INTEGRATED COST-BENEFIT ANALYSIS OF CONVENTIONAL AND REGENERATIVE ALMOND MONOCULTURE IN THE DRYLANDS OF SOUTH-EAST SPAIN

MSc. Thesis in Environmental Science,

Aimilia Paraschou

Picture 1: Almond blossoms in Altiplano, Spain, where the AlVelAl Association has implemented initiatives to promote four returns restoration. (Commonland)

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WAGENINGEN UNIVERSITY & RESEARCH

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For Mati, and A & B who were born there,

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Finally, I would like to thank my parents and boyfriend for their support and encouragement in my studies as well as my best friend who always stood by me, and unfortunately passed away on April 1st, 2019 before the completion of this thesis.

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Summary

Spain is a country in the Mediterranean that is affected by land degradation; harsh climatic conditions and intensive agriculture. One of the largest economic activities in particular regions intensified this vicious cycle of land degradation. In the South-East region the Altiplano de Granada, Los Velez and Alto Almanzora, and newly added Guadix and northeaster Murcia, referred to as the AlVelAl territory have collaborated to share information on their common agricultural practices and traditions. They created the AlVelAl association and advocate the implementation of the Almendrehesa concept which is an integrative management system that combines an array of crops and other regenerative practices to perform sustainable agriculture. Commonland an international NGO, is interested in investigating whether almond monoculture systems that have been intensified in the region because of the subsidies they get from the government are more beneficial or not than the regenerative almond systems, considering all ecosystem services affected.

Ecosystem services refer to the benefits humans receive from the environment; such as material goods known as the provisioning services, the regulation of environmental processes called the regulating services, recreation known as the cultural services, and habitat availability for species protection, the so-called habitat services.

I conducted an Integrated Cost-Benefit Analysis on two such almond monoculture systems to examine their differences. By posing some basic Research Questions, I began investigating what types of land use systems exist in the area. I then found some of the ecosystem services that exist in these systems and figured out the costs and benefits in monetary values these systems have. By answering these questions, I could reach a conclusion and question the economic implications of imposing one of these systems over another.

To analyze the values for such services, specific study locations needed to be determined. After conducting a few semi-structured interviews with farmers and experts in the area two farming systems were identified as the best examples to compare as they are the exact opposite types: a conventional almond monoculture farm of 40 hectares along with a regenerative almond monoculture farm of 62 hectares, both located in the same region.

In order, to investigate the costs and benefits, I determined the ecosystem services they provide and analyzed them in monetary terms. The TEEB classification provides 22 common ecosystem services out of which I examined only a few; from the provisioning services I examined only almonds. From the regulating services, I analyzed climate regulation, erosion control, fire control, pollination, soil fertility, and biological control. The habitat service examined was one, biological diversity, and the last category was cultural services, of which I examined recreation and education.

Both farms used totally different management practices. The conventional applied only basic techniques, such as conventional fertilizer and synthetic pesticides, along with intensive tillage. The regenerative farm used as many regenerative practices available, compost, natural

repellants, swales, inter-cropping, reduced tillage, vegetation cover, sheep grazing, beehives are some key practices adopted.

I calculated the Total Economic Value (TEV) by subtracting the costs from the benefits for each farm; the results show that the conventional farm has a net financial benefit of 500€ per hectare per year and the regenerative almost 2.000€, provided all private and public benefits and costs are taken into account (including both market and non-market values).

I calculated the Net Present Value (NPV) for both systems for a time frame of 20 years and for both with discount rates of 0%, 5% and 10%. The NPV for a 20-year scenario with a 5% discount rate suggest that the regenerative farm represents a 'true value' of 26.000€ per hectare, whereas the value of the conventional farm is around 7.000€ per hectare.

A main issue to consider when it comes to this study is the scarcity of data, because of which I had to use benefit transfer for most services. The results therefore have a higher margin of uncertainty but since the same methods were used for both farm-types it can be concluded that the regenerative farm provides almost four times more welfare-effects than the conventional farm. This conclusion is strengthened by the fact that not all the negative externalities of the conventional farm could be considered.

The results indicate that regenerative almond agriculture provides higher welfare effect (total economic value) than conventional farming if all ecosystem services are taken into account. A big challenge is still how to turn this value into actual financing mechanisms. Transitioning to such farming techniques is therefore slow and more research is needed to provide both better information in on the 'true value' of different land use systems and the and the development of monitoring and financial arrangements to stimulate this transition.

1.Introduction

1.1 Background

Ecosystems provide both the energy and materials needed for the production of economic goods and services (Gómez-Baggethun, De Groot, 2010). Ecosystem services and the natural capital they are made up of are critical in the functioning of the earth's life support system. They support human welfare both directly and indirectly and therefore are an important part of the planet's economic value (Costanza,1997). In recent years there has been a rise of interest towards examining them because of the understanding of how vital they are for our survival. The Millennium Ecosystem Assessment (MA), created in 2001, was a program designed to further investigate the repercussions of ecosystem change with a focus on ecosystem services. It examined how the change in ecosystem services have affected the human well-being until now and in the future, as it also proposed options for adoption to maintain them sustainably (MA, 2005).

To better grasp the purpose and value of the ecosystem services, The Economics of Ecosystems and Biodiversity (TEEB) report created in 2010, places ecosystem services into categories. These categories are provisioning, regulating, habitat and cultural services. Examples of provisioning services are food, fresh water, fuel, regulating services are climate regulation and water regulation, habitat services are nursery functions and, cultural services are the historic value or recreational value provided by ecosystems (Braat, De Groot, 2012). Among these services some have a direct value, one that is visible by the public such as the provisioning services but for some of the other categories, it is difficult to perceive and establish a specific value for them. The TEEB is striving to provide an economic value for such services, for it to be understood what we gain from them and what we lose from their deterioration.

At the landscape level, the main challenge is how to decide on the optimal allocation and management of the many land use options (De Groot, 2010). This challenge is intensified by the increasing land degradation that exists today. Land degradation caused by pervasive land use changes that impact the soil (Lambin et. al., 2001). Among other human-made problems affecting landscapes today are the intensification of agriculture and the need for agricultural and climate change which plays a significant role in their degradation. Land degradation is one of the main problems affecting ecosystems and their services.

1.2 Problem Description

Southern Spain has been notably affected by land degradation throughout the years. The Altiplano de Granada, Los Velez and Alto Almanzora, Guadix and northeastern Murcia, referred to as the AlVelAl area, are three regions joined together that have a long agricultural tradition. Because of their position, a desert-like environment can characterize them. Impending climate change projections for the area estimate raised temperatures, reduction in precipitation, and increased frequency of extreme events (Carillo et.al.). The AlVelAl region which has recently expanded with the addition by the Comarca del Noroeste and Guadix encompasses a total area of 1,000,000 hectares (Laurent, 2018). The territory comprises natural protected areas, agricultural areas that produce mostly olives, almonds, cereals but also aromatic herbs and livestock areas. The leading economic activity in these areas occurs from agriculture and livestock production. Some vital problems of the region are the scarcity of water resources and mediocre quality soils with low water retention that have become further degraded throughout the years (Laurent, 2018).

A variety of almond orchards exist in the area that can be classified according to the land use types, the most common though is conventional almond monoculture. Currently, the is a regenerative almond farming system which integrates an array of regenerative management practices, such as the mixed land use type which includes a collection of almond trees with aromatic plants, and other crops, and the natural areas which include the livestock farming use.

Recently an international NGO Commonland, which focuses on a strategy of four returns (return of inspiration, return of social capita, return of natural capital and return of financial capital) for landscape restoration, has collaborated with the AlVelAl association to help restore the area in the coming years (Commonland, 2014). To accomplish this, they are promoting the implementation of the Almendrehesa concept which is an integrative production system that combines a variety of trees and plant species with beekeeping and sustainable grazing of the livestock. They have already developed this concept in the mixed land use types found in the region.

To guarantee though that the Almendrehesa concept is the best system for the area there is a need to document the ecosystem services provided by all three types of land use (Almond monoculture, mixed land use systems and natural areas) that already exist along with their costs and benefits they provide to the area.

1.3 Study Area

After the USA, Spain is the second largest producer and exporter in the world of almonds, even though its area of cultivation is larger than that found in the USA (Garcia, 2004). This is because Spain has dry land cultivation conditions with soil degradation and depends on rainfall to maintain the crops compared to USA's intense cultivation with constant irrigation. In Andalusia where almond cultivation is a traditional practice, there are many types of almond cultivation systems, such as conventional practices and a new form of regenerative practices. These have grown rapidly throughout the preceding few decades because of the CAP (Common Agriculture Practices) subsidies granted to the local farmers, who have shown an interest to enhance their yields. Thus, as they permit the subsidies under the condition of promoting a particular farming almond monoculture has taken over the areas found within the AlVelAl territory. The almond monoculture, as the term monoculture itself implies, is the repeated plantation of the same almond tree throughout a cultivation area without incorporating other types of plants in it. As stated in that region there are diverse types of almond monoculture, the conventional which uses common chemical fertilizers yet also a new form of regenerative monocultures that use a variety of practices that try to reduce the amount of chemical fertilizers (Schoonohoven, 2017).

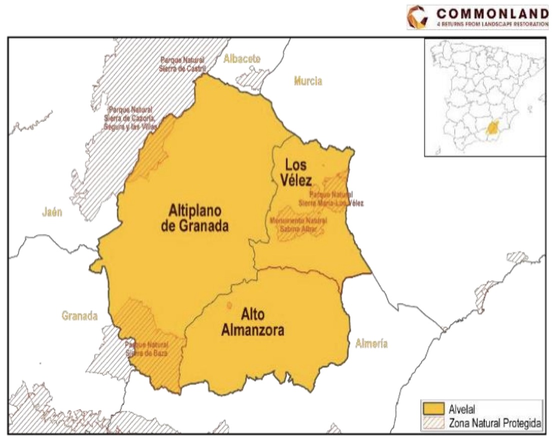

Figure 1: AlVelAl territory with the new included regions on a map created by the Almendrehesa initiative. The red dot: Velez Rubio is the location of both farms studied. (On the left)

Figure 2: AlVelAl territory, South-east of Spain, Commonland. (On the right)

1.4 Purpose of Study

The objective of this research was to gather information on the costs and benefits of almond monoculture production in the AlVelAl region. In terms of the almond monoculture the investigation was both on the conventional type that exists but also on the regenerative in order to have a comparison of the two monoculture systems. This investigation will then further aid in comparing monoculture land use systems to mixed types such as the Almendrehesa concept and also compare them to the natural areas. In the future, such research can help inform the AlVelAl association and diverse stakeholders what land use type is better suited in the region and all other stakeholders how to further develop the area and establish a viable and sustainable future of the landscape and livelihoods of the local communities.

1.5 Research questions

1. What is the typology of the almond monoculture land use systems found in the AlVelAl region?
2. What are the main ecosystem services provided by conventional and regenerative almond monoculture?
3. What are the costs of the ecosystem services derived from both types of monoculture?
4. What are the benefits of the ecosystem services provided by both types of almond monoculture?

5. What is the monetary value of the ecosystem services provided by both types of almond monoculture?
6. What are the economic implications of restoring the ecosystem services provided by the almond monocultures (comparison of the two types of monoculture)?
7. How can the ecosystem services provided by the almond monocultures contribute to large-scale land restoration?

1.6 Thesis Outline

After this brief introduction (Chapter 1) to the topic the remaining chapters are dedicated to answer the research questions and provide a form of a conclusion to this matter. Chapter 2 that follows describes the methodology used to conduct the research and the reasons for choosing such a methodology. Chapter 3, contains the typology of the Almond monoculture systems in the AlVelAl territory, and the description of both farms with the management practices they use. Once both study areas are introduced then they are analyzed in more detail, Chapter 4 examines the costs of the management practices used for both farms. Chapter 5 describes the ecosystem service benefits in monetary terms in the conventional farm and Chapter 6 does the same for the regenerative farm. By placing all ecosystem services in monetary terms and knowing the costs for each farm, a comparison between them is performed in Chapter 7 along with a description of the economic implications of the results found within this chapter. Chapter 8, tries to evaluate the results in close connection to all the issues faced during the whole procedure. Chapter 9 finally is the conclusion of the thesis where all research questions are answered in a brief summary and the main take home messages are stated.

2. Methodology

2.1 Introduction & Conceptual framework

To investigate and capture the benefits of landscape restoration, nature conservation and sustainable land management, guidelines for ecosystem services assessments have been created (De Groot, et al., 2018). After defining the ecosystem services of a particular location and gathering the needed information, the guideline steps in to provide a conceptual framework. The guideline created by De Groot, et al., (2017) helps to proceed further with the analysis of the gathered data, and by following the steps, perhaps find the right solution for the specific case. The basic steps are nine and these are: scoping, environmental impact assessment, ecosystem service analysis, benefit analysis, monetary valuation, economic analysis, value capture, value communication, and capacity building. Along with these steps of the guideline, there are also the steps provided by the concept of the four returns created by Commonland. These are Return of Financial Capital, Return of Natural Capital, Return of Social Capital and the Return of Inspiration. All the steps can be clearly seen in *Figure 2*, where the progression from one step to another is shown visually though the arrows along with those of the four returns.

The first step of scoping involves defining the purpose of the project in close collaboration with the relevant stakeholders. This step helps define precisely what I need without missing important aspects and avoiding any unnecessary data collection. A stakeholder analysis can be a useful tool to begin with. The stakeholder's views and opinions on the topic can be helpful to see what they envision of the future based on the project. The second step, the environmental impact assessment examines the impact of the land use change and the restoration activities. It examines the changes in a before and after manner of a project and links them to their beneficiaries. Then the ecosystem services analysis follows, where the ecosystem services of the certain project can be investigated to see how they can be affected. After this step it is logical that the benefit analysis follows showing how these ecosystem services provide benefits and are linked to the certain stakeholders and communities involved in the case. The monetary valuation can provide actual results on how these changes actually affect an area both socially and environmentally. The valuation is done by figuring out the Total Economic Value (TEV) of the system examined either through use values such as direct or indirect or non-use values. The economic analysis examines the return of financial capital in the region the project is conducted. Capturing the value, which is the next step, aims to use all information gathered in the previous steps to see whether investments should be made. The communication of value promotes inspiration for further projects, which leads to the next step that of capacity building. By addressing policy makers with the results, it can promote a long-term institutional change (De Groot, et al., 2018).

Out of these steps of the framework I will use steps 3 to 7 to help analyze the information gathered and help answer the main research questions of this paper. In addition, I will use the four return steps to make future recommendations and suggestions based on the outcomes.

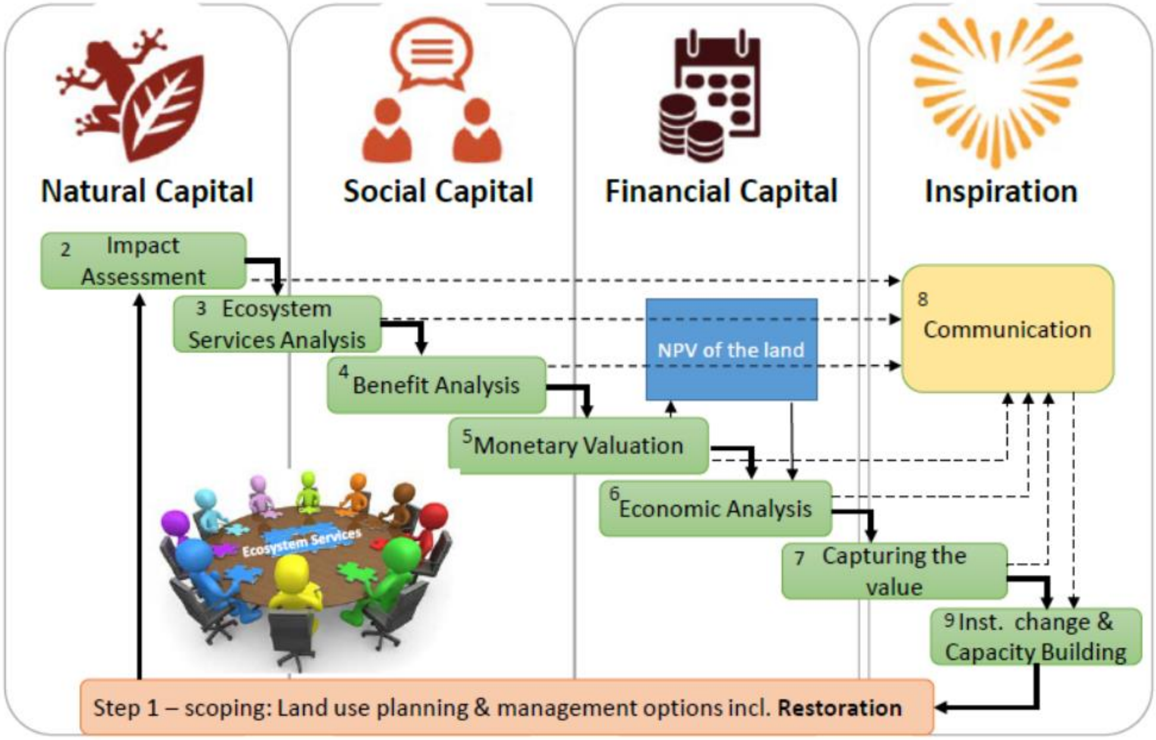

Figure 3: Framework for integrated ecosystem services assessment, to analyze effects of land use change and ecosystem management. (De Groot et. al., 2018)

2.2 Research methods

2.2.1 Ecosystem Services Analysis

The ecosystem services analysis follows after recording the land use and land use change and the available ecosystem services provided by it in an area. All ecosystem services are collected and classified according to the established categories available by different sources. One of the most used is that of 'The Economics of Ecosystems and Biodiversity' (TEEB) 2010. The TEEB has the largest classification-level providing 22 main service types. After discovering the ecosystem services of the study areas, this step helps assess the changes in ecosystem services in biophysical terms and prioritizes those that are most affected and relevant to the concerned stakeholders (De Groot et al., 2017). The almond monocultures both for the conventional and regenerative type, these ecosystem services will be recorded along with their indicators. To record them, stakeholder involvement will be vital for the collection of the data.

The first category of ecosystem services is the provisioning, the physical, tangible material received from the ecosystem. The regulating services is the next category, these are the benefits obtained from the ecosystems regulating processes. The habitat services come next, those that provide support to species in the ecosystem and finally the cultural services, provide benefits to the stakeholders involved, such as the local communities in the area. Bellow a few services that are located in the area and found within the TEEB categorization are mentioned.

However, among these ecosystem services not all are considered in these two farms for various reason such as the lack of data or the fact that they may not be provided in these farms. In the table below all ecosystem services are mentioned; however, out of those only the ones that are underlined are measured for both farms. The services further examined are:

Provisioning services: Food

The only category of ecosystem services examined in both farms as they only provide this type is food and more specifically almonds. A service rather straightforward; however, agriculture most often can provide a variety of food, not only for mass production but also to feed the animals found in the area.

Regulating Services

Climate regulation: Carbon Sequestration

Agriculture has become one of the most dominant land uses of the earths land surface, covering approximately 40% (Lorenz, Lal, 2018). This has caused a significant land use change which in turn affects the carbon stocks in the soil, as soil organic carbon (SOC) stocks in croplands are lower than in other land uses such as forests because carbon is not only stored in the soil but also in the great amount of biomass found in the forests (Schulp et al., 2008). Croplands are estimated to be responsible for the largest loss of carbon to the atmosphere per year in Europe (Smith, 2004). This occurs from the intensification of agriculture and the harsh to the soil management practices used to obtain more produce, practices such as frequent tillage, pesticides and fertilizers. On the contrary it has been stated that agricultural lands can often be considered providing many beneficial regulating services such as carbon sequestration (Swinton et al., 2007). Carbon sequestration depends on the quality of the soil, yet soil loss can also be increased by intensive agriculture. Improved management practices in agriculture can potentially increase the amount of carbon sequestered in the soil (Follett, 2001).

Erosion control

Erosion control is an important regulating ecosystem service in this case, as it is closely linked to agriculture. From the introduction of agriculture erosion has been a cause of irreversible land degradation through the loss of fertility and consequently the productivity of the soil (Lal, 1994). In semi-arid regions such as the southeast of Spain precipitation is relatively low throughout the year, causing the soils to be fairly poor in organic matter and alkaline making it susceptible to soil erosion (Gomes et al., 2003).

Extreme events: Fire control

Wildfires have affected the Mediterranean basin for thousands of years, altering the landscapes and ecosystems (del Pino, Ruiz-Gallardo, 2015). Particularly vulnerable to fires are forests often made up of a single plant species due to the lack of structural diversity and biodiversity (Robles et al., 2009) fire can easily spread and affect large areas at once. The same can apply in agriculture and specifically monoculture systems.

Soil fertility

Soil structure and fertility in agriculture determines the quantity and quality of agricultural output. Microorganisms, earthworms, and nutrient cycling are methods of critical importance to preserve this ecosystem service (Zhang et al., 2007). In the semi-arid region where the farm is located, the soil is rather dry and sandy, making more of it prone to lose its fertility. The management practices that are used by a farm will determine the soil quality. Tillage and the constant use of chemicals such as fertilizers and pesticides (Li et al., 2018) can affect the soil along with the removal of natural vegetation or the lack of practices that prevent soil erosion and thus the leaching of the nutrients leading to low soil quality and fertility.

Having non-crop plants incorporated can protect the soil fertility as well as increase the water retention, which in turn maintains fertility in the soil. By inter-cropping, planting aromatic plants as borders, mixing the green manure from the almond into the ground, by applying natural compost and allowing sheep to graze off the ground the soil is enriched with nutrients and can more readily retain water to keep a good quality.

Pollination

Pollination, as an ecosystem service is provided by a variety of insects such as butterflies, moths, flies, beetles and wasps but most importantly by bees. Bees are the most important pollinator as they are predominantly found in most geographic regions and are more economically beneficial. In agriculture, pollination is often required by animal species (Kremen et al., 2004). Intensive agriculture is linked to the loss of wild pollinators and the services they provide. Yet, on the contrary, many have liked this fragmentation in the natural landscape of the agricultural land beneficial to pollinators. Only if the crops provide can provide a vast number of flowers and hedgerows, which can be seen as an alternative forage for bees (Kremen et al., 2004).

In addition to animal pollinator almond species can also be self-pollinators, such as the species Antoñeta and Marta, which are self-compatible with a high degree of autogamy (Egea et al., 2000). This allows them not to be dependent on animal pollinators and be a single species in a field.

Biological control

Biological control as an ecosystem service in agriculture refers to the sub-service of pest management and disease control. In large-scale agriculture in order to minimize and control the pest infestation, pesticides are used on a regular basis to ensure a safe crop. By applying such pesticides, they can be seen as a benefit for biological control yet effect degrading the soil many other ecosystem services. In many cases often to tackle pests' natural predators and plant enemies are introduced to avoid chemical pesticide use (Robertson & Swinton, 2005). Organic farming does not apply synthetic pesticides, thus increasing the species richness found within a crop in comparison to conventional agriculture (Roschewitz et al., 2005).

Habitat Services

The habitat services that are often examined when looking into the benefits provided by ecosystem services are genetic diversity in this case better defined as the conservation of biological diversity. Agriculture can lead to biodiversity loss as natural land is converted to croplands which eliminate certain flora and fauna, in addition, the fragmentation that is caused to the natural forests intensifies this issue (Harvey et al., 2008). Practices done in conventional agriculture, such as minimizing crop diversity to a few species, eliminating cover crop vegetation, not practicing crop rotation, using chemical fertilizers and pesticides and practicing deep ploughing all affect either biodiversity itself by reducing the species either by degrading the habitats of the species minimizing them in this way (Tscharntke et al., 2005).

Cultural services

In agriculture, cultural services can often be overlooked and not perceived as an important ecosystem service. But there are a variety of services found, such as aesthetic value, recreation and tourism, as well as education and traditional cultural heritage value. Agricultural places and their products are often used traditionally to bond human communities (Power, 2010). in the Mediterranean region, landscapes have been historically shaped from the social systems (García-Llorente et al., 2012).

Table 1. The typology of ecosystem services used in this study, based on the TEEB study adapted from De Groot et al. (2010)

Provisioning services	**Regulating services**	**Habitat services**	**Cultural Services**
Food	Erosion control	Genepool protection	Education
Raw Materials: Timber or fuelwood	Carbon sequestration	Biological diversity	Tourism and recreation
Water	Water purification	Nursery habitat	Spirituality and mindfulness
Genetic Resources	Fire control		Inspiration for arts
Ornamental Resources	Soil fertility		Landscape aesthetic value
Medicinal Resources	Pollination		Cultural heritage
	Biological control		

2.2.2 Benefit Analysis

The benefit analysis aims to evaluate the effects of the ecosystem services on human wellbeing (social capital). The Millennium Ecosystem Assessment MEA has established four aspects that can determine human wellbeing and realize the benefits gained from ecosystem services. These are: health, both physical and mental. Livelihood, which represents the basic needs of humans to have a good life, the tangible goods: food, water, but also job positions etc. Safety and security, in terms of environmental safety such as from natural disasters and, good social relations, in terms of the life of humans in communities and social identity (De Groot et al., 2017). Based on these indicators, the benefit analysis will be made for the ecosystem services and the stakeholders involved for the almond monoculture farms in the AlVelal region. In addition, Commonland has further added a few more aspects that can be considered those of entrepreneurship/skills and networks/new ventures and access to occupational tools and job opportunities and local investments as recorded by De Groot et al. in the Guidelines. To complete this step, a detailed stakeholder analysis was created to assess the involvement and record through the help of interviews the benefits they receive from the ecosystem services. Figure 3 bellow, shows the pathway from the biophysical structures of the ecosystems leading to human wellbeing.

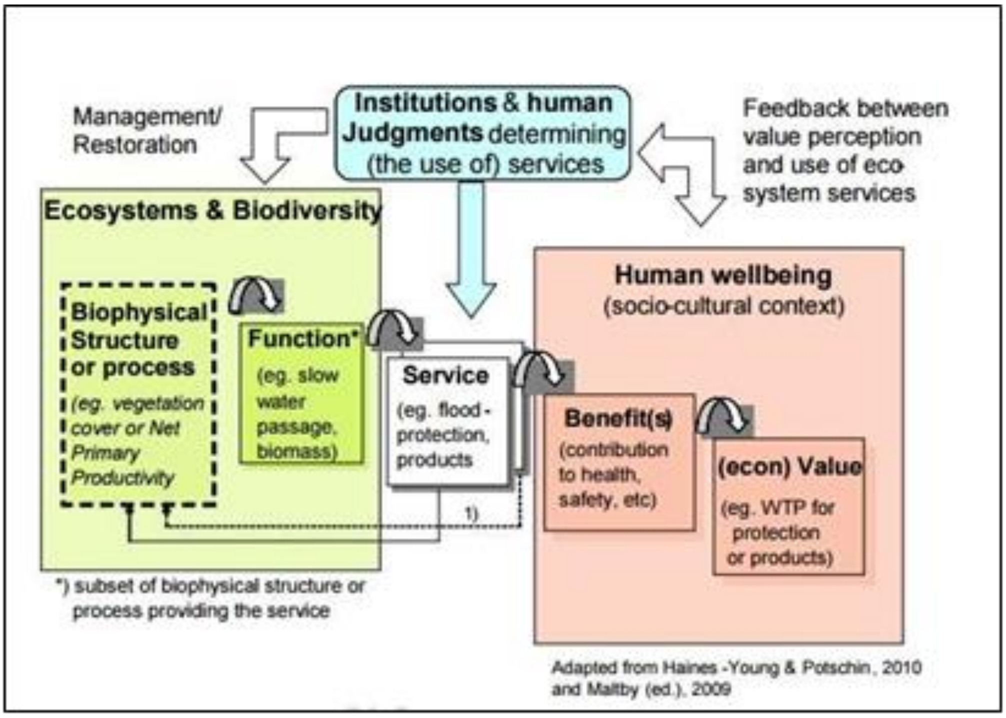

Figure 4. Pathway from ecosystem structures to human wellbeing. (de Groot et al., 2010)

2.2.3 Monetary Valuation

The monetary valuation step, of the almond monoculture systems is done to quantify the costs and benefits of both such types of monoculture, their land use along with the benefits obtained from their ecosystem services and place them into monetary terms. To further analyze such information, both costs and benefits need to be recorded for an area. Different market values exist and are used to calculate different ecosystem services. Direct market value is useful for provisioning services, whereas indirect is useful for the estimation of the regulating services. After gathering both costs and benefits, the Total Economic Value (TEV) is calculated to identify which of the two systems obtains more benefits. Figure 4, shows the Framework of the TEV along with the variety of types of monetary valuation methods. Further on the Net Present Value (NPV) or Capital value is calculated by discounting the future costs and benefits of each type of almond monoculture, while considering the discount rate and time horizon used (De Groot et al., 2017).

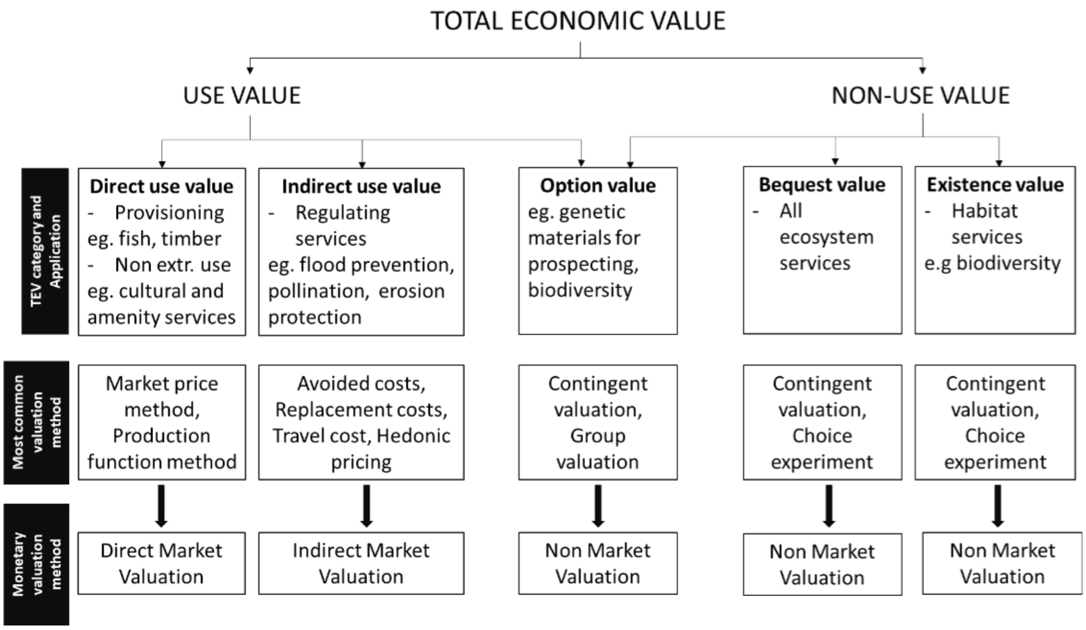

Figure 5. The Total Economic Value (TEV) Framework. Adapted by de Groot et al., 2018; from Ding et al., 2017 and several other sources

2.2.4 Economic Analysis

The economic analysis focuses on the implications of the land use or restoration project under investigation. Through this, it can be seen what returns the project can indeed provide if investments are made. Essentially an economic analysis is what will be communicated to investors or policy makers and indicate which form of land use is more beneficial in a holistic way both for the investors themselves and the area; It will suggest a system that provides the most benefits in terms of ecosystem services and therefore a sustainable future of that area. The economic analysis, can be achieved by diverse methods, however in this case an integrated cost-benefit analysis is adopted that examines the Net Present Values (NPV) of the two systems studied to recommend what type of system is viable for the future in the area.

The Millennium Ecosystem Assessment MA, mentions that human well-being depends on the benefits provided by the ecosystems and their services. However, in the recent years the great damaging of the ecosystems can provide negative feedbacks to the people and ultimately endanger their well-being (Tallis et al., 2008). The millennium ecosystem assessment links four aspects needed for human well-being with each of the categories if the ecosystem service. Health can be achieved through the provisioning as well as the regulating services, but also through the cultural ones as for mental health. In this case, while examining both land use systems the one that provides the most values both measurements and monetary ones can be linked to provide more benefits to human health. A system that can provide more benefits for climate control or soil fertility can provide less polluted air or soil to humans. For the livelihood category the second one mentioned all categories can be linked, this goes without saying that a system that in general can provide more benefits in all aspects can prove the most beneficial to human livelihood. Safety and security are the third main aspects needed for good well-being.

These are closely connected to the regulating services in terms of having a safe environment to survive in as well as the other categories. Finally, good social relations can be linked once again to all the ecosystem services categories, especially to the cultural services. Cultural services can often be overlooked in terms of importance; However, they are so closely linked to human well-being and allow for the development and protection of the other ecosystem services.

2.3 Data Collection Methods

The main data collection methods used in the study were literature review and interviews. I did a preliminary literature review on the subject to collect information that I would need for the field work.

During the fieldwork, I conducted several interviews along with informal conversations both with experts and farmers. The first few interviews helped to determine the best study areas and often by interviewing a farmer on his or her farm it was evident that it may not be suitable but they still provided a lot of interesting information, that I recorded. As a result, even though approximately six interviews were done, two of them are used, those of the two farms.

For the farmers, semi-structured interviews were performed through the help of a questionnaire *(Appendix 1)* that guided the interview and built on the existing available information. The interviews were performed informally during a guide throughout the farms. The questionnaire comprised various parts. It began with general questions about the characteristics of the farm (size, years of existing, etc.) and about the climatic conditions in the area, then the questions focused on the almond trees and their use and characteristics. It continued, with a section of the management practices done on the farm, with a specific focus always on the almond orchards. The final questions asked about any cultural use of the farm such as recreational or educational activities and how connected the farm was with its surrounding community and any benefits they may gain from it.

Interviewing the experts was mainly used to help with the selection of an appropriate case study both for the regenerative almond farming and the conventional. To determine the best cases of regenerative farming, questions were asked on the management methods of the farms in order avoid visiting no suitable examples of regenerative farming. Experts could suggest which ecosystem services to focus on and where to get such information. Informal conversations with the experts also helped to understand the general picture of the situation in almond monoculture farming in Spain. Whether the regenerative practices they have seen being applied have helped improve the area and provide any benefits either environmental economical or sociocultural.

Upon finishing the interviews and conducting the field work, further literature review is used to expand and fill in the gaps of the collected data. Gathering data on ecosystem services, where no measurements for these specific areas and case studies have been performed is done through literature review, which helped synthesize the final work.

2.4 Data Analysis

Quantitative Data

The quantitative data found either through the interviews or through the literature review were all analyzed using Excel. Excel was the best option since it helped create all the tables and graphs needed. I did this for both cases, that of the conventional and the regenerative farm.

Qualitative Data

The qualitative data gathered came from the interviews and the literature reviews. The interview questions were created and given to the farmers sometimes in English and for others in Spanish. For the Spanish version, the answers received were also written in Spanish. As I do not speak Spanish the translation was done through Google Translate and often with the help of native speakers in the field. The content of the interview questions was then further analyzed per category of data such as the management practices or the characteristics of the farm when needed for each chapter.

3. Typology & Management practices in the selected case study sites

3.1 Introduction

From the beginning of almond cultivations in the region until today, the form of agriculture has shifted greatly. Before the 1950s, the yields of the almonds were rather low; Later, the modern type of agriculture was introduced, forming new land use systems that can produce commercially (de Molina, 2002). The original agricultural lands had traditionally mixed farming, merging all kinds of crops such as cereals, vegetables, almonds, olive groves and fig trees. This type of mixed land use system also incorporates terraces and livestock farming (Caraveli, 2000). Pastoralism has again played a key role in shaping the agricultural landscapes as it was a traditional practice in the Mediterranean (Oteros-Rozas et al., 2013).

After Spain entered the European Union, that's when the socio-economic changes completely transformed the agricultural lands as many traditional farms were abandoned. The Common Agricultural Policy (CAP) played a vital role in that as well. The CAP promoted subsidies for almond monoculture systems. This turn to intensive monoculture brought with it the degradation of the environment (Bonet, 2004). The focus on the agricultural production lead to a remarkable economic development, adding important social dimensions to the desertification of the land (Onate, Peco, 2005).

Today, after the degradation of the land which has been a consequence of a long period of both human and climatic impact (Hooke, 2006) there is a realization that the traditional mixed land use systems can present a variety of benefits both economically and environmentally leading to a switch back to such systems.

3.1.1 Typology of the Almond Monoculture Areas in the AlVelAl region

The AlVelAl region in the south-east of Spain comprising three counties Altiplano de Granada, Los Velez, Alto Almanzora, located within Granada and Almeria has now been united by the Guadix region and the Northwest of Murcia (AlveLal). The territory is characterized by the vastest area of organic almonds cultivated in dry land in the world, along with the native segureño lamb with Protected Geographical Indication. The area is known for its high-quality organic almond trees, which are 45.000 hectares out of the 100.000 hectares of almonds in total. The AlVeLal initiative promotes the well-being of their territory's environment, the positive change in agriculture systems in a cohesive territory (AlveLal).

As previously suggested, the territory is characterized by 100.000 hectares out of which the 45.000 are organic almonds. This implies that the rest 65.000 must be conventional almond agriculture systems since the use of fertilizers and chemical pesticides defines a non-organic almond nut. Yet, out of those 45.000 hectares of organic almond, it is not clear what type of land use systems occur. As they could be monoculture systems, mixed land use, having only various types of crops on their lands perhaps along with sheep or even promote more regenerative practices and be regenerative farms.

Based on the database provided by Yianniek Schoonhoven, (2018), who recorded approximately 80 farms within the AlVelAl territory to report their characteristics. The farmers were interviewed about the characteristics of their farms, which are summed up in the database. The categories examined are many such as their crop types and sizes and quantity of production, whether they belong in the Almendrehesa corporation, whether they are considered regenerative, the management practices (tillage, fertilizer, compost, manure, pesticides, pruning, cover crops, bees, livestock, sediment traps, swales, bokasi systems, ponds, hedges and borders) all of which their quantities are recorded.

Out of this database, 21 farms out of the 80 mentioned being regenerative farms. Although this value may not be accurate, some farmers may not have mentioned such information. This value does not also define the whole territory as the 80 farmers interviewed are not the total number of farmers in the region. Out of the 21 recorded regenerative farms, all had almonds within their systems except for one. From the 80 farms, the 50 have almond orchards. Suggesting that they rest 30 non-regenerative farms are simple monocultures or mixed land use systems that do not apply many practices that define them as regenerative. The total farms that have mixed land uses are 22, suggesting that the 28 are only monoculture systems. Though much information is lacking from the database, perhaps for the difficulty of gathering all the information of the farmers, making it difficult to define all the systems. However, various types of almond agricultural lands exist within the territory comprising different crops and different management systems.

Two quite opposite systems were selected and further described along with their management practices. Those of a conventional almond monoculture farm and a regenerative farm that uses many regenerative practices.

The map below was created through maps provided by the Spanish Ministry of Agriculture along with the help of Commonland and the research institute of Murcia CEBAS-CSIC. They represent aggregated land use classes of the territory among which almond orchards can be seen in the category of the woody crops. Based on the map and information provided the total percentage of almond orchards in the territory is 9%.

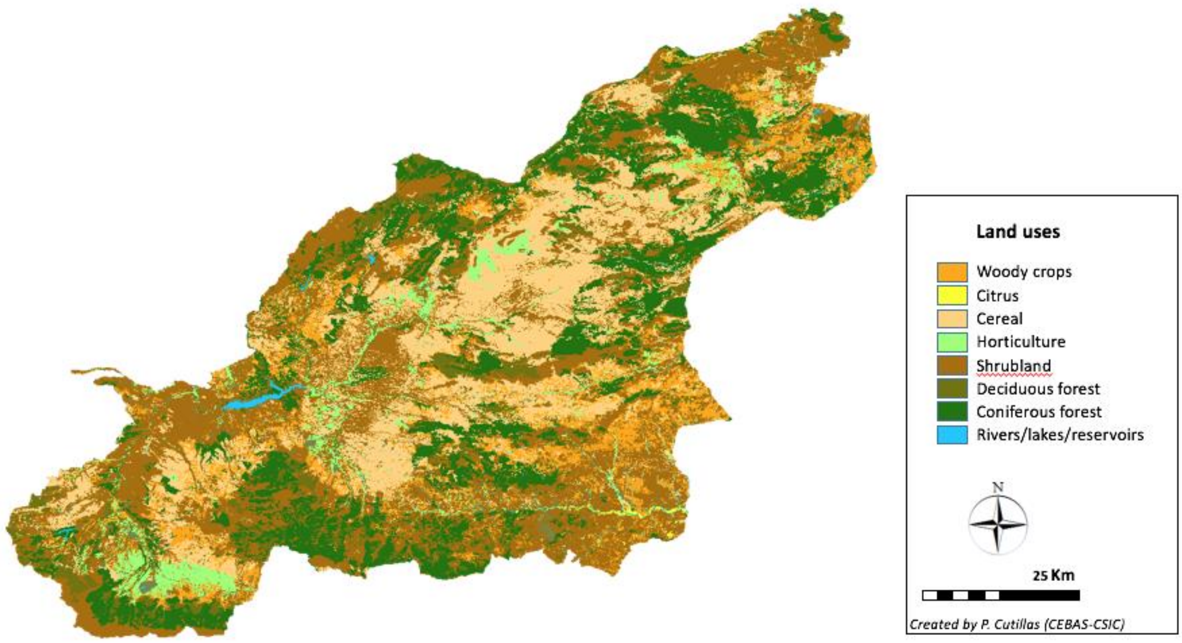

Figure 6. Land use map of the AlVelAl Region, 'Maps of crops and uses 1999-2008' Cutillas (CEBAS-CSIC)

The almond trees are found within the 'Horticulture'; however, there are many other types of cultivated species within this category.

3.1.2 Management Practices

The management practices of both farms are summarized below to clearly show the different approaches of almond agriculture.

Table 2. The management practices in the Conventional and Regenerative farm

Management Practices	Regenerative	Conventional
Fertilizers	Compost, manure from sheep	Chemical & mineral fertilizers
Pesticides	Natural-ecological repellents	Chemical antifungal treatment, pyrethrin
Tillage	2/yr, 15 cm depth	3/yr, 20 cm depth
Pruning	1 every two year	1/yr
Vegetation cover	yes	Some
Terraces	Yes, natural	Yes, from original crops
swales	1line 7km long	No
Hedges & Borders	Yes, with aromatics	Naturally aromatics on the borders
Intercropping	Yes, with leguminous species	No
Sheep grazing	Yes	no
Pollination	Bees/Beehives, self-pollinated species	self-pollinated species

3.2 Conventional Almond Monoculture

The conventional farm used as a case study for this cost-benefit analysis will remain anonymous and thus will just be called throughout the paper the 'conventional farm'.

A reason for choosing this farm as a study area is the fact it is located in the same region as the regenerative one, within the AlVelAl territory and in the Velez Rubio municipality in the province of Almeria in Andalucía, Spain. The farm owner provided the characteristics of the farm through a series of questions. As he suggests, the average temperature in the area is 19 degrees Co, but this can vary from year to year. The altitude is between 700 to 800 m with a slope of 10 to 25%.

The farm is 40 hectares and consists only of rain-fed almond trees as it is almond monoculture at the present time. The density of the trees in the farm is 7 by 7 meters apart. The plantation is 15 years old and, in the past, there used to be crops of cereals and legumes. The estimated productivity of the trees is between 35 and 40 years. There are three varieties of almond trees which are some of the most commonly found in the south of Spain, these are Marcona, Guara and Desmayo. Guara is a variety found as well in the regenerative farm, and it is known for its resistance to harsh weather. Marcona and Desmayo are also varieties that are considered of high quality and thus their high market price (Pérez-Campos et al., 2011). The farm benefits off of the almonds that are sold and the subsidies it receives. These are the national aid because of the CAP payments provided by the EU of nuts fruits single or basic payment rights as mentioned by the farmer.

The farm's focus is simple almond production and does not apply many management techniques other than the basics needed to aid production. Simple practices such as tillage, pruning, applying pesticides and fertilizers are all that are done beyond that in the farm some terraces where made in the beginning of its operations. Yet they require little maintenance only if extreme weather conditions affect them. In addition, aromatic plants native to the area grow around the borders of the farm naturally. All operations on the farm are done only by one employee who is in charge and operates all the machinery. To transport the almonds, the company that buys them come to the farm and picks them up themselves when they are ready to be sold.

3.2.1 Management practices of the Conventional Almond Monoculture

Harvesting

Harvesting in the farm is done once a year in august and sometimes it takes up to the beginning of September. They do the harvesting by the one main employee that works on the farm using the necessary harvesting machinery. They collect the almonds and then left to dry in a specific drying room that exists on the farm. When the almond is then optimal for sale, the company that buys it comes and collects it. They sell the almonds bare to the company and no other use comes out of the skin or hard shell of the nut.

Tillage

Tillage is a practice done traditionally in almond agriculture in Spain; It helps control unwanted weeds. Tillage can affect the soil by removing the green cover and plant roots leading to severe negative effects such as the inability to retain water as a result of a loss of organic matter, destruction of the soil structure and ultimately soil erosion (Martínez-Mena et al., 2013). Based on the article, reduced tillage can be considered when it is done 1 to 2 times a year. Tillage in the farm is done 3 times a year in November, March and June making it a conventional tillage method, and at a depth of 20cm.

Fertilizer

There are three types of fertilizers used in agriculture: organic matter, packaged organic fertilizers and the more common chemical and mineral fertilizers (Alonso, Guzmán, 2010). Chemical and mineral fertilizers provide nutrients directly to the soil, allowing the crops to grow faster than those that have been cultivated with organic fertilizers (Sánchez-Bel et al., 2008). Through the questions asked to the farmer it was mentioned that common granulated fertilizer is used without defining what type specifically, since the almonds, though that are produced are not considered organic it is safe to assume that they are chemical mineral fertilizers. This makes sense fertilizers help provide a fast and guaranteed almond production every year. The application of the fertilizer is done once a year in November, and a total of 150 kilos of fertilizer are applied per hectare.

Pesticides

The pesticides used on the farm, as mentioned by the farmer, are for antifungal treatment and when needed during a pest infestation pyrethrin. The antifungal treatment is done once a year in the wintertime. In a study conducted in almond orchards in California it was evident that fungal diseases were found in several nuts that were tested, the fungal and bacterial diseases developed in the nuts found on the ground and then affected the healthy nuts on the trees (Eilers, Klein, 2009). Pyrethrin, on the other hand is a pesticide that is considered toxic to certain species and that's how it eliminates it, though they are low in toxicity to humans and other mammals (Npic., n.d). However, it was found that it can have an adverse effect on aquatic species if it enters the water stream and thus farmers should be advised not to use it, though in recent years there has been an increase (Zhang et al., 2008).

Pruning

Pruning is a method used to clear out dead branches from the trees and make them able to produce better. Pruning is done systematically once a year in autumn. Traditionally in Spain, pruning residues are collected and burned; however, it seems to be a rather costly practice (Cerdà et al., 2018). However, for a variety of different crops pruning residues depending on their size along with the almond skins are left in the field and incorporated in the soil (Calatrava, Franco, 2011). In the farm, after the pruning the thickest pieces of wood are collected and used in the farmers' households and they burn the finest pieces in the field.

Hedges & Borders

The farm has naturally on its 'borders' (no physical borders exist but rather a conceptual boundary which is distinguished by the farmer himself) native aromatic plants such as thyme, rosemary and broom. These have not been planted and they are not maintained. Aromatics in the Mediterranean can grow naturally and are resistant to weather.

Vegetation cover

Vegetation cover is known to have many beneficial effects on the soil and helps protect it from degradation. In areas such as Spain, where the soil is dry and sandy, vegetation cover can protect the soil from extreme weather conditions. It can protect the soil both physically as it is found on the surface and through contributing organic matter, it can also help maintain the soil water balance (Ruiz-Colmenero et al., 2013). In the farm there is some spontaneous vegetation cover, however there is no mention how the farmer handles it, implying that it is left as is and when tilling is done, the vegetation cover is mixed in the soil.

Pollination

The pollination in the farm is done either by cross-pollinating the almond trees or by the trees themselves since they are self-pollinators. Cross-pollination refers to transferring pollen from one tree variety to another, even though almond trees can be self-pollinated it is difficult by the wind for commercial orchards (Goodrich, 2019). No bees are used in this case, yet as there are aromatic plants on the border of the farm that may attract other insects the trees can benefit from them.

Terraces

In Spain terraces are considered a traditional management practice, however *Faulkner & Hazel (2003)* in their paper, found a connection between abandoned agricultural lands with terraces and erosion risk they mention that the historical maintenance of the terraces prevented erosion. Thus, terraces can be seen both as a beneficial management practice and one that can lead to degradation in ecosystem services, if the fields where they are installed are abandoned, comprise erodible lithologies and climate conditions are unfavorable for establishment of a vegetation cover in the first years after abandonment.

They have made some terraces on the farm since it began being an agricultural land. Maintenance is not really considered since it is minimal. The only time they require maintenance is if perhaps during extreme rainfall the terraces have been affected.

3.3 Regenerative Almond Monoculture

Within the AlVelAl region, as it is formed by the association, there are many farms that perform or recently have been transitioning towards regenerative practices. The area of study of regenerative almond monoculture came from one of the farm members of the AlVelAl association. During conversations with experts in the field, this farm was repeatedly mentioned as a wonderful example of regenerative farming. It seemed to apply various such practices in order to maintain a sustainable farm.

La Solana, as the farm is named, is based in the Velez Rubio municipality in the province of Almeria in Andalucía, Spain. Velez-Rubio is the capital of the district of Los Velez which is a part of the Sierra Maria-Los Velez Natural Park. The temperature in the area ranges from 5 degrees Celsius in the cold months of winter to up to 34 degrees Celsius in the summer with an annual mean average of 14.3 C. The annual precipitation in the region also differs between the winter and the summer with a mean of 300 mm (Climate data). The farm was only rain-fed, and the soil is characterized as a calcareous soil, a soil low in organic matter content (Zhao et al.,2009).

La Solana farm, is 250 hectares in total and among the almond trees it comprises a variety of crops, such as 2.5 hectares of vineyards, 50 hectares of cereals, 1 hectare of pistachio and 125 hectares of wheat. Within the farm there was also a part of a natural area that was that of a part of a mountain. The focus, though, was in the almond monoculture area. The almond orchards were located at an altitude of approximately 1100-1250 meters. This difference in elevation occurred because they were located near the mountain area. The total area of the almond cultivations was 62 hectares. Three different varieties of almonds exist. Those of Guara which took up the 30 hectares and the remaining 32 comprise the species Marta and Antonieta.

Guara, Prunus dulcis (Mill) in Spain is one of the most cultivated almonds in the country amounting for approximately 40% of the current plantations, because of its strong performance and resistance to extreme weather such as frost (Dicenta et al., 2015). Antonieta and Marta have also been used in Spain as they are self-compatible cultivars and late-blooming species (Egea et al., 2000). As expressed by the farmer himself, Marta produces faster than the rest but Antonieta produces a larger almond.

The farm was handed down to the farmer from family members and in 2003 the existing almond trees were removed and sold for wood allowing the new ones to be planted. Some, in January and others in December of the same year, making most of the trees approximately 16 years old. As an example of regenerative farming, the farm focuses on incorporating various methods and considering the land's history and the societal norms found in the area. As such, beyond land use practices it allows for sheep herding within the almond area as well as the incorporation of beehives but additionally for recreational purposes. Hunting is a common activity in the country and area specifically as there are a variety of species found. Some animals that are found and hunted are hare (Lepus) which are often hunted using the help of dogs, partridges (Perdix perdix), boars (Sus scrofa), Arrui (Ammotragus lervia) as they are known in the region and the Spanish goat (Capra aegagrus hircus).

3.3.1 Management practices of the Regenerative Almond Monoculture

Harvesting

Harvesting is done only once a year, usually in September. However, this may change according to the climatic conditions of that year. It is performed with the use of tractors along with a couple of contractors that come specifically for this purpose.

Tillage

Tillage has been used intensively in agriculture for more than a century in a variety of different ways. It seems that it can provide many benefits and increase the productivity of the crops. It can help soften the soil and place the seed to be planted at an appropriate depth. It can help with the removal of the weeds that may grow under the crops and compete with them for nutrients, water and sun. During tilling, some of these weeds can get mixed into the topsoil along with other residues of the crops and increase the organic matter of the soil. Tilling is also known to help with the oxidation of the soil (Hobbs et al., 2007). Among these, there are many more benefits that can be seen to be provided by tillage and control the successful production of crops, hence be very useful for intensive agriculture.

However, there are many negative effects of tillage, and a new approach to agriculture promotes reduced tillage or no tillage. Agriculture under intensive tillage does not seem to be able to deliver many environmental ecosystem services. In the Mediterranean region, many agricultural soils seem to be poor in organic matter and with a low soil aggregate structure which continues to get worse from the excessive tillage and overgrazing (Kassam et al., 2012). Reduced tillage, allows to get some possible benefits of the practice with a low disturbance rate. Reduced tillage in this case refers to a reduction in the frequency of tillage throughout the year and a reduction in the depth of the tilling. Improvements in this case have been seen in the availability of biological nitrogen, as well as nutrient availability (Almagro et al.,2016). In fact, the cover of the topsoil with temporary vegetation cover has shown a decrease in the runoff, which may have carried seeds or fertilizers. This decrease in tillage can reduce the costs of production in a farm as well as help with the reduction of emissions from lesser use of tractors (Kassam et al., 2012). Overall, although there are still few data available it is expected that such a practice in dry regions by increasing the soil quality can help increase in the long run the production yields.

In la Solana tillage is done twice a year in the winter and in the spring with a maximum depth of 15 cm. this can be considered reduce tillage as it does not exceed the amount of twice a year (Martínez-Mena et al., 2013).

Compost

The compost is used as an alternative to regular fertilizers to maintain organic agriculture on the farm. It is often considered that compost may not be an economic and feasible alternative, as it requires larger amounts to supply the soil with the nitrogen requirements (Evanylo et al.,2008). Yet the use of compost on agricultural land has shown several benefits such as pH stabilization, faster water infiltration from increased soil aggregation with a reduction in nitrogen runoff and beneficial microorganisms (Bulluck et al.,2002). In the farm, compost is applied once a year and the amount per hectare is $5m^3$.

Pesticides

Pesticides have been widely used in agriculture as they are known to decrease the harmful insect populations to the crop and thus increase productivity. However, conventional pesticides/insecticides have been linked to both humans and animal species and the environment. They can be toxic through direct contact but also through the food chain. In the environment, pesticides can pollute both the soil and the water stream (Aktar et al.,2009). This can influence other species further away from the area where the pesticides have been applied. However, insecticides and pesticides are used until today, as they can control safe, fast agricultural production.

Despite this common use, natural organic repellant has been more and more used through organic agriculture. Certain insects and spiders may be beneficial in almond orchards. Because of an increase in the abundance of such species, other predatory animals will feed of these species and control the pests found in almond crops (Hendricks, 1995).

Ecological pesticides are applied once a year, even if there is no pest infestation as a precaution.

Pruning

Pruning is a method used to maintain the trees in good shape. Almond trees spread their branches to get as much sunlight as possible and allow the air to pass through. Pruning is done as a method to preserve the leaf-to-wood ratio and to prevent it from pest and disease contamination. After pruning, the debris produced from it can be used to improve the soil texture and help reduce water runoff (Rodríguez-Entrena et al.,2013). Often some branches may die and by cutting them new ones can grow. It also helps shape the tree into growing taller or as wanted. Pruning on the farm is only conducted once every two years to help maintain the trees.

Hedges & Borders

They often create hedges and borders within agricultural farms to provide various benefits to the crops. Erosion control and a home of pollinators are some main benefits. Most times, they can be considered eliminating pest infestations, yet on the contrary, many farmers indicate that they increase unwanted pests as they do attract them (Schoonhoven, 2017). It is difficult for many to grasp the benefits that come as they are obtained in the long term and are targeted to help the ecosystem services of the land. As a result, they are often avoided as a management method as they can be costly and difficult to maintain since they eliminate the space for the tractors to pass through.

In regenerative farming, hedges and borders are observed as a positive management method and used as in La Solana. In the farm a border with hedges of rosemary Rosmarinus officinalis, and broom Genista monspessulana, of 2.5 kilometers has been planted.

Swales

Swales are channels in the soil that help store surface water. The can vary in size and are used to help minimize surface runoff when it rains and allow slow water infiltration later on. They can help reduce flood risks and erosion control and sediment loss (European Commission, 2013).

Essentially, they are a simpler, more traditional rainwater retention system. They are often placed in-between tree lines in order to enhance the water retention in the soil near the trees and increase their productivity (Nolasco, 2011). A 7-kilometer swale line was carefully and thoughtfully constructed on the farm.

Vegetation cover

On the farm, there is a natural vegetation cover between the autumn and spring due to the increase in rainfall. The vegetation cover is allowed to be and actually maintained through the sheep. The sheep that are allowed to graze in the almond field control the levels of the vegetation and get to feed off of the land and additionally provide manure to the area. This 'relationship' agreed with the sheep herders benefits both the sheep and the farm.

Pollination

Pollination in the farm is done both by the almond trees themselves as the varieties that are planted Marta, Guara and Antoñeta are self-pollinated species (Dicenta et al., 2002). Beyond this method which may not always be effective the farm rent out the land to beekeepers who benefit off of using the land and trees for their bees and they help with the pollination of the almond trees.

Terraces

In Spain and in the Mediterranean in general, terraces are a traditional land management practice in order to increase the land area for cultivation on the hill slopes in such semi-arid environments (Bevan, Conolly, 2011). In the farm, naturally formed terraces exist since before the farm's current condition. As the farmer stated not much is done in order to preserve them, the tractors manage to pass by one and do not alter them in any way.

Inter-cropping

Inter-cropping is done on the farm only in a certain area between the almond trees as an experiment in this case. The Inter-cropping is done with leguminous species every three to four lines that are not utilized in any way. Inter-cropping can help with water retention in the field and ultimately benefit many ecosystem services such as soil erosion.

Sheep grazing

The sheep are allowed to graze in the farm as a management practice that provides a benefit both to the sheep herders in the region and the farm. The farm rents out the land to the sheep herders, who bring in the sheep to graze off of the vegetation cover and thus control it in this way. Additionally, the sheep provide naturally, manure to the area.

4.Management Costs of Regenerative and Conventional Almond Monoculture

4.1 Introduction

The climatic conditions of semiarid regions affect the soil characteristics, constricting this way the management practices (Ramos et al., 2011). To maintain rain-fed agriculture, sustainably, the goal is to implement practices that ensure water availability and protect the environment from extreme events. Yet, most times to obtain a higher production and exploit as best the ecosystem services of an area, such visions of future sustainability are not considered. The management practices that a farmer or farm implements have a given cost. These costs can vary based on management practices. For example, regenerative agriculture might bear more costs to ensure future sustainability; conventional farming may also bear more cost to ensure a fast growth of production. It is interesting to see how various management practices differ in their costs and the results that these bring in the long run to the land. Bellow, both regenerative and conventional almond monoculture are compared.

4.2 Management costs of the Conventional farm

The conventional farm, focuses on simple practices that enhance and ensure almond production. Thus, the costs it bears are from only a few practices.

Fertilizer

The fertilizers used on the farm, as mentioned by the farmer, are 'granulated fertilizers. Since the farm is a conventional almond monoculture farm as no other information was given on the type of the fertilizer it can be assumed that those applied are chemical or mineral fertilizers as the other categories of fertilizer are used for organic agriculture (Alonso et al., 2010). The quantity used is 150 kg / ha / year at a cost of 0.50 euro / kg, by this we can calculate that 75€ are spent per hectare per year. The farm in total is 40 hectares, thus annually 3.000€ are spent on fertilizers. Applying the fertilizer is done once a year in November.

Pesticides

The pesticides used on the farm are for antifungal treatment and pyrethrins. These are applied once in the wintertime and the pyrethrins are applied only when there is a pest infestation. Since pest infestations are not a predictable thing, there is no certain value spent per year on pesticides and the farmer estimates that between 20€ and 100€ are spent per hectare per year. In this case, in order to provide a specific value, the mean was taken among these two values, so approximately 60€ are spent per hectare per year for pesticides. By applying this to the total area of the farm, ~2.400€ are spent annually.

Salaries and machinery

On the farm, there is only one main employer who is responsible for all the necessary management practices and activities needed on a daily basis. Such activities involve using the machinery for harvesting, tilling the soil, using the necessary machinery to apply the fertilizers and pesticides. Other activities involve collecting the harvest of almonds and transporting them to the drying area where the almonds are kept until they are ready to be sold. Pruning is another task done by the employer when necessary, after which he is responsible for collecting fallen branches and the wood which is used personally by the farm. The pieces of fine wood that remain are burned in the field. The salary for the employee who works full time on the farm is 1.200€/month, resulting in a total 14.400€ a year.

The machinery used on the farm are tractors, farm tools, harvesting machinery, an atomizer which is essentially a spray gun that can be used to apply fertilizers or pesticides. These machineries are used for all necessary activities on the farm in terms of tillage and collection of the almonds. For the costs spent per year on all machinery including maintenance, repairs and fuel, the farmer provided a single value of 15.000€. It is unclear how the value applies to each machine separately, but it was mentioned that all costs spent throughout the year involving the machinery are within this value. Depreciation of the machinery was not mentioned by the farmer and perhaps not considered at all by him.

Total costs

In total, the costs spent on an annual basis on the farm are for salaries, machinery, pesticides and fertilizers. These are approximately 34.800€.

Table 3. Management costs for Conventional Almond Monoculture

Management Costs	Quantity	Cost	Total Cost
Salaries	1 full time worker	1200 €/month	14.400€
Machinery	n/a	n/a	15.000€
Fertilizer	150kg/ha/yr* 40 ha	0.50€	3.000€
Pesticides	40 ha	~60€/ha	2.400€
Total Costs			34.800€

4.3 Management costs of the Regenerative farm

La Solana is a farm that has focused in regenerative agriculture from its creation in 2003. Based on the characteristics of the territory, it has managed to implement as many as possible regenerative practices. In order to maintain these practices that consider the land ecosystem services and the future benefits both the land and farm obtain from them, there are many costs to bear.

Tillage

In La Solana, tilling is not minimized completely but performed only twice a year. This occurs in the winter time between January and February and in the spring/summer between May and June. The depth of the tilling is also kept to a maximum of 15 centimeters. The cost, as stated from the farmer, is at 60 euros per hectare. Thus, by multiplying it with the 62 hectares and by twice a year it results in 7.440€ in total annually.

Compost

Compost is applied once a year on the farm and the amount per hectare is 5m^3. The cost for this quantity comes to be 125 euros per hectare, thus 25€/ m^3. Based on the fact that the almond plot is 62 hectares, the total cost spent on compost per year is 7.750 euros.

Pesticides

Natural repellants can also be beneficial in organic agriculture in order to safely maintain the crops. On the farm, only natural or ecological as the farmer mentioned, repellants were used every year. Even if there was no observed pest infestation as a precaution, they were applied. As the exact cost per hectare varies between 50 to 60€ per hectare, an average will be used to calculate the total amount used in the farm. Thus, approximately 55€ per hectare of natural repellants is used. By multiplying this with the 62 hectares of almond trees, the total cost of repellants 3.410€ annually.

Hedges and borders

On the farm a border with hedges of rosemary *Rosmarinus officinalis,* and broom *Genista monspessulana*, of 2.5 kilometers has been planted. The cost of creating this is at 3.000 euros, yet it is not an annual cost as they were planted and simply maintained annually. There is no specific cost for maintenance, as it is considered in the salaries of the farm workers throughout the year.

Swales

In the almond area in the farm, a swale line was created, which is 7 kilometers long. The swale tends to hinder the operation of the tractors, but they provide many benefits to the farm. The cost of creating them amounts to 12,000€. Yet, that is a onetime cost as they are maintained on the farm, and the maintenance as stated by the farmer is a relatively easy procedure and is not calculated as a cost.

Salaries and Machinery

Costs in terms of salaries for the workers help maintain various of the ecosystem services, as the workers of the farm are responsible for all necessary activities to be performed. They help with the provisioning services in general the treatment of the almond trees and the collection of the nut, but also for performing other regenerative practices on the land that consider the regulating services.

There are approximately two to three people working on the land per year. On a regular basis the farm owner himself tends to coordinate and control things. Even though he is considered full-time worker on the farm he does not obtain a specific salary for it. Beyond that extra contractors come during specific times. Two people come during the harvest season for approximate 15 days or a month depending how much work is needed. According to the farmer they get paid 7€ an hour and work approximately 350 to 380 hours a year which in total sums up to 2.660€. A couple more workers also may come for the pruning season, which is done on the farm once every two years. These two contractors receive 11€ an hour, work approximately 200 to 220 hours a year and thus receive 2.420€ a year. The salary of the worker that helps during the harvesting period is included with the amount spent for renting the tractor and is mentioned further below. As there are two contractors per position this amounts to in total for all workers on the farm 10.160€ per year.

In terms of the machinery used on the farm, a contractor comes during the harvesting period along with his own tractor. The amount spent for that is 35 euros per hour. This price includes all expenses, the salary of the worker as well as the fuel needed for the tractor and any maintenance costs that it may require such as simple repairs or breakdowns, it also includes the taxes. By multiplying this to the number of hours approximately used per year, which are 425 it seems to amount to 14.875€ per year.

Additionally, 3 trucks are hired for the transportation of the almonds to the company where they are sold. This cost is 150 € per trip, again including in this price costs of the fuel and any possible needed maintenance costs. In total, in a year the trucks are used for three trips. Resulting in a total of 450 € per year. If all prices are added up in terms of the machinery it comes out in 15.325 € per year.

Total Costs

The following table concentrates all the management practices used in La Solana to perform regenerative agriculture and their respective costs per year. Calculating all costs in total is useful in order to further perform the cost-benefit analysis and understand the actual benefits that come from regenerative agriculture. The total costs come out to be 44.085€.

Table 4. Management costs for Regenerative Almond Monoculture, La Solana

Management Costs	Quantity	Cost	Total Cost
Salaries	Contactors	7 €/h	10.160 €
Machinery	Trucks	150 €	450 €
	Tractors	35€/h	14.875 €
Compost	62 ha	125 €/ha	7.750 €
Repellents	62 ha	~55 €/ha	3.410 €
Tillage	2*year*62 ha	60 €/ha	7.440 €
Swales	7 km	12.000 €	12.000 €*
Hedges & Borders		3.000 €	3.000 €*
Total Costs			**44.085 €**

* costs of the swales along with the hedges are not considered in the total costs of the farm for the past year as they are costs spent in the past as a one-time thing and do not require any further costs. However, it is interesting to examine such costs.

5. Ecosystem Service Benefits of the Conventional Farm

The benefits received from the ecosystem services on the conventional farm are split into all the basic categories, the provisioning, the regulating, the cultural and habitat services. As a conventional almond monoculture, the farm focuses on benefiting from provisioning services since it focuses on the quantity of the crop. However, it is interesting to examine what monetary benefits it receives from the other categories of the ecosystem services. Table 5, summarizes all the ecosystem service benefits the farm receives per year for each category.

5.1 Provisioning services

Almonds

Provisioning services in commercial agriculture are the focus point for beneficiaries, and the remaining ecosystem services are basically helping to obtain the provisioning. These are the benefits derived directly from the crops, food, and more specifically, in this case almonds. The farm which is 40 hectares has only rain-fed almond trees of the Marcona, Desmayo and Guara varieties. The almonds of the farm are all sold to the cooperative they are a member of. The almonds are collected only once a year and approximately 700 kg/ ha/year are produced. Based on the question answered by the farmer, the price provided for them was 1.5€/kg. In total, the farm sells annually 28.000 kilos at a total benefit of 42.000€.

5.2 Regulating services

Climate regulation

Often, conventional management practices in almond monoculture such as tillage removes the vegetation cover, leaving the soil bare between the orchards. This practice along with the use of conventional pesticides and fertilizers can lead to a loss of soil organic carbon (SOC) from the increase in mineralization rates and erosion rates, respectively (Vicente- Vicente et al., 2016).

In the farm examined such conventional management practices take place, thus in order to calculate the amount of carbon sequestration and monetize it in such a system similar cases are considered. However, due to the lack of data that focuses on recording the carbon sequestration in almond monoculture systems in Spain the value was taken by a study conducted by Padilla et al. (2010) who examined the implications of land use change on carbon sequestration. In the paper, a value of 7ton C/ha/yr was recorded from almond orchards in California, USA under intensive farming. By applying this value to the case of the conventional farm examined and by using the value of one ton of CO_2 used in the stock exchange at the current moment, which is at 22.35€ based on the European Emission Allowances (EUA), an approximation to the value of carbon sequestration performed in the farm can be estimated. This results in 156.45€ ha/yr.

Using this hypothetical direct market valuation, the value of the total amount of carbon sequestration by the farm is 6.258€.

Erosion control

Erosion in conventional agriculture, especially located on a slope, is inevitable in one way or another. In a semi-arid dry-land already consisting of sandy soil, frequent tillage that eliminates regularly the vegetation cover can increase the rate of soil erosion. Even though intensive tillage is used as a practice to improve the water infiltration to the tree roots, it can increase the vulnerability of the land to water erosion (Calatrava et al., 2011). As the vegetation cover could help retain water, improve the soil quality and thus eliminate the risk of erosion.

On the farm, tillage is a frequent management practice to help increase the production of the crop throughout the year. In addition, naturally created terraces exist which have often been linked to soil erosion in the Mediterranean due to their improper maintenance and frequent abandonment from previous agricultural lands (Koulouri, Giourga, 2007). Though as the farmer stated, the terraces are maintained and can be beneficial for soil erosion. However, as the farm does perform such management practices, we cannot consider that it provides a benefit in terms of erosion control but rather a negative effect. This negative effect is monetized through the costs of the fertilizers and money spent on plowing the land and is calculated in chapter 4.2.

Fire control

The management practices performed on a farm are those that can help enhance fire control and reduce the potential risk. In the conventional monoculture farm, only almond orchards do not provide any fire control benefits. Along the borders of the farm native aromatic plants grow, which were not planted but they are not eliminated as they can provide a form of a break in the landscape between the almond trees, yet it cannot be considered a sufficient fire control mechanism. Tillage is another technique associated with fire control as the vegetation cover is eliminated, which could pose an additional potential fire hazard in the summer months (Zuazo et al., 2009).

However, in the farm fire control is not a service that is considered as there are no precautionary methods applied. In this case, since eliminating a natural area to grow a monoculture that is easily destroyed by fire can have a negative rather than a positive effect on the area.

Pollination

Pollination is a beneficial ecosystem service in agriculture as it helps produce food products such as almonds (Fisher, Turner, 2008). Pollination on the farm is done by the self-fertile almond trees planted. These are Desmayo, Guara and Marcona which are used a lot in Spain due to their high productivity and self-fertile ability (Vargas et al., 2008). This may not always be enough so the trees are also cross-pollinated. Cross-pollination is done between the species found on the farm and it is often done by hand. In a study conducted by Ortega et al. (2006) the traits of the almonds were examined under the different methods of pollination of the trees and cross-pollination can be seen to provide a relatively larger kernel. Beyond these methods, pollination is also done by the native pollinators that may enter the fields from the surroundings and because of the native aromatic plants found on the borders of the farm. However, no bees are used for pollination, as it is common in the region to rent out the farm to beekeepers. The farmer is not concerned with this issue and thus relies on the previous methods to maintain pollination.

Soil fertility

In the almond orchards examined, the practices used are conventional tillage meaning three times a year as well as common chemical fertilizers and pesticides, spontaneous vegetation cover in the winter exists yet it is removed through the tillage.

Soil fertility cannot be considered as a positive ecosystem service the farm provides but rather a negative one as the methods only deplete the natural soil fertility that can be found in the area. Soil fertility can be monetized in this case as the amount spent on fertilizers which are mentioned in chapter 4.2 (The management costs of the farm)

Biological control

Biological control as a regulating service is used in the sub-service of pest control for the case almond agriculture. Biological control indicates the population control through trophic-dynamic relations such as those of pests and diseases (De Groot et al., 2002). In agriculture, various management practices are used to treat pests and avoid devastating disasters to the crops and environment. For this reason, biological and disease control is an interesting ecosystem service to examine, since it can provide many benefits to the land. Farm pest control is managed by the use of antifungal treatment once every year as a precautionary method. In addition to that in case of a pest infestation pyrethrin is used, pyrethrin is a chemical used as a pesticide since it is rather potent for insects and small vertebrates but rather environmentally stable (Valentine, 1990).

Since in conventional farming, biological control is replaced by chemical pesticides it can be monetized in this case through the actual value of the amount of pesticides used per year which is mentioned in the management costs of the farm in chapter 4.2.

5.3 Habitat services

The habitat service found on conventional agriculture and examined in this case is the biological diversity. In this case it is interesting to examine the capacity almond monoculture systems have to host a variety of species whether they are plant or animal. As it is known from the farmer the land has three different types of almond trees and additionally allows the naturally growing native aromatic plants and shrubs to exist around the farm. It is unknown what other land uses surround the farm whether other native species exist in the area and interact with those of the farm, such as insects, however it is known that no bees are used within the farm for pollination. The management practices used by the farmer try to eliminate unwanted pests through the use of conventional chemical pesticides. Boars as mentioned by the farmer found wild in the region can often be found around the farm and they tend to feed off of and ultimately destroy the trees, thus an effort is made to minimize such damage. Yet what is done is unknown, but it is perceived as a problem. In addition, by minimizing the amount of vegetation found in the farm it does not provide many alternative plant species for other than those already existing insects to the farm.

The monetization of the biological diversity of the farm comes from the Master thesis of Bedoya (2018), who examined the habitat services of various land use systems, among them that of almond monoculture in the region. Moratilla (2010), calculates the value of biological diversity based on the cost needed for conservation from the subsidies and other monetary help provided to the farmers by the government. This value is 3.44€/ha/yr, if we apply this to the total area of the farm the total benefit provided by the land for biological diversity results to 137.6€ per year.

5.4 Cultural services

Assessments in Europe on ecosystem services have often been carried out "cultural landscapes" suggesting their importance in examining the benefits they can provide. In many cases, they can have a more significant value in an area than some other ecosystem services that may be degraded, such as provisioning services (Plieninger et al., 2013). As almond trees tend to grow in dry environments in Spain they have been cultivated for many years and almond monoculture systems can be seen as a traditional cultural landscape.

Recreation

The specific farm does not provide a direct form of recreation as to utilizing its land by hunting or for touristic purposes, however as almond agriculture exists through the south-east of Spain tourists that visit the area are bound to observe the trees. As almond trees during their blooming period can be very spectacular. As there is no direct measurement of the recreational value on the specific farm benefit, transfer has been used for the TEEB database. Brenner et al., (2010), among other ecosystem services, provided a monetary value of recreation as a service for cropland Catalonia, Spain. Even though it is not based on almond trees specifically, it is the closest best option in the case of the farm. The value recorded for this area is at 37 US$ /ha/yr. Converting this value based on the exchange rate currently results in 32.38€/ha/yr. For the total farm, the value is 1295.2€ annually.

Table 5. Ecosystem service benefits, the farm receives per year.
Some of which are directly gained by the farmer and some are shadow prices of which the farmer receives the benefits in other ways (he does not need to allocate money to sustain in this case biological diversity and he provides climate regulation to his local community)

Provisioning	Food	Almonds	28.000 kg	1.5 €/kg	42.000 €	Direct
Regulating	Climate regulation	Carbon sequestrati on	7-ton Co2/ha/y	156.45€/h/y r	6.258 €	Shadow Price Carbon Stock market Price
	Moderation of extreme events	Fire control	n/a	n/a	n/a	
	Erosion control		n/a	n/a	n/a	
	Pollination		n/a	n/a	n/a	
	Soil fertility		n/a	n/a	n/a	
	Biological control	Pest & disease control	n/a	n/a	n/a	
Habitat	Biological diversity			3.44 €/ha/yr	138 €/yr	Indirect Avoided Cost
Cultural	Recreation			32.38 €/ha/yr	1.295 €	Indirect Avoided Cost

Subsidies

The subsidies that the farm receives add to the benefits gained from this type of agriculture (almond monoculture). As the farmer stated they receive from the Common Agricultural Policy CAP, which applies to the member states of the European Union the national aid for nuts along with the single or basic payment entitlements. For the national aid for nuts as well as for the single payment subsidy, the value differs per farm (Europa, 2007). However, the farmer stated that they receive approximately 190€/ha. This amounts to a total of 7.600€ for the total area of the farm.

Total benefits

The farm receives various benefits in terms of ecosystem services. Table 6, shows the benefits received per category of ecosystem services for the whole farm and for a per hectare basis. For the provisioning services, the total amount comes only from the almonds and it 42.000€ per year. For the regulating services the total value is derived only from the climate regulation and the fire control, the erosion control, the soil pollination, the soil fertility and the biological control, are services that do not provide any extra benefits and in order to maintain them there are certain costs which can be seen in Chapter 4.2; thus, the regulating services as a positive value result in 6.258€. For the cultural services, the value is derived from the recreation at a total of 1.295€. Finally, the habitat services provide 138€ for biological diversity per year. In addition to this ecosystem service values, the farm benefits of the subsidies it receives from the government. The total amount of the benefits received by the farm comes out to 57.291€ per year out of which the direct market value the farmer receives are 49.600€ the rest 7.691€ are a shadow price the farm and local community receive from having this farm in the area. On a per hectare basis the farm receives 1.431€ out of which the direct value the farmer receives is 1.240€ and the rest 191€ is indirectly.

Table 6. Total amount of benefits per category of ecosystem services in €/yr for the whole farm and on a per hectare basis.

The benefits per category of Ecosystem Services derived for the total farm and on a per hectare basis per year			Types of monetary valuation
Provisioning	42.000€	1.050€	Market/Direct value
Regulating	6.258€	156€	Shadow price/ indirect
Habitat	138€	3€	Avoided Cost/ indirect
Cultural	1.295€	32€	Shadow price/ indirect
Subsidies	7.600€	190€	Market/Direct value
Total benefits	**57.291 €**	**1.431€**	**Direct→49.600€/ 1240€/ha** **Indirect→7.691€ /191€/ha**

6. Ecosystem Service Benefits of the Regenerative farm

La Solana performs various management practices in order to maintain its sustainability in the future. Some management methods that are considered regenerative practices are more beneficial to the ecosystem services. These management practices are using natural pesticides, reduced tillage, swales, terraces, cultivating leguminous species in-between the crop lines, incorporating bees as pollinators and allowing sheep herding on the land. These management measures, benefit provisioning services, regulating ecosystem services, habitat services but also cultural services. Table 7, summarizes all the benefits gained from the ecosystem services found on La Solana.

6.1 Provisioning services

The provisioning services in the case of La Solana are minimized to the production of food and specifically only almonds. The focus is placed on the almond monoculture plot. The number of almonds produced per year in the plot of 62 hectares is 15 tons. This means that approximately 242 kilos of almond produce per hectare per year. This provides a benefit to the farm of 105.000€ per year as the almonds are sold at 7€ per kilo. However, this value applies for the past year and may differ year by year. The almonds are sold without the soft shell, but with their hard shell, which is removed at the company they are sold at.

6.2 Regulating services

In agricultural ecosystems, the regulating services are those that control and determine the availability of the provisioning services through the regulation of the soil properties and pollination of crop (Zhang et al.,2007). The regulating services that are of great importance in the case almond orchards are climate regulation through carbon sequestration, soil erosion control, moderation of extreme events such as fire control, soil fertility, pollination, biological control.

Carbon sequestration

The agricultural management practices used in la Solana can be linked to help increase the carbon sequestration in the soil and the whole farm. Reducing the tillage amount to two times per year at a depth of 15 cm while incorporating some green manure, allowing natural vegetation to occur throughout the almond trees and introducing leguminous species, using compost and natural pest repellents instead of commonly used fertilizers and pesticides are some of these beneficial practices.

A study conducted in almond orchards in the southeast of Spain measured the benefits of reduced tillage and recorded important changes in the soil organic carbon (SOC). Specifically, it focused on the combination of reduced tillage with incorporating the green manure and found an increase in carbon sequestration and an improvement in the soil structure (Garcia-Franco, 2015). Crop rotation with the leguminous species planted within the lines of the almond trees have also been found to have some of the best results in carbon sequestration in almond orchards (González-Sánchez, 2012). This suggests the beneficial effects of incorporating the aromatic plant rows, La Solana has placed as borders in the field. In addition, switching from fertilizers to composts can contribute to the accumulation of carbon in the soil. Other practices need also to be considered as the farm allows for the sheep to graze in the almond plot area, providing, cleaning thus the soil from the weeds and providing manure.

All these various management practices can contribute to the accumulation of carbon in the soil. Yet this shows the complexity in examining the actual value found in a specific field such as La Solana, as no specific measurements have been performed there and a variety of variables make it a different case to measurements found through literature in other locations; when it comes to trying in monetizing the value of carbon sequestration as a benefit.

In a study conducted in the northeast of Spain, a variety of management practices are linked to the abatement costs of carbon in almond orchards. The focus is placed on the cover crops, minimum tillage, residue management, manure fertilization, crop rotations and optimized fertilization (Sánchez et al., 2016). This case seemed to be the closest option as it incorporated a variety of practices that are performed on La Solana and the almond plantations in Spain are fairly grown under similar conditions. As the authors suggest cover crops were most linked to the abatement potential of about 0.06MtCO2e at a positive value of 238/tCO2e ha/yr euros. If this is value is considered for the 62 ha of the farm, a positive benefit of 14.756 euros is provided through the adopted management practices for carbon sequestration.

Erosion control

As mentioned in the interview in the case of La Solana the soil is relatively calcareous and sandy. This, along with the large slopes upon which much rain-fed almond orchards are found, causes them to be more prone to wind erosion. Wind erosion on agricultural land affects the fine soil particles that contain greater amounts of plant nutrients. If this continues in the long run, it can have an effect on the soil, water storage and a further degradation of the land (Gomes et al., 2003). In agriculture, in such semi-arid regions in Spain the management practices performed to produce intensively worsen the case, such as constant tillage and removal of the ground cover vegetations.

In contrast, the regenerative management practices used in La Solana help to avert soil degradation and erosion. The reduction of tillage, the intercropping with leguminous species, the allowance of the natural vegetation, as well as methods of incorporating swales and terraces all decrease the amount of soil erosion. Reduced tillage helps increase the water content of the soil which allows for vegetation cover; both these practices can improve soil structure stability (Ramos et al., 2011). Well constructed and preserved terraces in addition have been considered a method used to avoid soil erosion in such Mediterranean landscapes. Terraces have often been linked to an increase in soil erosion, as the top layers of the terraces that may not be well maintained are susceptible to wind erosion. This has intensified along with agriculture, where in the south of Spain many terraces have failed from the passage of machinery and the lack of vegetation cover (García-Ruiz, 2010). However, if terraces are well constructed and maintained over a long period they can be linked to a decrease in erosion (Hooke, Sandercock, 2012).

In La Solana, the terraces have occurred naturally up the mountain area where the almond trees are planted for as long as the farm has been there. According to the farmer, as the tractors paced through the trees, the terraces were even more well-formed and currently are only maintained by avoiding any damage to them. Vegetation cover is found on the terraces and it the farmer believes through his observations that they help with soil erosion, as the wind blows particles and pieces of sediments that land on the rows of the terraces and not further down the mountain into the fields.

Swales is a new practice implemented in almond orchards in Spain and only a few farmers have implemented them as they are difficult to design and implement and are considered an obstacle for machinery (Schoonhoven, 2017). Swales are essentially a shallow line passing through the farm that can help with water retention, especially in rain-fed agriculture and stop sediments being eroded further along the field. There is not much research as to what extent swales help control soil erosion, but it has been implemented as a regenerative practice in La Solana.

In terms of quantifying and monetizing soil erosion in such regenerative almond orchards, the available information that considers all management practices is rather insufficient. In a case study conducted in the Puentes catchment in Guadalentin river in the southeast of Spain, Hein (2007), calculated the erosion control for almond monoculture systems by using a replacement cost method. This was done by measuring the nutrients being removed by erosion based on the prices paid by farmers for fertilizers per hectare and in accordance with the slope of the specific area. However, this value represents almond monoculture and not a regenerative almond orchard, thus the value was obtained from the Master thesis of Angelucci, (2018) who examined the mixed land use systems for almond orchards that incorporate a variety of various regenerative management methods. By adapting the value of the almond monocultures in accordance with the questionnaire he conducted he came up with the value of 39 euros per hectare per year, for an area with a slope of 10% to 20%, as is also the case with La Solana. Based on this value, La Solana in total benefits 2.418€.

Fire control

Fire control is an important ecosystem service to consider, especially in this farm, as it is located in a semi-arid region, neighboring natural areas with vegetation cover. Agricultural land, found between forests and in general vast areas of vegetation are often considered as a means of preventing forest fires. According to a study conducted in Spain, farmers and inhabitants of the area were asked to value which type of landscape is better for providing ecosystem services such as fire control between traditional croplands that allow sheep grazing and forests, the results indicated that the locals and a farmer, perceived croplands as the better option (López-Santiago et al., 2014). The management practices conducted in the agricultural lands are those that make them more fire resistant such as those performed on La Solana.

Incorporating sheep grazing to remove once in a while the natural vegetation covers as well as planting lines of aromatics and inter-cropping with leguminous species are some of these benefits to fire control measures done tillage on the conventional farm.

Even though the Mediterranean region and Spain are susceptible to forest fires particularly in the summer months not much data have been recorded to understand which different agricultural land use systems and management practices can be beneficial for fire control; even less to actually monetize such information. For this reason, benefit transfer is done for the Master thesis of Angelucci, (2018), where he analyzed a paper of Varela et al. (2007) who quantified the fire control in the livestock farming systems by comparing grazing to the use of machinery and calculating the avoided cost of doing so. In this case, Angelluci, adjusted the average value from the livestock ecosystems of mixed land use systems based on questionnaires he conducted in the area. The mixed land used system described in his thesis refers to the use of sheep grazing and incorporating inter-cropping and lines of aromatics as is done in La Solana. The result, he provides amounts to 240€/ha/yr. Based on this value, the total amount that La Solana benefits from its management practices on fire control is 14.880€.

Pollination

In La Solana, pollination is fairly interesting to examine as the farm has both of these self-pollinating almond species but also incorporates bee species. The farm rents out part of its land between the almond lines to beekeepers. There they place beehives and both parties gain the benefits the farm receives pollination and the beekeepers benefit from the land and trees that accommodate the bees. In addition to both these methods used for pollination, the lines of aromatic plants, the intercropping and the fact that the almond fields are located next to a natural area all help increase and maintain a good level of pollination in the farm.

Pollination can be seen as beneficial, as it helps increase productivity of the crop species, especially in such a mixed land use system. However, not much data is available in recording such a benefit and monetizing it especially in such a versatile land use system. For this reason, the method of benefit transfer is applied to obtain the value from the TEEB database. Specifically, the value found for pollination from the TEEB database comes from a study of Brenner et al., (2010), conducted in Catalonia, Spain. Using a non-market monetary value in this case avoided cost of the paper it is assumed that approximately 20 USD/ha/yr is avoided for pollination. Currently, the conversion of 20 dollars to euros provides 17,69€/ha/yr. If this is applied to the total area of the almond fields of La Solana, it adds up to a benefit of 1.096,78€ per year.

Biological control

In la Solana a regenerative farm that produces organic almond pesticides is not applied rather natural-ecological repellants. During the field interview and questions posed to the farmer, the use of such repellants was mentioned but without explaining the type of repellants. However, in many cases natural repellants such as natural plant products/botanicals, including essential oils, can be seen to be used in organic farming (Batish et al., 2008). Other practices such as cover cropping and intercropping help in their way to exclude certain pests from being beneficial for other species (Kristiansen et al., 2006). Methods that are performed in la Solana.

Measuring the benefits of such biological control has not been conducted under such specific measurement practices in Spain, furthermore monetizing such values. Once again benefit transfer is used from the TEEB database for the study of Brenner et al., (2010) in Catalonia, Spain which is the closest possible value to the real situation. The method used is avoided cost, and it is calculated that around 30 USD/ha/yr is avoided in terms of biological control methods. Currently, 30 USD is converted to 26.54€ /ha/yr as a result the total benefit provided for biological control in La Solana 1.645,48 € per year.

Soil fertility

In such an intertwined system affected by a variety of measures, unfortunately no readily available data exist that consider all the beneficial practices. In this case the data for soil fertility comes from Martín-López et al. (2011) who examines the ecosystem services of the Doñana social–ecological system (southwestern Spain). The authors examine the most important ecosystem services found to assess the effectiveness of the conservation, as the Doñana is a protected area. The services are each found through a variety of economic valuation methods, and they are compared to the national and international values. Although the area is considered protected, there are many land use types in the territory, such as agriculture and forestry. For this reason, the value for soil fertility is used in the case of La Solana as it has similar climatic conditions and traditional agriculture as mentioned by Martín-López et al. (2011) is the closest best option. For soil fertility, as with the other regulating ecosystem services, Contingent Valuation was used through the help of a questionnaire survey conducted from 2008 to 2009. As the regulating values were the most highly rated in terms of importance in the questionnaire, soil fertility was the least amongst them. Nevertheless, the mean value for soil fertility was 20.6€ ha/yr. Transferring this value to La Solana amounts to a total of 1.277,2€ as a benefit per year from soil fertility.

6.3 Habitat Services

In la Solana, the management practices are used to help promote biological diversity. By inter-cropping, reducing tillage and the depth of it, using compost instead of fertilizers and natural repellants instead of chemical ones, by allowing vegetation cover and planting aromatic plants it promotes all possible beneficial agricultural practices to maintain biodiversity. Additionally, the farm is located near to a natural mountain area that helps pollinator species and sheep which tend to graze in the field. To calculate the value of biological diversity as a beneficial ecosystem service benefit transfer is done from the Master thesis of Bedoya (2018), who examined the habitat services of such mixed land use systems and found through literature a paper by Moratilla (2010). The author calculated such values from the conservation costs based on the subsidies and other monetary help provided by the government. The value for such types of landscapes that incorporate rain-fed crops along with vegetation cover was estimated to be

17.90€/ha/yr. By applying this to the total hectares of la Solana, a total benefit of 1.109,8 € per year is derived for biological diversity conservation.

6.4 Cultural services

The cultural ecosystem services that are seen to provide benefits to regenerative agriculture and will be further examined in this case are recreation, education and cultural heritage.

Recreation: Hunting

Recreation can have many sub-services such as tourism and hunting. Hunting is a recreational activity practiced a lot by the locals in the south of Spain. Most commonly, the hunters as groups tend to rent out farms for a long period in order to utilize them in the hunting season. For example, from observations in the area, many farms rent out their land for a year or even up to five years in a single hunting group. The most common animals to hunt based on the interviews with farmers are the partridges, boars, birds and hare. La Solana does rent out the land to hunters that come into the hunting season as a recreation, as the farmer mentioned they hunt using the help of dogs for birds mainly and that it is a very pleasant traditional activity for the locals.

Renting out the land provides an additional income benefit to the farm and helps to reduce the number of animals that can be destructive towards the crops. The amount gained for hunting per year is 300€ per hunter, with a maximum of 10 hunters in a year. This adds up to 3.000€ in total per year.

Education

As a cultural ecosystem service, education in agriculture is considered environmental education. This could be done through educational workshops, field activities and tours on the agricultural land. La Solana is an interesting case to examine as it is a farm that is often used for educational purposes as a study site because it is one of the few well working regenerative farms that applies many of the regenerative practices conducted in regenerative agriculture worldwide. As the farmer, he stated he has many students and scientist visitors from around the world that are interested in looking at the way the farm works. Yet, the farmer does not receive any direct monetary value from this ecosystem service, as he does not charge any type of fee.

For the purpose of monetizing this ecosystem service benefit transfer is made from the paper of Martín-López et al. (2011) who have calculated the value of education in the area of the Doñana social–ecological system, (southwestern Spain). The values they have used are obtained from annual budgets of research and environmental education. The hypothetical willingness to pay, mean value of education is 3€ /ha/year. While applying this value to La Solana, it seems that 186€ are benefited in terms of education as a cultural ecosystem service per year.

Cultural heritage

The farm benefits off renting the land to sheep herders that bring in their sheep to graze on the natural vegetation cover among the almond trees. This benefit both, as the sheep graze in their natural environment, it provides manure to the farm naturally, but also allows the traditional sheep herding to continue without restricting any areas in the region. The farmer rents out the land for approximately 800€ per year; On a per hectare basis this results in 12.9€ a year.

Subsidies

Most agriculture in Spain benefits from the subsidies provided by the government for particular types of agriculture. These subsidies come from the Common Agricultural Policy (CAP) provided by the EU (Europa, 2007). The CAP provides a variety of forms of subsidies that farmers can receive depends on the type of agriculture they have. Based on the answers provided by the farmer, it was not defined which subsidies the farm receives yet a total value was given. This was 300€ per hectare amounting to a total of 18.600€ for the total area of the farm.

Table 7. Ecosystem Services and the benefits they provide on Regenerative farm

Category: Ecosystem services	**Ecosystem Service**	**Sub-service**	**Quantity**	**Benefit value per ha/yr**	**Total value**	**Value category**
Provisioning	Food	Almonds	15.000 kg	7 €/kg	105.000€	Direct
Regulating	Climate regulation	Carbon sequestration		238€/tCO2e ha^{1} yr^{1}	14.756€	Indirect Carbon Stock Market values
	Moderation of extreme events	Fire control		240 €/ha/yr	14.880€	Indirect Avoided Cost
	Erosion control			39€/ha/yr	2.418€	Indirect Replacement Cost
	Pollination			17,69€/ha/yr	1.097€	Indirect Avoided Cost
	Soil fertility			20.6€ ha^{-1} y ear^{-}	1.277€	Indirect Contingent Valuation
	Biological control	Pest & disease control		26.54 € /ha/yr	1.645€	Indirect Avoided Cost
Habitat	Biological diversity			17.90 €/ha/yr	1.110€	Indirect Avoided Cost
Cultural	Recreation	Hunting	10 hunters	300€	3.000€	Direct
	Education			3€/ha	186 €	Avoided Cost

	Heritage	Sheep herding	1 shepherd	13€/ha	800 €	Direct

Total Benefits

The total benefits received for all categories of ecosystem services, along with the benefits received from the subsidies are 164.769€ a year. Out of this amount the farmer receives directly 127.400€/yr for the whole farm or 2.006€/ha/yr. Indirectly the benefits the farm provides to the farmer the society and the environment in monetary terms essentially a shadow price, are 37.369€/yr for the whole farm or 603€/ha/yr.

Table 8. Total amount of benefits per category of ecosystem services in €/yr for the whole farm and on a per hectare basis

The benefits per category of Ecosystem Services derived for the total farm and on a per hectare basis per year			Types of monetary valuation
Provisioning	105.000 €	1.693€	Market/Direct value
Regulating	36.073 €	582€	Shadow price/ indirect
Habitat	1.110€	18€	Shadow price/ indirect
Cultural	3.986€	64€	Market/Direct value
Subsidies	18.600€	300€	Direct value/ Indirect towards ecosystem services
Total benefits	**164.769€**	**2.657€**	**Direct→** 127.400€/2.006€/ha **Indirect→**37.369€/603€/ha

7.Comparison & economic implications

7.1 Comparison of farm management practices

Both farms have similar characteristics in terms of their climatic conditions, the slope upon which they are as well as the soil properties. In addition, they are relatively similar in size, as for the regenerative is the area of almond monoculture is 62 hectares and the conventional one is 40. The only true difference is the fact that the regenerative as a whole farm has other crops in it and the study is based on the plot level of the 62 ha of almond monoculture whereas the conventional one is only an almond monoculture land. This does not affect the case though, as only the plot of almonds is examined and compared to that of the total almond farm.

In terms of their management practices, however, they differ drastically. First of all, the almond tree varieties differ as the conventional farm has Marcona, Guara and Desmayo almond orchards and the regenerative has Guara, Marta and Antonieta. All these varieties, however, are commonly found in almond agriculture throughout Spain and are all self-fertile species.

For the conventional farm, as the description suggests, it truly uses a few conventional practices with the goal to produce a certain quantity of almonds to be sold. The main practices are tillage, pruning when needed, the use of conventional granulated fertilizer and chemical pesticides, allowing some spontaneous vegetation cover which is further removed by the tillage and finally having native plants around the border of the farm such as aromatics which are not planted but provide benefits to certain ecosystem services. In addition, it has an area of naturally created terraces that are utilized and preserved.

In contrast, the regenerative almond monoculture uses many practices in order to preserve its ecosystem services and achieve a sustainable future of the farm and the area in general. To begin with, tillage is done twice a year at a lower depth, as a fertilizer, compost is used instead, as well as manure from the sheep that are allowed to graze in the area another form of a management practice that provides benefits both to the local sheep herders who access the land and by the farmer for the elimination of certain vegetation cover. Natural vegetation cover is allowed and in addition to that inter-cropping is applied in between the tree lines with some leguminous species. Instead of using common chemical pesticides, natural repellants are used. Beehives are found within the almond area to increase the pollination and allow the beekeepers of the region to use the trees for their bees. A large swale has been made throughout the farm to manage the water runoff. Aromatic herbs are also being planted along the lines of the almond orchards. Finally, this farm has also naturally created terraces that already existed, which are also have almond trees on them and maintained as is. Hunting is also allowed in the farm is it helps maintain the level of unwanted damages to the trees and it promotes the traditional recreation of the locals.

As it is clear the regenerative farm has tried to sustain the environment with respect to the tradition of agriculture in the area and by considering the benefits it can provide to the local community. Since not only the farmer benefits by producing a higher quality almond but also the land is considered and the local beekeepers and shepherds as well as the community who can utilize the land for recreation. Finally, as the system seems to work rather well it is used as a study area in order to further promote such management practices in other forms of agriculture.

7.2 Total Economic Value (TEV)

The Total Economic Value (=benefits-costs), was calculated for both the conventional and regenerative farm on a per hectare basis and for the total farm, they were further on compared.

7.2.1 Comparison of costs and benefits for the conventional and regenerative farm

1.Comparison of Costs

In order to determine the total economic value of the two systems, the costs spent on the farms are considered. (See Chapter 4) The costs differ for various reasons, first of all the size of the farms is not exactly the same and secondly, and most importantly the management practices used on the regenerative farm are many more. However, the costs of the regenerative farm which is larger than the conventional one is not much higher than the conventional farm even if they use more management practices. It is important to consider though the costs the farm inquired for the swales and the hedges in the starting process of becoming regenerative. In this case, they are not calculated in the TEV as they did not represent costs used in the past year. The costs of the conventional farm in the past year are at 37.200€ whereas the regenerative 44.055€. If the extra costs were considered for the swales and hedges, it would be an added one-time price of 15.000€. Furthermore, costs for certain practices such as fertilizer, even though applied less frequently in the regenerative farm, are more than double the value of the conventional. Yet compost tends to be more expensive than a commonly found cheap fertilizer. The same can apply to the pesticides. For the regenerative farm, there are costs that can be invested into practices that can be beneficial to the farm in the future.

2.Comparison of Benefits

Looking closer into the benefits received by both farms in terms of the ecosystem services and the subsidies, there are great differences in the values. (See Table 11&12) To begin with a large difference that alters greatly the grand total of benefits comes from the provisioning services as the regenerative farm sells its almonds at a much higher price than the conventional as it is considered of higher quality than any conventional almond. Beyond the provisioning services though, every category of the ecosystem services for the regenerative farm is double the amount or even more than double on the conventional farm. This also applies for the subsidies received, leading to a more than double total value of the regenerative farm.

7.2.2 Conventional farm, Total Economic Value (TEV)

The Total Economic Value (TEV) is the total value derived from an ecosystem or man-made infrastructure system (De Groot et al., 2017). To calculate the TEV of specific case examined such as a farm all costs must be subtracted from all the benefits gained in order to find the true final benefits. This allows for a comparison with any other system to see which can provide more benefits. In this case both the Conventional farm and Regenerative TEV are calculated and compared.

In the table below, all values necessary to calculate the TEV are summed up and the final TEV is calculated by subtracting the total amount of costs from the total amount of benefits. The amount of the TEV for the whole farm is 20.091€ and on a per hectare basis is 501€. This value suggests the total amount of farm benefits per year; however, this TEV does not include the externalities associated with this land use. Table 9, shows all values used to calculate the TEV for the conventional farm.

Table 9. TEV of the conventional almond farm in €/yr for the whole farm and on a per hectare basis

Ecosystem services	**Total value €/yr**	**Per ha/€/yr**
Provisioning	42.000€	1.050€
Regulating	6.258€	156€
Habitat	138 €	3€
Cultural	1295€	32€
Subsidies		
CAP	7.600€	190€
Total benefits €/yr	**57.291€**	**1.431€**
Costs		
Harvesting	2.400 €	60€
Salaries	14.400 €	360€
Machinery	15.000 €	375€
Fertilizer	3.000 €	75€
Pesticides	2.400 €	60€
Total costs €/yr	**37.200€**	**930€**
TEV		
Total €/yr	**20.091€**	**501€**

7.2.2 Regenerative farm, Total Economic Value (TEV)

The TEV of the regenerative farm is also calculated in a similar fashion. After gathering all costs spent on the farm, all benefits gained were also recorded. These were from the all ecosystem services and once again the subsidies received by the government. Further on the costs were subtracted from the benefits in order to see the true TEV of acquiring such an agricultural system. The total amounts to 119.436€ per year for the whole farm, on a per hectare basis the amount results in 1.946€. Table 10, shows all values used to calculate the TEV for the regenerative farm.

Table 10. TEV of the regenerative almond farm in €/yr

Ecosystem services	**Total value €/yr**	**Per ha/€/yr**
Provisioning	105.000 €	1.693 €
Regulating	36.073 €	582 €
Habitat	1.110 €	18 €
Cultural	3.986 €	64 €
Subsidies		
CAP	18.600€	300€
Total benefits €/yr	**164.769 €**	**2.657€**
Costs		
Salaries	10.160 €	164€
Machinery	15.295 €	247€
Fertilizer (Compost)	7.750 €	125€
Pesticides (Natural Repellants)	3.410 €	55€
Tillage	7.440 €	120€
Total costs €/yr	**44.055 €**	**711€**
TEV		
Total €/yr	**120.714 €**	**1.946€**

7.2.3 Comparison of TEV of both farms

Based on the costs examined in both cases which are relatively close to both farms and the benefits which differ greatly, it is clear that the TEV of the one farming system is significantly larger. This implies that the farm under those management practices in the end receives the most monetary benefits after subtracting all operating costs. Among the two farms that with the larger TEV is the regenerative farm. The TEV of the conventional farm is 20.091€ whereas for the regenerative farm it is 120.714€. However, a variety of reasons could have contributed to these results suggesting that more in-depth analysis is needed to determine a more precise and realistic value for these two farming systems.

Per hectare calculations

For both systems, the per hectare value was calculated both for the benefits and the costs in order to calculate the TEV on a per hectare basis. The benefits were interesting to examine as for certain ecosystem services; values were similar, thus resulting in a similar result. However, even more so for the conventional system the total amount of benefits on a per hectare basis are 1.431€ and the total amount of costs on a per hectare basis are 930€. Resulting in a TEV of 501€. For the regenerative farm the total amount of benefits on a per hectare basis are 2.657€ were as the costs are 711€. This results in a TEV of 1.946.4€ which is almost quadruple to that of the conventional farm.

7.3 Net Present Value (NPV)

The NPV is calculated by using the formula $NPV = \sum_{t=0}^{T} \frac{(Bt-Ct)}{(1+r)_t}$. $\sum$ is the sum of the NPV of each system for the specific amount of years examined. B stands for the benefits at the specific year. C are the costs of that year. Finally, t stands for the time and r for the discount rate used (Snelder et al, 2007).

The Net Present Value (NPV) or Capital Value examines the aggregated TEV over time to calculate the total net benefit (Wegner, Pascual, 2011). It can be used for decision making as it can show, up to which point in time this land use can provide benefits. In order to calculate such a value a discount rate is included, the discount rate, which most commonly a positive discount rate is used as it signifies the discounting of the future stream of ecosystem services. Future discounting ofcosts and benefits can also be considered necessary as to compensate the present generations on any costs they have incurred in order to maintain future generations (Wegner, Pascual, 2011). However, the discount rate does not benefit projects that aim for a long-term environment and social sustainability. By applying a higher discounting rate, the NPV ends up being lower, neglecting the realistic long-term benefits and costs. Discount rates should be more flexible and consider issues such as the resilience of the ecosystems of the needs of the people and the reliability of the resource (De Groot, 2018).

7.3.1 Conventional farm, NPV

In this case of the conventional farm, in order to calculate the NPV, the TEV is considered remaining constant throughout the years. The NPV is calculated for a 20-year time period in order to see any long-term effects with two discount rates. To begin with, the NPV is calculated with a zero-discount rate and then to 5% and a 10% discount rate, and the TEV over time is assumed to remain constant. The results show that the NPV at a zero-discount rate adds up to 421.911€ for a time period of 20 years. By applying the discount rate of 5% the NPV is 270.469€. Finally, by applying the 10% discount rate, the value is 191.137€. When applying the same discount rates for the same time period on a per hectare basis the results are, for a zero-discount rate, 10.521€, for a five percent discount rate, 6.745€, and for a ten percent discount rate 4.766€.

7.3.2 Regenerative farm, NPV

The NPV of the regenerative farm is calculated in a similar way as the conventional one. The TEV is assumed to remain constant for the number of years examined. The time frame is 20 years, and it is calculated with three different discount rates, those of 0% 5% and 10% to see the differences in time and different possible scenarios of discount rates. At a zero-discount rate, the NPV is 2.534.994€. For the 5% discount rate, the value diminishes significantly to 1.625.077€. The 10% discount rate is even lower at a value of 1.148.420€. Yet again, these NPV's are not necessarily exact as the time frame along with these discount rates may not be the best for this scenario. On a per hectare basis, at a zero percent discount rate the result is 40.866€, for a five percent discount rate 26.196 and for a ten percent discount rate 18.513€.

7.3.3 Comparison of both NPV's

The NPV in both cases was calculated at a time frame of 20 years and for both with discount rates of 0%, 5% and 10%. For both, the value diminishes drastically with the larger discount rate. However, there is a significantly larger value for the regenerative farm to begin with almost three times larger than the conventional farm. Below, Figure 5 shows distinctively the great difference of the NPV between the two farms, on a per hectare basis.

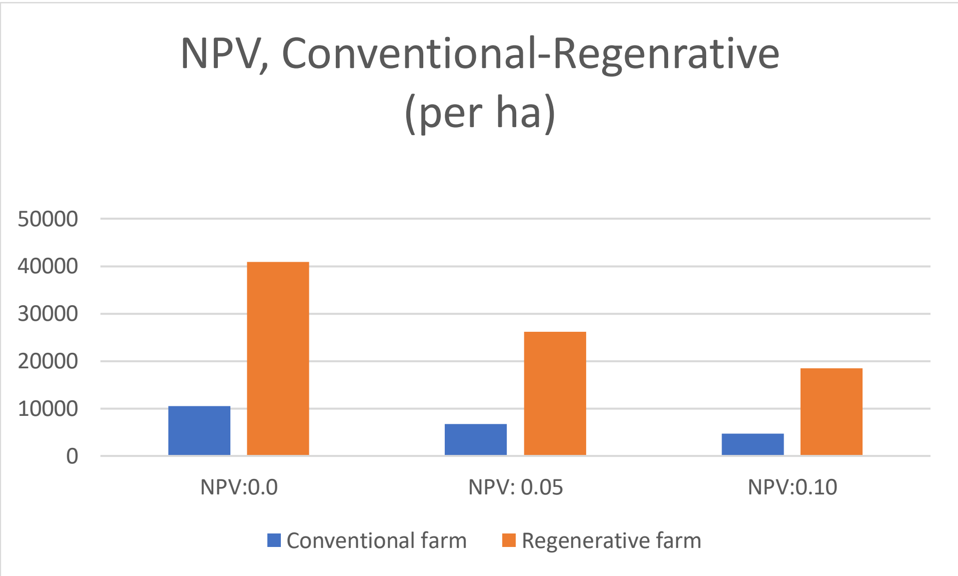

Figure 7: NPV on a per hectare basis of both farms (Conventional and Regenerative)

7.4 Socio-Economic Benefits

By restoring a landscape under proper conditions and holistically considering it can provide many benefits. Commonland therefore has created the four returns principle suggesting 4 basic categories will be returned from this transition. (See figure 8) The return of inspiration, the return of social capital, the return of natural capital and the return of financial capital. Based on my research, some first returns that would occur if the agricultural landscape in the South-East of Spain were restored by converting monoculture lands to regenerative farming have become visible.

In this region of Andalucía, agriculture is rooted in the local culture and tradition of the area. Olives, fruits and vegetables are some first crops found there. Since water scarcity had always been an issue in the Mediterranean, the locals who possessed the knowledge managed their available water (Roth et al., 2016). This suggests that even traditionally locals understood the benefits their lands provided and worked with them for the best utilization and preservation. As proven, conventional monoculture systems can be very degrading to the land, causing environmental change in the area, which can then affect socio-economically the area. The consequences of environmental change on the society have not been yet studied in depth but they have been correlated to abandonment due to the lack of ecosystem services for the livelihoods, food security and employment of farmers and cattle herders (Afifi, 2011).

If more farmers were to transition towards regenerative almond farming, which provides more benefits in environmental, social and economic aspects, it could help improve local communities. By increasing the economic benefits, the farmers directly receive from producing higher quality products and selling them at a much higher price than they once did with conventional almonds the local economy would increase. In terms of the regulating services if the area recovers and can provide fresh water and air, as well as soil quality this would increase the stability safety and security of the area and its inhabitants. By applying all these regenerative techniques job opportunities may increase as already the regenerative farm even though relatively similar in size requires more employers for the different jobs such as creating swales which are technique few people could apply in the region. Culturally, regenerative farming already seems to provide many services, opportunities for tourism, which again increases the local economy. Educational opportunities for the studying of such systems and their future improvements. Aesthetic value will increase tourism in agricultural areas, but also traditional values as the area will return to the old Mediterranean agricultural systems. *Laurant*, (2018) already recorded the willingness to pay for aesthetic value between conventional monoculture and mixed land use systems and found the highest value for mixed land use systems. Even though regenerative farming is not the same as mixed land use systems they have similar characteristics implying that aesthetic value would be more appreciated in regenerative agriculture rather than conventional.

Figure 8: The 4 returns, Commonland

8.Discussion

8.1 Assumptions & Limitations

1.Selection of suitable farms

To begin with, the first limitation was faced during the first period of the thesis, since due to the lack of previous fieldwork it was unclear how the thesis would proceed in terms of how to figure out which land use systems exist and should be examined. The idea was to investigate the almond monoculture systems to those of the regenerative monoculture systems. However, as the regenerative systems are defined by the various practices, they do to promote a sustainable land use, such systems incorporate other crops within them. This thought before going on field work was rather unclear. This issue was latter on solved during the field work.

2.Variation in the land use systems in the AlVelAl territory

The land use systems in the territory vary dramatically. Either by having a conventional almond monoculture or conventional mixed land use systems, or organic almond monoculture, or organic mixed land use systems or regenerative almond agriculture. After discussion with the experts and the farmers in the region since no clear distinction can be found in literature as regenerative farming is relatively a new form of agriculture, it is clear that it is still fairly vague as to what differentiates the organic mixed land use system to that of the regenerative. A clear regenerative monoculture almond farm does not really exist as a system, since a regenerative method incorporates mixed crops. This system can only be seen at the plot level. As stated by experts in the area the best way of differentiating a regenerative land use to a mixed land, use system is if the first, applies around 7 (The 7 practices were decided amongst those who perform regenerative agriculture to distinguish their farming systems from other types) beneficial management practices among them mixing crops. The regenerative farm examined is also a large farm with a variety of crops. In order to consider it as a regenerative almond farm, it was decided to consider it at the plot level. Fortunately, the conventional almond monoculture farm was similar in size to the plot level, in fact smaller making them easy to compare. The two farms examined were perfect to see the large and distinctive difference between the two land use systems. The conventional farm used very few management practices with the use of chemicals. Whereas the regenerative farm which was one of the first farms in the territory to adopt such a regenerative approach used as much as possible management practices to benefit its land.

3. Physical constraints

During the fieldwork, physical constraints were an issue as to having access to travel around and visit as many possible farms in order to find suitable candidates as case studies. The lack of speaking the language made it even more challenging since the meetings were based mostly on farmers that could speak English, eliminating potential areas of study. During conversations and interviews with Spanish farmers, even though many things were translated with the help of others, lots of information was lost in the process. This complicated the available visitations to certain farms along with the long distances between them. As the issue of the different language was faced in almost all cases it was clear that I should choose the most suitable farms to study and deal with the translation issues with the help of others and by translating interview questions using Google Translate. Time was another clear physical limitation, either by the little time farmers had to spend in terms of answering questions, either by the long time it would take to arrange meetings. Since the time spent in Spain was rather limited. Thus, I tried to arrange meetings almost every day and make sure that before leaving the country I would have found two suitable cases arranged a meeting and established further contact with the farmers, which I managed to do.

4.Limitations with interviews

For the almond monoculture system, which seemed to be the easiest type to distinguish and find a location to examine, other factors came into play. The fact that they are conventional farms made the farmers reluctant to answer questions on their farms and the management practices. Thus, finding the conventional farm proved more difficult than the regenerative. In order to find suitable farms and farmers willing to collaborate I began by asking the farmers of the various regenerative farms I visited, whether their neighbors would do so. Yet even if the farmers themselves asked politely they did not accept. In the end the conventional farm was studied was a relative of a farmer I communicated a lot with during my stay there. Since the farmer spoke only Spanish, there was no meeting with him; rather, he filled in the questions posed to him, which were then translated.

The interviews with the farmers were not done under the best conditions, as questions were informally asked during a tour of the farm. This made it difficult to record many of the answers, leaving many blank spots. In addition, coming up with the values of certain things was not an easy task for the farmer. This led to further communication with the farmers to obtain the remaining information needed. Yet this was a time-consuming process and written text is not the same as a personal communication on the matters.

5.Lack of data

The lack of data for such systems made it difficult to decide how the values found should be applied and to which land use, and then how to further calculate the same value for the other land use. In order to find such information, experiments need to be conducted to quantify the values and then to try to monetize them. Sadly, some of these values are unrealistic, not showing the true potential of the systems. This results in not showing a true TEV and further NPV for decision making and future policy implementations. Some ecosystem services, even though originally planned to be recorded due to the lack of data, were eliminated as a whole. This was the case for many cultural services, such as aesthetic value. All the data gathered in terms of the costs and certain benefits such as the provisioning are fairly accurate. Fairly, is used here since many values were not even clear for the farmers themselves yet they made their best estimations. The information, however, on the other categories of the ecosystem services was very limited.

6.Benefit transfer

After examining the information received from the farmers, the remaining needed information was done through literature reviews. This proved very time consuming, as little data exist on quantifying and monetizing ecosystem services. Especially when it comes to searching for values that share similar conditions in the regions of the farms and most importantly by applying the same management practices. Finding values that realistically depict the management practices used in regenerative almond agriculture was rather impossible. This tests the validity of the values recorder from other areas and without the given practices, making them rather arbitrary. In addition, when doing benefit transfer from previous studies, I did not recalculate the value considering the inflation as they may be recorded a few years ago.

For the provisioning and cultural services, the values were direct market values either provided by the almonds sold or the recreational activities the farms provide. However, the regulating services are recorded through benefit transfer. As many of the regulating services do not exist on the conventional farm they were mostly recorded for the regenerative. The regenerative though as previously mentioned is a rather complex system and not many studies exist to record the ecosystem services in such a farm. Thus, the best solution for benefit transfer was to use the recently conducted theses of other students who conducted more in detail studies on certain ecosystem services. Further on for values such as carbon sequestration for the regenerative farm even though it was known that almond trees exist not the exact amount is recorded, in addition other species exist, so to calculate the carbon sequestration was best using a value from an already existing similar land use system in the area. The same also applied to the conventional farm but the regenerative was even more complicated.

7.Different ecosystem services per farm

As both farms are relatively similar, (both almond monocultures) I tried to record the same ecosystem services; however, they do not provide the same services. For example, erosion control in the conventional farm does not exist as the soil quality is diminished and the almond trees themselves do not provide better control over the natural vegetation that would exist there. However, in the regenerative farm the trees and methods used are considered in a way to help avoid any erosion which is perhaps better in a way than the natural vegetation Education is another service that is recorded for the regenerative farm as they provide it as a study area to researchers but in the conventional farm this simply does not exist.

One may argue that stating, that various of the regulating services in the conventional farm are not applicable as to providing a benefit, is not accurate. Both farms do have all of the ecosystem services mentioned however, they are examined in reference to the natural environment in the area (See Chapter 3). When comparing the management practices used in the conventional farm which are frequent tillage and the use of pesticides it is obvious that ecosystem services such as soil quality, pollination etc. are in a worst state than the natural environment. So, in this way many ecosystem services in the conventional farm do not provide benefits but rather only the costs to maintain the cultivation as it is. On the contrary, the regenerative farming that applies such a variety of methods to the land can indeed provide benefits in reference to the natural area (which in fact is rather degraded itself (See Chapter 1).

8.Calculations per farm or per hectare

Calculating the values on a per hectare basis makes more sense to show the true differences between the two systems, especially since they differ in size. However, in many cases not all costs and benefits can be applied on a per hectare basis as each hectare is not similar to each other and may not bare a cost or a benefit.

9.Investment costs not considered

Another important aspect to consider in terms of the costs recorded for both farms are the investment costs. While examining both cases it was decided to consider the costs and benefits of the farm in a certain year, most probably the year that past as the values for certain things fluctuate so it's best to have a standard year as a reference. This may apply, for the costs of the farms and the provisioning services, but does not necessarily apply for the rest of the ecosystem services. Since for those the values were found through literature for various years. Yet such values do not fluctuate so significantly and in any case the values are not precisely accurate. In terms of the investment costs, for the regenerative farm a large amount of money 15.000 euros was invested when the farm first started working for the creation of the swale and the hedges. This value, was not considered in the calculation of the TEV as it was paid for, years ago. However, both are very important regenerative management practices that should be considered in the future. Another important issue in the costs of machinery that was not included by the farmers themselves is the depreciation of their equipment over time.

10.Negative externalities

Negative externalities are another very important parameter to consider that unfortunately was not included in this thesis. As there are many benefits provided to the farms by these types of land use systems, there are many negative effects as well. For the conventional farm, the way it uses chemical fertilizers and pesticides as well as plough the land must certainly have a negative effect on the soil structure and quality as well as the underground water stream. In addition, there are many socio-economic negative effects from monoculture systems. Conventional farming systems are often not an area of tourist attraction and with diminished qualities of the local communities.

11.Net Present Value (NPV) calculations

The NPV, was calculated for a 20-year time period with 3 different discount rates, however, these may not be suitable for this specific case. The results show that the at a zero discount rate the regenerative farm benefits almost three times the amount of the conventional farm both for the direct and indirect values. This relationship continues to exist and with the other discount rate of 5% and 10% but the total value of both diminishes dramatically. This drop though may indicate the fact that these discount rates and this time period (20 years) may not be the best choice and in the future other alternative scenarios should be tested. However, it serves the purpose of showing the great difference between the two farms.

12.Difference in the price of the almonds

A serious issue, to consider is the significant difference between the conventional and regenerative price of the almonds sold to the companies. During the interview with the farmer of the regenerative farm, he first stated that the almond is send to the company that buys it with its hard shell on it. This typically means that the price the almond is sold at is usually less than if the peeled/cleaned nut itself is sold; since the almond it has been through the whole procedure of removal of the shell and a selection of only the good quality final products are actually sold. Even though the prices might fluctuate greatly throughout the years the difference between shelled and unshelled almonds always remains the same with the shelled always being cheaper than the unshelled; the General Statistical Company of Spain records that difference between the years 2013 and 2018 per kilo of almonds (Statista, 2019). However, the farmer mentioned the price of the almond was 7 euros per kilo. This price is rather large if we consider that the almond is sold with its shell. In fact, if we compare it to the price of the conventional farm that sells its almonds without the shell for 1.5 euro per kilo it is unclear what causes such a great difference. I first examined whether the information recorded was accurate and asked again for an explanation if the almond is sold with the shell or not. As it turns out the price of 7 euros per kilo is for the nut only. Even though a difference in the price is expected due to the fact that one almond is organic and regenerative whereas the other conventional, this dramatic difference is not. To properly compare with other prices of almonds I examined previously conducted theses of students as they provide the latest measurements of regenerative farms in the area. By examining *De Leijster* Master Thesis conducted in 2016 who analyzed various farms I discovered that he reported by conducting interviews and handing out questionnaires, average prices of organic and regenerative almonds of about 3.5 euros per kilo. This value is still half than the one I have recorded for the regenerative farm. However, the farmer sells its regenerative nuts to the Almendrehesa company, which itself promotes that it offers a higher price to the farmers enabling them to invest into regenerative farming. (4returns.earth)

13.Double counting

Double counting is an issue that may occur when it comes to the costs of the machinery and salaries. In the conventional farm the costs recorded are rather straightforward however, in the regenerative farm there may be some double counting of costs. There are costs recorded for the salaries of the workers mainly the contractors that are responsible for all activities on the farm and there is a different cost recorded for the machinery they use for those activities. However, a separate cost is provided for tillage, yet tillage is a practice done with the machineries and the contractors. It is unclear why this is separated and provided as a separate cost if it is one. In the thesis it is assumed that it is an extra cost indeed.

14.Private and public benefits

The TEV that results in the total benefits received by eliminating the costs of each farm, does not suggest that the value is actual direct cost to the farmer. The ecosystem services that do provide direct monetary benefits to the farmers are the provisioning services and some of the cultural ones. The rest of the ecosystem services provide values calculated as shadow prices. Prices that can hypothetically benefit the society in a long term rather than the farmer himself. As a result, it can be seen that a certain type of farming can provide benefits both private to the farmers and public to the local communities and regions.

8.2 Connection to literature

Beyond these numerous discussion points that indicate the issues and gaps this study has, it is evident through literature that indeed regenerative agriculture provides more benefits in a holistic way. The results, even though not necessarily realistic in the final calculations (the wide gap between the conventional and regenerative farm and the large benefits of certain ecosystem services of the regenerative farm) in the cost-benefit analysis do in fact suggest a realistic bigger picture as indicated in other studies. In a book published by *Toensmeier, 2016,* the regenerative annual crop production is questioned in comparison to conventional farms and it is suggested that organic crop yields are lower than conventional; a significant issue when it comes to the case of almond production in Spain as it supports a large percentage of the worlds almond production. However, as Toensmeier mentions regenerative farming by imposing techniques such as crop rotation and intercropping can cut this gap in half or more. This along with the other benefits regenerative agriculture provides can suggest regenerative farming is indeed a viable solution.

Looking closer to a certain ecosystem service, that of carbon sequestration one of the most important service's agriculture can provide, the author emphasizes on the large values of sequestration reported in various individual farms that apply regenerative practices and how these are higher than any other annual crop system he has come across. In fact, such levels indicate high soil organic matter content that allow for larger crop yields. Thus, regenerative farming can prove as a positive adaptation strategy during drought years and at a time affected severely by climate change.

9.Conclusion

This thesis was conducted in order to analyze two different land use systems those of conventional almond monoculture and regenerative and understand which can be more beneficial. Beneficial in terms of many aspects such as economical for the farmers and the local community, environmentally beneficial as to how sustainable this farming could be in the future and socially.

Typology of the almond monoculture land use systems (RQ.1)

I began by trying to figure out the land use systems that exist in the area in order to find the most suitable farms to further examine. By figuring out approximately the amount of almond cultivations in the area out of which a certain part belonged to the AlVelAl territory it was evident that 45.000 hectares of organic almond is cultivated in the region. However, the types of management are what define the form of agriculture and those are not so evident. Conventional almond monoculture is rather straight forward and is the most common type in the South-East of Spain (outside the 45.000 hectares). But regenerative and organic almond are not so simple to distinguish. The farmers themselves have determined that a farm that performs 7 (Stated during interviews) regenerative management practices can be considered a regenerative farm. However, in the region there are various types of farms that have different management practices one from another making them all unique types of farming systems. But as regenerative monoculture has been stablished among the AlVelAl association and local community as a beneficial practice, it has become more widespread in the region. During the fieldwork there two farms where identified as god case studies and where further analysed.

Costs of the ecosystem services of both systems, (RQ.2)

After understanding the typology of the area and figuring out two systems to examine I looked into their management practices to better understand how they work. The costs of each management practice were recorded and all costs per farm were calculated to see which system invests more money in terms of beneficial management practices. The regenerative farm clearly performed many more management practices than the conventional farm, but without a much larger amount in total costs spent per year. In fact, if calculated on a per hectare basis, the conventional farm spends more money than the regenerative. As the regenerative farm is also slightly larger than the conventional one, 62 ha and 40, respectively. The total amount of costs for the regenerative farm is 44.055€ with approximately 710.56€ per hectare and for the conventional farm the total amount of costs is 37.200€ with 930€ per hectare.

Benefits of the ecosystem services of both systems, (RQ.3)

In terms of the ecosystem services and the benefits they provide, many were found in both farms. Yet, as their management practices are at the opposite end from one farm to another, their value differed greatly. Due to the lack of primary data in these specific case studies benefit transfer was used to record the benefits both farms obtain. If experiments were conducted, much more realistic results could be recorded. The conventional farm evidently does not receive as many benefits in ecosystem services as the regenerative farm does. In fact, the conventional farm receives 57.500€ per year and 1.500€ per hectare per year. Whereas the regenerative farm receives approximately 165.000€ for the whole farm and almost 3.000€ per hectare per year. On a whole farm scale, its more than three times the amount, however the regenerative farm is larger; but on a per hectare basis the amount of benefits the regenerative farm receives is again twice of the conventional farm. However, it should be clear that out of these benefits not all are actual direct benefits the farmers themselves receive but also indirect benefits the farmers and the local community receive, currently and in the future.

The monetary value of the ecosystem services of both farms (TEV), (RQ.4)

If experiments were conducted, much more realistic results could be recorded. In any case, the conventional farm TEV resulted in 20.091€ per year for the whole 40 hectares, whereas the regenerative farm resulted 120.714€ per year for 62 hectares. On a per hectare base things differ as there is not such a dramatic difference in the values, the conventional farm TEV resulted in 501€, whereas the regenerative to 1.946€. Once again, the regenerative farm does provide a better result, when you consider the per hectare basis as they are comparable were the value is almost four times of that of the conventional farm.

The economic implications of restoring the ecosystem services (NPV), (RQ.5)

These results, which are simply approximations/estimations to the benefits that such systems provide already strongly indicate how much better regenerative farming is. If there were experiments conducted to determine the true values, the results would be more realistic and most probably even better for the regenerative farming with a larger gap between them. This assumption is based on viewing two tremendously opposite systems. The Net present Value (NPV) was calculated to see the benefits of each system in a 20-year time plan but also with the effect of discount rates. The results indicate once again that regenerative farming provides three times more benefits than the conventional farming system. Even if we apply the discount rates the value diminishes quite significantly but the regenerative farming remains the better option.

The ecosystem services of almond monoculture contribute to large-scale land restoration (RQ.6)

In order to use such results in a constructive way and to promote such farming systems as a large-scale restoration project in the area but also other similar areas lots more need to be done besides the true recording of measurements. Negative externalities definitely need to be included as well as many possibly missed services, all that the system under examination provides. Finally, a monitoring system needs to be created to see the possible negative externalities of the regenerative system, as regenerative agriculture is so new in the area that it is perceived only as a beneficial form of agriculture. In fact, there certainly are reasons why all farmers in the area have not converted their farms. One of the most important reasons to consider is the significantly a smaller number of kilos of almonds produced from the regenerative in comparison to the conventional farm. The regenerative which is 62 hectares produces 15.000 kilos of almonds a year, whereas the conventional farm which is 40 hectares produces 28.000 kilos of almond a year. This is almost double the amount suggesting that regenerative agriculture needs large land areas in order to produce a sufficient amount under proper practices. However, other factors should be considered and perhaps a weighing and scoring of values should be considered based on the needs of the farmer and area before applying such a system. Yet up until now it is evident that the ecosystem services in the regenerative farm provide great benefits to the local area and can indeed be more promoted to ultimately lead to large landscape restoration created by the farmers themselves for their own communities.

In conclusion, even though this thesis may not produce accurate results it manages to provide a first comparison and estimation on the benefits two such different farming systems may have. Already it is rather visible from the results of the TEV and NPV that regenerative farming provides many more benefits than conventional farming. These are both the private benefits to the farmers, the direct financial gains from some of the ecosystem services, but also it provides many public benefits. The public benefits are shadow prices not direct money but rather benefits the local communities receive by preserving their lands, and will continue to receive for a long time in the future.

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Appendices

Appendix 1: Interview Questions

Questions: Regenerative farm
Visit: 23/11/2018

General Questions: About the area

1. What are the climatic conditions of the area?
2. What is the altitude of the almond area?
3. What is the size of the area?
4. What type of soil is found in the area? What are the characteristics of the soil?
5. What are the types of almonds planted there?
6. What is the crop density? (Trees per ha)?
7. Are they only rainfed?
8. How old are the almond trees?
9. How long has the area had almond monoculture?
10. What is the density of the trees? (How far apart are they?)
11. Do they receive any subsidies specifically for this area?
12. Which subsidies? How much are they? (euros)
13. How many people work in this area? (how long)
14. What do they get paid to do so (per position, per hour)?
15. What machinery is used in this area?
16. What is the cost of the machinery per year (oil, maintaining, buying parts)?

Almond Use

17. What is the use of the skin?

18. What is the use of the shell?

19. What is the use the almond nut?

20. The tree? (timber?)

21.
22. Where are they sold?

23. How much do they produce per year?

24. Skin:

25. Shell:

26. Nut:

27. What is the cost per kg? (for all: skin, shell, nut)

28. Does the cost differentiate per type of almond?

29. When are the almonds picked?

Management Practices

30. What are the regenerative practices done in this area?

31. Is there natural vegetation cover in the area? (Winter/Summer)

32. Do the sheep graze on it?

33. How many sheep are allowed in the area?

34. What is the cost and quantity of the feed used for the sheep?

35. What is the cost of maintaining the sheep and their shelter?

36. Do they provide manure to the area? What is the quantity(kg)? Is there a cost?

37. Or is manure collected elsewhere and brought in?

38. Do you apply compost in that area?

39. What is the quantity(kg)? Cost?

40. When is the compost applied, how many times throughout the year?

41. Is any other type of fertilizer used? What is the quantity(kg)? Cost?

42. Do you use pesticides in the area?

43. What is the quantity(kg)? Cost?

44. Is tilling done in the area (how often, when)?

45. What is the depth of tilling?

46. Cost?

47. Is pruning done in the area? how often, when? Cost?

48. Are there beehives present? Cost of buying them, maintaining them?

49. How is there pollination done in the area?

50. Are there terraces in the area? How are they made?

51. How much do they cost to be made?

52. When where they made?

53. How are they maintained? Does it cost to maintain them?

54. Do they help for fire control?

55. Do they help with soil erosion?

56. Are there swales in the area?

57. How many in total?

58. Cost of creating, maintaining?

59. Are there sediment traps? Cost of creating, maintaining?

60. Are there hedges and boarders?

61. Cost of creating, maintaining?

62. Are other animals found in the area? Do they affect the almond trees?

63. If yes, what are they? How are they handled?

64. Is there any form of prevention from them?

65. Do any of these practices help with water retention in the soil?

66. Is there any measurement done for the water retention in the soil of the area?

67. Do the almond trees and natural vegetation help with carbon sequestration?

Cultural Use

68. Is it used at all for recreational purposes?

69. Are people allowed to come and pick up the almonds from the ground after the harvesting?

***These Questions where created to guide the interview, after the process and do to missing information they were later send out to the farmer with the answers he provided in order to fill in the missing gaps**

Appendix 2: Glossary

Regenerative Agriculture Regenerative agriculture is a system of farming principles and practices that increases biodiversity, enrichens soils, improves watersheds, and enhances ecosystem services.

Swales A swale is a shady spot, or a sunken or marshy place, infiltration basins, designed to manage water runoff, filter pollutants, and increase rainwater infiltration.

Pruning Trimming a plant by cutting away dead or overgrown branches or stems, especially to encourage growth.

Terrace In agriculture, a terrace is a piece of sloped plane that has been cut into a series of successively receding flat surfaces or platforms, which resemble steps, for the purposes of more effective farming.

Appendix 3: Stakeholder Analysis

The shift to Regenerative agriculture will have many effects on the stakeholders in play. To accomplish this result, all stakeholders must be considered both before and after the switch to determine how they will be impacted. While I worked on this specific case, I identified the key stakeholders and grouped them into categories. These are the farmers, the scientists, the AlVelAl association, Commonland, the local society and the policy makers. I further examined how these stakeholders would have both an interest in such a project and impact and how they would be impacted after the implementation. In the Figure below, I arranged all stakeholders in a graph based on their level of interest and impact in this case.

Scientists

The scientists have a high interest as it already shows by examining the method of regenerative agriculture and working on the further implementation on the existing conventional farms in the area. As scientists, they have the power to advocate the benefits of the system through composing a more in-depth cost benefit analysis such as this. They also have a moderate impact on such a project.

Farmers

The farmers have a significant role in this case, as they are those who will have a large impact if they implement this change from conventional to regenerative agriculture. To do so, they will need to have some incentives such as the increase in subsidies set by the policy makers to promote this form of agriculture. True facts of their future benefits which they can obtain should be mentioned from the scientists; Thus, if they are educated on the issue, they may have a moderate to high interest in performing the switch.

AlVelAl

The AlVelAl association is one of the most important stakeholders in this case, as they are those that have performed regenerative agriculture and have promoted its benefits. I place them in the graph below as the stakeholders with the highest impact and interest.

Commonland

Commonland is a very important stakeholder, as it will help both promote and implement the transition to regenerative agriculture through the help of the other stakeholders.

Policy Makers

Policy makers are those that will have a large impact in making the change possible if they impose certain policies in terms of the subsidies farmers can receive. However, until they are informed appropriately on the matter, they have no interest in this case.

Society

I have placed the society in a moderate position on the graph since before implementing the project they do not have nor a large impact nor a large interest in regenerative agriculture. However, after the transition, society will benefit if the quality of the environment improves or at least does not diminish as it could from conventional agriculture. In addition, as regenerative agriculture adopts many practices, it can become an opportunity for employment for many locals in the area.

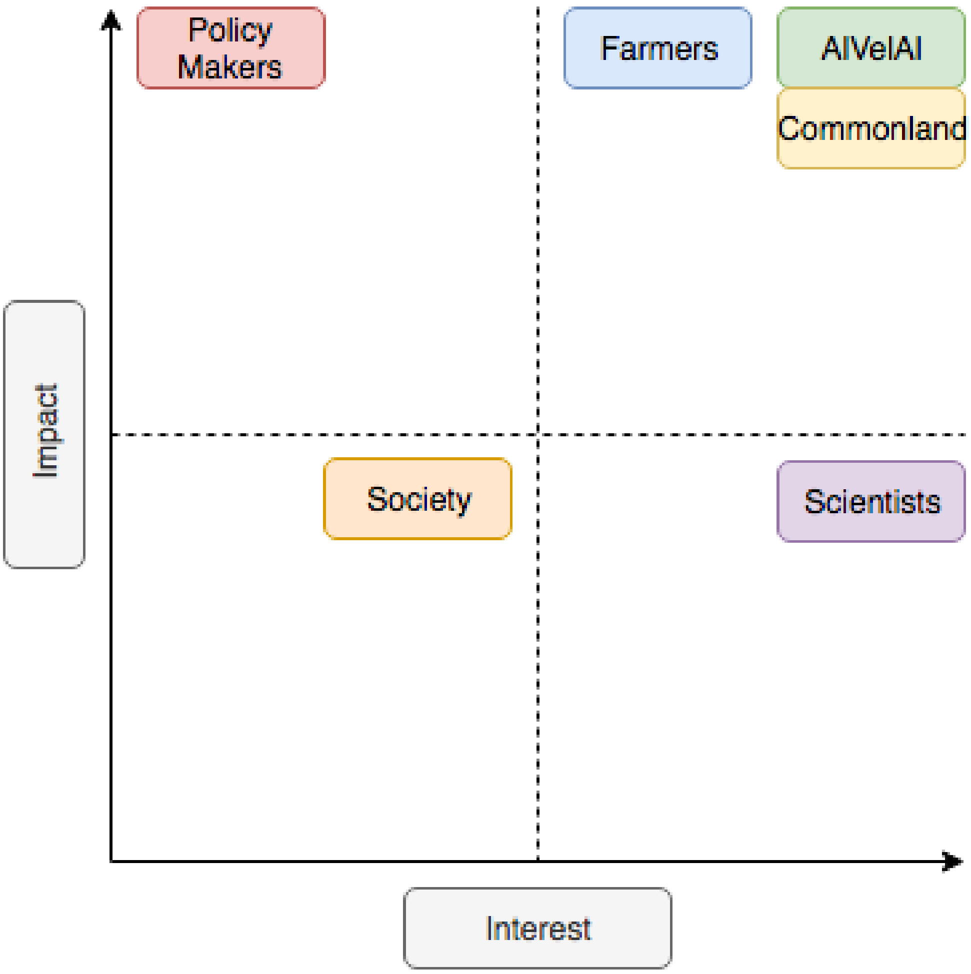

Figure 9: Stakeholder Analysis for the Implementation of regenerative agriculture