to inspire the design and implementation of landscape restoration initiatives. However, more is needed than just calculating a monetary value for the returns provided. The key question for capturing the values created by landscape restoration initiatives is how to attract and involve (private and public) investors to finance the landscape transformation process and develop long-term business opportunities (de Groot & Moolenaar, 2019).

To achieve sustainable financing mechanisms (step 7), it is essential to commit stakeholders to a joint long-term vision and forge landscape (restoration) partnerships. No organization can achieve all landscape and financial objectives by itself. Such landscape restoration partnerships are multi-stakeholder partnerships by definition and could mobilize blended finance through public–private-civic collaboration based on innovative, sustainable and investible business models.

These stakeholders will need to design a finance structure that enables investments to flow into the landscape. Appropriate, blended, finance structuring should be supported by proper governance and institutions to manage and mitigate risks for all involved. Eventually, sustainable (land) management (step 9) will then become the norm rather than the exception because it is both financially more profitable for the private land owner and economically, environmentally and socially more beneficial to the community and the wider society than non-sustainable land use.

9. Discussion

The aim of our study was to develop a Framework for integrated Ecosystem Services Assessment to value and capture the costs and benefits of large scale landscape restoration, and test this in a case study in Mediterranean Spain by comparing different land use options for almond production. Our study shows that the net-benefits of sustainable almond production, combined with other services, shows a higher net-welfare effect than conventional almond production. The points below serve to further support and discuss this main conclusion.

(1) For a robust and practical assessment method data availability is essential. However, for many reasons (e.g. lack of funding, time, awareness) data on many services in the study area is still fragmentary. For example, additional data are required on the benefits of restoration for improved water regulation, drought resilience, yield stability, water quality, soil erosion at the farm and off-site impacts like (muddy) floods and damage to infrastructures. Since the same lack of empirical data applies to all three land use alternatives analysed in this study, the conclusions regarding the difference in net-benefits (TEV, see Table 3) are robust and relevant. This is also supported by literature on the comparison of effects of SLM on individual ecosystem services in a similar context (e.g. Ramos et al., 2011; Almagro et al., 2016; Vicente-Vicente et al., 2016; de Leijster et al., 2019; Luján Soto et al., 2021a; Luján Soto et al., 2021b).

(2) Scaling up the results to analyse the effects of restoring the entire AlVelal landscape was not possible yet, because of limited data availability. The restoration activities are underway since 2016, and after 5 years, a limited number of farms are transitioning to SLM and MFU. Therefore, still little (large-scale) data is available on both the costs and the benefits of the restoration measures. Data scarcety on the costs and benefits of ecosystem and landscape restoration is a general problem but in the context of the UN decade on restoration two important initiatives can help to improve this situation: the TEER-initiative (The Economics of Ecosystem Restoration: https://www.fao.org/in-action/forest-landscape-restoration-mechanism/our-work/gl/teer/en/), led by FAO,

Box 1. Examples of sustainable financing mechanisms in the Spanish case study area

In the Spanisch case described here, two basic avenues exist to capture the values created (see Appendix D for details):

1) Explore services that have potential for direct private cash flows, such as higher prices for almonds produced in SLM and MFU land use systems and derived products with added value (e.g. almond cake), aromatics, lamb- & bee-keeping, and recreation. Such business initiatives are already being implemented successfully in the AlVelAl region, with the most important one being the Almendrehesa company (Ltd) (http://almendrehesa.es) supporting, among others, marketing of the regenerative almonds resulting in higher total benefits than based on conventional almond monoculture. Another example is investing in landscape restoration while developing agri-/eco-tourism. This looks very promising as well and will create new employment opportunities while improving environmental quality and enhancing social cohesion. A practical example of this is the collaboration between the Alvelal association and the TUI care foundation that collaboratively develop activities to connect the regenerative farmers with touristic centra at the coast.

2) Explore ways to internalize public externalities: a) positive public externalities can be turned into payments for public services (e.g. climate mitigation, erosion control, water supply), initially through subsidies and grants (e.g. through AlVelAl for farmers who shift to SLM practices or MFU) or incorporated in the new Common Agricultural Policy (CAP) reform (2021–2027); and b) negative public externalities can be internalized through regulations and/or taxes, e.g. effects of pesticides, chemical fertilizers and soil erosion on environmental quality and eventually human health.

CIFOR and WRI, and the Ecosystem Services Valuation Database (www.esvd.info).

(3) An important factor influencing the outcome is our assumption regarding the division and type of land uses on the MFU farm that affects the revenues. For example, if we had chosen a higher value crop instead of cereals and legumes as the second main crop (e.g. pistachio, caper, saffron) or other crop diversification (e.g. % of almonds, cereals, legumes and aromatics) in the hypothetical MFU-farm, the TEV of the MFU-farm would have been (much) higher. Therefore, our TEV estimates are likely an underestimate of the possible true welfare effect of SLM and especially of MFU. However, we preferred to stay as close as possible to the current main land use practices and crop types in the region. The feasibility of other potentially interesting crop diversifications using autochthonous species like caper and azafran, either used in intercropping or as crop rotations in larger areas, are currently studied in several research projects (e.g. DIVERFARMING; www.diverfarming.eu).

(4) In our example the difference in NPV seems small, which is partly caused by the fact that we did not include investment becasue we assumed the three land use types to be fully operational, we kept the TEV constant over 20 years and we used the same discount rate for all three land uses. It is very likeley, and also observed, that revenues under CM steadily decrease while management costs increase while SLM and MFU have the opposite effect. Since we have no clear data on that (yet) we used differentiated discount rates for these three land use options to account for changes in TEV, and thus NPV over time. If we apply these differentiated discount rates, Fig. 5 (right-bars with each land use option) shows that MFU clearly has a higher net-welfare effect than conventional land use, with SLM in between, highlighting the need for flexible discount rates as argued among others by Crookes and Blignaut (2019).

(5) Our study confirms the need to reframe risk/return calculations and to take a longer-term perspective on investment impacts. Reduced risk and increased resilience resulting from landscape restoration and sustainable land management would justify using a lower discount rate than for conventional, non-sustainable land use. This would lead to higher NPVs for the MFU-like land use scenarios and more trust and stability for investors who would then be considering a "Risk/Resilience" ratio instead of a "Risk/Return" ratio. These more inclusive i-CBA calculations provide a significant opportunity to diversify landscape restoration investment portfolios (see also Limketkai et al., 2019).

(6) Use of different valuation methodologies, including benefit transfer, makes comparison with other studies difficult. For the 'internal' comparison of the welfare effects of the three land use options studied, this is not problematic. However, to incorporate iCBA as an accepted tool in decision making about land use alternatives and in the creation of sustainable landscape finance mechanisms for investors, the development of generally accepted ecosystem valuation methodologies and standardized and robust data are essential (Limketkai et al., 2019). This requires solid and trusted valuation methods and sufficient and reliable data to support the integrated CBA-method presented in this paper.

Often the time for collecting empirical data is scarce and expensive. For our study, we used a mix of empirical data collected through interviews and some field experiments, complemented by literature data through value transfer. Even after 4 years of (student) work, some data gaps remained, highlighting the need for reliable, reproducable and easily accessible databases such as the Ecosystem Services Value Database (www.esvd.net).

(7) As our analysis has shown, investing in a transition from conventional almond monoculture to sustainable and multi-functional land use only 'pays' when all externalities (mainly public benefits) are acknowledged and compensated (paid) for. These externalities (like higher carbon sequestration, reduced erosion, improved water management and increased biodiversity) are mainly relevant at the landscape scale. For example, loss of soil organic carbon under CM will lead to lower water retention capacity of soils with local and off-site impacts reflected in a redistribution of water at a catchment scale. Water storage in soil decreases (green water), and inflow to streams and reservoirs increases (blue water) as the soil's infiltration and retention capacity decreases. At the same, time the storage capacity of these reservoirs will decrease due to higher sediment inflow (Eekhout & de Vente 2019). On the other hand, landscape restoration can help reducing greenhouse gasses in the atmosphere and increase overall water security, including flood prevention, drought resilience, reservoir storage, and water quality (Sanz et al., 2017; Eekhout & de Vente 2019). Also, many socio-economic benefits (more jobs, higher tax income for the community etc.) occur at the wider regional scale. Limiting CBA to financial values at the farm level will therefore continue to favour conventional monoculture as the supposedly best economic option while it is clearly not the case at the landscape level.

(8) Our farm-level analysis based the private financial values on net-revenues, i.e. the management costs of labour, resources, machinery, taxes, etc., have been subtracted, as is common practice in financial CBA. If we consider the full welfare effect of a given activity (in this case, landscape restoration involving various forms of farming) we should actually see these management 'costs' as benefits to the community: expenditures on labour, resources, taxes etc. all contribute to the local, regional and national economy. The distribution of benefits and costs across stakeholders should therefore be considered to better understand who gains, who loses and who pays.

(9) Our analysis showed that MFU leads, naturally, to higher diversification of revenues. Thus, 'MFU-farmers' not only depend on price premiums for regenerative almonds but can diversify the revenue streams by including other agricultural produce (aromatics, cereal, legumes, meat, wine, olives, pistachio, honey, etc.) and other revenues (e.g. from tourism, conservation payments, training etc.). Not depending on only one crop leads to lower risk, both for the farmer (e.g. higher resilience to fluctuating market prices of a single crop and lower risk of crop failure due to, e.g. climate variability or plagues) and for the community (i.e. MFU usually implies more employed people) reducing the risk of unemployment and a more stable provision of other public and private benefits. Thus both financial and social-ecological resilience can be increased by further developing and implementing MFU-based land use and business models. However, making such transitions is not easy and requires institutional support, for example, through incentives and capacity building.

(10) In order to define clear business cases for different kinds of public and private investors, it is important to clearly distinguish between financial returns (generating direct cash flows) and additional benefits or "social impact returns" (i.e. the externalities such as improved regulating services monetized through shadow prices). Monetizing the social impact returns helps to strengthen the financial business case but it may be even more effective to present these benefits as risk reduction for both governments and commercial investors. These social impact returns are to a large extent related to water retention, erosion prevention and other usually ignored factors in financial CBA that reduce the risk associated with the main cash flows and reduce damage costs. Through shadow prices, these factors can be included explicitly in iCBA and business models as positive externalities. Due to the lag-time involved in the generation of economic returns from these positive externalities, business models for resilience can only be made investable when supported by public financing during the investment phase (see Appendix D).

(11) As was shown in section 8, mechanisms need to be developed to capture the 'full value' of sustainable, multi-functional land use by diversification of, and creating synergies within, investment portfolios (see Step 7 inFigure 1). Blended finance mechanisms to build a portfolio of investable projects should: a) incentivize investments based on integrated value with full cost-benefit analyses, including cost of inaction (Ding et al., 2017); b) bridge the gap to develop bankable projects by risk mitigation (Shames & Scherr, 2020) and catalyze private capital

investments into new markets and business models; c) include payments for public benefits: farmers and other land users should also be compensated (paid) for the many off-site ecosystem services they provide. The emerging voluntary carbon market is a good example, but this could also work to integrate other ‘externalities’ (Schoenmaker, 2017). These payments should not be seen as subsidies but as a fair price (public payment) for the public services provided by the land owner. See also Appendix D for other options to capture these ‘shared values’.

(12) To be successful in the large scale implementation of landscape restoration, every stakeholder involved will need to be convinced to invest in restoration by involving them in the design of the landscape restoration initiatives based on a consistent and compelling narrative about what is in it for them (de Vente et al., 2016; Reed et al., 2018) (step 8, see Appendix D). To increase impact through social learning, stakeholder participation should preferably build on the integration of participatory monitoring, research infrastructures, and scientific collaboration networks to support co-creation, evaluation and assessment of landscape restoration initiatives (e.g. de Vente et al., 2017; Martínez-López et al., 2019; Luján Soto et al., 2020; Luján Soto et al., 2021a; Luján Soto et al., 2021b). This also relates to integrated land use planning in which the spatial configuration of land use decisions is organised to optimise the delivery of ecosystem services, accounting for interactions between up- and downstream areas and between different sectors and different interests or priorities (e.g. Boix-Fayos et al., 2020).

10. Conclusions

The Framework presented here provides the basis for a practical, reproducable and scalable approach for integrated assessment of all costs and benefits of landscape restoration. It is particularly useful to support better informed decision making and helps to identify blended finance mechanisms to capture the many direct and indirect benefits of sustainable, multi-functional use of the restored landscape.

Application of the Framework to a case study in SE Spain shows that the financial value (DMV) of conventional almond monoculture (CM) was higher than the financial value of almond monoculture under SLM as well as Multi-Functional land use (MFU) (Fig. 5). However, if we include the (net) benefits of the positive and negative externalities of all ecosystem services, the Total Economic Value (TEV) was highest for SLM, followed by MFU and then CM. Our study thus clearly demonstrates that conventional, financial CBA favours non-sustainable land use. Only when we include all other services and values (shadow prices), SLM and MFU show a higher ‘social’ NPV than CM. This result becomes even more clear when applying differentiated discount rates that take account of sustainability aspects and long-term effects of the different land use options.

Our analysis reflects the actual dilemma in the region of SE Spain quite well: when using only financial values (both at the farm and landscape scale), and ignoring time-effects, switching from CM to MFU does not ‘pay’, even when including shadow prices of externalities (rigth bars in Fig. 5). Only when also using differentiated discount rates, switching from CM to SLM increases the NPV by 10,411 €/ha (75%) and from CM to MFU even by 17,926/ha € (130%).

In the current economic system, this transition thus needs substantial subsidies in combination with actual payments for positive externalities and/or appropriate regulation and taxes on polluting/degrading activities to compensate for the investment costs. Crop diversification with a higher value crop than cereals and legumes can further help to make the MFU system financially feasible.

We conclude that using integrated CBA (iCBA) to calculate the social NPV gives a more realistic insight into the true welfare effects of the direct and indirect returns of landscape restoration and should become the norm to support investment analyses and decision-making. Once ecosystem services, as a proxy for externalities, become integrated with standard accounting procedures, as was recently decided by the UN Statistical Commission (2021) and supported by the Dasgupta-report (Dasgupta, 2021), NPV calculations could become an important indicator for the ‘true’ returns on investment and the improved risk/resilience ratio of landscape restoration investments.

Due to the complexity of environmental, social, and economic implications involved, landscape restoration must be considered as a grand societal challenge. Close collaboration with all stakeholders for shared vision creation, the implementation, monitoring and evaluation of landscape restoration initiatives and identification of blended finance mechanisms is therefore fundamental. Only if all relevant parties buy into the overall story and have a clear picture based on accurate data of the benefits they will receive, either as financial or as impact returns, they may become inspired to jointly make large-scale landscape restoration work.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary data

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