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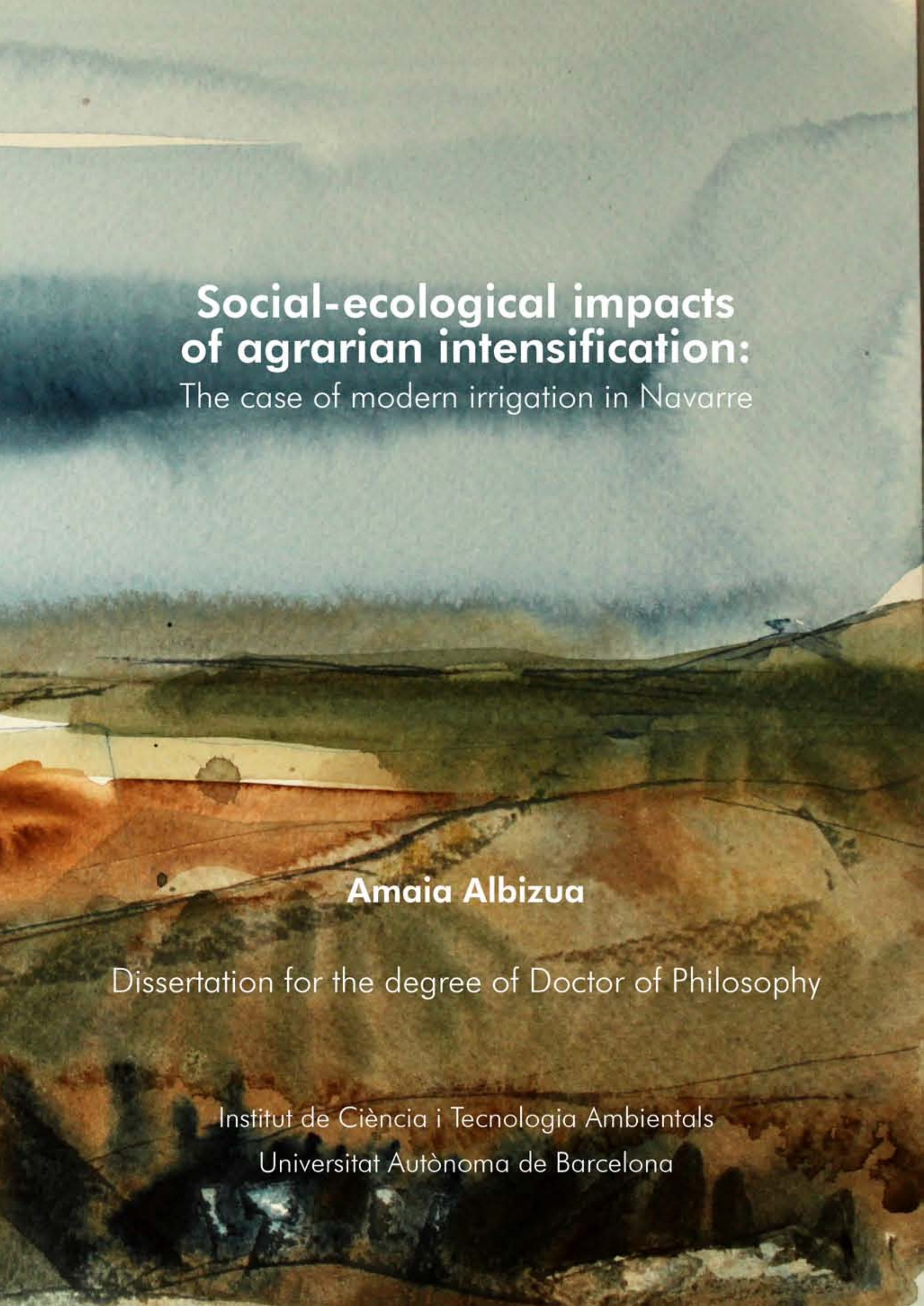

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Dissertation for the degree of Doctor of Philosophy

Institut de Ciència i Tecnologia Ambientals
Universitat Autònoma de Barcelona

Ph.D. dissertation

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A dissertation submitted for the degree of Ph.D. in Environmental Science and Technology

2016

Amaia Albizua 2016

Cover: Painting by Txaro Otxaran, Navarre case study region

Universitat Autònoma de Barcelona

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BASQUE CENTRE
FOR CLIMATE CHANGE
Klima Aldaketa Ikergai

Nire familiari, ama, aita ta Josebari

Ta batez ere, amama Felisaren memorian

Preface

This dissertation is the product of nearly five years of intense personal and professional development. The exploration began when a series of coincidences led me to the Basque Centre for Climate Change Centre (BC3). I had considered doing a PhD since the beginning of my professional career, but the long duration of a PhD and focusing on a particular topic discouraged such intentions. After some years working in the private sector, I realised I still had much to learn. For this reason, I applied for and subsequently received a grant for an MSc programme on soil and water management and then, in 2010, I obtained a grant to go to Ghana, working as a consultant in the UNESCO's office in Accra. My time there made me realise that doing a PhD transcended becoming an expert in a topic. Through various positions, I shared time with politicians and professors from whom I learned that the personal and technical skills gained from pursuing a PhD were invaluable; consequently, I aspired to incorporate these aptitudes in my own self-development.

Thereafter, I explored PhD opportunities, preferably in the Basque Country, as I had been studying and working abroad, and I was keen on understanding my native land. I had the opportunity to work in the BC3, but the former scientific director suggested that I pursue an additional master's degree in economics. After reviewing several master's programs and speaking with different professors, I understood that the masters of ecological economics offered at ICTA-UAB provided a new scientific paradigm, one of complexity, and from a notably socially and environmentally-committed perspective. It was a crucial moment of lucidity when I realised that I had to bridge those areas (the land/ecosystems dimension with the social dimension) to build my own research career. During the MSc programme at ICTA, I discovered political ecology and my enthusiasm amplified. This knowledge acquisition shaped the ideas which I then began to develop for my PhD.

After completing the MSc at ICTA, I moved home and started the PhD in Bilbao with Unai Pascual. I have spent all my PhD years there, making at least one visit per year to Barcelona, where I typically spent several days with Esteve Corbera discussing PhD issues and ideas. I must admit that the early years were challenging, when after reading so much information, I was still unable to properly formulate the research questions of my thesis. I felt a bit lost, but this way of proceeding also allowed for a more creative and thought-invoking process, where I developed my own interests through my personal learning on an iterative basis. The camaraderie of BC3 and ICTA colleagues and their unconditional support have made this learning process much more dynamic and productive.

By the end of the first year, I moved to Lund, Sweden, supported by EcoFINDERs project funds, an EU-funded program on Ecological Function and Biodiversity Indicators in European Soils in which Unai was involved. It was in September 2012 when I developed the ecological aspects of my ideas with the help of Katarina Hedlund’s team in the Department of Biology of Lund University. More specifically, I assessed the effects of different types of land management practices on the soil properties and the trade-offs and synergies of soil ecosystem services (ES) under different intensities of land management. I greatly value the learning experience that I received from my participation in this group regarding statistics and understanding ecological processes. The product of this collaborative work resulted in publishing the first article of this thesis. However, I have not included it within the dissertation. The cases of Sweden and Navarre are completely different, as the Swedish case was conducted under controlled conditions (which focused on rotations of crop varieties and the amount of mineral fertilisers used), whereas the Navarre case encompassed a broad quantity of crops and land management practices, including in turn different crop varieties (not considering rotations), types of fertilisers (not considering quantities) and use of irrigation. Initially, I intended to make two separate sections addressing each case study, but as my research thinking evolved, I decided to focus the dissertation on Navarre only, in order to produce a more coherent and less convoluted thesis.

The research process has been anything but linear. The learning path has been cyclical and has been continuously adapted to emerging ideas and reflections, to questions and debates arising through in-depth research. I dedicated approximately one year intermittently to fieldwork, which has been the best part of the PhD. Another year was devoted to analysing the Navarre case study results using R, which was a challenging learning process. Lastly, I dedicated a year or more on writing. Combining all the pieces together and communicating results with fluidity has been more arduous work than first expected. I hope to have succeeded in constructing an interesting research narrative, and that the final reading reflects the long and stimulating journey it entailed. I hope you enjoy and learn from it as much as I have.

Amaia Albizua Aguinaco

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Albizua, A. Synergies and trade-offs of agricultural management decision making under climate change. Political ecology of soil management. KLIMAGUNE From Euskadi to Rio + 20 (June, 2012). Bilbao (Spain)

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Abstract

The introduction of modern irrigation technology in agroecosystems often leads to an intensification of land management practices. Modern irrigation is expected to increase crops' productivity but it can also have negative environmental impacts, such as greenhouse gas emissions, water pollution, or/and social ones, including for instance the unequal social access to natural resources. The *Itoiz-Canal de Navarra* irrigation project, implemented in the region of Navarre, northern Spain, is inducing the intensification of land management practices and favouring in turn the use of heavy machinery and higher applications of fertilisers and pesticides.

This dissertation aims to understand the effects of such intensification on farmers' lives, paying specific attention to changes in their livelihoods, their farming strategies and perceptions of ecosystem services, the institutions governing land and water resources and their vulnerability and capacity to adapt to global change. Discerning uneven effects among rural inhabitants will shed light on which kind of rural livelihoods and values are enhanced by the irrigation project and which kind of rural development model is likely to dominate in the future.

The manuscript includes eight chapters. After an introduction, I develop a conceptual chapter that lays out the key ideas and debates underpinning my work, including: social-ecological systems, ecosystem services, rural livelihoods, social vulnerability and institutions. The subsequent chapter presents the research strategy and the methods employed to operationalise the theoretical framework, which include a large-scale survey, semi-structured interviews, participant observation and a focus group.

In the first empirical chapter, I adopt the rural livelihood approach to describe the rural livelihoods that exist in the study region. I find four main types: *small-scale diversified*, *medium-scale rainfed organic* and two differentiated degrees of *intensive* livelihoods when attending to the combination of capital assets associated with particular land management intensities. Farmers holding intense livelihoods with a clear market-oriented agriculture have mainly adopted modern irrigation. In contrast, *small-scale diversified* farmers have not adopted modern irrigation and are being consequently displaced from the agrarian landscape.

In the second empirical chapter, I show how farmers' perspectives and their values regarding agrarian ecosystem services are affected by their chosen land management practices. Informed by a socio-cultural valuation approach, I find that *intensive* farmers value highly the capacity of agrarian land to absorb pollutants, whereas they disregard other cultural services such as traditional knowledge. In contrast, I demonstrate that *small-scale diversified* farmers appreciate cultural services greater than other kinds of farmers and they are the most aware of the contribution of their management practices to enhanced food quality.

In the third empirical chapter, I highlight that farmers' livelihoods in the case study region are exposed to climatic stressors and shocks as well as structural economic transformations that make crop prices fluctuate with the potential to significantly increase farmers' vulnerability. I employ a "double vulnerable" framework combined with political ecology to interrogate if the adoption of modern irrigation technology makes farmers more able to adapt or increases instead their vulnerability. I find that modern irrigation increases farmers' robustness against the mentioned stressors and does so despite most intensive farmers are more sensitive to such stressors given their full time dedication to agriculture and their specialisation in water demanding cash crops, among other factors.

In the fourth and last empirical chapter, I assess the role played by modern irrigation institutions (both formal and informal) in influencing land management and access to common property resources. I find that the robustness of water and land resource governance seems to increase control over water consumption, but it negatively impacts upon the recognition of farmers' right to organise. Farmers become more dependent on nested enterprises that control irrigation water, which makes them more dependent on external aid in case of necessity. Additionally, using the lenses of legitimacy and equity, I show that those who are doubly vulnerable – *small-scale diversified* farmers – are not acknowledged in the norms that legitimate modern irrigation and that their participation in decision-making is limited compared to intensive farmers.

Overall, the findings of this dissertation portray differences in farmers' understanding and values of ecosystem services, and they reveal that modern irrigation results in very uneven effects on farming livelihoods and water management institutions. This research is hoped to be of interest to epistemic communities interested in broader, intricate and overarching debates over ecosystem services and rural livelihoods in agrarian social-ecological systems undergoing global change.

Keywords: modern irrigation, agrarian intensification, agrarian ecosystem services, rural livelihoods, social vulnerability, equity and legitimacy

Resumen

La introducción de la tecnología moderna de riego en los agro-ecosistemas a menudo conduce a una intensificación de las prácticas de manejo del suelo. La irrigación moderna está destinada a aumentar la productividad, pero al mismo tiempo también puede tener impactos ambientales negativos, tales como las emisiones de gases de efecto invernadero, la contaminación del agua, y / o impactos sociales, como por ejemplo, el acceso desigual a los recursos naturales. Itoiz-Canal de Navarra, una región del norte de España, está experimentando una transformación rural significativa mediante la intensificación del manejo de la tierra cuya transformación está asociada al riego moderno, que a su vez favorece el uso de maquinaria pesada, y mayores aplicaciones de fertilizantes y pesticidas.

Esta tesis incluye ocho capítulos, entre ellos un capítulo conceptual, otro metodológico, y cuatro capítulos empíricos. En el primer capítulo empírico, adopto el enfoque de medios de vida rurales para descubrir los diversos medios de vida rurales existentes en dicha región en transformación. He encontrado cuatro tipos principales de medios de vida rurales: agricultores de pequeña escala diversificados, agricultores orgánicos de mediana escala y dos grados diferenciados de los medios de vida intensivos. Esta clasificación atiende a la combinación de activos de capital asociados a determinadas intensidades de manejo de la tierra. El regadío moderno ha sido adoptado principalmente por los agricultores intensivos con una clara agricultura orientada al mercado. Por el contrario, los agricultores diversificados a pequeña escala no adoptan la irrigación moderna y consecuentemente son desplazados del paisaje agrario dado que algunos deciden vender sus tierras.

En el segundo capítulo empírico muestro cómo las perspectivas de los agricultores y sus valores con respecto a los servicios de los ecosistemas agrarios se ven afectados por sus prácticas de manejo de la tierra. Utilizo un enfoque de valoración socio-cultural y encuentro que los agricultores intensivos valoran altamente la capacidad de la tierra agraria para absorber contaminantes, mientras que no tienen en cuenta otros servicios culturales como el conocimiento tradicional. Por el contrario, los agricultores diversificados a pequeña escala aprecian los servicios culturales en mayor medida que otros tipos de agricultores, siendo este grupo además más consciente de los efectos que sus prácticas agrícolas tienen en la calidad de los alimentos.

En el tercer capítulo empírico, destaco que en el caso de estudio de Itoiz-Canal de Navarra, los medios de vida de los agricultores están expuestos a factores de estrés como las perturbaciones climáticas, y las transformaciones económicas estructurales que hacen que los precios de los cultivos fluctúen, aumentando de esta manera la potencial vulnerabilidad de los agricultores. Empleo el marco de doble vulnerabilidad y lo combino con la ecología política para responder a la pregunta de si la adopción de la tecnología moderna de riego hace que los agricultores sean más capaces de adaptarse o, por el

contrario, aumentan su vulnerabilidad. Encuentro que el nuevo regadío hace más robustos a los agricultores frente a los factores de estrés mencionados pero también encuentro que al mismo tiempo los agricultores más intensivos son más sensibles al adoptar la irrigación moderna debido a su dedicación a tiempo completo a la agricultura y su especialización en cultivos comerciales con alta demanda de agua, entre otros factores.

En el cuarto y último capítulo empírico evalúo el papel que desempeñan las instituciones (formales e informales) relacionadas con el regadío moderno para influir en la gestión de la tierra y el acceso a los recursos de propiedad común. Encuentro que el nuevo regadío es más sólido respecto a la gestión de los recursos hídricos y de la tierra debido a que parece aumentar el control sobre el consumo de agua. Sin embargo, tiene un impacto negativo sobre el reconocimiento del derecho de los agricultores a organizarse. Esto hace que los agricultores sean más dependientes de las empresas anidadas que controlan el agua de riego, a su vez, haciéndolos más dependientes de la ayuda externa en caso de necesidad. Además, la aproximación de análisis desde la legitimidad y la equidad, muestra que aquellos agricultores doblemente vulnerables - los agricultores diversificados a pequeña escala - no están reconocidos en las normas que legitiman la introducción del riego moderno y su participación en la toma de decisiones es menor en comparación con los agricultores más intensivos.

Esta tesis retrata diferentes visiones acerca del valor de los servicios de los ecosistemas, el desarrollo rural y los efectos de la modernización y la vulnerabilidad de los agricultores integrados en el más amplio nexo entre medio ambiente y desarrollo. Esta investigación se espera que sea de interés para comunidades interesadas en debates sobre los servicios de los ecosistemas y los medios de vida rurales de los sistemas socio-ecológicos agrarios influidos por el proceso de cambio global.

Palabras clave: riego moderno, de intensificación agraria, servicios de los ecosistemas agrarios, los medios de vida rurales, la vulnerabilidad social, equidad y legitimidad

Laburpena

Ureztaketa teknologiaren hastapenak nekazal-ekosistemetan askotan lur erabilera intensiboari loturik egon da. Ureztaketa modernoak emankortasuna handitzen du, baina aldi berean ingurune-inpaktu kaltegarriak ere baditu, berotegi- efektuko gasem izurketa, uraren kutsadura edo inpakt sozialak, besteak beste. Itoiz- Nafarroako ubidea, Espainiako estatuaren iparraldean, landa- bizitza eraldatze sakon bat jasaten ari da, ureztaketa modernoa eta honi loturiko; makineria astun zein ongarri eta pestiziden erabilpenaren ondorioz.

Doktoretza-tesi hau zortzi ataletan banatuta dago. Atal bat kontzeptuala da, beste bat metodologikoa, gainontzeko lauak enpirikoak eta sarrera eta konklusioak. Lehenengo atal enpirikoan, nekazal ikuspegitik, herrialdean dauden bizimodu desberdinak azaltzen ditut. Oinarrizko lau bizimodu desberdin bereizten ditut: nekazari txiki dibertsifikatuak, eskala ertaineko nekazari organikoak, eta bi gradu ezberdineko nekazari intentsiboak. Honako sailkapena kaptial-aktibo eta lur erabilerare intentsitate maila desberdinen konbinazioei dagokio. Ureztaketa modernoa batik bat nekazari intentsiboek aukeratu dute merkataritzari zuzendutako ekoizpen argi batekin. Nekazari txiki dibertsifikatuak berriz, ez dute gaur egungo ureztaketa hautatzen eta honen ondorioz nakazaritza eremutik baztertuak izaten dira, batzuk beraien lurrak saltzeraino.

Bigarren atal enpirikoan nekazarien ikuspegiak eta ekosistemen zerbitzuekiko balioak nola moldatzen diren, lurraren erabileraren arabera, azaltzen dut. Ikuzpegi sozio-kultural batetik, nekazari intentziboek asko balioztatzen dute lurrak kutsagarriak xurgatzeko duen gaitasuna, baina ez dituzten kontutan hartzen ekosistemen beste zerbitzuak , jakintza tradizionala esaterako. Nekazari txikiek berriz, kultur zerbitzuak beste nekazariek baino gehiago balioesten dituzte. Azken multzo honek nekazal-jarduera desberdinek elikagaien kalitatean dituzten eraginak besteek baino gehiago hartzen dituzte kontutan.

Hirugarren kapitulu enpirikoan, Itoiz- Nafarroa ubideko kasuan nabarmentzen dut nekazarien bizibideak estres-faktoreen menpe daudela, hala nola eguraldi perturbazioak eta eraldatze ekonomiko estrukturalak, landaketen prezioei gorabeherak eragiten dizkienak, nekazarien ahultasuna areagotuz. Ahultasun bikoitzaren markoa erabiltzen dut eta ekologia politikoarekin batera, nekazariek gaur egungo ureztaketa adoptatuz hobeto egokitzen diren edo beren ahultasuna areagotzen duten galderari erantzuten diot. Gaur egungo ureztaketak aipatutako estres-faktorearen aurka, nekazariak indartzen dituela aurkitzen dut. Era berean, nekazari intentsiboak sentikorragoak dira erabateko dedikazioa baitute eta ur behar izan handia duten labore komertzial espezializazioaren menpe bait daude, besteak beste.

Laugaren eta azken atal enpirikoan, gaur egungo ureztaketarekin zerikusia duten erakundeen papera aztertzen dut (erakunde formalak eta informalak). Hauek lur erabilera eta guztien baliabideen kudeaketan duten eragina alegia. Gaur egungo ureztaketa lur eta ur-baliabidean kudaketan eraginkorragoa dela ikusten dut, ur erabileraren kontrola handiagoa baita da.

Honela bada, nekazariek ura kontrolatzen duten enpresekin menpekotasun haundiago dute, beharra izanez gero kanpoko laguntzarekiko menpetakosuna handituz. Azterketa zilegitasun eta berdintasun ikuspuntutik hartuz, nekazari ahulenak direnak, nekazari txiki dibertsifikatuak, ez dira kontutan hartzen ureztatze modernoaren erabilera justifikatzeko orduan, eta beraien erabakitzeko indarra txikiagoa da nekazari intentziboekin alderatuz.

Doktoretza-tesi honek konbergentziak eta desadostasunak azalarazten ditu ekosistemen zerbitzuen ikuspegitik , nekazarien garapen eta modernizazioren arteko lotura kontuan hartuz eta, ingurumen zein garapenari loturiko nekazaritzaren ahultasunak kontextu zabalago batetatik aztertuta. Honekin, ikuspegi sozio-ecologikotik, aldaketa globalari loturik , ekosistema-zerbitzuen zein nekazal-bizimoduen inguruan diarduten jakintza eremuetan interesa sustatuko duen itxaropena dugu.

Hitz gakoak: ureztaketa modernoa, nekazaritza intensifikazioa, nekazal ekosistem-serbitzuak, baserri bizimoduak, ahaltasun soziala, ekitatea, zilegitasuna

Resum

La introducció de la tecnologia moderna del reg en els agroecosistemes sovint condueix a una intensificació de les pràctiques de gestió del sòl. La irrigació moderna està destinada a augmentar la productivitat, però al mateix temps també pot tenir impactes ambientals negatius, com ara les emissions de gasos d'efecte hivernacle, la contaminació de l'aigua, i/o impactes socials, com per exemple, l'accés desigual als recursos naturals. *Itoiz-Canal de Navarra* és un projecte de regadiu modern que s'està adoptant en una zona de navarresa, al nord d'Espanya. Aquesta regió està experimentant una transformació rural significativa mitjançant la intensificació de la gestió de la terra, associada al reg modern, que alhora afavoreix l'ús de maquinària pesada, i majors aplicacions de fertilitzants i pesticides.

Aquesta tesi inclou vuit capítols, entre ells un capítol conceptual, un altre metodològic, i quatre capítols empírics. En el primer capítol empíric, adopto l'enfocament dels mitjans de vida rurals per descobrir els diversos mitjans de vida rurals existents en la dita regió en transformació. He trobat quatre tipologies principals de mitjans de vida rurals: *agricultors de petita escala diversificats*, *agricultors orgànics de mitjana escala*, i dos graus diferenciats de mitjans de vida *intensius*. Aquesta classificació té en compte la combinació d'actius de capital associats a determinades intensitats de gestió de la terra. El regadiu modern s'ha adoptat principalment pels agricultors intensius amb una clara agricultura orientada al mercat. Per contra, els agricultors diversificats a petita escala no adopten la irrigació moderna i conseqüentment són desplaçats del paisatge agrari, ja que alguns decideixen vendre les seves terres.

En el segon capítol empíric mostro com les perspectives dels agricultors i els seus valors respecte als serveis dels ecosistemes agraris es veuen afectats per les seves pràctiques de gestió de la terra. Utilitzo l'enfocament de valoració socio-cultural i trobo que els agricultors intensius valoren altament la capacitat de la terra agrària per absorbir contaminants, mentre que no tenen en compte altres serveis culturals com els coneixements tradicionals. Per contra, els agricultors diversificats a petita escala aprecien els serveis culturals en major mesura que altres tipologies d'agricultors, essent el grup més conscient dels efectes que les seves pràctiques agrícoles tenen en la qualitat dels aliments.

En el tercer capítol empíric, destaco que en el cas d'estudi de *Itoiz-Canal de Navarra*, els mitjans de vida dels agricultors estan exposats a factors d'estrès com les pertorbacions climàtiques i les transformacions econòmiques estructurals que fan que els preus dels cultius fluctuïn, augmentant d'aquesta manera la potencial vulnerabilitat dels agricultors. Utilitzo aquí el marc de la doble vulnerabilitat i el combino amb l'ecologia política per a respondre a la pregunta de si l'adopció de la tecnologia moderna de reg fa que els agricultors siguin més capaços d'adaptar-se o, pel contrari,

augmenten la seva vulnerabilitat. Trobo que el nou regadiu fa més robustos als agricultors davant dels factors d'estrès mencionats, però al mateix temps també trobo que els agricultors més intensius són més sensibles quan han adoptat la irrigació moderna degut a la seva dedicació a temps complet a l'agricultura i la seva especialització en cultius comercials amb alta demanda d'aigua, entre altres factors.

En el quart i últim capítol empíric avaluo el paper que desenvolupen les institucions (formals i informals) relacionades amb el regadiu modern per influir en la gestió de la terra i l'accés als recursos de propietat comuna. Trobo que el nou regadiu és més sòlid respecte a la gestió dels recursos hídrics i de la terra ja que sembla augmentar el control sobre el consum d'aigua. Tot i així, té un impacte negatiu sobre el reconeixement del dret dels agricultors a organitzar-se. Això fa que els agricultors siguin més dependents de les empreses que controlen l'aigua de reg, alhora, fent-los més dependents de l'ajuda externa en cas de necessitat. A més, l'aproximació analítica des de la legitimitat i l'equitat mostra que aquells agricultors doblement vulnerables - els agricultors diversificats a petita escala - no estan reconeguts en les normes que legitimen la introducció del reg modern i la seva participació en la presa de decisions és menor en comparació amb els agricultors més intensius.

Aquesta tesi retrata les diferències sobre visions referents al valor dels serveis dels ecosistemes, el desenvolupament rural i els efectes de la modernització i la vulnerabilitat dels agricultors integrats en el més ampli nexe entre medi ambient i desenvolupament. Aquesta investigació s'espera que sigui d'interès per les comunitats interessades en debats sobre els serveis dels ecosistemes i els mitjans de vida rurals dels sistemes socio-ecològics agraris influïts pel procés de canvi global.

Paraules clau: reg modern, intensificació agrària, serveis dels ecosistemes agraris, els mitjans de vida rurals, la vulnerabilitat social, equitat i legitimitat.

Acknowledgements

This work has been possible thanks to several people who have supported me in many different ways. When I embarked on the PhD process, I aspired to equip myself in many different aspects, not only by advancing my knowledge of socio-ecological dynamics, which I am passionate about, but also by becoming a more patient, resolute and politically mature person. For me it has always been, and still is, a learning process where the journey itself is more important than the destination.

First of all, I would like to thank Nerea Ortiz and Anil Markandya for financing four years of PhD studies at the Basque Centre for Climate Change Centre (BC3). They trusted me since the beginning of the journey, when I arrived with few fuzzy research ideas focused on relating soil ecosystems management with social governance structures.

These ideas took shape when Unai Pascual agreed to supervise my PhD within the EcoFINDERs European project. This project allowed me to gain access to valuable databases and finance a three months stay in Sweden, and to develop fieldwork in Navarre, Spain. I will always be indebted to Unai for his confidence. Although he warned me about the high level of expertise he expected from me, he never excessively pressured me and has guided me, providing me with inspiration in difficult moments of design, analysis and throughout the writing process. With his attention to detail, accuracy and critical analysis, Unai has provided me with many invaluable insights and comments over the years that have made the conceptualisation and execution of this dissertation much stronger.

I also owe my gratitude to my other supervisor, Esteve Corbera, at the Institute of Environmental Science and Technology (ICTA), Universitat Autònoma Barcelona. Esteve is an esteemed professional, and I appreciate his spirits that, along with Unai's, have encouraged and motivated me all the way through. I thank you for all the guidance in designing this thesis, the inspiring discussions through Skype and the transferred strength to keep searching for answers to the 'not always obvious' questions.

Both Unai and Esteve's support has had great value through the ellaboration of the thesis as a whole. They have set an incredible example and a mirror in which I aspire to see myself reflected. Both have contributed not only to this dissertation, but also to my intellectual and personal development. Despite moments of uncertainty in which I could not "see the end", they encouraged me and explained that every process deserves its maturation time. Perhaps I would have been more optimistic if mine had developed a bit faster…

I also want to thank the invaluable team of BC3. I have really felt at home there. I would like to first begin by thanking with my desk mates: Elisa Sainz de Murieta, Marta Olazabal, Patricia Gallejones.

Elisa, Marta and Patri have, in close proximity, supported the good but also the bad moments of nerves and desperation when I could not concentrate or in certain moments struggling with statistics or writing. I have learned a lot from them and enjoyed their company very much. They helped me with Zotero citation skills and provided many other advice, at both personal and professional levels, which were always useful and perceptive.

I also had great support for the dissertation collaboration from Marc Neumann. He has acted as my professional mentor, primarily at the last stages of my PhD and he was of great support on R scripts writing. Thank you for your always good disposition and your good humour. I really appreciate it.

I would also like to thank Elena Ojea for her guidance, especially in the beginning stages of the thesis. I greatly enjoyed our meals where I could speak through my thoughts, which revitalised my work. Agustin del Prado and Iñaki Arto have also been good advisors whenever I was in doubt. Iñaki, together with Ignacio Cazcarro, helped with the vulnerability indexes and Agus provided excellent feedback for a useful agrarian contextualisation; thank you, for always making me feel very comfortable when talking to you. Ignacio Palomo and Eneko Garmendia were also of great assistance whenever I asked them about ecosystem services and methodological doubts (survey, interviews and focus groups) and about political ecology doubts.

R programming and statistics have been by far the most difficult tasks I have had to learn. To express my gratitude in this regard, I have a long list of names of whom I owe considerable appreciation: Arelly Ornelas, Vicente Nuñez, Juan Ignacio Modroño, Aitor Larrañaga, Ignacio Palomo, Victor Urrea, Dae-Jin Lee, Iñigo Capellan, Josue Polanco, Javier Martínez, Elena Perez-Miñana, Alwyn Williams and especially Marc Neumann. I can be very tiresome when stuck in R!

I owe a significant thank you to all those who helped at the end with the writing of this dissertation. Julen Ugalde, Mary Thomson, Bosco Lliso, Noelia Zafra, Iñigo Capellan, Mavi Román, Elena Galan, Martha Kerr and especially Ane Zubizarreta for their help on English edits while writing the dissertation manuscript. You have demonstrated great camaraderie and affection. I would also like to thank to Rebekah Breding for the proof reading of the thesis. I have learnt a lot during the process and she has been very fast mainly at the last stage when my demands were much shorter in time.

I would also thank to the Oketa group for the stimulating discussions and field trips we took together. Most of the mates in BC3 have become good friends over time. Many of them have already been mentioned but I would also like to include Amaia de Ayala, Marta Pascual, Maialen Garmendia, Alina Tempes, Itxaso Ruiz, Pablo Martinez, Guillermo Pardo, Xaquin García, Kishore Davala, Nadine Sahouri, and many others. They all have been of immense help over the years. Thanks for the beers after work and the humorous coffee breaks.

I cannot forget to express my extreme gratitude to Mari Jose, the current director of BC3, who has supported me to finish this stage of my life, advising me through those chapters and also in future career opportunities.

I especially want to thank all the support of Julen Ugalde, in and outside of BC3. He has read several chapters of the dissertation, assisting me with writing and has endured some of my troubled times and disappointments but always maintained confidence in me, despite my most stressed moments.

Outside of BC3, I would also like to thank Jose Ramon Olarieta and Christoz Zografos, both of whom supervised the two masters' dissertations and kindled the flame of curiosity and enthusiasm, which was crucial in starting the PhD. They have always been helpful during the PhD process, especially at the beginning.

I do not want to forget about my mates during my stay in Sweden: my supervisor there, Katarina Hedlund, who offered me the warmest welcome and who always took consideration of my comfort level and intellectual curiosities. I really appreciated she always had time for me whenever I knocked on her door. I really learnt a lot and had the calmest mind of the process while I was there, which allowed me to advance and savour my stay. Alwyn Williams, Helene Bracht Jörgensen, Ronggang Cong (Leo) and Mark Brady, thank you! Likewise, to my Latin friends who made my visit much more interesting: Soraya Maya, Alejo and Jesus. Thanks for all the trips and long and interesting discussions we shared together.

I would also like to include in these acknowledgements to my WACHI friends from the University Autonomous of Barcelona: Diana Calvo, Sara Maestre and Mar Grau. I am always looking forward to seeing you whenever I go to Catalunya. Our workshop in Vielha was incredible and it was the seed of, I hope, many other meetings to continue our discussions on institutions and political ecology. You all inspire me a great deal! I dedicate a special thank you to Diana Calvo for our discussions since the master's and within the last stages of the thesis. You have always been ready to share references and discuss complicated concepts. I am glad to have met you and to discover that we are traveling parallel paths! Laura Calvet was also of considerable help when designing my survey for the fieldwork and mainly for the socio-cultural valuation methods. Marta Borros with the maps. In Barcelona, I cannot forget about Natalia Jojart and Felipe Díaz, both good friends, who are always willing to host me in my visits or to help with administrative issues.

I would like also to express my gratitude to Marc Vizcano. You were there before, during and almost up until the end of the journey. You know very well how difficult this has been at certain moments and you have always helped me to your best ability; reviewing drafts, lending your car for work purposes, accompanying me through lows and listening to all my complaints, all while trying to make me feel better.

Julien Brun and Idoia Urrutia deserve an enormous thank you for their professionalism during the three intensive months of fieldwork in Navarre. I am grateful for their patience and understanding at some challenging moments. I also want to thank Begoña Renteria and Imanol Okiñena for their assistance during the focus groups. You provided more than merely transcribing the discussion, time management and photography. You also gave me the necessary energy which propelled me through that day. I have many fieldwork participants in mind that made this work much more pleasant: Patxi Sueskun, Leire Elorz, Juan Jesus Corcin, Charo Brinquis, Jokin del Valle, Celsa Peitado, Milagros and Mari, among others. I have learnt so much from all of you; not only about rural life but also about myself.

Other friends who deserve a special mention for all the encouragement throughout these doctoral years (despite my periods of silence and disappearance) include my friends from Amurrio. Although sometimes I felt as if my situation was difficult to relate to, you helped me to disconnect from work through long walks, mountain trips, party nights and the funniest pintxo-potes. You have encouraged me by attending a few of my seminars and listening to my long boring rehearsals beforehand. I have felt very fortunate of having all you in my life: Begoña Renteria, Garazi Ibarretxe, Miriam Larrakoetxea, Leire Cuadra, Oihane Abrisketa, Aitziber Lazkano, Maria Larrea, and Ana Isabel Romero.

Most definitely, this would have not been possible without the help of my family. You have always facilitated the construction of the person I am today. My brother, Joseba Albizua has always provided me with the calm atmosphere I needed through his company and long walks. You have educated me and I have learnt from you that with effort and determination all is possible, or at least, you taught me to learn from the process, which may be more important. I have climbed the highest mountains and visited the farthest places while dreaming of my future. Thank you for sharing all of this and for helping me realise about my ambitions. Although I may have complained about your strictness, I know you only wanted to help me grow and better myself. My father, Iñaki Albizua has always helped with all that he was capable. He provided me a shoulder to rest on or by taking me to the airport, train or bus whenever I had to travel. He has always listened patiently and trusted me. Finally, my mother has greatly assisted me with everything she could. She has listened and patiently advised and accompanied me throughout the worst moments of the doctorate. She has not only provided me with the best meals but also nourished me emotionally. Thank you.

Agradecimientos

Este trabajo ha sido posible gracias a muchas personas que me han ayudado de diversas maneras. Cuando me embarqué en esta aventura quería 'equipar mi mente'. No sólo avanzar en el conocimiento sobre las dinámicas socio-ecológicas, un tema que me apasiona, sino también convertirme en una persona más paciente, decidida y madura a nivel político. Para mí siempre ha sido y sigue siendo, un proceso de aprendizaje donde el viaje en sí mismo es más importante que el destino.

En primer lugar, me gustaría dar las gracias a Nerea Ortiz y Anil Markandya por financiar mis cuatro años de estudios de doctorado en el Basque Centre for Climate Change (BC3). Ellos confiaron en mí al principio, cuando llegué con algunas ideas difusas sobre los ecosistemas de suelo y las estructuras de gobernanza social.

Esto tomó forma con el tiempo, cuando Unai Pascual decidió supervisar mi doctorado dentro del proyecto europeo EcoFINDERs. Este proyecto me permitió acceder a una valiosa base de datos y financiar la estancia de tres meses en Suecia y el trabajo de campo desarrollado en Navarra. Siempre estaré en deuda con Unai por su confianza. Aunque me advirtió acerca del nivel de exigencia que esperaba de mí, nunca me ha presionado en exceso, ha hecho que supere este reto dirigiendo el trabajo y aportándome inspiración en los momentos más difíciles del diseño, análisis y escritura. Con su atención al detalle, precisión y análisis crítico, Unai me ha proporcionado muchas ideas invaluables y comentarios durante estos años, haciendo que la conceptualización y la redacción de esta tesis sea mucho más fuerte. También debo mi agradecimiento a mi supervisor Esteve Corbera, en el Institut de Ciència i Tecnologia Ambientals (ICTA), de la Universidad Autónoma de Barcelona. Esteve no es sólo un gran profesional, también reconozco y agradezco su gran vitalidad y espíritu, que me ha animado y motivado. Le agradezco toda la ayuda en el diseño de esta tesis, las discusiones inspiradoras al otro lado del Skype y la fuerza transmitida a seguir buscando respuestas a preguntas que no siempre resultaban obvias. Tanto, el apoyo de Unai como el de Esteve, han tenido un gran valor en la elaboración de esta tesis. Ambos han sido un modelo y un espejo en el que me ha agradado verme fugazmente reflejada. Los dos han contribuido mucho a esta tesis doctoral y a mi desarrollo intelectual y personal. A pesar de los malos momentos, cuando no podía ver el final, me han animado y explicado que cada proceso merece su tiempo de maduración. Habría agradecido si el mío hubiera sido un poco más rápido...

Agradezco al gran equipo de BC3. Realmente me he sentido en casa allí. Me gustaría empezar con mis compañeras de mesa: Elisa Sainz de Murieta, Marta Olazabal y Patricia Gallejones. Elisa, Marta y Patri han vivido de cerca los buenos pero también los malos momentos de nervios cuando no me podía concentrar o lidiaba con bloqueos en la estadística y la escritura. He aprendido mucho de ellas y he disfrutado de su compañía. No sólo me han ayudado a nivel académico, sus consejos a nivel personal y profesional siempre fueron útiles y perspicaces.

También tuve un gran apoyo de Marc Neumann. Marc ha actuado como mi mentor profesional, sobre todo en las etapas finales de mi tesis doctoral. Debo agradecer de corazón su siempre positiva disposición y su buen humor para ayudarme con los comandos de R.

También me gustaría agradecer a Elena Ojea por su orientación, especialmente en las primeras etapas de la tesis. He disfrutado mucho de nuestras comidas en las que aireaba mis dudas sobre la tesis y estas conversaciones me daban fuerza y energía para empezar de nuevo el trabajo.

Agustín del Prado e Iñaki Arto también han sido buenos consejeros. Iñaki, junto con Ignacio Cazcarro, me han ayudado con los índices de vulnerabilidad y Agus me ha aportado excelentes comentarios para una mejor contextualización agraria. Ignacio Palomo y Eneko Garmendia también fueron de gran ayuda con temas relacionados con los servicios eco-sistémicos y la ecología política, tanto a nivel metodológico como conceptual.

La estadística y sobre todo la programación en R han sido las tareas más difíciles que he tenido que aprender. En este sentido, tengo una larga lista de nombres a quien debo considerable reconocimiento: Arelly Ornelas, Vicente Nuñez, Juan Ignacio Modroño, Aitor Larrañaga, Ignacio Palomo, Víctor Urrea, Dae-Jin Lee, Iñigo Capellan, Josue Polanco, Javier Martínez, Elena Perez-Miñana, Alwyn Williams y especialmente Marc Neumann. Puedo ser muy cansina cuando estoy bloqueda en R!

Debo un gran agradecimiento a todos los que me han ayudado al final con la escritura de esta tesis. Mary Thomson, Bosco Lliso, Noelia Zafra, Iñigo Capellan, Mavi Román, Elena Galán, Martha Kerr y especialmente Ane Zubizarreta. Gracias Ane por tu gran ayuda en las ediciones de inglés mientras escribía el manuscrito. Habéis demostrado cariño y gran camaradería. También me gustaría agradecer a Rebekah Breding la mejora de la escritura. He aprendido mucho durante el proceso y ha sido muy rápida principalmente al final cuando mis demandas eran cada vez más cortas en el tiempo.

Quiero también dar las gracias al grupo Oketa por las estimulantes discusiones y excursiones. La mayoría de los compañeros en BC3 se han convertido en buenos amigos con el tiempo. Muchos de ellos ya los he mencionado, pero también me gustaría incluir a Amaia de Ayala, Marta Pascual, Maialen Garmendia, Alina Tempes, Itxaso Ruiz, Pablo Martinez, Guillermo Pardo, Xaquin García, Kishore Davala, Nadine Sahouri y muchos otros. Todos ellos han sido de enorme ayuda durante estos años. Gracias por las cervezas después del trabajo y los divertidos descansos a la hora del café.

No puedo olvidar mi gratitud a Mari Jose, la actual directora de BC3, que me ha apoyado para terminar esta etapa de mi vida, y también me ha asesorado en estos capítulos así como me ha brindado su apoyo en mis perspectivas futuras como científica.

Especialmente quiero agradecer todo el apoyo de Julen Ugalde, dentro y fuera de BC3. Ha leído varios capítulos de la tesis y me ha ayudado no sólo con la escritura sino que también ha sufrido algunos de mis malos momentos y decepciones. Gracias por tu confianza, y por ayudarme a desconectar y hacer mucho más llevadero este final de tesis.

Fuera de BC3, también me gustaría agradecer a Jose Ramon Olarieta y Christoz Zografos, ambos me supervisaros las dos tesinas de master y encendieron la llama de la curiosidad y el entusiasmo que fue crucial en el inicio de la tesis doctoral. Siempre han sido de ayuda durante el proceso de tesis, especialmente al principio.

No quiero olvidarme de mis compañeros durante mi estancia en Suecia: mi supervisora, Katarina Hedlund, quien me ofreció la más cordial bienvenida y siempre se preocupó de mi bienestar tanto intelectual como personal. Aprecio muy profundamente el tiempo dedicado. Fue un placer tu atención cada vez que tocaba tu puerta. Realmente aprendí mucho y tuve la mayor calma de todo el proceso mientras estaba allí, que me permitió avanzar y disfrutar de mi estancia. Alwyn Williams, Helene Bracht Jörgensen, Ronggang Cong (Leo) y Mark Brady, gracias! Además, a mis amigos latinos allí que hicieron mi visita mucho más interesante: Soraya Maya, Alejo y Jesús. Gracias por todos los viajes y largas e interesantes conversaciones que compartimos.

También me gustaría incluir en los agradecimientos a mis amigas WACHI de la Universidad Autónoma de Barcelona: Diana Calvo, Sara Maestre y Mar de Grau. Siempre espero veros cuando viajo a Barcelona. Nuestro taller en Vielha fue increíble y fue la semilla de, espero, muchos otros encuentros para continuar nuestras discusiones sobre instituciones y ecología política. Todas vosotras me inspiráis mucho! Dedico un agradecimiento especial a Diana Calvo, por nuestros debates desde el comienzo y sobre todo en las últimas etapas de la tesis. Gracias por tu cooperación a la hora de compartir referencias y discutir conceptos complicados. Me alegro de haberte conocido y descubrir que estamos viajando en caminos paralelos. Laura Calvet también fue de considerable ayuda en el diseño de la valoración socio-cultural para el trabajo de campo y Marta Borros me ha ayudado con los mapas. No puedo olvidar a Natalia Jojart y Felipe Díaz, ambos buenos amigos, que siempre están dispuestos a hospedarme en mis visitas o a ayudarme con cuestiones administrativas.

También me gustaría expresar mi agradecimiento a Marc Vizcano. Estabas ahí antes, durante y casi hasta el final del viaje. Sabes muy bien lo difícil que ha sido en algunos momentos y siempre has tratado de ayudarme lo mejor que has sabido; has revisado borradores, me has prestado tu coche para trabajar y me has acompañado y escuchando todas mis quejas, al mismo tiempo tratando de hacerme sentir mejor.

Julien Brun e Idoia Urrutia merecen un gracias enorme, por su profesionalidad durante los tres meses de intensivo trabajo en Navarra. Agradezco vuestra paciencia y comprensión en momentos difíciles. También quiero agradecer a Begoña Renteria e Imanol Okiñena por su ayuda durante el taller en Miranda de Arga. Más allá de transcribir la discusión, gestionar el tiempo y sacar fotos, me disteis la energía que necesitaba ese día.

Tengo a muchos de los participantes en este trabajo de campo en la mente que han hecho este trabajo mucho más agradable: Patxi Sueskun, por su increíble generosidad dejándome quedar en su casa, Leire Elorz, Juan Jesus Corcin, Charo Brinquis, Jokin del Valle, Celsa Peitado, Milagros y Mari, entre otros. He aprendido mucho de vosotros; no sólo sobre la vida rural sino también sobre mí misma.

Una mención especial por todo el estímulo a lo largo de estos años de doctorado (a pesar de mis periodos de silencio y desaparición) a mis amigas de Amurrio. Aunque a veces me sentía un poco incomprendida en este tema, me habéis ayudado a desconectar del trabajo a través de caminatas, excursiones, noches de fiesta y los divertidos pintxo-potes. Algunas de vosotras me habéis animado asistiendo a algunos de mis seminarios y escuchando mis aburridos ensayos previamente. Me siento muy afortunada de teneros en mi vida: Begoña Renteria, Garazi Ibarretxe, Miriam Larrakoetxea, Leire Cuadra, Oihane Abrisketa, Aitziber Lazkano, María Larrea, Ana Isabel Romero y mi prima, Amaia Diego.

Definitivamente, esto no hubiera sido posible sin la ayuda de mi familia. Vosotros habéis contribuido los que más en hacer de mí la persona que soy. Mi hermano, Joseba Albizua siempre me ha aportado la tranquilidad necesaria, a través de su compañía y las largas caminatas. Él me ha educado y de él he aprendido que con esfuerzo y determinación casi todo es posible, o al menos consigues enriquecerte en el proceso. He subido las montañas más altas y he visitado los lugares más lejanos mientras soñaba con mi futuro. Gracias por compartir todo esto y por ayudarme a llevar a cabo mis ambiciones. Aunque muchas veces me he quejado de que eres muy estricto, sé que sólo quieres ayudarme a crecer y mejorar. Mi padre, Iñaki Albizua me ha ayudado siempre con todo lo que era capaz. Prestándome un hombro para descansar o llevándome al aeropuerto, tren o autobús cada vez que tenía que viajar. Él siempre ha escuchado y confiado en mí. Finalmente, mi madre ha ayudado con todo lo que ha podido. Ella ha escuchado pacientemente, me ha aconsejado y me ha acompañado en los peores momentos del doctorado. No sólo me proporciona las mejores comidas sino que también me nutre emocionalmente. Gracias.

Eskerrak

Lan hau posiblea izan da jende askori esker. Abentura hontan sartu nintzenean, nire burua garatu nahi nuen. Sozio-ekologiko dinamikaei buruz adimena aurreratzeaz aparte, izugarri atsegin dudan gaia, pertsona pazienteago, seguruago eta politikoki heldu batean bilakatu nahi nuen. Niretzat, ikasteko prozesu honetan bidaia helmuga baino garrantzitsuagoa da.

Lehengoz, Nerea Ortizi eta Anil Markandyari eskertu nahi diet, doktoretza Basque Centre for Climate Change (BC3)-an lau urte finantzatzeagatik. Nitaz fidatu ziren hasieran, lur ekosistema eta gizarte gobernu egiturei buruzko ideia batzuekin heldu nintzenean.

Ideia hauek forma hartu zuten Unai Pascualek nire lana gainbegiratzea erabaki zuenean eta nire doktoretza EcoFINDERS europar proiektuan sartu zuenean. Proiektu honi esker datu baliotsuetara heldu eta Suedian estantzia bat finantziatu ahal izan nuen. Beti izango naiz zorretan Unairekin, bere konfiantzagatik. Nahiz eta exigentzia maila altua adierazi izana, ez nau inoiz presio gehiegi jarri eta erronka gainditzea lagundu dit momentu zailetan, bere laguntza oso baliogarria izan da, disenuan, analisietan eta idazkeran. Bere arreta xehetasuna, zehaztasun eta analisi kritikoa, Unaik ideia eta komentario baliotsu asko eman dizkit urteetan zehar, berak kontzeptualizazio eta idazkera asko indartu ditu. Baita Esteve Corbera-ri, Institut de Ciència i Tecnologia Ambientals-ean (ICTA), Bartzelonako Unibertsitate Autonomoan, eskerrak eman nahi dizkiot. Esteve ez da soilik profesional handi bat, bere bizitasunak eta espirituak animatu eta asko motibatu naute. Tesi honen diseinuari buruz emandako laguntza guztiak eskertzen dizkiot, baita Skype atzean iradoki eztabaidak eta transmititzen duen indarra begi-bistako galderak ez zirenei erantzunak bilatzerakoan. Biok, Unai eta Esteve eredu bat jarraitzeko izan dira niretzat. Biok asko lagundu dute tesi honen eta nire garapen intelektualan eta pertsonalan. Momentu txarrak izan arren, bukaera ezin nuenean ikusi, animatu naute eta prozesu guztiek bere denbora behar dutela azaldu didate. Eskertuko nuke nirea pixkat arinago izango balitz...

BC3 taldeari eskerrak eman behar dizkiot. Benetan etxean bezala sentitu naiz han. Hasiko naiz nire mahai kideekin: Elisa Sainz de Murieta, Marta Olazabal eta Patricia Gallejones. Elisa, Marta eta Patri hurbiletik bizi dute momentu onak baina urduritasun momentu txarrak ere bai. Asko ikasi eta disfrutatu dut haiekin. Ez naute bakarrik akademikoki lagundu baina pertsonal arloan ere oso baliogarriak izan dira.

Marc Neumann-ek ere asko lagundu dit. Marc nire aholkulari profesionala izan da, batez ere nire doktoretzaren azken txanpetan. Bihotzez eskertzen diot bere laguntza, beti jarrera positiboarekin eta umore onarekin R idazkeran asko lagundu nau.

Elena Ojeari ere bere orientabidea eskertu nahi diot, betez ere abentura honen hasieran. Oso ondo pasatu dut gure bazkarietan beti nire zalantzak ateratzen nituenean. Elkarrizketa horiek indarra ematen zidaten lana berriz hasteko.

Agustín del Prado eta Iñaki Arto aholkulari onak ere izan dira. Iñakik eta Ignacio Cazcarrok ahultasuna indizerekin lagundu naute eta Agus komentario baliogarriekin nekazal-ekosistema kontextua indartzeko. Ignacio Palomo eta Eneko Garmendia ere oso lagungarriak izan dira, ekosistema zerbitzuak eta ekologia politika gaietan.

Estatistika eta bereziki R programazioa ikasi behar izana, lan zailena izan da. Zentzu honetan, izenen zerrenda luze bat daukat onarpen handia dudan jendearentzat: Arelly Ornelas, Vicente Nuñez, Juan Ignacio Modroño, Aitor Larrañaga, Ignacio Palomo, Víctor Urrea, Dae-Jin Lee, Iñigo Capellan, Josue Polanco, Javier Martínez, Elena Perez-Miñana, Alwyn Williams eta batez ere Marc Neumann. Oso astuna izan naiteke R-n blokeatuta nagoenean!

Esker handia azken etapan idazketan lagun didatenei: Mary Thomson, Bosco Lliso, Noelia Zafra, Iñigo Capellan, Mavi Román, Elena Galán, Martha Kerr eta bereziki Ane Zubizarreta. Ane, mila esker zure ingelesa zuzenketengatik. Maitasuna eta adiskidetasun handia erakutsi duzue. Rebeka Bredingi ere eskerrak ematea nahiko nuke. Oso azkarra izan da batez ere, amaieran, nire eskaerak denboran laburragotan bilakatu zirenean.

Oketa taldeari ere eskerrak eman nahi dizkiot, ibilaldi eta elkarrizketengatik. BC3 bazkide gehienak lagun onak bihurtu dira denboran zehar. Horietako asko jada aipatu ditut, baina, era berean sartu nahi ditut: Amaia de Ayala, Marta Pascual, Maialen Garmendia, Alina Tempes, Itxaso Ruiz, Pablo Martinez, Guillermo Pardo, Xaquin García, Kishore Davala, Nadine Sahouri eta abar. Haiek guztiak laguntza handi bat izan dira urte hauetan. Mila esker lana bukatu osteko garagardoengatik eta kafe atseden dibertigarriengatik.

Ezin dut ahaztu Mari Jose, egungo BC3ko zuzendaria. Asken etapa hau amaitzea lagundu dit. Kapitulu hauetan aholkatu dit eta zientifiko gisa nire etorkizuneko perspektibetan ere bai.

Batez ere, Julen Ugalderen laguntza eskertu nahi dut, BC3 barruan eta kanpoan. Ez duzu bakarrik tesiaren kapitulu batzuk irakurri eta idazkeran lagundu baina baita nire une txarrak eta etsipen batzuk jasan dituzu. Eskerrik asko nigan sinesteagatik eta azken txanpa hau askoz errazagoa egiteagatik.

BC3-tik kanpo, Jose Ramon Olarieta eta Christoz Zografos ere aipatu nahi ditut. Biek master tesiak gainbegiratu zituzten eta kuriositate grina piztu zuten. Hau erabakigarria izan zen doktoretza tesi hau hasterakoan. Beti lagungarriak izan dira tesi prozesuan, bereziki hasieran.

Ez dut Suediako lagunak ahaztu nahi. Nire superbisorak Katarina Hedlund-ek ongietorri bero bat eskaini zidan eta nire ongizateaz beti kezkatu zen. Eman zuen denbora asko eskertzen dut. Plazer bat izan zen beti denbora izatea niretzat. Asko ikasi nuen denbora hartan eta tesi prozesuaren lasaitasun momentu onena izan zen. Honekin tesi lana aurreratu eta estantziaz gozatu ahal izan nuen. Eskerrak to Alwyn Williams, Helene Bracht Jörgensen, Ronggang Cong (Leo) eta Mark Brady! Lagun latinoak ere egonaldi hura interesgarriagoa egin zuten: Soraya Maya, Alejo eta Jesús. Eskerrik asko bidaiengatik eta elkarrizketa luzeak eta interesgarriak izateagatik.

Bartzelonako Unibertsitate Autonoma WACHI lagunak ere sartu nahi ditut atal honetan: Diana Calvo, Sara Maestre eta Mar Grau. Beti Bartzelonara noa zuek ikusteko gogoekin. Vielhan egindako tailerra sinestezina izan zen eta espero dut instituzio eta ekologia politikoari buruz eztabaidak izaten jarraitzea. Zuek denok inspirazio handi bat zarete niretzat! esker berezi bat Dianarentzat, hasieratik gure elkarrizketengatik. Eskerrik asko zure erreferentziak banatzeagatik eta kontzeptu konplikatuak eztabaidatzegatik. Asko pozten naiz zu aurkitzeaz eta bide paralelo batean bidaiatzeaz. Laura Calvet ere laguntza handikoa izan zen balorazio sozio-kulturalaren disenuan eta Marta Borros mapak egiten. Ezin ditut ahaztu Natalia Jojart eta Felipe Díaz lagunak, beti ostatu bat eman didate ala administrazio paperekin lagundu didate.

Eskerrak eman nahi dizkiot Marc Vizcanori. Bidaia aurretik, bitartean eta ia amaieran han egon zara. Oso ondo dakizu ze zaila izan den momentu batzuetan eta beti laguntzen ahalegindu zara. Zirriborroak irakurri dituzu, zure kotxea utzi didazu lan egiteko eta nire kezka guztiak entzun dituzu aldi berean ni hobeto egotea saiatzen.

Julien Brunek eta Idoia Urrutiak esker handia merezi dute, erakutsitako profesionaltasunagatik Nafarroan emandako hiru hilabetetan egindako lan gogorraren geroztik. Une zailetan zuen pazientzia eta ulermena eskertzen ditut. Begoña Renteriari eta Imanol Okiñenari ere eskerrak eman nahi dizkiet emandako laguntzagatik Miranda de Arga tailerrean. Denbora kontrolatu, argazkiak atera eta eztabaida idatziz aparte, egun horretan behar nuen energia eman zidaten.

Lan honetan parte hartu dutenen izen asko ditut buruan, lana askoz atseginagoa egin dutenak: Patxi Sueskun, euren eskuzabaltasunagatik bere etxea eskaintzean, Leire Elorz, Juan Jesus Corcin, Charo Brinquis, Jokin del Valle, Celsa Peitado, Milagros y Mari, besteak beste. Zuetaz asko ikasi dut; ez bakarrik nekazal bizitzari buruz baina baita neure buruari buruz.

Aipamen berezi bat Amurrioko lagunentzat. Doktoretza urte hauetan (nire isiltasuna eta desagertze epeak gorabehera) emandako animoengatik. Nahiz eta batzuetan ulertzen ez nautelakoan sentitu, deskonektatzen lagundu didazue, mendi martxetan, txangoetan, jaietan eta pintxo-pote

dibertigarrietan. Zuetako batzuk hitzaldi batzuetara etorri zarete animoak emateko eta nire saio aspergarri eta luzeak ere entzun dituzue. Oso zoriontsu sentitzen naiz nire bizitzan zuek izateagatik: Begoña Renteria, Garazi Ibarretxe, Miriam Larrakoetxea, Leire Cuadra, Oihane Abrisketa, Aitziber Lazkano, María Larrea, Ana Isabel Romero eta nire lehengusina, Amaia Diego.

Behin betiko, hau ez litzateke posible izan nire familiaren laguntza barik. Gehien lagundu didazue naizen pertsona bihurtzen. Nire neba, Joseba Albizua beti eman dit beharrezko lasaitasuna bere konpainia eta ibilaldi luzeen bidez. Berak hezi nau eta erakutsi dit, ahalegin eta determinazioarekin ia dena posible dela, edo , gutxienez, prozesuan ikasten duzula. Mendi altuenak igo ditut toki urrunenak bisitatu ditut berarekin nire etorkizunari buruz ametsetan nenbilen bitartean. Mila esker guzti horretan parte-hartzeagatik eta nire ametsak lortzen laguntzeagatik. Nahiz eta askotan zure zorrotaz kexatu izan, badakit bakarrik lagundu nahi duzula. Nire aitak, Iñaki Albizua, beti ahal zuen guztian lagundu dit. Atseden hartzen edo aireportura edo autobus / tren geltokira eramaten bidaiatu behar nuen bakoitzean. Beti niri entzun eta nigan konfiantza izan du. Amaitzeko nire amak, Gloria Aguinaco, aholkuak eman eta momentu txarrenetan nirekin egon da. Ez du bakarrik bazkaririk hoberenak ematen baina sentiberaz ere elikatzen nau. Mila esker.

Agraïments

Aquesta feina ha estat possible gràcies a moltes persones que m'han donat suport de moltes maneres diferents. Quan vaig embarcar-me en el procés del doctorat vaig voler ‘equipar la meva ment' en molts aspectes diferents, no només avançant en les dinàmiques socioecològiques del coneixement, de les quals en sóc apassionada, sinò també esdevenint una persona més pacient, resolutiva i madura políticament. Per a mi sempre ha estat, i encara és, un procés d'aprenentatge on el viatge és més important per sí mateix que la destinació.

Primer de tot, m'agradaria donar les gràcies a Nerea Ortiz i Anil Markandya per finançar els meus 4 anys d’estudis de doctorat al Basque Centre for Climate Change Centre (BC3). Van confiar en mi al començament quan vaig arribar amb idees borroses sobre com cavar més profund en els ecosistemes del sòl connectant la seva gestió amb les estructures socials de governança.

Tot va agafar molta més forma amb temps quan Unai Pascual va decidir supervisar el meu doctorat dins del projecte europeu EcoFINDERs. Aquest projecte em va permetre aconseguir accés a una base de dades valuosa i finançar tres mesos d’estada Suècia i el treball de camp que vaig desenvolupar més tard a Navarra, Espanya. Sempre estaré en deute amb Unai per la seva confiança. Tot i que em va advertir de l’alt nivel que esperava de mi, mai m’ha pressionat en excès i ha guiat aquesta tesi tot proporcionant-me inspiració en moments de dificultat durant el procès de disseny, anàlisi i escriptura. Amb la seva atenció pel detall, la precisió i l’anàlisi crítica Unai m’ha proporcionat moltes idees inavaluables i comentaris durant aquests anys que han fet la conceptualització i la redacció d'aquesta dissertació molt més forta. També dec el meu agraïment al meu altre supervisor, Esteve Corbera, de l’Institut de Ciència i Tecnologia Ambientals (ICTA), a l'Universitat Autònoma de Barcelona. Esteve no és només un gran professional sinó que també reconec els seus esforços, que es van unir a Unai i m’han animat i motivat. Agraeixo tota l'ajuda en el disseny d’aquesta tesi, les discussions inspiradores darrere de la línia de l’Skype i la força transmesa per continuar buscant respostes a unes preguntes que no sempre eren evidents. El suport de tots dos, d’Unai i Esteve, ha tingut un gran valor al llarg de l’elaboració de la tesi. Han estat un molt bon exemple i un mirall on vaig voler veure’m reflectida. Ambdós han contribuït a aquesta dissertació i al meu desenvolupament intel·lectual i personal. Malgrat els moments dolents que vaig tenir quan no podria veure el final, m'han animat i m’han explicat que cada procés mereix el seu temps de maduració. Hauria agraït que el meu haguès estat una mica més ràpid…

Dono les gràcies al magnífic equip del BC3. Realment m’he sentit com a casa. M'agradaria començar pels els meus companys de taula: Elisa Sainz de Murieta, Marta Olazabal, Patricia Gallejones al començament, i Ane Zubizarreta més tard. Elisa, Marta i Patri principalment que han viscut aquest

període en la distància curta donant-me suport tant en els bons moments com també als moments dolents de nervis i desperació quan no podria concentrar-me o durant els moments de lluita estadística o d'escriptura. He après molt d'ells i he gauidit molt de la seva companyia. Em van ajudar amb Zotero i amb molts altres consells, tant a nivell personal i com professional, el qual ha estat sempre molt útil.

També vaig tenir un gran suport per l'elaboració de la dissertació d'en Marc Neumann, que ha actuat com el meu mentor professional, principalment en les últimes etapes del meu doctorat i va ser de gran ajuda en l'escriptura de scripts de R. Gràcies per la teva bona dispossició i el teu bon humor. Realment l'aprecio.

També m'agradaria donar les gràcies a Elena Ojea pel seu guidatge, especialment a principis de la tesi. Vaig gaudir molt els nostres àpats on podia parlar amb ella i trobar com re-començar per fer la feina millor. Agustin del Prado i Iñaki Arto també han estat bons consellers sempre que tenia dubtes. Iñaki, juntament amb Ignacio Cazcarro, em van ajudar ajudar en l'elaboració dels índexs de vulnerabilitat i Agus va donar un bon feedback per a la conceptualització agraria. Sempre m'he sentit molt còmode parlant amb vosaltres. Ignacio Palomo també ha estat de gran ajut sempre que li preguntava sobre serveis ecosistèmics i dubtes metodològics (enquesta, entrevistes i focus groups). També he buscat el consell d'Eneko Garmendia moltes vegades durant aquest procés.

Estadístiques i sobretot la programació en R han estat les tasques més difícils que he tingut d'aprendre. En aquest sentit, tinc una llarga llista de noms a qui devem considerable reconeixement: Arelly Ornelas, Vicente Nuñez, Juan Ignacio Modroño, Aitor Larrañaga, Ignacio Palomo, Víctor Urrea, Dae-Jin Lee, Iñigo Capellan, Josue Polanco, Javier Martínez, Elena Pérez-Miñana, Alwyn Williams i especialment Marc Neumann. Que pot ser molt cansat quan estic bloquejat per la R!

Li dec un gran gràcies a tots els que m'han ajudat amb l'escriptura d'aquesta tesi. Mary Thomson, Bosco Lliso, Noelia Zafra, Iñigo Capellan, Mavi Román, Elena Galán, Martha Kerr i especialment Ane Zubizarreta, gràcies Ane per la teva ajuda en les edicions de l'anglès mentre escrivia el manuscrit. Heu demostrat l'afecte i la companyonia gran. També m'agradaria agrair Rebeca Breding. He après molt durant el procés i ha estat molt ràpid principalment al final quan les meves demandes eren cada cop més curt temps.

També vull donar les gràcies al grup de Oketa per els debats i excursions. La majoria de companys en BC3 han esdevingut bons amics amb el temps. Molts d'ells esmentat, però jo també vull incloure Amaia de Ayala, Marta Pascual, Maialen Garmendia, Alina Tempes, Itxaso Ruiz, Pablo Martínez, Guillermo Pardo, Xaquin García, Kishore Davala, Nadine Sahouri i molts altres. Tots ells han estat de gran ajuda durant aquests anys. Gràcies per les cerveses després de treballar i diversió es trenca quan es tracta de cafè.

Meu agraïment no em puc oblidar de Mari Jose, la directora actual de BC3, que m'ha donat el seu suport per acabar aquesta etapa de la meva vida i també m'aconsellava en aquests capítols, així com ha donat suport en el meu futur com a científic.

Especialment vull agrair tot el suport de Julen Ugalde, dins i fora BC3. Has llegit diversos capítols de la tesi i m'has ajudat no només amb l'escriptura, sinó també has sofert alguns dels meus mals moments i decepcions. Gràcies per la teva confiança en mi i per ajudar-me a desconnectar i fer molt més suportable aquest final de la tesi.

Fora de BC3, vull també agrair José Ramón Olarieta i Christoz Zografos, per supervisar les dues tesis de master i encesa la flama de la curiositat i entusiasme que va ser crucial en l'inici de la tesi doctoral. Ells sempre han estat útils durant el procés de tesi, sobretot al començament.

No vull oblidar els meus companys durant la meva estada a Suècia: la meu supervisora, Katarina Hedlund, que em va donar la benvinguda i sempre es preocupava pel meu benestar personal i intel·lectual. Agraeixo molt profundament el temps invertit. Ha estat un plaer rebre la seva atenció cada vegada que va tocar la porta. Realment he après molt i estava més tranquila durant tot el procés, mentre era allà, ja que això em va permetre avançar i gaudir de la meva estada. Alwyn Williams, Helene Bracht Jörgensen, Ronggang Cong (Leo) i Mark Brady, gràcies! A més, als meus amics, els llatins d'allà que feia la meva visita molt més interessant: Soraya Maya, Alejo i Jesús. Gràcies per tots els viatges i converses de llargs i interessants que compartim.

També m'agradaria incloure en els agraïments als meus amics WACHI de la Universitat Autònoma de Barcelona: Diana Calvo, Sara Maestre i mar Grau. Sempre espero veure't quan viatjo a Barcelona. El nostre taller de Vielha va ser increïble, espero que sigui el començament de molts altres tallers per continuar els nostres debats sobre institucions i ecologia política. Tots vosaltres m'inspireu molt! Vull dedicar un especial agraïment a Diana Calvo, pels nostres debats des del principi i sobretot en les últimes etapes de la tesi. Gràcies per la teva col·laboració, per compartir referències i debatre els conceptes complicats. M'alegro d'haver-te conegut i descobrir que estem viatjant per camins paral·lels. Laura Calvet va ser també d'ajuda considerable en el disseny de l'avaluació sociocultural per a treball de camp. No puc oblidar a Natalia Jojart i Felipe Díaz, dos bons amics, que sempre estan disposats a acollir-me en les meves visites o ajudar amb temes administratius.

També vull expressar el meu agraïment al Marc Vizcano. Hi erets abans, durant i gairebé fins al final del viatge. Saps molt bé el difícil que ha estat de vegades i sempre has intentat ajudar-me com millor

sabies; has revisat esborranys, he utilitzat el seu cotxe per anar treballar i m’ha acompanyat a mi i ha escoltat totes les meves queixes, al mateix temps tractant de fer-me sentir millor.

Julien Brun i Idoia Urrutia mereixen un enorme gràcies per la seva professionalitat durant els tres mesos d'intens treball a Navarra. Agraeixo la vostra paciència i comprensió en moments difícils. També vull donar les gràcies Begoña Renteria i Imanol Okiñena per la seva ajuda durant el taller en Miranda de Arga. A més de transcriure la discussió, gestionar el temps i fer fotografies, em van donar l'energia que necessitava aquell dia.

Molts dels participants en aquest treball de camp que tinc en ment que han fet aquesta tasca molt més agradable: Patxi Sueskun, per la seva generositat increïble i deixar que em quedés a la teva casa, Leire Elorz, Juan Jesús Corcin, Charo Brinquis, Jokin del Valle, Celsa Peitado, Milagros i Mari, entre d'altres. He après molt de vosaltres; no només sobre la vida rural, sinó també sobre mi mateix.

Una menció especial per l'alè durant aquests anys de doctorat (tot i els meus períodes de silenci i desaparició) als meus amics de Amurrio. Encara que de vegades em sentia una mica incompresa en aquest tema, ells m’han ajudat a desconnectar del treball a través de passejades, excursions, les nits de festa i divertit pintxo-potes. Algunes de vosaltres m'heu animat assistint a alguns dels meus seminaris i escoltant els meus avorrits assajos prèviament. Em sento molt afortunada tenir-vos en la meva vida: Begoña Renteria, Garazi Ibarretxe, Miriam Larrakoetxea, Leire Cuadra, Oihane Abrisketa, Aitziber Lazkano, María Larrea, Ana Isabel Romero i la meu cosí, Amaia Diego.

Definitivament, això no hagués estat possible sense l'ajuda de la meva familia. Vosaltres heu contribuït els que més en fer de mi la persona que sóc. El meu germà, Joseba Albizua que sempre m'ha aportat la tranquillitat necessària, a través de la seva companyia i les llargues caminades. Ell m'ha educat i d'ell he après que amb esforç i determinació gairebé tot és possible, o almenys aconsegueixes enriquir-te en el procés. He pujat les muntanyes més altes i he visitat els llocs més llunyans mentre somiava en el meu futur. Gràcies per compartir tot això i per ajudar-me a dur a terme les meves ambicions. Encara que moltes vegades m'he queixat que ets molt estricte, sé que només vols ajudar-me a créixer i millorar. Al meu pare, Iñaki Albizua m'ha ajudat sempre amb tot el que era capaç. Posant l’espatlla per descansar o portant-me l'aeroport, tren o autobús cada vegada que havia de viatjar. Ell sempre m’ha escoltat i confiat en mi. Finalment, la meva mare, Gloria Aguinaco, que m’ha ajudat aen tot el que ha pogut. Ella ha escoltat pacientment, m'ha aconsellat i m'ha acompanyat en els pitjors moments del doctorat. No només em proporciona els millors menjars sinó que també em nodreix emocionalment. Gràcies.

Contents

Tables

Figures

Acronyms

AGBAR Aigües de Barcelona, an international water management company

ASES Agrarian Social-Ecological Systems

CAP Common Agricutlural Policy

CHE Confederación Hidrográfica del Ebro (English: Ebro River Basin Agency)

CICES Common International Classification of Ecosystem Services

CUMA Cooperativas de utilización de maquinaria agrícola (English: Cooperatives for the use of agricultural machinery)

EHNE Euskal Herriko Nekazarien Elkartasuna (English: farmers from the Basque Country Union)

ES Ecosystem Services

FEADER Fondo Europeo Agrícola de Desarrollo Rural (English: Rural Development Agrarian European Funds)

FEAGA Fondo Europeo de Garantía Agraria (English: Agrarian Insurance European Fund)

GHG Greenhouse Gases

HCA Hierarchical Cluster Analysis

INTIA Tecnologías e Infraestructuras Agroalimentarias. Public company attached to Navarre Government that projected *Itoiz-Canal de Navarra* canal

IPBES Intergovernmental Platform on Biodiversity and Ecosystem Services

IPCC Intergovernmental Panel on Climate Change

MA Millennium Ecosystem Assessment

MCA Multiple Correspondence Analysis

SAU Superficie Agraria Útil (English: Agrarian useful land)

SES Social-Ecological System

SLA Sustainable Livelihoods Approach

TEEB The Economics of Ecosystems and Biodiversity

UAGN Union de Agricultores y Ganaderos de Navarra (English: farmers and ranchers from Navarre Union)

UK-NEA UK National Ecosystem Assessment

CHAPTER 1

"We shape the world by the questions we ask"

John Wheeler

1. Introduction

Agrarian ecosystems are social-ecological systems. They play a crucial role in providing the conditions and processes to sustain terrestrial life and shape the outputs (goods and services) that directly or indirectly affect human wellbeing (Turner et al., 2007; Díaz et al., 2015; Berbés-Blázquez et al., 2016). Such ecosystems are a dominant land use. More than 1.5 billion hectares – approximately 12% of the world's land area – are used for crop production. Likewise, agriculture accounts for approximately 70% of the total freshwater withdrawn in the world, predominately through irrigation (FAO, 2015).

Agrarian ecosystems are simultaneously drivers of and responsive to cross-scale environmental changes, from climate to macro-economic related stressors (Turner et al., 2013). They supply food for humanity, provide energy and materials to urban regions, while simultaneously absorbing urban impacts (Kroll et al., 2012; Radford and James, 2013). Agrarian ecosystems are the largest source of biologically active nitrogen to the atmosphere, are active sources and sinks of carbon and are a major component of the hydrologic cycle (Pielke, 2005; Raudsepp-Hearne et al., 2010).

Such social-ecological systems, however, are under rising stress. Population growth, dietary changes and the increase of average incomes apply further pressures on the global food system, both on the demand and on the supply side, caused by greater competition for inputs (Godfray and Garnett, 2014). Additionally, climate change – an increase in temperatures and climate variability with more frequent extreme events - is presenting an unprecedented challenge for agriculture (Jackson et al., 2011; Barros et al., 2014; FAO, 2015).

To contest such stressors globally, scientific advances and government investments have industrialised agriculture to a large extent with two primary alternatives: 1) agricultural expansion - increasing arable land, and; 2) intensification –increasing the productivity of the existing agricultural footprint (Rivera-Ferre, 2008; Foley et al., 2011; Godfray and Garnett, 2014; FAO, 2015).

This dissertation focuses on intensification, which may be regarded as one of the main pillars of agriculture's 'modernisation paradigm'. This paradigm assumes that farmers aim to: specialise the crops they cultivate; increase the size of their cultivated land; develop more intensified management practices; and fit such practices with the 'logic of the market' (Van der Ploeg et al., 2000). In contrast, the 'rural development paradigm' emphasises new forms of farm-based rural development activities and includes different actors competing for resource access in new areas such as rural tourism and landscape conservation. Such new actors are considered crucial for the management and conservation of nature and landscape (Van der Ploeg et al., 2000).

It may be argued that agricultural intensification has enabled the increase of food production exponentially in order to feed the growing industrial and urban populations. However, it has also resulted in negative social effects, such as the displacement of small-scale or organic farmers. Additionally, agricultural intensification has had dire adverse effects on the environment (Montanarella, 2007; Tilman et al., 2011; Foley et al., 2011; Godfray and Garnett, 2014), including water pollution, soil erosion and loss of biodiversity, among others (Baldock et al., 2000; Power, 2010; Bacon et al., 2011).

As the 'rural development paradigm' suggests, agriculture is not only about producing food or generating economic income, but also about transferring ecological knowledge, supporting biodiversity, and regulating pests; as well as several additional related benefits and services for society (Calvet-Mir et al., 2012; Martín-López et al., 2012). In recent decades, multifunctional agriculture (Van der Ploeg et al., 2000; Marsden and Sonnino, 2008; Renting et al., 2009) and its relevance in conserving the diversity of ecosystem services (ES) is emerging in scientific and policy debates (MEA, 2005; Díaz et al., 2015; White, 2016). However, agricultural intensification continues to increase (Kull et al., 2015). Often sustainability approaches are adopted not to combat over-consumption, but rather to gain improved and more modern technology (Kull et al., 2015).

In this context, irrigation technology is a key element of the 'modernisation paradigm' and its 'sustainability'; a critical element for both increased production and local adaptation to climate-related stressors (Pielke, 2005; IPCC, 2014). However, limitations to the availability of water will affect this potential due to large uncertainties about the availability of water in many regions (Jackson et al., 2011; IPCC, 2014). Moreover, irrigation has been detected as one of the largest sources of human greenhouse gasses to the atmosphere (Aguilera et al., 2013; Turner et al., 2007). In addition, some authors warn about adverse aspects and potentially negative implications of adapting large-scale modern irrigation techniques, such as irrigation at the downstream watershed scale and the predicted increase in water consumption (Wilhelmi and Wilhite, 2002; Lopez-Gunn et al., 2012; Berbel and Mateos, 2014; Cabello et al., 2015).

Agrarian ecosystems therefore, have a remarkable role in the delivery of ES and for global environmental change mitigation and adaptation. However, little attention has been paid to the effects of different land management intensities, including the analysis of trade-offs and synergies across and between ES and land management (Kroeger and Casey, 2007; Swinton et al., 2007; Turner et al., 2007; Turner and Daily, 2008, 2008, p. 200; Daily et al., 2009; C. Raudsepp-Hearne et al., 2010).

This thesis investigates such land management intensification effects through the examination of the *Itoiz-Canal de Navarra* modern irrigation project, located in Navarre, Spain. The research analyses how the agrarian intensification process induced by the irrigation project influences farmers' perceptions regarding ecosystem service values and social vulnerability to multiple stressors. In doing so, it first assesses the context and the variability of types of farmers being affected by the modern irrigation transformation process. With this aim, a rural livelihoods approach is used to classify the different types of rural livelihoods in the area. This provides further understanding regarding which assets are typically combined and which are discarded to pursue different livelihood strategies (Allison and Ellis, 2001; Scoones, 2009). The land management interface between humans and agrarian ecosystems is used as a pivotal aspect of this research with particular attention to whether or not farmers adopt modern irrigation.

Secondly, grounded on the idea that diverse worldviews are relevant in valuation, this dissertation adheres to an ES framework and explores the effect of intensification on farmers' worldviews and values relative to agrarian ES (Calvet-Mir et al., 2012; Iniesta-Arandia et al., 2014; Klain et al., 2014; Bennett et al., 2015). Thirdly, it combines a sustainable livelihood approach with a human vulnerability framework to understand the influences of modern irrigation on farmers' adaptive capacity and their social vulnerability to climate-related stressors and shocks, as well as to the volatility of crops' price (Eakin, 2003; Adger, 2006; Birkmann, 2006; Eakin and Bojórquez-Tapia, 2008). Finally, the dissertation assesses how the new water-management institutions brought about by modern irrigation influence farmers' vulnerability, focusing on how such new institutions mediate access to water and influence the value systems that establish how natural resources should be managed (Vatn, 2007; Young, 2010).

1.1. Aims and rationale

The adoption of large-scale modern irrigation contributes centrally to land management intensification processes in Europe and beyond. This dissertation postulates that modern irrigation may confine this agrarian social-ecological system onto an unsustainable path. On the one hand, farmers will become more vulnerable to the multiple rural stressors (e.g. climate and market variability) and will be unable to maintain their livelihoods. On the other hand, the adoption of an intensive agricultural strategy will contribute to the degradation of the agrarian ecosystem's ecological base .

Focusing on the case of the *Itoiz-Canal de Navarra* modern irrigation project, the objective of this thesis is fourfold:

1) To explore the contextual factors and the access to different assets that shape farmers' livelihood strategies;

2) To interrogate if modern irrigation influences farmers' perceptions and valuation of agrarian ES;

3) To identify the stressors that affect farmers in Navarre and the livelihoods that result more vulnerable to such stressors, and;

4) To examine how and why modern irrigation and its concerned institutions influence farmers' vulnerability.

In addressing these four objectives, the dissertation seeks to contribute to the debate concerning the nexus between land management intensification, ES, social vulnerability, rural development and resource governance.

1.2. Research questions

The thesis is organised around four main research questions that derive from the four objectives highlighted above.

1) What combinations of capital assets are associated with particular livelihood strategies in Navarre?

This question is addressed in the first empirical chapter, Chapter 4, where the sustainable livelihoods approach is applied to understand i) how natural, financial, man-made, human and social assets are combined and used strategically by different types of farmers; and ii) if modern irrigation technology adoption leads to asymmetrical outcomes among existing livelihoods. Classifying farmers attending to their land management practices reveals the co-existence of very distinct livelihoods in the *Itoiz-Canal de Navarra* case. Moreover, Chapter 4 identifies the critical features and the key assets that distinguish the livelihoods of the case study area. The chapter also demonstrates some of the early outcomes such as land purchases and water tenure changes, that accompany modern irrigation introduction and which will be further analysed in Chapter 7.

2) Does the current process of agrarian intensification in Navarre influence farmers' perceptions and valuation of multiple agrarian ES?

This question is addressed in Chapter 5 and investigates famers' perceptions and valuation of agrarian ES. Classifying farmers according to their land management practices (Chapter 0) permits differentiating whether those who implement intensive practices value higher provisioning services at the expense of other types of services. The study of famers' values regarding agrarian ES sheds light on farmers' preferences regarding ES, disclosing preferential trade-offs, a key area of future research (Klain et al., 2014; Kull et al., 2015). Furthermore, this chapter endorses an insufficiently explored socio-cultural approach (Calvet-Mir et al., 2012; K. Chan et al., 2012) regarding ES assessments (Díaz et al., 2015a; Martin-Lopez et al., 2007; Orenstein and Groner, 2014; Ciara Raudsepp-Hearne et al., 2010). Additionally, it contributes to convey key information regarding the influence of agrarian ES to human wellbeing. There are limited number of studies that indicate merely a causal connection between ES and wellbeing which is a significant caveat in the literature (Suich, 2008; Mulder et al., 2015). Recent research also suggests that understanding such connections can be useful to identify the services most relevant to people (Martín-López et al., 2012) and can help to anticipate possible impacts resulting from land management decisions. This chapter also reveals information about the level of awareness of farmers regarding the co-production of ES (De Haan and Zoomers, 2005; Seppelt et al., 2011).

3) Which livelihoods are more vulnerable to (1) climate variability and (2) crop price volatility and why may this be the case?

Chapter 6 examines farmers' vulnerability to climate variability (including drought shock) and crops' price volatility and further investigates the role played by modern irrigation in reducing or increasing such vulnerability (Wilhelmi and Wilhite, 2002; Edwards et al., 2010). It analyses farmers' perceptions regarding the stressors they face and it highlights which types of farmers are more exposed to different stressors, as well as which assets contribute to farm households' sensitivity and adaptive capacity. The chapter uses sustainable livelihood approach (SLA), also used in Chapter 0, to calculate a vulnerability index that fits with the Intergovernmental Panel on Climate Change (IPCC) definition of vulnerability. This approach allows to better understand the impacts of external and internal shocks and stressors on social vulnerability and discusses whether the introduction of modern irrigation adheres with the priorities of stakeholders' livelihood strategies (Ashley, 2000). This chapter sheds light on the reasons that determine farmers' vulnerability as well as on those that influence their adaptive capacity, including their level of exposure and sensitivity to climate and market-based stressors.

4) How has the development of modern irrigation transformed traditional irrigation systems and how has such transformation, in turn, influenced farmers' vulnerability?

Chapter 7 explores the substitution process of traditional irrigation by modern irrigation by examining how such transformation may influence farmers' vulnerability. For this, I use two different conceptual lenses. First, I study the change of ordinances within irrigation communities from a robustness perspective (Ostrom, 1990; Anderies et al., 2003). I analyse whether such institutions (irrigation norms) become weaker with the adoption of modern irrigation. In doing so, the chapter analyses to what extent farmers' vulnerability will be exacerbated, since they may find an absence of mechanisms (e.g. rights to organise or means to solve conflicts) to manage various stressors and shocks (Vatn, 2005; Adger, 2006; Paavola, 2007). Second, I adopt a legitimacy and equity-based analytical approach to understand how the adoption of modern irrigation influences farmers' vulnerability. Uneven power relations and injustice are seen as fundamental drivers of vulnerability and insecurity (Kloos et al., 2013). The chapter sheds light on the effects of modern irrigation on communal land and water access relations, and they contribute to improve our understanding of how local stakeholders participate and benefit from common water resources.

1.3. Outline of the thesis

This dissertation is divided into eight chapters, including this Introduction.

Chapter 2 presents an inter-disciplinary theoretical framework, which establishes the conceptual basis for the subsequent empirical chapters. It includes explanations about social-ecological systems, rural livelihood theories, agrarian ES and their valuation, the notion of vulnerability and institutional analysis. It considers the interaction between land management activities, farmers' values about ES, their livelihood strategies and their vulnerability. It also addresses the issue of what is meant by access and institutional robustness and advocates for a plural approximation to the assessment of modern irrigation that goes beyond the analysis of income gains as the sole proxy to measure modern irrigation success and pays attention also to livelihoods diversity, fairness and equity in access to water, and institutional dynamics at local and larger administrative scales.

Chapter 3 presents the research strategy and the methods employed to operationalise the theoretical framework. Methods include both quantitative and qualitative research techniques. It presents a case study approach to analyse the social-ecological implications of modern irrigation adoption: the irrigation project takes place in the *Itoiz-Canal de Navarra* area in the *Zona Media* and *Ribera Alta* regions, both in Navarre, Spain. The institutional context in which modern irrigation is embedded is also presented in this chapter because it is critical to understand farmers' uneven access to natural resources and other types of assets.

Chapter 4 illustrates the socio-demographic features, assets and key institutions within the study area. It reveals how human, social, man-made, natural and financial assets are connected, and it classifies these features according to farmers' livelihoods strategies. This chapter illustrates the existing diversity of farmers co-existing in this region (Lynam, 2006) and it describes the outcomes which result from farmers' livelihood strategies, as well as which livelihoods benefit most from modern irrigation adoption.

Chapter 5 connects agrarian ES valuation to the previously found livelihood profiles, grounded on the hypothesis that their land management choices and held values are interconnected (Vatn, 2007). This chapter reveals legitimate differences between farmers' preferences (Costanza et al., 2007; Gómez-Baggethun and de Groot, 2010; Pascual et al., 2014) and it does not only disclose which agrarian services are valued and why they are important as a contribution to human wellbeing, but it also shows which services are perceived as being coproduced through farmers' effort.

Chapter 6 describes external stressors connected to climate and the global markets that affect rural Navarre. It analyses if the adoption of modern irrigation increases or decreases farmers' vulnerability to such stressors. The analysis is based on the development of a vulnerability index drawing on the sustainable livelihood approach presented in Chapter 4. This chapter reveals if there are double vulnerable farmer groups and also explores the reasons of their vulnerability; whether it is due to high exposure, sensitivity, adaptive capacity features or a combination of these dimensions. This chapter also includes a reflection on the strengths and weaknesses of using vulnerability indexes.

Chapter 7 offers a historical approach to understand formal and informal irrigation institutions. It assesses the robustness of traditional irrigation norms as they evolve to meet a modern irrigation framework. The chapter analyses which types of farmers are favoured with such ongoing institutional change and uses the lens of legitimacy and equity to understand further how modern irrigation influences farmers' vulnerability.

Lastly, **Chapter 8** concludes with a synthesis of research findings and discusses their implications for agrarian ES in the context of rural livelihoods sustainability. The chapter also outlines a series of questions for further research.

CHAPTER 2

"A Nation that destroys its soil destroys itself."

Roosevelt in a letter to all State Governors, 1937

2. A conceptual approach for the study of agrarian social-ecological systems

This chapter presents the dissertation's theoretical framework. It encompasses a number of concepts and approaches that are helpful for characterising *agrarian social-ecological systems* (ASES). ASES are dynamic: they can change when new markets emerge and new crops or varieties become profitable, their ecological conditions evolve as a result of climate change, or their management practices adapt to new technologies. These are just a few factors that contribute to such dynamism. This dissertation focuses on an ASES that is being transformed to become a more intensively managed system as a result of modern irrigation. Transformation here is referred to a shift of the ASES's components to a different state – i.e. change of farmers' livelihoods, farmers' values and perceptions of agrarian services alteration and agrarian institutions governing resource management.

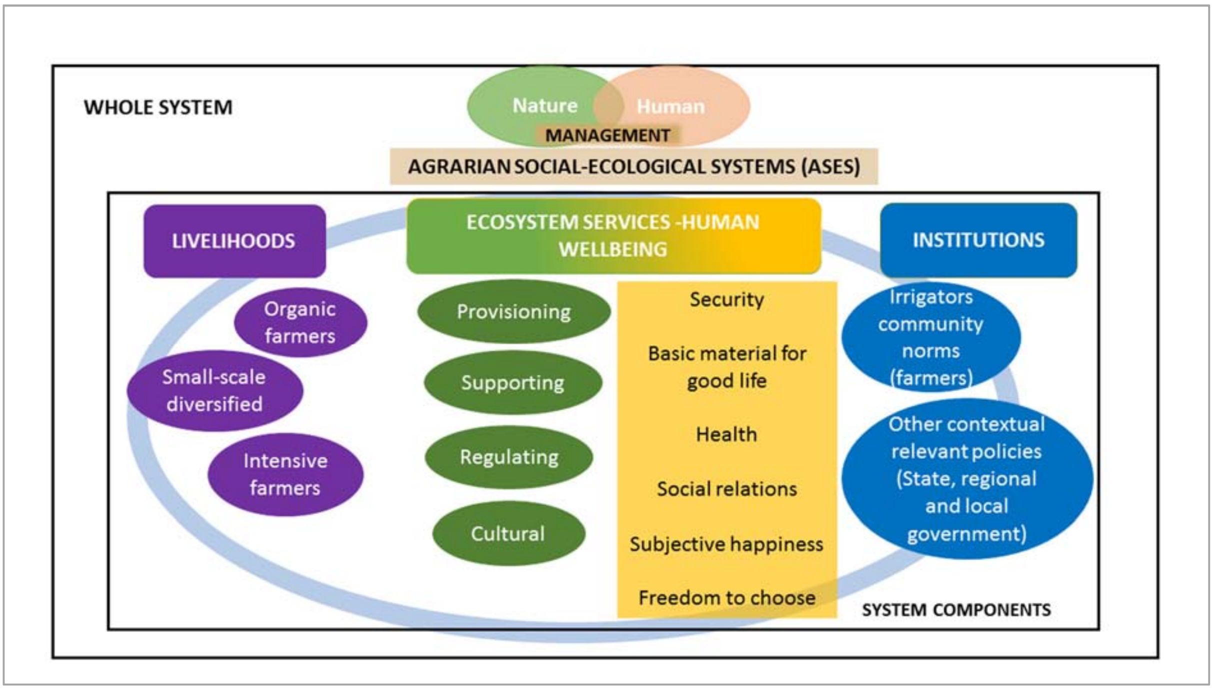

Figure 2.1 represents an example of the analysed ASES components and their sub-components. On the left hand side, it aims to illustrate that in a given context there are different kinds of farmers classified by their livelihood strategies. These farmers may also change their perceptions and values about agrarian ES. In this regard, the centre of the figure illustrates human wellbeing as being closely dependent on ecosystems (McMichael et al., 2005). There are several agrarian ecosystems services

categories and dimensions of wellbeing depicted. Wellbeing is understood in this dissertation as a desirable state in which the household reaches economic or material objectives, as well as the connections and affirmation of its members' personal significance and group identity (Tang et al., 2013) (further developed in Section 2.3). Disaggregation of these categories and dimensions helps understanding the complexity of a change within one of these components, since shifts in farmers' values in certain services can affect one or several wellbeing dimensions simultaneously. The right hand side of the figure shows the organisations and the norms that govern natural resources and are relevant for this dissertation. Such institutions influence, as well as are influenced by, farmers' values and perceptions, which in turn affect their preferences over livelihood strategies.

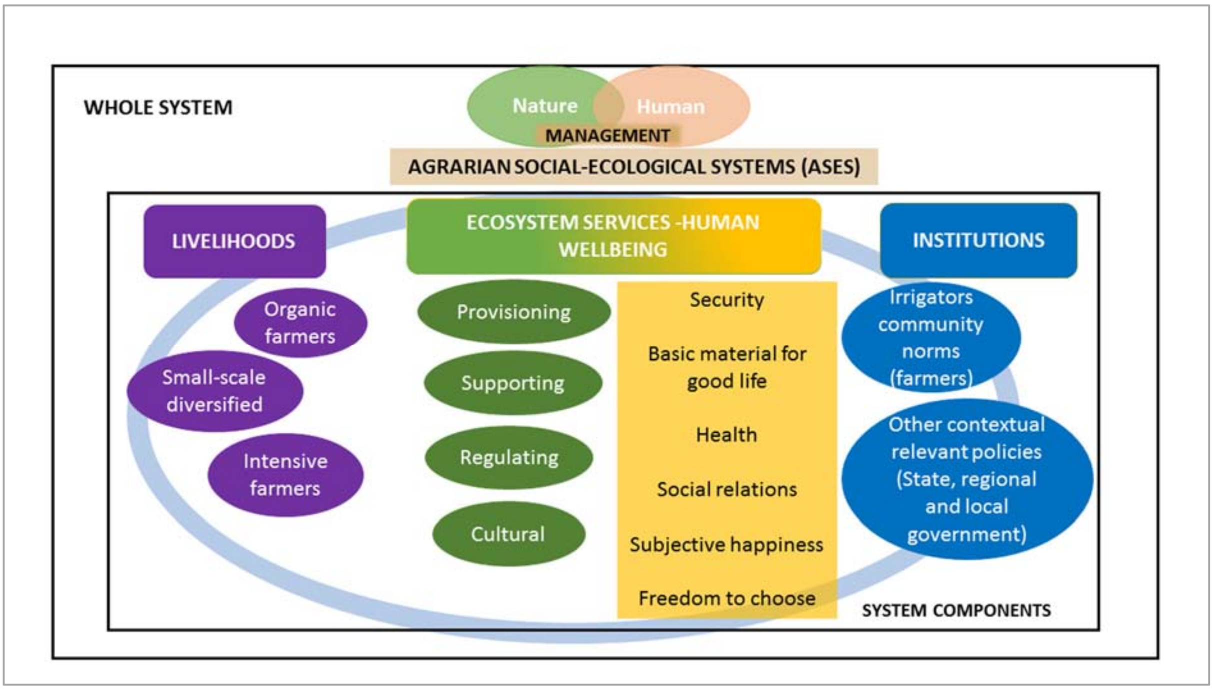

Figure 2.1 ASES components and sub-components

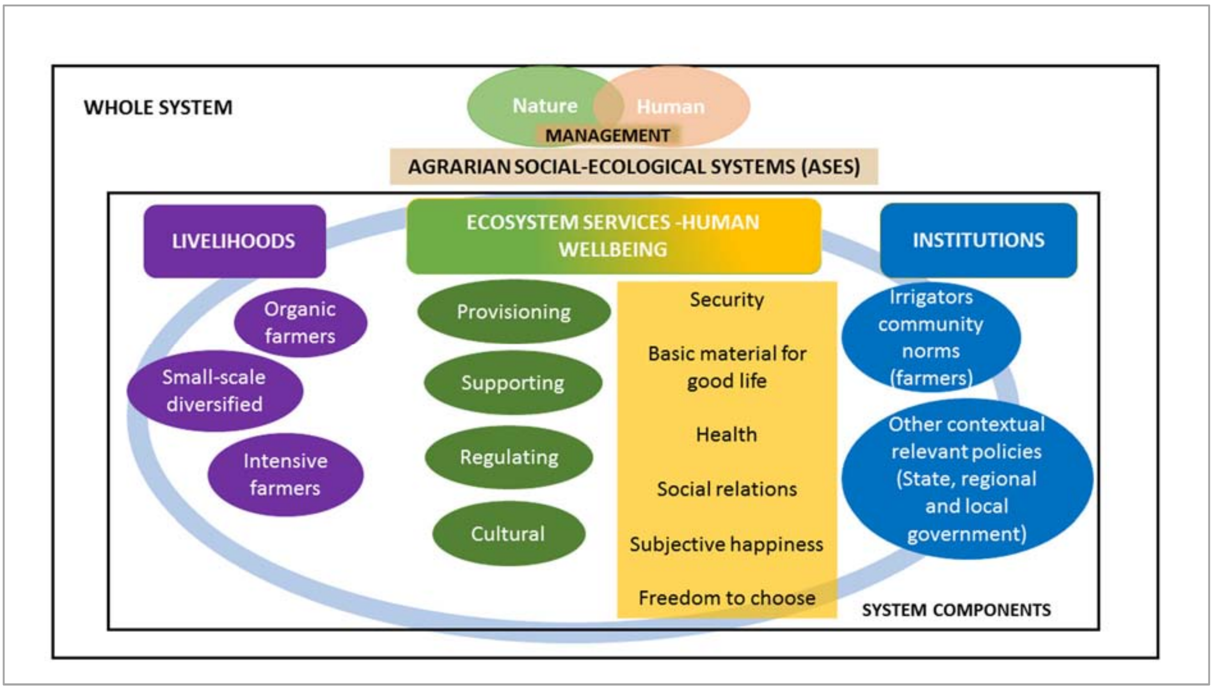

Figure **2.1** and **Figure 2.2** (below) refer to the concept of agrarian social-ecological system (ASES), and they contribute to highlight the interdependencies of social and ecological systems. In the current dissertation, it is assumed that such interdependencies are mediated by the interface of land management, which is in turn affected by institutions and livelihood strategies (links **A** and **B** of **Figure 2.2**).

The left side of **Figure 2.2** describes the sustainable livelihoods framework. This framework is useful to discuss the variety of livelihoods assets – i.e. available resources - that result in distinctive development strategies, including numerous ways to access and use natural resources, ecosystems and their services (Chambers and Conway, 1992; Scoones, 1998; Carney, 1999; Allison and Ellis, 2001). Additionally, this framework can be used to characterise farmers according to their land management strategies. Link **A** refers to the effect that land management practices have over natural resources' properties and that farmers co-produce agrarian ES. Agrarian ecosystems, in turn, determine the possibilities farmers can develop, supported by technological, financial human and social assets.

The central part of the figure (middle-upper section of **Figure 2.2**) concerns ES for human wellbeing and is further discussed in section 2.3. Grounded on the Millennium Ecosystem Assessment (MA, 2005), and the more recent Intergovermental Platform on Biodiversity and Ecosystem Services (IPBES, 2015; Díaz et al., 2015a), the diversity of ES types and the several dimensions of human wellbeing are explored and their interrelations analysed. Farmers' values influence their choices over livelihood strategies and the latter impact on ecosystems and their services (illustrated by link **A**).

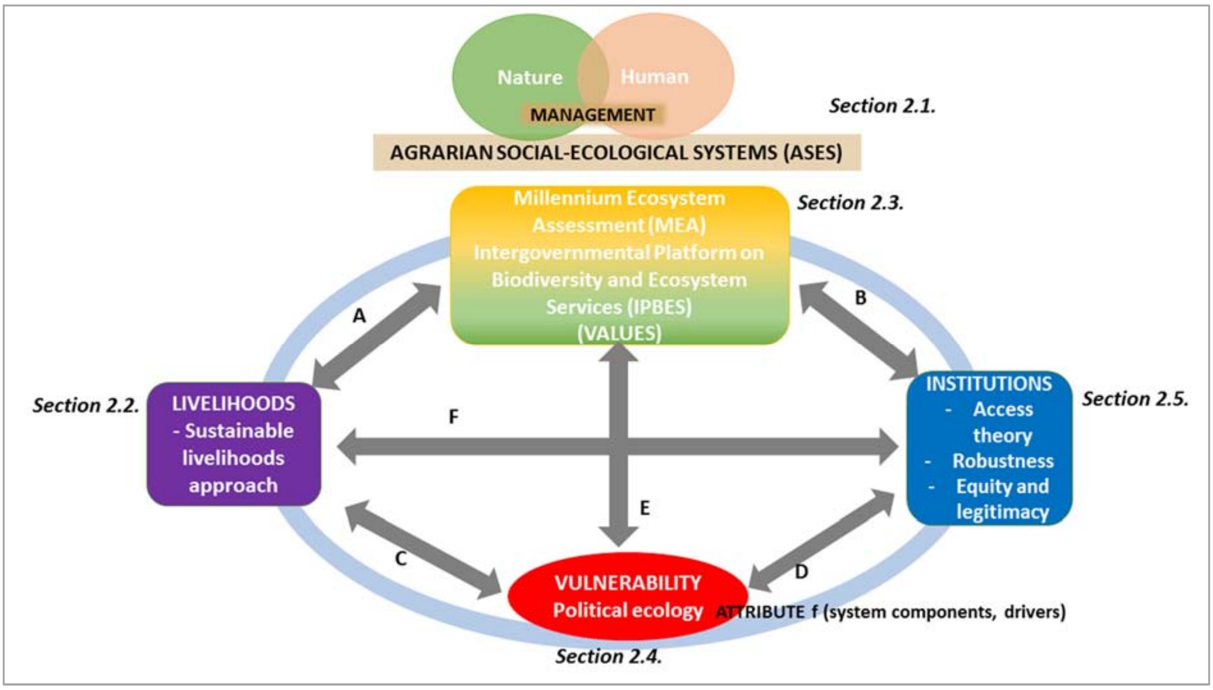

Figure 2.2 Connectivity across the main conceptual lenses of the dissertation

Note: Rectangular shapes represent key concepts that are a part of ASES (livelihoods, ES for human wellbeing and institutions) whereas the circular shape illustrates a key concept that is an attribute of the ASES which depends on internal components and external disturbances such as climate change and economic globalisation. The number of the section where each concept appears throughout this chapter is also indicated on the side of each shape. All the concepts are interconnected through bi-directional arrows and letters represent connections and explanations:
A refers to the co-production of agrarian ES by farmers (by combining their assets) and ecosystems
B relates social values and awareness about ES influence over existing institutions and *vice versa*
C connects the importance of accessing livelihoods' assets' to avoid vulnerability and how vulnerable farmers are at risk of not keeping their livelihoods
D links institutions to farmers' vulnerability. Institutions set the conditions for accessing natural resources. There are differences on how stakeholders participate to define such institutions
E connects vulnerability to ES and human wellbeing reflects that if farmers are vulnerable, their wellbeing decreases. The dimensions of human wellbeing increment normally encompass higher demands of ES, which may affect (increase) the vulnerability of ASES in the long-term may increase
F connects the fact that institutions and social relations regulate access to different kind of assets. Access to certain assets can enable individuals to influence the institutions that govern them

The fourth section of the chapter reviews the literature on social vulnerability (bottom middle of **Figure 2.2**). This dissertation combines both quantitative methods (index, based on data collected through a survey) (McLaughlin and Dietz, 2008; Hinkel, 2011; Tang et al., 2013) and qualitative methods (interviews) to understand the vulnerability of the studied population to different stressors over a given time. If farmers or the ecosystems are vulnerable, their livelihoods cannot be environmentally and socially sustainable (Link **C**). Moreover, when certain parts of a group are differently affected by changes, such as the adoption of a new technology like modern irrigation, impacts or benefits may not be fairly distributed and conflicts may arise. This may lead to an increase of vulnerability and a reduction in human wellbeing for those farmers whose values are not considered by existing policies (Vatn, 2005) (links **B, D** and **E**).

The last section of the chapter reviews institutional analysis literature to discuss the role that norms, rules, and policies play in mediating access to farming assets (link **F in Figure 2.2**) and thus, on the capacity to co-produce services and benefits (link **A**) and to influence social vulnerability (link **D**) of ASES. This dissertation adopts a *historical institutionalism* perspective, which defines institutions as formal and informal procedures, routines, norms and conventions (Hall and Taylor, 1996). Furthermore, the thesis uses the concept of 'institutional robustness' as a suitable means to evaluate success in natural resource governance (Anderies et al., 2004a). Additionally, legitimacy and equity act as complementary analytical criteria to analyse which farmers are (un)able to shape and benefit from the new irrigation institution (link **C**) (Adger, 2006; Barros et al., 2014; Berbés-Blázquez et al., 2016).

Table 2.1 Summary of the links between the main concepts of the dissertation

Link	Connected concepts	Description of the links	Key references from the literature
A	Sustainable livelihoods and ES for human wellbeing	Farmers need natural resources for making their living whereas they simultaneously co-produce ES and disservices	(Seppelt et al., 2011; Lele et al., 2013; Díaz et al., 2015a; Mulder et al., 2015; Palomo et al., 2016)
B	ES for human wellbeing and institutions	Social values shape the rules, norms and convections and those simultaneously influence perspectives about agrarian management and the importance of ES	(Chan et al., 2012; Duraiappah et al., 2014; Spangenberg et al., 2014; Farhad et al., 2015; Felipe-Lucia and Comín, 2015)
C	Sustainable livelihoods and social vulnerability	The combination of different assets' determines people's vulnerability to external stressors. Farmers' vulnerability, in turn, determines their livelihoods sustainability and fairness	(Scoones, 1998; Palomo et al., 2016)
D	Institutions and social vulnerability	Institutions shape farmers vulnerability through enhancing or avoiding farmers' access to different kind of resources. Vulnerability information may also be useful to guide policies towards higher equitable and effective outcomes	(Adger, 2006; Anderies et al., 2004a; Barros et al., 2014; Berbés-Blázquez et al., 2016; Corbera et al., 2007a; Paavola, 2007; Ribot and Peluso, 2003; Vatn, 2005)
E	Vulnerability and ES for human wellbeing	When farmers are vulnerable, human wellbeing decreases since some dimensions (e.g. security, social relations) may be negatively affected. When some farmers increase their human wellbeing demands over ES increase and consequently, vulnerability may increase	(Vatn, 2005; De Haan and Zoomers, 2005; Adger, 2006; Eakin et al., 2009)
F	Institutions and sustainable livelihoods	Institutions and social relations regulate the access to different kind of assets. Assets enable people to influence the institutions that govern them	(Bebbington, 1999; Ribot and Peluso, 2003; Ribot, 2014; Palomo et al., 2016)

2.1. Conceptualising agrarian social-ecological systems

Human and natural systems have traditionally been studied as isolated, separate systems. An ASES, however, is a complex system that requires holistic analytical approaches. Individuals invest time and effort in developing forms of physical and institutional infrastructure which affect natural system functions over time (Janssen and Ostrom, 2006). Grounded on Ostrom's (2009a) understanding of agrarian SES, this dissertation acknowledges that an ASES is made up of other sub-components, including a resource system (e.g. an agrarian ecosystem), resource units (e.g. crops, organic matter, nutrients), users (e.g. farmers, society), and governance systems (e.g. organisations and rules that guide farming in a given context), which are connected to each other. Those subsystems are relatively divisible but interact to produce outcomes at ASES level, influencing these subsystems and their components, as well as other ASES (Janssen and Ostrom, 2006).

Farmers' main activity –i.e. land cultivation - is performed through land management practices, understood here as the human activities that affect ecosystems' properties and functions (Van Oudenhoven et al., 2012). Management becomes then the nexus between human and ecological systems. Positive and negative effects of management are shaped by the degree of land management intensity (McMichael et al., 2005). Here, intensification is understood as the management utilisation to increase yield per surface and time. Intensification typically incorporates intensive tillage regimes, increased application of fertilisers, irrigation when necessary (Baldock et al., 2000), and reductions in crop diversity both in time and space, at plot or landscape levels (Matson et al., 1997).

2.2. The sustainable livelihoods approach from a social-ecological perspective

The SLA proposes that ES do not occur in a vacuum, and there are other necessary human, social, physical and financial assets to make a livelihood possible. These assets are determined by: (i) social relations, which are simultaneously determined by factors such as gender and age; (ii) institutions – e.g. rules and customs, land tenure and markets– that regulate resources access operation (link **F** in **Figure 2.2**); and (iii), organisations, including associations, and local and national public administration (Allison and Ellis, 2001).

Often, farmers' practices and identities are diverse and not all rural people have a full-time dedication to agriculture, but usually perform a range of agricultural and non-agricultural activities to sustain their livelihoods (Carney, 1999; Gorman et al., 2001; Van der Ploeg et al., 2000). The SLA framework looks at individuals or groups of social actors and their relationships, concerning their livelihood strategies. Such strategies typically encompass different land management regimes (e.g. cropping systems, fertilising and pest control patterns, and crop varieties), non-natural resource management activities (e.g. how much time will be invested in alternative income sources or other livelihood activities, including leisure) and the distribution of control over resources (De Haan and Zoomers, 2005) (links **A** and **F** in **Figure 2.2**). The combination of these strategies affect farmers' livelihood outcomes (e.g. income level, income stability) and environmental sustainability (e.g. soils and water quality and biodiversity) (Scoones, 1998; Allison and Ellis, 2001; Hahn et al., 2009).

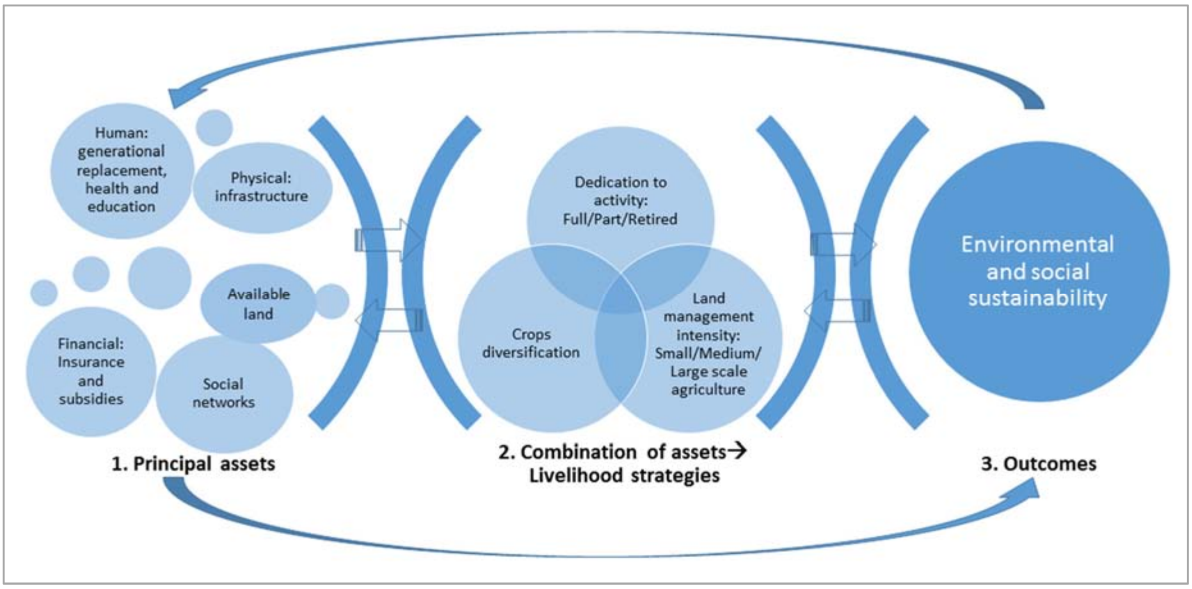

Figure 2.3 The sustainable livelihoods approach applied to the analysis of ASES

Human capital is the knowledge, talents, skills, abilities, experience, intelligence, training, judgment, wisdom and health possessed individually and collectively within a population. This concept encompasses one's capacity to work (physical and mental ability) to labour power itself (Becker, 1962; Bruce and Yearley, 2006). Thus, measuring human capital in the survey involves identifying variables such as formal education and health (Hahn et al., 2009; Ifejika Speranza et al., 2014).

Financial capital is understood as any economic resource, monetarily measured and utilised by households to buy necessities to support their livelihood. This asset distinguishes between 'agricultural' or 'farm' income (derived from the production/gathering of unprocessed crops or livestock from natural resources) and 'non-agricultural' or 'nonfarm' income (all other sources of income) (Barrett et al., 2001). The household's financial situation is determined by the income and its savings and investments on for example machinery, insurances and workforce (Bruce and Yearley, 2006). Physical (man-made) capital includes infrastructure such as roads and irrigation systems, but also other assets such as machinery. It is a fixed reproducible product of human activity (Turner, 2006; Ostrom, 2007).In this dissertation physical capital refers to the installation of modern irrigation and the use of Internet for agrarian purposes.

Social capital is the result of relationships between individuals, families, groups, or communities that provide access to valuable benefits and/or resources (Turner, 2006). Bourdieu (cited in Turner, 2006, p. 558) views social capital as a resource that individuals possess and can be used strategically to gain access to other, especially economic, resources. He also argued that social capital is one form of capital closely tied to other forms he called 'symbolic' and 'cultural' capital. These forms of capital are important as they disguise the processes by which power relations and material inequalities are reproduced. A key aspect of Bourdieu's conceptions of social and cultural capital is their *instrumentality*. Coleman's functional theory of social capital (also cited in Turner, 2006, p. 558), on the other hand, focuses on groups and the collective nature of social capital (Ishihara and Pascual, 2009). He highlights the benefits accrued by dense networks characterised by trust and mutual obligation. Coleman's model views social capital in terms of social structure cited in Turner, 2006, p. 558). This capital domain is associated with the preservation of a range of cultural practices and routines, such as card games, rural festivals, religious traditions as well as commitment to the family as part of stakeholders' identity. Social capital in this dissertation includes belongingness to cooperatives and syndicates as well as information share among neighbors.

Natural capital encompasses physical assets such as land, water, biota and other resources an individual may mobilize or access to make a living (Costanza et al., 1997; Fisher et al., 2009). In this dissertation, it is constrained to the availability of agrarian land among surveyed farmers (Ifejika Speranza et al., 2014).

Different combinations of capital assets determine people's capability to define the type of livelihood strategy they aim to adopt. There are different attributes to consider when combining assets. Firstly, there are usual packages of assets. Being associated with a particular livelihood and securing a certain capital can often allow access to other assets (Scoones, 1998). Such assets are triggers for reaching a particular livelihood strategy (Scoones, 1998) and are typically irreplaceable. For example, as it is the case in the case study in this dissertation, to access certain agrarian subsidies (financial asset) farmers must attend a training course, for which they need certain level of education (human asset).

Secondly, time and resources enable people to make demands and influence the institutions that govern them (Ribot, 2014). This allows restructuring an agent's power structure, as these surplus assets allow for individuals to challenge the rules that govern the control, use and transformation of resources (Bebbington, 1999; Ribot, 2014) (Link **F** of **Figure 2.2**). In this regard, 'capabilities' are outcomes to which individuals have access given their personal characteristics and assets, along with the resources and rights that enable them to act (Scoones, 1998).

There are multiple ways of classifying livelihood strategies (Chambers and Conway, 1992; Rakodi, 1999; Barrett et al., 2001; De Haan and Zoomers, 2005). This dissertation adopts the classification of De Haan and Zoomers (2005), which is grounded on Zoomers (1999). These authors distinguish four categories of strategies: *accumulation*, *consolidation*, *compensatory* and *security* (see section 4.4). Recognising which trade-offs occur when deciding upon a livelihood strategy is another key concern of the SLA framework (Scoones, 1998). An individual or a household may decide to disinvestment in certain capital assets in order to sustain their livelihood. This may be natural capital (e.g. selling arable land), social capital (e.g. weakening social bonds by diminishing participation in social organisations or networks), and human capital (e.g. sending children to work in order to mobilise labour or to avoid paying school fees). Other strategies may also encompass the sale of other assets to compensate for a consumption shortfall or to release funds for investment (Rakodi, 1999).

Finally, ASES sustainability is presented in **Figure 2.3** as the desirable outcome of rural livelihoods. A livelihood is sustainable when it can manage and overcome stressors and shocks, maintain or enhance its capabilities and assets (Link **C** in **Figure 2.2**), while not weakening the natural resource base (link **A** in **Figure 2.2**) (Scoones, 1998). It is debatable the 'level of sustainability' to which different groups of people may aspire towards (Bebbington, 1999), particularly because diverse people may value different dimensions of human wellbeing in a different way (see section 2.3) (Bebbington, 1999) (link **A** in **Figure 2.2**). Some may prioritise income gains, while others may prefer to maintain certain social or cultural practices, even if such maintenance is secured at the expense of economic improvement. The SLA implicitly portrays farmers as active actors with capacity to deal with the diverse stressors they might face (De Haan and Zoomers, 2005) (link **C** in **Figure 2.2**).

In this dissertation, the SLA framework helps to reveal how development interventions, such as the introduction of large infrastructure (i.e. irrigation), fit with current livelihood strategies, which can then contribute to redefine such interventions (Ashley, 2000). Finally, it contributes to acknowledge the importance of multiple actors' varied aims and interests. It makes explicit social differences that can subsequently allow for the development of more effective, legitimate and fair agrarian policies (O'Brien and Wolf, 2010; Albizua and Zografos, 2014).

2.3. Ecosystem services for human wellbeing

In this dissertation, the framework of ES is adopted to analyse the dynamics of farmers within ASES, from a different perspective from the one adopted by the SLA. The concept of ES generally refers to the benefits that ecosystems provide to people (MA, 2005; Díaz et al., 2015). It is grounded on the notion of ecosystems' multi-functionality, i.e. their capacity to deliver multiple benefits simultaneously, from the same source (McMichael et al., 2005). In the context of ASES, ecosystems support crop production and other benefits and services as it has long been recognised in the literature (McIntyre et al., 2008; Martín-López et al., 2012; Díaz et al., 2015a).

However, it is not just ecosystems that are important to produce services, ignoring humans' contribution in this regard would be misleading (Palomo et al., 2016). Farmers' use of anthropogenic assets to deliver ES is termed as 'co-production' (Anderies et al., 2003; Seppelt et al., 2011; Palomo et al., 2016). This research focuses on the influence of farmers' labour, the connection to utilised assets, and the delivery of agrarian ES. When co-production of services' effects are negative, such as soil erosion, salinity and water quality loss, services become 'disservices' (Power, 2010; Bacon et al., 2011). This thesis supports the idea that the magnitude of disservices is shaped by the grade of land management intensity (Kremen et al., 2002; Klein et al., 2007; Zhang et al., 2007) (Link **A** in **Figure 2.2**).

How ES are defined and classified influences the appropriate analytical approach. Most research has focused on the ecological or the economic analysis of ES. However, it is critical to consider an interdisciplinary assessment of ES which embraces the multiple types of existing services in order to obtain an image which encompasses existing ES (Orenstein and Groner, 2014). This is why a common classificatory framework is needed to facilitate multidisciplinary efforts towards a better understanding of complex ASES (Ostrom, 2009a).

The Millennium Ecosystem Assessment (MA, 2005) developed a classification of ES through different categories of services, represented by proxies, to understand the multiple types of services ecosystems provide. Although other approaches exist to classify ES (e.g., Fisher et al., 2009; Bryan et al., 2010; De Groot et al., 2010; Dominati et al., 2010; EEA, 2013), this research follows The Economics of Ecosystems and Biodiversity (TEEB) proposal (Sukhdev and Kumar, 2008), which combined with the Common International Classification of Ecosystem Services (CICES) (EEA, 2013)[1] classification, results in an updated version of the MA (2005) classification.

MA developed a classification of ES in terms of provisioning (e.g. agricultural yield), supporting (e.g. microbial community biomass), regulating (e.g. climate and water regulation) and cultural services (e.g. aesthetic, spiritual and recreational benefits). This classification of ES is the most wide-spread and commonly accepted, allowing for meaningful comparisons across time and space (Barrios, 2007; Daily, 1997; Swinton et al., 2007; Zhang et al., 2007). In order to overcome challenges identified during the research process, classifying ES has required complementing classifications of ES with fieldwork insights (Mulder et al., 2015).

As noted in the UK National Ecosystem Assessment (UK-NEA), however, the assessment of ES entails multiple challenges. It is critical to understand which services are provided by which ecosystems, how such services may evolve over time, and how such evolution affects the quantity and quality of the services provided. Difficulty increases with the fact that changes in ES are not necessarily linear, and there may be thresholds in which ecosystems' response is unknown (DEFRA, 2011).

[1] Consulted in April 2016: < http://biodiversity.europa.eu/maes/ecosystem-services-categories-in-millennium-ecosystem-assessment-ma-the-economics-of-ecosystem-and-biodiversity-teeb-and-common-international-classification-of-ecosystem-services-cices>.

2.3.1. ES classifications

The first challenge encountered in this dissertation when operationalising the TEEB classification is distinguishing between ES and benefits. Although ES are defined as benefits for humans, benefits may also be seen as an outcome of the services. Taking them as synonyms may lead us to an inaccurate accountability of ES and to a misunderstanding of why they are considered important for humans (Watson, 2012). In this regard, the UK-NEA report distinguishes between final and intermediate services to prevent double-counting and the difficulty of valuing certain ES (DEFRA, 2011). Likewise, the IPBES (Díaz et al., 2015a) discerns that among the ecosystem benefits there are services and goods. Goods are objects from ecosystems that people value through experience, use or consumption (i.e. direct benefits), whereas services benefit people even though they might not be perceived as such (Palomo et al., 2016).

This mentioned challenge was more relevant when it concerned cultural services and their related benefits. Distinguishing among those two was a complex issue and for this reason this dissertation adapts Klain et al's (2014) classification of cultural ES, based, in turn, on Chan et. al, (2012). **Table 2.2** displays cultural services and benefits definitions. I have added a symbol after the services to show which are shared in the MA, TEEB and Klain et al. (2014) classifications. This ES/benefits classification of cultural services allows accommodating the views of different social actors and/or cultures into conceptual approaches of ES (Castillo et al., 2005; Fisher et al., 2009; Klain et al., 2014; Diaz et al., 2015).

Table 2.2 Typology of cultural services and benefits associated to ecosystems

Category	**Definition**
Cultural ES	Input flows for producting benefits from ecosystems. They tend to be fund-service (non-consumptive) in nature and are by definition subjective (Mulder et al., 2015)
Outdoor recreation (=)	Activities in natural or semi-natural settings for the purpose of relaxation or amusements (e.g. kayaking, mushroom-picking etc.)
Education & research (=)	Activities associated with learning about the natural world or research related to a natural or semi-natural landscape
Artistic	Associated with the creation and appreciation of beauty from nature
Ceremonial	Set of actions performed on special occasions for symbolic value and linked to biotic features
Self-fulfilment *	Energy that land ecosystem provides farmers and consequently allows for contentment through a metaphysical force and/or identity connected strength
Ecosystem benefits	**Valued goods, experiences and conditions**
Material	Tangible products of ecosystems (e.g. crops, wood)
Aesthetic (≠)	Relating to beauty or appreciation of beauty
Place/Heritage (≠)	Meaning or importance associated with a location, locations that serve as reminders of past events for people and communities
Activity	Intangible benefits associated with an action (e.g. sports in nature)
Spiritual (≠)	Related to metaphysical forces that exist beyond the individual
Inspiration (≠)	Mental stimulation to do or feel something
Knowledge	Theoretical as well as practical information and/or skills
Existence/bequest	Intangible non-use benefits associated with knowing that something exists or satisfaction in preserving a natural landscape for future generations
Option	The predicted benefit of future use of a natural resource
Social cohesion	Contributing to enhancing relationships among people
Identity	Ideas, relationships and sense of belonging that shape people
Employment	Contribution to work that provides monetary income

Source: (Klain et al., 2014, p. 6).
≠ classified as a service in the MA and TEEB frameworks, but as a benefit within the Klain et al (2014) classification
= Considered a service in the three classifications.
* Not included in MA (2005) and TEEB (2015) nor in Klain et al (2014).

The second challenge identified when operationalising the ES framework results from the existing interaction between the various ecological, social and economic components of ASES which occur at different spatio-temporal scales (White, 2016). Ecological data are typically collected from indicators that operate at local and short-term spatio-temporal scales. Social scientists work with individuals or populations of humans at larger spatial scales and over a mid-length period of time (annual to decadal). Economists, however, work at scales including the global economy and often over much longer time periods (White, 2016). The research scale of this dissertation is confined to the regional scale, but integrates ecological insights as ES proxies, and global factors as contextual stressors that affect current rural dynamics.

The transformation of a given ASES due to, for example, the introduction of modern irrigation can lead to changes within agrarian ES, as well as to changes in farmers' perceptions over the system, the goods and services delivered and their role in the co-production of ES. ES contribution to human wellbeing is a common omission of many of the ES studies (Turner et al., 2003; Adger, 2006; Kroeger and Casey, 2007; Raudsepp-Hearne et al., 2010) and this research also attempts to clarify these connections (see section 5.2).It is important to remark also that this thesis supports that ES exist whether we are aware of them or not. However, attention to conserve those services is dependent on humans' observation, analysis and valuation of the utility of the ecosystem functions (Norgaard, 2010).

The IPBES defined wellbeing as 'a perspective on a good life that comprises access to basic materials for a good life, freedom and choice, health and physical wellbeing, good social relations, security, peace of mind and spiritual experience' (Díaz et al., 2015b, p. 14). The contribution of certain agrarian ES (such as supporting and cultural services) towards the fulfilment of human needs is complex (Daniel et al., 2012a). Supporting services are 'indirect' in the sense that they are associated with a longer process of human cognition. Such services (e.g. soil formation) normally require long-term processes for the production of the other three categories of services (provisioning, regulating and cultural services) (Kull et al., 2015). In contrast, provisioning services, such as healthy crops and fibres, are intuitively perceived. Changes in provisioning services have strong impacts on food security for example, since there may be a loss of access to essential resources such as food and water. Regulating services, on the other hand are abundant, but often human intervention makes them decrease or exceeds ecosystems' capacity to provide them (Carpenter et al., 2009). These services are also difficult to perceive and are not typically included within policy evaluation. A greater focus on them could be useful (DEFRA, 2011) since changes in regulating services, such as climate and flood regulation, can have strong influence on human security at global and national scales.

Finally, as briefly introduced above, cultural ES are non-material and consequently difficult to measure. Cultural services influence stakeholders' attitudes (i.e. sense of responsibility and identity) towards nature (Calvet-Mir et al., 2012; Daniel et al., 2012; Tengberg et al., 2012; Turner et al., 2003). Changes in such services may imply alterations in many other ES and different dimensions of human wellbeing. For instance, they may contribute to the breakdown or strengthening of social networks, which will have an effect on the stability of social relations. Another example could be the effect of social-ecological transitions towards intensive agriculture over human dietary changes (cultural service linked to identity) and landscape (cultural service connected to outdoor recreation activities) (Gonzalez de Molina, 2010) due to alterations in provisioning services (e.g. crops shifts).

2.3.2. ES values

Stakeholders' judgement and action are guided by their value system, which is simultaneously affected by contextual norms and principles – i.e. normative and moral frameworks people use to endorse their beliefs and engagements (Pritchard et al., 2000). In the context of this dissertation, it is advocated that the valuation[2] of ecosystems is important in at least two ways: a) to know what matters most to farmers when it comes to their relationship with nature (link **A** in **Figure 2.2**); and b) to develop a solid base of evidence to design more effective, inclusive and legitimate policies for ASES (Link **B** in **Figure 2.2**).

In addition to the various valuation approaches that can be implemented, the different categories of ES are also difficult to compare. Provisioning services have a clear exchange value while cultural services are generally intangible and incommensurable (Vatn, 2007; Chan et al., 2012). Another constraint is linked to the motivations of different stakeholders' valuations of ES. This is, some ES are valued from an individual point of view, whereas others are appreciated from a social standpoint. For example, provisioning services may be understood as a direct source of welfare for the farmer producing such crops (individual standpoint) or as a crucial feeding source for humanity (social standpoint). Some cultural services can also relate to a metaphysical experience (e.g. self-fulfilment) rather than an experiential one. Cultural services may have a supporting or inherent value rather than a final value such as with provisioning services (Chan et al., 2012). Also, cultural services may often be connected to bio-centric worldviews as well as relational values[3] whereas provisioning services are always anthropocentric.

This dissertation aims to find a way of revealing trade-offs between ES valuations since they are inevitable in any land management decision-making context (Bennett et al., 2009) (see Chapter 0). Farmers will typically consider effects on provisioning services (yields) in a short term temporal scale (Klapwijk et al., 2014). However, their management also has impacts on long term and spatially distant services. Identifying trade-offs can help policy makers to understand the long-term effect of preferring

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[2] Valuation is the process of assigning a value to a particular action or object (Farber et al., 2002).

[3] Relational values refer to the relations humans have with nature so that such interactions importance does not lay on instrumental neither intrinsic reasons but rather an intimate kin and stewardship relationship with nature (Chan et al., 2016).

one ES over another, and the consequences of focusing only on the present provision of a service rather than on its future sustainability (Rodríguez et al., 2006). Socio-cultural valuation can illuminate both individual and social preferences over ES and shed light on the reasons behind the preferences of certain ES (Vatn, 2007). Still, disclosing stakeholders' preferences over ES is not enough to understand who are the beneficiaries and losers of certain types of ES (Daw et al., 2011). However, such analysis aids in understanding the different ES and the potential distribution among diverse stakeholders (see link **D** and **F** in **Figure 2.2**).

In this dissertation, farmers' stated preferences may reveal potential ES trade-offs under the hypothesis that ES preferences are aligned with their land management choices, which in turn result in different levels of provision and types of ES (see link **A** in **Figure 2.2**) (see Section 5.4). As Chan, Poe and colleagues argue (cited in Klain et al., 2014, p. 310), such analysis can be a useful way to illuminate why some services that are valued only by some farmers become so central to policy-making and resource management institutions (links **A**, **D** and **F** in **Figure 2.2**). Revealing contrasting preferences may be used to legitimate sometimes 'invisible' positions (Klain et al., 2014).

2.4. Livelihood vulnerability to external stressors in agrarian social-ecological systems

The Intergovernmental Panel on Climate Change (IPPC) defines vulnerability as the propensity or predisposition to be adversely affected by a stressor (e.g. climate change) (IPCC, 2014).[4] The origins of this concept should be found on the natural hazards and food security literature. It has more recently been applied in assessments of climate change impacts (Luers et al., 2003a; Vincent, 2004). In this dissertation, vulnerability, as human wellbeing, is multi-dimensional. Securing wellbeing requires then finding ways to reduce vulnerability and to take into account the interdependencies of global (e.g. global market influences and climate change) and local mechanisms that create these vulnerabilities (e.g. lack of access to irrigation or markets) (Adger, 2006; Eakin et al., 2009) (see link **E** in **Figure 2.2**).

The natural hazards school of thought arises out of a positivist perspective, and focuses on the 'objective' study of hazards (Vincent, 2004). Under this approach, emphasis is placed on a particular environmental stress, and vulnerability then refers to the risk of exposure of an ecosystem to a hazard. In contrast, the human ecology and political economy schools of thought are grounded on interpretive social sciences (Vincent, 2004). Vulnerability in these two schools focus on a particular group or social unit of exposure and particularly on the structures and institutions that govern it (Vincent, 2004) (see links **C** and **D** in **Figure 2.2**). The different approaches involved in vulnerability studies are thus

[4] For a review of other definitions see Cutter, (1996a).

strengthening the division between top-down biophysical risk exposure on one hand, and bottom-up social vulnerability on the other (Vincent, 2004).

Political ecology brings together critical insights from the human ecology and political economy perspectives with concerns about the interaction of physical and human systems (Vincent, 2004). This is the adopted perspective in this dissertation and its value pivots on recognising the physical phenomena to which individuals, families or households are exposed and embedded within and mediated by the particular human context in which they live (social, political, economic, and institutional) (see links **C** and **D** in **Figure 2.2**). Whilst physical phenomena are necessary for the production of a natural hazard, their translation into risk and potential for disaster is therefore contingent upon human exposure and the level of capacity to cope with the negative impacts that exposure might bring to individuals or human systems (Adger, 2006). In political ecology, vulnerability should be understood as a two-sided phenomenon involving an external side of disturbances in which a system is exposed and an internal side that represents the ability or lack of ability to adequately respond to and recover from external stressors (Chambers, 1983; Luers et al., 2003a; Scoones, 1998).

There is a wide variety of definitions and frameworks to assess vulnerability of households and ecosystems (e.g. Adger 2006). In line with other scholars (IPCC, 2001; Notenbaert et al., 2013), this research also assumes that the vulnerability of any system is a function of three main components: *exposure, sensitivity* and *adaptive capacity*. Therefore, these are presented as the vulnerability dimensions of farmers' livelihoods in the context of global change (climate variability and market volatility) and technological transition (modern irrigation).

Analysing the exposure of farming livelihoods to gradual and continual stressors such as climate variability is more difficult than examining their exposure to discrete stressors, such as floods. Likewise, vulnerability as a current state is difficult to assess due to the variety of factors interacting on different scales. However, this work aligns with Adger et al., (2003) who consider that understanding the current state of the ASES is the best possible proxy to understand existing and potential vulnerability for preventive action. Thus, this approach enables preliminary assessment to decide where adaptation efforts are most required (Vincent, 2004).

2.5. Institutions influence access to natural resources in agrarian social-ecological systems

Institutions, understood as formal and informal procedures, routines, norms and conventions (Hall and Taylor, 1996), mediate access to ES and other assets that may evolve to become opportunities or barriers to different types of livelihoods (Anderies et al., 2004a; McDermott et al., 2013) (see link **B** and **F** in **Figure 2.2**). Therefore, to understand contestations, negotiations and trade-offs it is necessary to investigate social relationships, their institutional forms and the power dynamics embedded within a modern irrigation technological shift (Scoones, 1998; Corbera et al., 2007b).

Following Ribot and Peluso (2003), *access* is defined in this dissertation as the ability to derive benefits from things whereas property right is defined as the right to benefit from things. By focusing on the *ability* rather than on the *right*, this conception brings attention to a wider range of social relationships that can constrain or enable people to benefit from resources without focusing solely on property relations. In this context property is just one set of access relationships among others (Ribot and Peluso, 2003).

Rights-based access can be *enforceable* through permissions; licenses controlled by the state and other organisations with power, such as watershed confederations within this dissertation. This prospect permits identifying the organisations in charge of controlling natural resources, e.g. water for irrigation. When there are contrasting perspectives about who should have access to a given resource, and whether their means of access are legitimate, the state often remains as the ultimate mediator, adjudicator and power holder. In this situation, some farmers may be able to enhance their own benefits by aligning with the government's position and/or possibly influencing government arrangements. In this way, some elite stakeholders may choose the government's position as the forum in which to claim their rights (see link **D** in **Figure 2.2**). These capabilities held by such elite stakeholders may shape who *controls* and who *maintains* access to resources (Ribot and Peluso, 2003).

When access is exercised through political-economic and cultural structures, one can refer to *structural and relational mechanisms of access*. As previously mentioned when exploring SLA, accessing certain assets (financial, human, social and physical) can synergistically influence who has priority to access other related assets and manage natural resources (see link **F** in **Figure 2.2**). Accessing technology, for instance, shapes the ways in which resources can be extracted or can benefit certain actors over others. Access to financial capital is also crucial since it determines who can benefit or keep their access to almost any kind of resource. Markets, simultaneously shaped by policies, licenses and taxes, also affect the distribution of resources and benefits. Knowledge is another key factor influencing access. For example, 'scientific expert' status or 'ecologist' narratives serve to justify control over resources. 'Economic crisis' narratives also serve to reject other petitions over access and control. Authority[5] serves to discern which legal paths favour or harm certain groups. Other social

[5] Authority can be categorised as a type of social identity and the access to authority as a social relation type but they are normally treated separately (Ribot and Peluso, 2003).

relations (e.g. friendship, trust, reciprocity or dependency) are of key importance to understand access (Ribot and Peluso, 2003).

If institutions are robust, resource users would be less vulnerable to different types of disturbances (Vatn, 2005; Adger, 2006; Paavola, 2007) (link **D** in **Figure 2.2**). A system is considered robust when it is long-living and the operational rules are formulated and modified over time according to a set of collective choice rules (Anderies et al., 2003). Institutions, then, should be flexible and able to adapt to human and ecosystem dynamics in ASES (Pritchard et al., 2000). Anderies et al., (2004), grounded on Ostrom, (2009) defined eight principles to discern when an institution is considered *robust.* The principles are as follows: i) the definition of clear boundaries; ii) the existence of proportional equivalence between benefits and costs; iii) collective choice arrangements option; iv) monitoring; v) graduated sanctions; vi) conflict resolutions mechanism presence; vii) recognition of rights to organise and viii) nested enterprises.

The bottom-up and top-down strategies often generate nested institutional structures where governance solutions with smaller jurisdiction are nested within larger solutions (Paavola, 2007). Institutions at a large scale should complement rather than remove locally evolved institutions. At a broader scale, institutions are typically necessary to protect common ES that may be undervalued at local scale (e.g. biodiversity, soil carbon). On the other hand, local institutions that protect services valued by local stakeholders are more likely to succeed in adapting management strategies and capturing the dynamics of the ecosystems, which is essential for the sustainable use of ES (see link **B** in **Figure 2.2**).

This research focuses on assessing how different farmers and land-holders' access common resources (e.g. water for irrigation and agrarian land), and how such access relations have changed over time due to the current technological shift (modern irrigation) affecting the ASES. This research also considers equity and legitimacy as useful criteria to design and evaluate natural resource governance regimes (Adger, 2006; McDermott et al., 2013). Current debates about global environmental governance indicate the importance of equity to fair and sustainable outcomes, yet there is lack of clarity regarding the definition and components of equity (Brown and Corbera, 2003; Forbes, 2008; McDermott et al., 2013; Martin et al., 2016).

This dissertation adheres to Corbera et al.'s approach to legitimacy and equity (2007a) . Legitimacy relates to the way in which livelihoods' outcomes are negotiated, accomplished and accepted by stakeholders. This is, the extent to which decisions are acceptable to participants and non-participants that are affected by decisions. There are three fundamental pillars sustaining the concept of legitimacy. First, *recognition*, which refers to the fact that diverse stakeholders have plural views;

second, *participation* in decision making; and third, the *distribution* of decision-making power (Paavola, 2007). This dissertation asserts that all affected stakeholders should be engaged in the decision-making process regarding the modern irrigation project, especially the most vulnerable, with the aim to guarantee that no farmer becomes worse off as a result of modern irrigation (Section 7.6).

Finally, the dissertation focuses also on the *distribution* of any outcomes (costs and benefits) resulting from the irrigation project. The extent to which a given policy or project outcomes result equitable to affected actors depend on decision-making procedures (legitimacy) as well as on project design factors, historical configuration of resource access institutions and the social relations concerning access to resources (Corbera et al., 2007a). Context is crucial to understand social impact or fairness of a project (McDermott et al., 2013). Initial social conditions need to be examined to determine whether modern irrigation implementation is fair for the different kind of farmers co-existing in Navarre. Equity[6], hence, must be understood within the context of the culture in question –i.e. beliefs, practices and institutions. The capabilities component reveals the interdependence of distribution and procedure (recognition and participation) (Schlosberg, 2004; Corbera et al., 2007b; McDermott et al., 2013).

[6] Equity is understood as environmental justice and it is used in this dissertation as synonyms as Martin et al., (2016) define in their recent research about recognition.

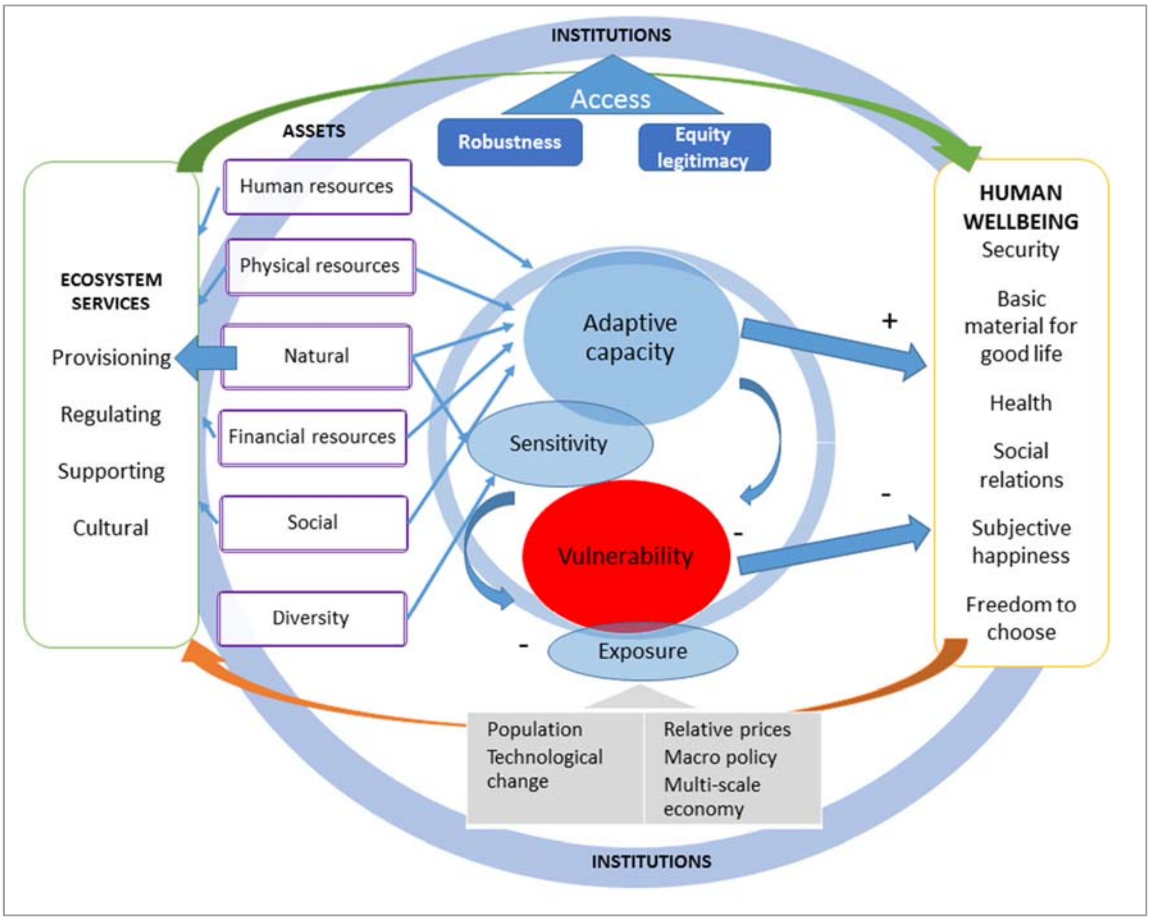

Figure 2.4 A conceptual roadmap about ES, sustainable livelihoods, institutions and vulnerability connections. Based on (Maru et al., 2014, p. 341)

Figure 2.4 draws from previous **Figure 2.1** and **Figure 2.2** to summarise the connections between the concepts explained thus far in this chapter. On the left side of the figure, ES categories are presented as the outcomes resulting from the combination of natural capital with human, physical, social and financial assets, in the 'co-production' process. These capitals make ES flow; the green arrow represents ES contribution on human wellbeing, whereas the orange arrow depicts human wellbeing influence on ecosystems (often reflected by the land management intensity regime used).

The grey box at the bottom of the figure illustrates examples of possible factors affecting farmers' vulnerability. The combination of the five capitals (left-side of **Figure 2.4**) contributes to define farmers' sensitivity and adaptive capacity. Farmers' agency is thus determined by the assets they can administer to adapt to the new or potential situation and the features that make them more or less sensible to climate and market fluctuations.

The middle part of the figure indicates the feedback loops between a desirable state of sustained adaptive capacity and a vulnerability state. Finally, on the right side of the figure the two blue arrows link adaptive capacity and vulnerability to the dimensions of human wellbeing. This represents their direct connection; since when farmers' vulnerability is high, human wellbeing decreases and when adaptive capacity increases, the sustainability of the SES increases. Institutions influence the access to ES and assets, consequently affecting farmers' wellbeing and their vulnerability. This presents a continuous feedback between human wellbeing and ES.

2.6. Summary

This chapter has provided the theoretical lenses that will be used throughout this dissertation to approach the research problem and to interpret the research findings. The chapter has argued that ASES are complex systems that require holistic analytical approaches to understand all the links among and between the related sub-components that constitute them. It has also suggested that the SLA is a useful approach to understand rural livelihoods diversity. The SLA approach permits undertanding how households combine different assets in order to deliver their livelihoods strategies, with a focus on the different land management regimes. An ES approach and farmers' co-production of agrarian services have also been presented. The importance of classifying and valuing ES in order to disclose trade-offs between ES valuations related to diferent land management practices has been emphasised.

The chapter has subsequently presented livelihoods vulnerability and the adoption of a political ecology approach to analyse the effects of modern irrigation on the human dimension of ASES. This chapter has assumed that vulnervility is a function of: exposure, sensitivity and adaptive capacity. Finally, it has defined institutions as formal and informal procedures, routines, norms and conventions that mediate access to ES and other assets. It has proposed a *robustnes* approach to analyse institutions influence over livelihoods vulnerability and it has also proposed *equity* and *legitimacy* as useful criteria to design and evaluate natural resource governance regimes. The next chapter outlines the research methodological framework, drawing its epistemological approach, the research tecniques employed and some ethical considerations.

CHAPTER 3

"Si buscas resultados distintos, no hagas siempre lo mismo"

Adapted from Albert Einstein

3. Case study and methods

This chapter explains the methods employed for data collection and analysis. The first section presents the overarching research approach, focusing on key ontological and epistemological considerations. The second section justifies the selection and the characteristics of the case study in Navarre and the third section provides a detailed explanation of the qualitative and quantitative methods employed in the empirical chapters. In the fourth and final section I reflect upon various aspects of field research, including research ethics.

3.1. Research approach

3.1.1. Ontology, epistemology and research strategy

The essence of research is to understand and explain the world (Scheba 2014). Research is deeply engaged with a philosophical debate over perceptions of reality and how it is organised (ontology), and what do we know about it (epistemology) (Newing et al. 2011). Epistemology and methodology are similar concepts, but differ in that although both deal with how we come to know, methodology is more practical in nature. Methodology focuses on specific techniques, the methods, which can be used to better understand the world.

This dissertation takes a *critical realist perspective* as its epistemological stance. Critical realism belongs to the post-positivist school of thought, one of the major philosophical schools in contemporary social-ecological research. It offers an alternative to positivism's reductionist scientificity and the relativist reactions to it. Critical realism considers that there is a 'real' world, existing independently of the researcher's knowledge of it (Sayer 2004). It becomes important to study how historical and contemporary factors shape different interpretations of a single material world (Scheba 2014). Critical realism stresses that the experience of knowledge imperfections, mistakes and unexpected outcomes give us the conviction that the world is not merely a social construction (Sayer 2004). There is an iterative process developing over time between what has been previously mentally constructed and the material world.

As a researcher, I agree with critical realists on the normative implications of our commitments with society. The 'critical' dimension of critical realism lies in the fact that social practices are informed by ideas, which may or may not be true. Identifying understandings in society as false implies that those beliefs and actions ought to be changed (Sayer 2004). However, one must be careful in this 'search for the truth'. Realists do not assume the truth to be an absolute, all-or-nothing matter. Rather, they prefer to talk about degrees of practical adequacy. Many social science dissensions are not mutually exclusive rivals, but they emphasise different aspects of complex processes (Sayer 2004). This approach emphasises the importance of multiple investigative measures and the need for triangulation across these multiple informative sources (e.g. actors' discourses, primary and secondary data).

Moreover, critical realism considers that objectivity is not merely the act of an individual, but rather a social phenomenon. Therefore, it is better suited within a broader context, among a community that reviews each other's work (Vatn 2007). Critical realists also argue that the world is 'stratified', as with biological phenomena, where new properties develop from objects emerging from their constituents (Sayer 2004). The relationship of these categories is examined within my analysis of ES, along with an assessment of influential livelihood assets, which are simultaneously affected by global factors assessed within a vulnerability index (see e.g., Sections 3.3.3 and 3.3.4).

Researchers may critically examine why reality is as it is, focusing on shaping features such as power structures and social networks (Scheba 2014). They emphasise that although people have causal powers, such powers are realised differently due to structural mechanisms and social contexts (Sayer 2000). I reflect upon these ideas first in Chapter 0, when I focus on farmers' motivations to value agrarian ES, and in Chapter 0, where I aim to understand new irrigation isntitutions that eventually influence individual and social land management choices.

The research strategy takes on a case study approach, which allows for an in-depth examination of the research questions and the use of a variety of research tools to gather reliable and accurate information. The research is performed through empirical observation, incorporating deductive and inductive strategies.

3.1.2. A case study approach

A case study approach enables the researcher to gain insights from a particular case, which can be utilised in other cases, allowing for a detailed research process and enabling the researcher to study social processes and relationships more in-depth. Referencing daily social practices allows the researcher to respond to such questions of *what* things are, and *how* and *why* they happen.

Each case study, though in itself unique, is an example of broader phenomena and its generalisation depends on how similar the case study is to others of similar type (Scheba 2014). Within this approach, it is therefore important to explain why or how the selected case is comparable to others, and to contrast findings, thus exploring possibilities for generalisation. In rural development literature, as shown in Section 3.2 below, the irrigation of agrarian systems in the Mediterranean region has received increasing attention over the past two decades. The ecological and productivity effects of irrigation have been largely studied and broadly discussed (Urama 2005; van Halsema & Vincent 2012). More recent studies have investigated whether irrigation can be understood as a practice of climate change mal-adaptation, and how it fits into a wider hydro-social system that distributes ecological and social costs inequitably (Connor et al. 2012; Cooper et al. 2008; Deressa et al. 2009; Fischer et al. 2007; Fleischer et al. 2008; Monaco et al. 2014; Swyngedouw, 2009).

Qualitative methods were used primarily for data collection and interpretation. This includes semi-structured interviews, focus group workshops, document analysis, and participant observation (see Sections 3.3.2, 3.3.4 and 3.3.5 below). These methods are valid for understanding case study specifics, such as the historical evolution of agrarian systems in the case study area, the functioning of existing institutions, and power relations among social actors. A complementary quantitative survey was also deployed to collect farmers' information relevant to characterise farmers' perceived stressors and calculate the household vulnerability index. The survey was also accompanied by an absolute and relative ranking exercise to capture farmers' valuation of ES (see Sections 3.3.2.2 below). Throughout the dissertation, I contrast my findings with literature published on the topic, including similar case studies.

I carried out fieldwork with an open mind and willing to listen to people without preconceptions. However, I acknowledge my familiarity with the context of the case study area, since I come from a neighbouring region and followed the development of the irrigation project through written press and e-media. In order to deepen my understanding of local livelihood strategies and grasp the drivers and the consequences of the irrigation project, I lived in one of the villages for nearly four months, and made frequent visits for an additional four months to conduct semi-structured interviews. This methodology obliged me to remain flexible and receptive to unforeseen findings during fieldwork, which led to continuous revision of the research strategy, questions and findings.

3.2. The Case study of Navarre

3.2.1. Country focus: Spain

Spain was selected as the case study country, primarily because Spanish agriculture is of high importance in terms of the surface it occupies, the generated employment (around 7% of total employment in the country) and the high subsidies it receives[7]. More than twenty-five million hectares (approximately 50% of Spain's total area) are classified as useful agricultural lands (SAU).[8] Accounting for meadows and pastures, this area reaches 80% (MAGRAMA 2013). Between 2007-2013, Spain ranked as the second highest receiving country in relation to the EU's Common Agricutlural Policy (CAP) (Carricondo & Peiteado 2010). There is a close connection between intensive land management practices (in terms of fertilisers and water consumption) and established agricultural subsisdies. Moreover, there is an overlap between CAP subsidies, overused aquifers, and nitrate-polluted areas that have been declared vulnerable due to agrarian sources (Carricondo & Peiteado 2010). This occurs in a context where croplands and bare soil are above the European average (28% versus 25% and 12% versus 5%, respectively), whereas surface water (0.9%) and wetlands (0.1%) are below the European average (MAGRAMA 2013).

Traditionally, much of the irrigation practiced in Spain consisted of gravity-fed systems, where water was transported from surface sources via small canals and used to flood agricultural land (Baldock et al. 2000). Currently, the most widespread irrigation method is by sprinklers utilising pressure systems. This has been facilitated through policy measures that have subsidised farmers' adoption of irrigation infrastructure, guaranteeing low water prices. Although sprinkler systems allow for a better control of water use during irrigation, higher quantities of water are used through such systems, causing overall a more severe impact on the environment (Baldock et al., 2000). While modern irrigation systems such as sprinkler and drip irrigation systems provide more efficiency, water consumption has also increased as agrarian land has expanded (INE 2011); confirming theories linked to the Jevons Paradox[9] (Swyngedouw 2004).

Water is considered a public good in Spain, yet historically, the use of it has been private. The River Basin Agency grants users long-term water-use concessions (approximately seventy-five years), based upon estimates of available water within the River Basin Hydraulic Plans. Irrigators'

[7] Available at http://www.lamoncloa.gob.es/espana/eh15/agricultura/Paginas/index.aspx.
[8] Spanish acronym for "Superficie Agraria Útil".
[9] In economics, the Jevons paradox occurs when technological progress increases the efficiency with which a resource is used (reducing the quantity necessary for any one use), yet increasing demand causes a rising rate of resource consumption.

associations, with regulating statutes drawn up and passed by the users themselves, mainly use such allocated water.

Water scarcity has been a reoccurring theme in Spain's public policy rhetoric during the last century, and the search for water persists (Swyngedouw 2004). Nearly every river basin has been altered, engineered, and transformed. The resulting water transfer has led to conflicts and given rise to new associations, ecological groups and movements such as *La Nueva Cultura del Agua.*[10]

Spain is the fourth country in number of dams after China, the USA, and India, and it has the highest number of dams per square kilometre per capita in the world (Mendez 2001). Today the country has nearly nine hundred dams, more than eight hundred of which were constructed during the second half of the 20th century. Dams are justified on the grounds of producing hydroelectricity and securing water availability in drought periods and, more recently, they have been further justified on the grounds of climate change-related concerns, such as buffering infrastructures to mitigate temperature rise and to regulate extreme flooding events (Bruckner et al., 2011). Relatedly, irrigation infrastructure has been also presented as a measure of climate change adaptation as long as stored water is available (Field et al. 2014).

Climate change can be approached as a catalyst for mitigation and adaption; an outcome which human activity should aim to avoid. Although Spanish agriculture's impact on the country's total greenhouse gas (GHG) emissions is a relatively low (11%) (Gallejones et al. 2012), the agriculture sector is responsible for emitting two of the most potent GHGs: methane (CH_4) and nitrous oxide (N_2O). Respectively, these gases have around 25 and 298 times more heating potential than CO_2 over a hundred year period (IPCC 2007). Irrigated systems also emit a higher level of N_2O compared to rainfed systems (Aguilera et al. 2013). Therefore, what could be considered a short-term climate change adaption strategy could also be a driver of climate change. The widespread transformation of rainfed systems into irrigated systems throughout the country, evoke a reflection of the latter's likely associated maladaptation characteristics. That is, insofar as they promote higher levels of water consumption, they also translate in higher emissions and induce irrigation-related environmental harms. Further examination of these issues is required given the heterogeneous Spanish climate conditions and differential water scarcity and environmental impacts across the country.

[10] The *Nueva Cultura del Agua – New Culture of Water* - is a social movement that emerged in the mid-1990s. It promotes a change in water management policy in favor of more rational and sustainable actions. Members are professionals from various fields (business, academic, cultural, social, etc.).

3.2.2. Regional focus: Navarre and its modern irrigation project

3.2.2.1. Location description

The case study area of this dissertation is Navarre, an autonomous community in northern Spain, which borders the autonomous communities of the Basque Country, La Rioja, and Aragon, and the region of Aquitaine in France. The research took place in the *Zona Media* and *Ribera Alta* zones of the Ebro River watershed, which hold 22.5% of Navarre's population (De Vries & Garcia 2012). In Navarre, the primary sector represents 4% of total employment, covering a total of 1,039,133 hectares in 2013 (MAGRAMA 2014). The region struggled during the confiscation process in the beginning of the XIX century that, through public sale, saw communal lands shift to private property. Despite this, it remains one of the few autonomous communities noted for still having large surfaces of communal lands (Aguas 2010), allowing many farmers to gain access to land. Private initiatives had bought and returned lands resulting in differing configurations of common lands in various villages.

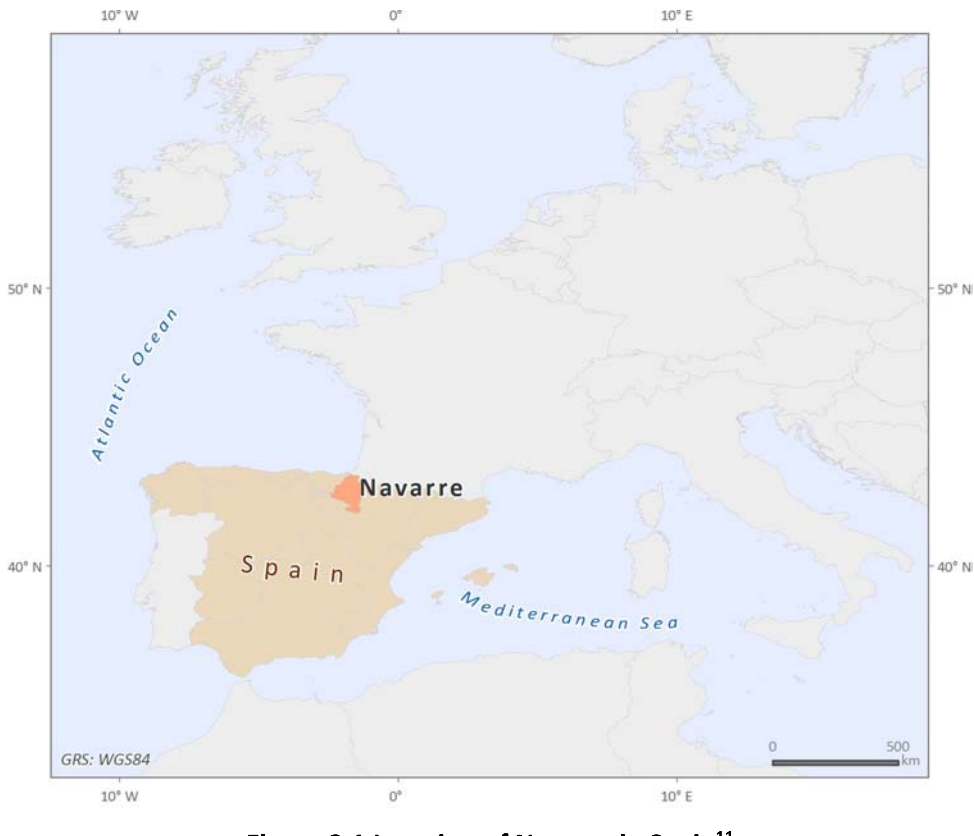

Figure 3.1 Location of Navarre in Spain[11]

[11] Own elaboration with cartographthic data of GADM.
GDAM - <http://www.gadm.org/>.

The Ebro watershed alone holds 299 dams, including those in operation, under construction, or projected and accepted (Confederación Hidrográfica del Ebro, 2015). Of these, 24 are in Navarre (Ministerio de Agricultura, Alimentación y Medio Ambiente, 2015). It is planned that water from one of these dams, the Itoiz dam, is to be used primarily for irrigation of 57,700 hectares of agricultural lands. The *Canal de Navarra* was built for this purpose, as well as to facilitate the generation of hydroelectricity and guarantee supply to neighbouring cities.

Figure 3.2 Map of Navarre's geographical regions[12]

[12] Own elaboration with cartographic data of Digital Chart of the World, GADM and IDENA repositories.
GDAM - <http://www.gadm.org/ IDENA>.

3.2.2.2. The modern irrigation project

The Navarre's government, coordinated with other Spanish administrations and European strategies, has provided farmers with infrastructure and public subsidies to favour the adoption of modern irrigation as a means to deal with current rural development challenges (e.g. productivity losses and climate variability). Formal norms and rules have accompanied the irrigation system transformation since the late 1990s. The *Real Decree 22/1997* allowed the construction of the Itoiz dam, arguing that the dam should be regarded as a benefit for farmers and Spanish society in general. Subsequently, the *Foral Law 7/1999, Navarre Irrigation Plan* and the *Foral Law 1/2002, regarding agrarian infrastructures,* among others, followed suit to establish favourable conditions for the modern irrigation project to be financed and to expand.

The *Water Framework Directive* (*2000/60/CE)* establishes water consumptions attending to type of crops and area, which in turn allows developing a charging system by blocks of consumption. Communal land decrees and laws, including the *Foral Law 6/1986* -repealed by *Foral Law 6/1990-*, have also been modified to facilitate modern irrigation. The *Foral Order 186/2011* and *Foral Order 185/2015* are about modern irrigation financing. Councils transforming communal lands can get a higher subsidy for the installation of the modern irrigation if such councils prioritise full time farmers rather than other kind of farmers when allocating communal lands among the neighbouring farmers.

Over these years, there have also been moments when the pursuit of modern irrigation was halted. In 1995, for example, the Court of Administrative Justice of the *Audiencia Nacional*[13], sentenced that the *Real Decree-Law 22/1997* had exaggerated when it had argued that building the Itoiz dam was urgently needed. Other outstanding events have also occurred as the construction of the *Itoiz-Canal de Navarra* project advanced. Some examples are the demonstrations against the *Itoiz-Canal de Navarra* project, non-binding referendums among local farmers to decide about modern irrigation implementation and alternative studies to the official ones about the adequacy of such project (Beaumont, 1997). The more extreme act against the project happened in 1996, when eight activists of *Solidari@s con Itoiz*[14] stopped the

- Infraestructura de Datos Espaciales de Navarra - <http://idena.navarra.es/Portal/Inicio>. For the meteorological stations location information was found in: <http://meteo.navarra.es/estaciones/mapadeestaciones.cfm>.

[13] The Audiencia Nacional (English: National Court) is a special and exceptional high court in Spain. It has jurisdiction over all of the Spanish territory. In most cases, the rulings and decisions of these different divisions of the Audiencia Nacional can be appealed before the Supreme Court of Spain (Díaz, 2004).

[14] The Solidari@s con Itoiz collective was born to cover a battle front of direct, public and non-violent action, within a strategy of civil disobedience in defense of land.

dam construction works for one year after cutting the transport system cables that conducted the concrete to any point of the dam. They peacefully entrusted themselves to the police and two people were imprisoned. This was a disobedience act that attracted much publicity and social support. Ultimately though, all such direct actions did not avoid the construction of the dam, the development of the canal and the installation of the modern irrigation system throughout the study area.

The *Canal de Navarra* was projected to be built in two phases; Phase One in the *Zona Media* and *Ribera Alta* zones, and Phase Two in the *Ribera Baja* zone. Phase One (2006-2014) which has a Mediterranean climate and an arid and semi-arid climates, respectively (as per the Papadakis classification) converted 22,445 ha to modern irrigation across twenty-two villages. This area is now divided into fifteen administrative sectors. Phase Two, however, has not yet happened due to lack of funding. Over half of the canal was intended to flow underground and would require the water to be pumped, as natural gravity would be impeded by orography. As a result, in 2015 the project was altered, with an extension of 15,000 hectares to the west of *Zona Media and Ribera Alta (*See **Figure 3.3**).

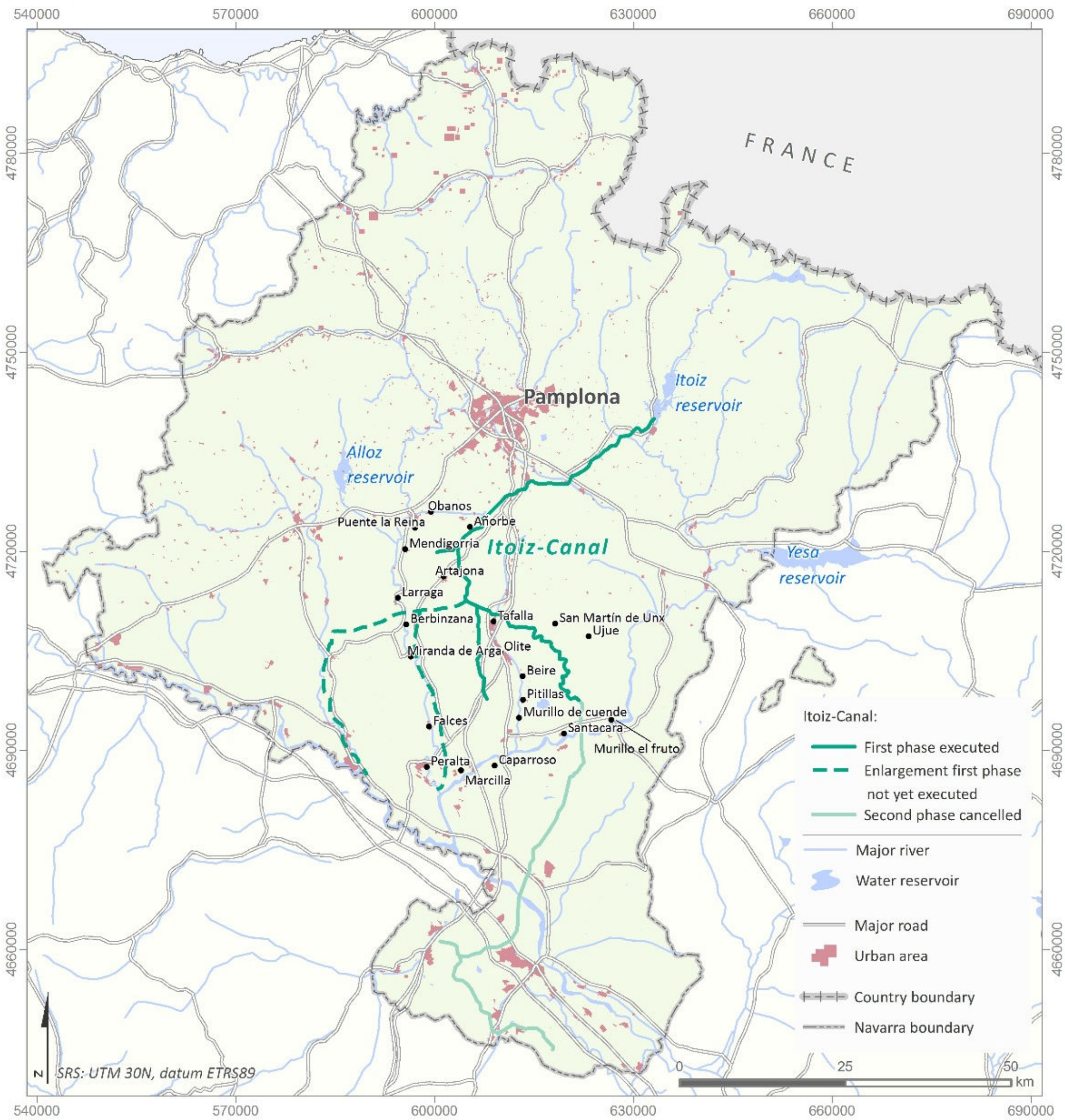

Figure 3.3 Phase One and its extension of Canal de Navarra[15]

Farmers who own land in the areas affected by the modern irrigation project expansion have three options: they can adopt modern irrigation, partnering with other farmers if they own less than five hectares; switch to lands in other areas with rainfed systems; or sell or rent their lands.

The *Canal de Navarra* has been financed using a shadow toll system. Navarre's government pays a monthly fee for the use and availability of infrastructure to Aguacanal (Aguacanal, 2015), which

[15] Own elaboration with cartographic data of Digital Chart of the World, GADM and IDENA repositories. GDAM - <http://www.gadm.org/ IDENA>.
Infraestructura de Datos Espaciales de Navarra - <http://idena.navarra.es/Portal/Inicio>.
For Canal sketch it was also used: GOBIERNO DE NAVARRA. DEPARTAMENTO DE OBRAS PÚBLICAS, TRANSPORTES Y COMUNICACIONES, 2000. Comunidad Foral de Navarra en cooperación con la Administración del Estado: Proyecto embalse de Itoiz, canal de Navarra. Tramificación y áreas regadas [map]. 1:200000. Pamplona.

is the concessionaire enterprise. Aguacanal shareholders are composed of seven companies. The largest holders are Acciona, a large construction group, with 35% and AGBAR, an international water management company, holding another 35%. The payment will be made over the next thirty years through INTIA S.A., the public company attached to Navarre Government that projected the canal. Aguacanal receives a monthly fee based on the hectares transformed into irrigation for each sector. Irrigators also pay annually for the maintenance and conservation work carried out by Aguacanal, through the community of irrigators in each sector.

A process called *concentraciones de tierras* (land concentration) was a prerequisite for transforming formerly rainfed agricultural lands into irrigated areas. In this process, small plots of lands were brought together to encompass five hectares at least. The resulting land parcels were classified in categories of quality and suitability for irrigation on the basis of soil productivity and properties such as texture, stony loam, and organic matter. Therefore, if a landholder holds two hectares of high quality land, for example, they could gain access to the same area of equal quality, or to a larger area of lower quality, whether in the same or different location. This process remained consistent for lands under traditional irrigation, yet the requirement of a minimal area of five hectares presented a significant challenge, as 96% of these plots were less than two hectares (De Vries & Garcia 2012). Also, farmers sharing a minimum of five hectares had to agree on an irrigation system, thus limiting crop selection choices. *Concentraciones de tierras* were then established to increase land profitability, as farmers would be then able to manage larger land surfaces with the introduction of more efficient machinery.

3.2.2.3. Crops in the case study area

The *Zona Media* is primarily cultivated with winter wheat (*Triticum spp.*), barley (*Hordeum vulgare*), and to a lesser extent, vineyards. Villages such as Olite and San Martín de Unx are famous for their wine production. In *Ribera Alta,* rotations of cereal crops and vineyards, in addition to vegetables are important. Olive and almond trees are also quite common and distributed throughout the case study area. Corn (*Zea mays*) and forage was the predominant crop introduced after modern irrigation was introduced. Traditional irrigation is still common across the study region, but mainly in the *Ribera Alta,* due to its semi-arid climate. Therefore, before the building of the *Canal de Navarra*, a large number of farmers already had access to water for irrigation.

Most farmers have abandoned crops with high labour costs such as asparagus, peppers and fruit trees, which compete with imports from countries like China or Peru and which are affected by other factors such as internal labour compositions change in which machineries replace human labour (see **Figure 3.4**). A small number of farmers still grow these crops in the traditional way. However, they are now for self-consumption or they are sold as specific origin denomination – i.e. when a product is exclusive of a certain region - that is typically associated to high quality products under the 'first' and 'extra' categories (Gobierno de Navarra, 2015a).[16]

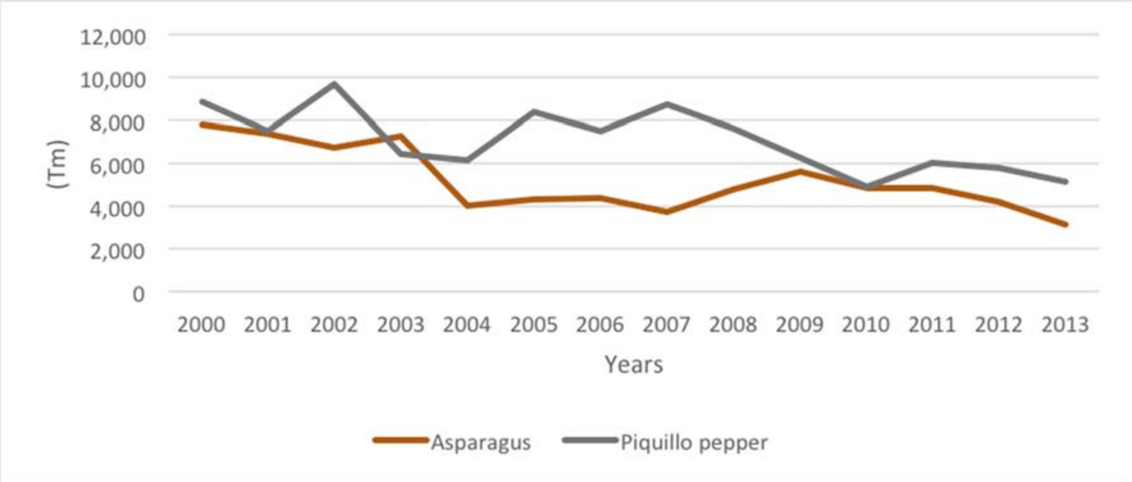

Figure 3.4 Data on production of traditional crops that are decreasing

With the introduction of modern irrigation, maize is expanding in the case study area (see **Figure 3.5**). Such trend has also offered new opportunities for the production of biofuels (personal communications during interviews; survey; focus group and De Vries, A, and Garcia M., 2012).

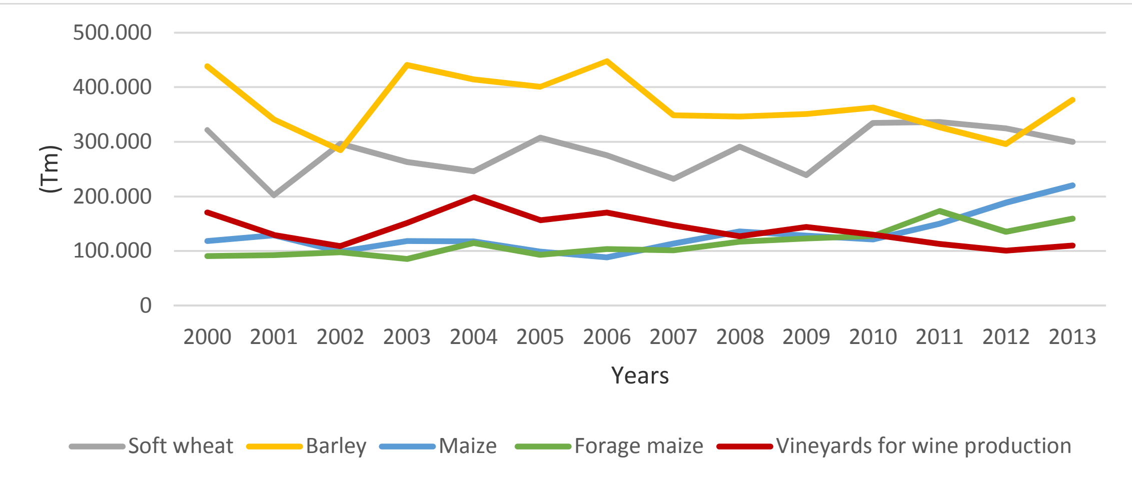

Figure 3.5 Data on production of main crops in Navarre

[16] Consult at <http://www.denominacionesnavarra.com/index.php/en/>.

In 2012, the primary sector in Navarre represented around 3% of the region's gross added value, slightly above the Spanish average, but far from autonomous communities with greater agricultural potential, such as *Aragón* (4.3%) and *La Rioja* (6.8%) (De Vries, A, and Garcia M., 2012). Navarre is a net cereals importer, buying cereals from France in 2012 and from Poland and Russia, Latvia and Lithuania in 2013. A share of its maize production is nonetheless exported to Portugal and France. Navarre exports wine to Germany and the United Kingdom, as well as to the Netherlands, Switzerland and the United States, but it also imports from France and other Spanish regions (De Vries, A, and Garcia M., 2012).

3.3. Research methods

3.3.1. Semi-structured interviews

The research involved two rounds of semi-structured interviews. In the first round (May-July 2013)**,** I conducted 29 in depth interviews following a snowball interviewee selection process that involved scientists (N=1), policy-makers (N=4), NGOs (N=2), syndicates (N=2), cooperative workers (N=1), members of consumer groups (N=2), water management companies' officers (N=1), INTIA technicians (N=3), and farmers (N=13). This allowed for a range of possible perspectives about the *Canal de Navarra* irrigation project. Preliminary interviews were arranged via email and telephone. The purpose of these interviews was to gather key information for the design of household surveys (see Section 3.3.2.). The interviews were organised according to a set of topics and questions defined *a priori* for each subset of stakeholders involved, distinguishing farmers and rural landowners from 'other' respondents. Appendix I outlines interview contents for these key stakeholders and Appendix II presents a descriptive list of participants. ES rhetoric was not used in the same manner with an academic, the regional government's environmental officer, or an elderly rural owner who was not familiar with technical terms.

The second round of interviews (May-June 2015) encompassed 19 interviews of two different types to explore institutional change and vulnerability resulting from the transformation to modern irrigation: one type addressed to a stratified sample of farmers in the village of Miranda de Arga (N=17) and another to actors of cross-scale government officers (N=2). The interviewee sample of the first type was stratified based on farmers' land management practices, which had been previously identified through the analysis of the survey (further explained in Section 3.3.2., below). Appendix III and IV outline interview contents and a descriptive list of participants. This second round of semi-structured interviews was key to be able to identify and select focus group participants (see Section 3.3.4).

Interviewees in both rounds were approached within their daily context; on the farm, in their office, or at home. They were always alone, with exception of two cases in which a family member or a friend of the interviewee was also present. They were shortly briefed about my research project and consent for both interviewing and tape-recording was sought orally (and obtained in all cases). Participants typically engaged easily in conversation, and interviews lasted between half an hour to one hour depending on the interviewee’s availability and flow of the conversation. Anonymity was ensured to all interviewees, though for consistency and accuracy within my research, I wrote up in my fieldwork diary key background information of each respondent. I remained flexible during the interview and attempted to adapt to contextual factors while ensuring that the conversation was useful to my research.

Specifically, I attempted to provide minimal direction or interruption, but often had to encourage interviewees to remain focused on the subject, while still allowing them to talk openly and freely. It was also important for me to consider aspects related to research design and practicalities, such as how much time interviewees would allocate, where the interview took place (formal office setting or evening drink), and not least, how well they already knew and trusted me. In this regard, the second round of interviews was much easier than the first: I had become acquainted with interviewees and they became more familiarised with my research. Thus, I spent less time explaining the purpose of the research beforehand and gained their trust more quickly, leading to more thorough and rich conversations within the time constraints.

In some interviews I had difficulties in accessing certain information, particularly during the first round. Such difficulties differed depending on the type of question. Farmers who had been directly involved in the irrigation project spoke more fluently about the strengths and difficulties of the project and about the experienced factors of stress they perceive in their profession. However, compared to other interviewees, some farmers had difficulties answering questions related to the link between agrarian ecosystem goods and services and their wellbeing. When the interviewee did not understand the question, I provided some examples to move the conversation forward. In these situations, my own perspective might have influenced the respondent’s views. In other interviews, the respondent declined to provide an answer on the basis of lack of information and knowledge.

Participants did not generally challenge my research purpose. Most interviewees actively contributed in interviews and also participated in the survey. At village level, motivations to participate in the interviews differed. Some refused to participate claiming lack of time during periods of intensive work such as harvesting. Others cited the recent grim experience of selling their lands due to modernisation, and stated they did not want to talk about it, or that they were not farmers anymore. In contrast, some were enthusiastic about participating, showing me their crops and lands, and sharing their practices and knowledge. Over the research process, only two government officers were unavailable for an interview. One of them probably felt uneasy, because his institution has a significant presence at the watershed level, and his participation could have been regarded as inappropriate. The other's reluctance to participate was justified by an ongoing electoral process, and the officer asserted he did not have the time.

3.3.1.1. Interview design

As noted in Appendix I, interviews covered a variety of themes, each containing a number of related questions. I tried to create simple, straightforward questions since the interview was expected to last about an hour.

Information from the first round of interviews was used to draft the survey (see Appendix V and Section 3.3.2), and to ensure that issues and variables of local concern and relevance were systematically captured. The interview was first contextualised by asking interviewees if they were familiar with the ES framework. Once their perception of ecosystem goods and services was established, I asked why they were important for them and how they contributed to their wellbeing. Interviewees were asked to briefly characterise and classify the different types of farmers in the research area.

Interviewees offered their views on the main challenges and stressors of Navarre's agrarian sector. I explicitly asked about climatic factors, how intense (magnitude, duration and scope) and frequent these stressors were, and how they had been confronting them in the past. I asked whether they thought there were more sensitive profiles, or more exposed agents, to the stated stressors. They were encouraged to reflect on the extent to which successful coping strategies relied on their knowledge, natural assets, social networks or financial standing. They also identified the institutional arrangements that helped them adapt to the stressors identified.

I asked interviewees if and how farmers collectively organised, and which forms of financial aid they had access to. Based on this information, I was able to produce a compilation of the main institutions playing a role in farmers' livelihoods. I enquired as to how the *concentraciones de tierras* were made, in which way parcels were distributed afterwards, and if and how they believed modern irrigation would help to improve their livelihoods. Possible conflicts resulting from the transformation were broadly discussed- including positive and negative aspects of modern irrigation, along with favoured production models.

For the second round of interviews (see Appendix III), I structured the conversation around the three main issues related to changes in water access over time: (1) a comparison between traditional irrigation institutions and modern irrigation, (2) the socio-economic precursors that led to modernisation, and (3) the implications of modern irrigation for rural livelihoods. Most interviews provided insights into the social relations in the village as well as personal opinions, feelings and experiences.

3.3.1.2. Interview data analysis

The first round of interviews was not completely transcribed except for statements where participants perceived a link between ES and human wellbeing dimensions. These statements were additionally organised according to the scale at which ES are delivered, whether the benefits are self or other-oriented, and whether such benefits are directly or indirectly received by the beneficiaries.

As highlighted in the previous chapter, there is disparity in the literature regarding the classifications of services and benefits, which created challenges in my analytical process. For example, landscape and traditional knowledge are treated as services in the Millennium Ecosystem Assessment (MA 2005), yet considered benefits by Chan et al. (2012) and Klain et al. (2014). Participants also discussed how several benefits might be produced from the same service (e.g. outdoor recreation might simultaneously lead to physical activity, artistic and spiritual benefits). Because of this, before going into the field, I erroneously organised participants' statements, confusing the concepts of services and benefits. Specifically, I classified some sentences for the Likert scale exercise and some cards for the Pebble Method (see Section 3.3.2.1) as if they were services when they were benefits (e.g. employment, economic gains, and happiness). This is an important caveat of my research, which fortunately was noted quickly and corrected to the best of my ability. Before data analysis I removed such sentences from the Likert Scale exercise. Since this valuation method consisted on absolute valuation, the valuations of such cases were just discarded without any other arrangement. In the case of Pebble method, however, since this method consisted of a relative valuation, removing such cards implied the distribution of farmers' allocated pebbles among the rest of cards proportionally to the values attached to the remaining cards (see Section 3.3.2.2).

For clarity, I deviated from the MA classification (2005) of ES and organised the participants statements in alignment with Klain et al. (2014), primarily for a more precise alignment of cultural services and connected benefits. In this process I discarded seven statements associated with cultural services and benefits, along with two statements related to provisioning services. The rest of the information was summarised as key parts to narratives about ES for human wellbeing and vulnerability analysis, which allowed me to identify key questions to include in the survey (see Section 3.3.2 below and Appendix III), and to compile the different assets that constituted local rural livelihoods.

For the second round of interviews I transcribed all recordings and coded them in an Excel dataset, excluding only irrelevant and off-topic sections. I compiled the codes and looked for themes that encompassed ideas revealing certain patterns (Saldana 2012), and attempted to provide an explanation for the patterns identified within the data. Documents, newspapers and other written sources were also assessed as a way of triangulating the information.

3.3.2. Household survey design

In addition to the interviews, I conducted a survey to complement and triangulate some of my qualitative findings with quantitative data. It took three months and involved two research assistants, employed full-time. The household was selected as the main unit of analysis (Thomas and Twyman, 2005).

The survey was performed in the 22 villages affected by the *Canal de Navarra* modern irrigation project. For the development of the questionnaire, the research assistants and I followed an iterative process. First, I conducted four pilot questionnaires to assess whether the questions were clear and if participants could fully understand them. Improved versions of the questionnaire were re-administered to initial participants, and I gauged their responses regarding comprehension of any alterations. Once this revision was complete, we performed 381 questionnaires between August and December 2013. The objectives of the survey were:

i) To value agrarian soil ES;
ii) To gather detailed information on livelihood assets (human, physical, natural, financial and social information);
iii) To identify the main prosperity challenges farmers faced;
iv) To obtain information on participants' views on modern irrigation, including how it fits with their livelihood strategies; and finally
v) To collect their views on the agrarian institutions that played a key role in their livelihoods.

The survey aimed to cover as many farmers affected by the modern irrigation project as possible. Aguacanal gave me the names of such farmers and which village they belonged to, but due to data protection restrictions I had to search for further contact details in public sources. Based on sample size calculation (Newing et al., 2011) and in order to achieve a 95% confidence interval, I required a minimum of 360 surveys to represent the 2,555 affected farmers in the area. In total 381 household surveys were conducted. Eight were found invalid due to 'missing data' and were discarded in the analysis.

To select participants, probability sampling[17] was followed. Potential interviewees were randomly contacted via telephone to schedule a date to complete the survey. The research team also used face-to-face approach as a common tactic in public spaces such as cooperatives and bars.

The 176-question survey typically took between one and a half hours to complete and, as in the case of interviews, the research project was briefly introduced and consent was orally sought. Surveys were conducted mainly in Spanish but there were also a few conducted in Basque. My mother tongue (Spanish) was spoken by most of the interviewed farmers and Basque was also spoken by one of the research assistants and myself.

Internal quality control procedures were established during a week-long training phase, and allowed me to identify areas for improvement. For example, when questions were identified as ambiguous with potential to misinterpretation, all field staff agreed to a common framing. Corrections to the original survey template were also made to eliminate repetitive information and to revise questions that impeded conversation flow.

As the survey advanced, it became increasingly difficult to find farmers willing to participate because of time constraints or due to their apprehensions regarding the length of the survey – which was noted to them on the phone. Weather conditions also influenced our access to participants. For example, farmers were more available on rainy days and therefore we were able to complete more surveys on that kind of days. Other uncontrollable aspects influenced the research process, such as my role in conducting the survey and my social characteristics (e.g. gender, age). I did not predict the implications of the researcher's gender during the interviews, though it became evident during survey administration that being a woman seemed to be

[17] The underlying principal of probability sampling is that every case – every member of the study population – has a known probability of being included in the sample, and therefore statistically valid inferences can be made from the sample to the overall population (Newing et al., 2011, p. 67).

beneficial in gaining access to farmers, as they were more receptive and trusting toward my female assistant and me in comparison to the male research assistant.

Initially, and unconsciously, we had avoided farmers who were negatively affected by the modern irrigation project. This happened because when we contacted them and explained the purpose of the study they were reluctant to participate on the basis of their limited involvement in and knowledge of modern irrigation. Subsequently, only those still holding land areas declared for modern irrigation were asked to participate. This occurred in the first villages surveyed (Artajona, Obanos, Añorbe, Puente la Reina, Mendigorria, and partly Tafalla all in *Zona Media*). Three weeks into survey administration, I noticed this bias and tried to correct it by deliberately looking for farmers who had been negatively affected by irrigation.

Overall, although we still used a random selection of farmers, we also targeted purposively a wide range of farmer typologies among those in the list provided by AguaCanal including landowners, retired and active farmers, and members of working cooperatives – i.e. farmers that labour other owners land in exchange of a salary. It became apparent it was an emotionally charged process, and many farmers still refused to participate, as they had previously lost lands. For instance, two participants started crying during the survey, and several people became angry on the telephone when I explained my research, reporting they did not wish to recall bad memories.

3.3.2.1. Soil ES valuation: Likert scale and Pebble method

The importance of ecosystems is approximately divided into three types: ecological, socio-cultural and economic (De Groot et al., 2002a). Ecological value encompasses the health state of a system, measured with ecological indicators such as diversity and integrity. An economic approach may operate through market prices that exist for some ES, especially for provisioning services such as crops. However, it has been estimated that more than 80% of the values of ES are not captured in markets (e.g. Costanza et al., 1997; De Groot et al., 2002). In these cases, indirect economic methods can be used (e.g. avoided damage cost methods (for regulating services), and hedonic pricing and travel cost methods (for some cultural services such as aesthetically pleasing landscapes) (De Groot et al., 2002a). This economic approach is considered adequate for conventional market-based commodities[18] but not that convenient when dealing with other types of ES (Martín-López et al., 2014; Pritchard et al., 2000).

[18] Commodity is defined as an exchangeable unit of economic wealth ("Definition of 'commodity' | Collins English Dictionary," n.d.).

Finally, there are socio-cultural methods (see Section 3.3.2). These are used in this dissertation because they go beyond utilitarian values and permit to explore other types of agrarian ecosystem values (Chiesura and De Groot, 2003; De Groot et al., 2002b; Turner et al., 2003), including the importance people give to, for example, the cultural identity and the degree to which identity is related to ES. The first two sections of the questionnaire (see Appendix V) were designed to capture the extent to which respondents valued agrarian ES and why.

First, I used a Likert scale design (Belin et al. 2005) and presented 27 statements about ES that had been previously identified during the first round of interviews. The design mixed both positive and negative statements as well as agrarian ES categories; farmers were asked to rank every statement between 0 and 5, depending on the degree to which they agreed or disagreed with the statement provided (0 = total disagreement; 5 = total agreement) (Calvet-Mir et al., 2012; Langemeyer et al., 2015) (see Section 5.3.2. for results). Farmers often highlighted which of their land management practices were critical in the provision of certain agrarian ES even if this was not directly asked. I instructed the research assistants to systematically quantify every time they mentioned a co-production effect (see Section 5.3.3). We also recorded the underlying reasons for the valuations and whether the respondents' preferences attended to holistic or individual inclinations.

With the Pebble method, participants had to distribute 15 stones among 16 image cards that represented links between agrarian ES and HWB dimensions (Colfer, 2005; Langemeyer et al., 2015). In this case, the expressed importance was relative, where the distribution of pebbles indicated the weight of the agrarian services values across the image cards. The number of pebbles distributed represented the importance allocated to each agrarian service, leaving zero stones when they did not attribute any importance to such service. We performed the exercise two times. First, participants valued each type of agrarian ES (e.g. 15 stones were distributed across all the *provisioning* services) and then participants distributed the 15 stones across all the agrarian ES-HWB image cards (see Section 5.3.2. for results). We chose the number of stones, fifteen, as it was manageable, and a multiple of the number of categories in which agrarian services were bundled.

The scale utilised (the number of possible 'agreement levels' in the Likert method, and the number of stones to distribute as within the Pebble method) influences the results. The larger the scale, the more precise the valuation of services is. However, uncertainty increases when the number of categories to choose is high.

Figure 3.6 Respondents executing Pebble Method Valuation

The execution of this exercise required patience and deliberate explanations. In very few cases (between two to four), some elderly participants warranted assistance; we discussed with them the number of stones assigned to each card, and when agreement was reached, we distributed the stones and waited for their confirmation for final distribution.

The Likert scale offers an absolute valuation, while the Pebble method deals with relative (comparative) valuation, among and between AES categories. Although Likert is designed for valuation, in practice I found responses rather corresponded to whether farmers agreed or disagreed with presented statements and normally assigned extreme values. A service may be highly regarded but does not necessarily mean it is valued when forced to choose - as evidenced when I presented all the cards and participants were asked to distribute the stones. Therefore, the relative valuation through the Pebble method provided richer information since clearer preferences were revealed.

I acknowledge that asking surveyed individuals to rank a service based on a pre-written positive statement could introduce a bias in the score provided. Therefore, my results might overvalue positively stated agrarian services and undervalue the negatively stated ones. Moreover, some concepts (e.g. the agrarian ecosystem capacity to absorb pollutants) were difficult to understand and this might have had an influence on the results. Combining both valuation techniques allowed respondents to consider agrarian ES while providing me further insights on the co-production of such services.

3.3.2.2. Quantitative data analysis

After manually performing data cleaning via Excel, I analysed quantitative data from the survey using the R statistical software (R i386 3.1.2.), and assigned a code for all the questions of the questionnaire. When allowed more than one response, I separated the questions into the number of possible responses and assigned *dummy* codes[19] (Yes/No responses option). There were six open questions for which I gave *categorical* codes.[20] Some numerical continuous variables were grouped into categories, and histograms were made to illustrate equilibrated categories in terms of the number of participants within each category, aligned with expert criteria (e.g. minimal land area to install irrigation). Questions with too many missing values were removed before data analysis. When there were few missing values (e.g. <ten missing data) it was retained, but respondents with missing values were removed from the analysis of such particular variable. Thus, the results of the dissertation rely on 364 respondents of the 381 total surveys performed.

Answers that were difficult to interpret were also discarded. For example, when the survey asked whether or not the respondent would request financial help from family members or friends, an answer could have several interpretations. Answering ‘no’ could mean they would not ask for it or that they had never received such help. It was also difficult to interpret a question about chronic illness since answers reflected a wide range of more or less acute illnesses, from back-pain to a missing arm.

‘Don’t know’ answers were categorised according to the type of question. In questions where not knowing the response was relevant within the field, the ‘Don’t know’ answer was kept as a response category; in the rest of responses, respondents were eliminated if there were less than twenty cases. If there were more than twenty, the question was deleted.

Likert scale and Pebble method valuation data analysis

In the case of the Likert scale valuation exercise, I analysed 18 statements instead of 27, as I realised I had made the mistake of showing sentences discussing benefits rather than services. Additionally, ‘Don’t know’ answers were treated in two ways. On one hand, in four cases I added the mean value of respondents’ valuation to the ‘Don’t know’ answers. Doing so meant keeping the rest of values attached to other services equal - not affecting therefore the general result. On the other hand, I also made the analysis computing the ‘Don’t know’ answer as an added category to catch the uncertainty and discern which types of services were not clearly perceived. Regarding the Pebble relative valuation, I removed three of the cards values (income, employment and happiness since they were considered benefits rather than services) and those values were proportionally distributed among the rest of services that had weights attributed.

[19] A dummy variable, in statistics and econometrics, is one that takes the value 0 or 1 to indicate the absence or presence of some categorical effect; this is Yes/No responses options.

[20] A categorical variable (sometimes called a nominal variable) is one that has two or more categories, but there is no intrinsic ordering to the categories.

Participants were classified based on the type of land management they performed. For this purpose, I included the type of crop, water consumption system, type of fertiliser (organic, mineral or mixed), size of the worked plots, and time invested in working the land (professional, hobby or household nourishment). These variables influence the land management intensification regimes (e.g. the type of crop is linked with water requirement levels; maize, for example, needs to be intensively irrigated compared to vineyards). Crop rotations also impact higher or lower harvest levels, in the same time and space. Additionally, surfaces of crop fields also are indicative of possible use of large machines.

Grouping and characterising process

I performed a Hierarchical Cluster Analysis (HCA) to identify groups of participants (so-called clusters) that shared particular characteristics, which were in turn dissimilar to those of another group. This technique is sequential; in the first phase, each case acts as a separated cluster, while in a second phase most similar groups (clusters) are grouped. The clustering process continues until a unique cluster that encompasses the whole sample is created. Groups are created as a function of a distance matrix. Cluster centres are defined, and the distance to another group is calculated from the centre of that group to the centre of the nearest group, such that the squared distances from the cluster are minimised. The closer the clusters are, the more similar they are in terms of land management.

Figure 3.7 below sets an example. The lower part of the figure represents the whole sample formed by *a, b, c, d, e* and *f* cases; a single cluster group. They are then separated according to their dissimilarities and I can discern that *a* is different to the rest of the cases. In the next iteration, I can differentiate *b* and *c* from the rest, and the process continues separating the cases until they all are individual cluster groups. I further characterised the clusters according to remaining socio-demographic features, by performing a Multiple Correspondance Analysis[21] to identify the variables explaining the highest variance.

[21] Multiple Correspondence Analysis (MCA) is based in the same foundations of Principal Component Analysis (PCA), but is used for qualitative analysis. It allows for a reduction of data dimensions, which is used to analyse the dependency and independency relations of categorical variables in a contingency table. It summarises the information of columns and rows in such a way that the projection of them on a reduced space simultaneously represents their points allowing conclusions about ordinal and nominal variables to be obtained (Nenadic and Greenacre 2007).

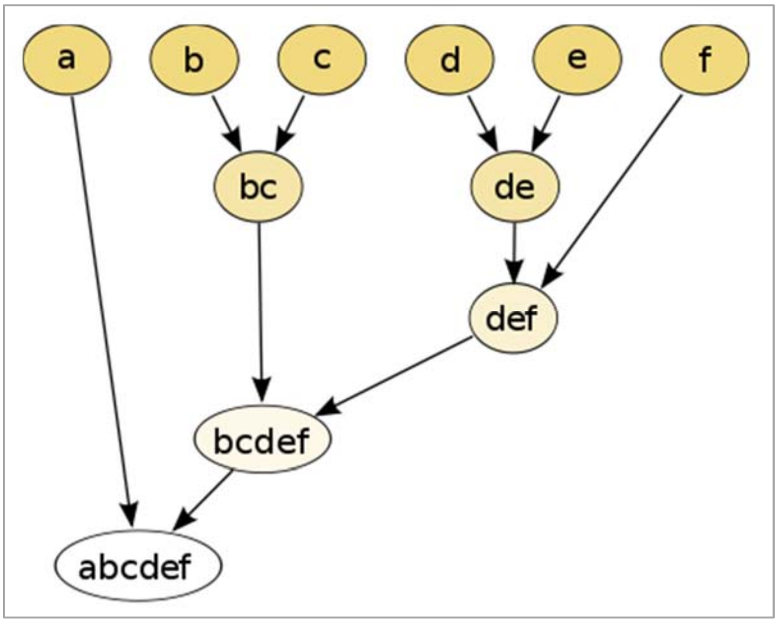

Figure 3.7 Hierarchical cluster analysis (HCA) representation[22]

To determine how agrarian ES were valued, I first calculated the mean values for the answers provided by respondents in each valuation-related question. These values were then ordered from highest to lowest and compared graphically. Dispersion measures such as variance were also contemplated to find out which connections were perceived most differently by respondents. These results were better interpreted with the qualitative information elicited by the exercises in which respondents provided motivations behind their answers.

Trade-off analysis

I conducted *trade-offs analysis* using ordination multivariate analysis to understand how multiple response variables were simultaneously related to one or more predictor variables. Principal Component Analysis (PCA) was used on Pebble valuation data. PCA creates vectors, or scores that explain how variables relate to each other. Such components encompass a combination of variables through a linear transformation using other coordinates for the original dataset. This method captures the highest variance of the sample in the first component. Since principal components are fewer than variables there is an accumulative error in the matrix, so that working on these vectors means working on an approximation of the real data. However, working with fewer variables means that data analysis is easier to handle, and more understandable, as it focuses on just the most informative variables.

[22] Example consulted in October 2015 at <https://es.wikipedia.org/w/index.php?title=Agrupamiento_jer%C3%A1rquico&oldid=82728752>.

Selecting the number of components is based on Kaiser criteria; that is, the selection of the components with eigenvalues higher than one. Results are discussed in terms of component scores (transformed variable values corresponding to a particular data point), and loadings (the weight by which each standardised original variable should be multiplied to get the component score). Principal components are guaranteed to be independent if the dataset is normally distributed. However, normality is not a requirement. Standardization was not made due to being in a similar scale (0-15).

Valuation differences analysis

Finally, I explored if there were significant valuation differences among the existing livelihood groups. In doing so, I used three different types of tests depending on the nature of the compared variables. When both variables compared in the same sample were categorical, I used the *chi-square test* to check if there was a significant association between those variables or if they were independent of each other (see Section 5.3.4). The *Spearman test* was performed when the co-relation test was applied to two continuous variables with no normal distribution. These tests allowed me to determine the variables that were significantly different across livelihood groups.

Finally, the *Kruskal-Wallis test* was used to understand if there were significant differences regarding the valuation of agrarian ES attributed in the Pebble exercise (Martín-López et al., 2012). The *Kruskal-Wallis* test is a non-parametric method for testing whether samples originate from the same distribution. It is used to compare more than two samples that are independent, or not related. This test does not assume a normal distribution. The method behind the test is a ranking of all data from all groups together. The algorithm is influenced by the number of observations in a group (364 in my case) and the rank among all observations of variables.

Since I made this comparison among four livelihoods, I decided to apply a method called *False Discovery Rate* (FDR) control, to counteract the problem of multiple comparisons (Brown et al., 2006). In this case, when the number of variables is high, there are more possibilities of significance by chance. For this reason, p-values are normally adjusted to a more restrictive p-value.

3.3.3. Livelihood Vulnerability Index

Indicators are quantifiable constructs that provide information on matters of wider significance than what is actually measured, or on processes or trends that otherwise might not be apparent (Vincent, 2004). In addition to being used in their own right, indicators can be aggregated to form indices, leading to a more comprehensive model of reality. We must consider that they are simplifications of reality and sometimes may not be valid.

I adopted a two-steps approach when developing the Vulnerability Index (VI). Firstly, the VI is expressed as a composite index comprised of seven major components, while this is later aggregated into three contributing factors to vulnerability: adaptive capacity, exposure and sensitivity, following the Intergovernmental Panel on Climate Change (IPPC) guidelines (IPCC, 2007b). Following Hahn et al. (2009), I used primary data from household surveys to develop VI and derived a generic vulnerability metric by translating a general definition of vulnerability into a mathematical expression. I characterised farmers' sensitivity and adaptive capacity using sustainable livelihoods assets (natural, social, human, physical and financial) and integrated exposure in order to comprehensively evaluate livelihood risks (Hahn et al., 2009). For simplification purposes, only final (aggregated) results are shown in Section 6.4 but disggregated results can be found in Appendix VIII, which allow a better understanding of the vulnerability results - i.e. whether a low level of adaptive capacity is due to lack of technology or reduced social connections for instance.

Farmers' testimonies were taken into account to understand if a given variable influenced, whether positively or negatively, the sensitivity and adaptive capacity of stakeholders in the local context. To calculate exposure, the survey provided evidence that crop prices volatility, and climate variability were the respondents' main perceived stressors. The statistical dataset (Gobierno de Navarra, 2015b) provided me with long-term climatic empirical measurements.

Farmers' exposure to climate variability was measured by average calculations conducted by Navarre's government. I analysed two climatic related stressors. For the climate variability calculation, the average standard deviation of the maximum and minimum monthly temperatures and monthly precipitation[23] (Ahmed et al. 2009; Hahn et al. 2009). For estimating the hydric deficit, I substracted evapotranspiration to the average rainfall. Data from seven stations were used (Caparroso, Falces, Miranda de Arga, Olite, Puente la Reina, Tafalla and Ujue) and assigned to the closest meteorological station to the village where each interviewee lived/worked. On average the stations provided a data series of eighty-nine years (1920-2009). I acknowledge that different crops have diverse growing periods, and the phases of their maturation have differentiated importance, but using annual averages was better suited to analyse four crops simultaneously.

[23] In order to understand whether climate variability was actually variable, we compared standard deviation of 30 years with the mean standard deviation of a larger period (80 years).

Prices volatility is the third analysed stressor. For each crop, data on prices and yields production were compiled for the region, using data provided by the Department of Agriculture of Navarre. The standard deviation for each crop was calculated for the period 1995-2013. Before doing this, it was important to subtract the inflation effect of the years prior to 2013, which was done using the annual average consumption prices index (Instituto Nacional de Estadística, 2015). Mean price divided by the standard deviation gives a ratio that can be compared with the mean annual inflation to interpret whether those fluctuations have a strong effect on the household economy. The standard deviation of crops prices was used to calculate exposure to prices volatility.

Subcomponents of adaptive capacity and sensitivity were selected through a review of the literature on sustainable livelihood assessment (SLA) (Ahmed et al., 2010; Eakin and Bojórquez-Tapia, 2008; Hahn et al., 2009; Haile et al., 2013; Ifejika Speranza et al., 2014; Notenbaert et al., 2013) (see Section 6.2.2 and 6.2.3) and recorded during fieldwork through data collection. I also discussed their influence on households' sensitivity and adaptive capacity with other experts and the farmers themselves.

Adaptive capacity was quantified based on a number of variables. For human features, I included knowledge through the academic level of studies, including agrarian-related studies, or years of experience. Socio-demographic variables were accounted for through age, gender and number of family members working on the same farm. Financial status was considered through the percentage of owned and rented land, the subsidies perceived (CAP, modernisation and irrigation) and the number of agrarian insurances (integral, hail and others) farmers regularly contract. Physical assets were counted, such as internet use and if they had installed modern irrigation. Social networks referred to farmers' participation in specific organisations, as an important means for information exchange.

Sensitivity was measured by assessing the current state of the household and the stressors' effect on the agro-ecological system. Indicators included the level of crops diversification, the number of economically dependent family members, and the cultivated hectares of maize – a crop that is more dependent on irrigation than others in the region.

The VI uses a balanced weighted average approach (Hahn et al. 2009) where each sub-component contributes equally to the overall index, despite each major component being comprised of a different number of sub-components. Once I had selected all the variables (sub-components) classified by each component, I normalised them as an index: Y = (value - min)/(max. – min.), where Y denotes an indicator of ES (Albizua et al. 2015; Hahn et al, 2009;

Yagiz & Gokceoglu 2010). Having standardised the sub-components, the same weight was given to each of the components:

$$CF= \sum_{i}^{n} WMiMi \ / \ \sum_{i}^{n} WMi \qquad (1)$$

CF is the IPCC-defined contributing factor (exposure, sensitivity, or adaptive capacity). *Mi* is the major components index. *WMi* is the weight of each component, and *n* is the number of major components in each contributing factor. Once exposure, sensitivity, and adaptive capacity were calculated, the three contributing factors were combined using the following equation:

$$VI= (E - AC) * S \quad (2)$$

The VI is the VI expressed using the IPCC vulnerability framework. E is the calculated exposure score to the main stressors (equivalent to drought, prices and climate variability). AC is the calculated adaptive capacity score (the weighted average of the socio-demographic, knowledge, physical, financial, and social networks major components), and S is the calculated sensitivity score (the weighted average of family members economically dependent, maize area and crops diversification).

The VI was calculated twice with regard to the three main stressors, including a slightly different selection of variables for the main components in each case depending on whether it was a climatic or a market-related stressor (see Section 6.4 for further details). The index aggregates all the information into a single score. Assessing the components separately allows for understanding the relative importance of each component in relation to farmers' vulnerability and why some farmer groups are more or less vulnerable. Finally, I used again the *Kruskal-Wallis* test to understand vulnerability differences between farmers' groups (see last part of Section 3.3.2 above).

3.3.4. Focus group discussion

Miranda de Arga was an interesting case because it had held a non-binding referendum in June 2014 to explore farmers' views about adopting the *Itoiz-Canal de Navarra* project in their traditionally irrigated lands. It resulted in more votes opposing modern irrigation than votes in favour. However, another voting process in December 2014 revealed that the majority was in favour of modern irrigation transformation. By this time some owners had already sold their lands. On 4th June 2015, I conducted a focus group discussion in the village of Miranda de Arga to analyse the institutional changes induced by the modern irrigation project.

The focus group was developed to complement the information gathered during the second round of interviews. A focus group allows participants to engage in discussions and the researcher to learn from the various views and opinions on a certain topic (Bryman 2004; Liamputtong 2011). Participants were recruited using purposive sampling based on farmers' profiles, which were simultaneously based on their livelihoods strategies– i.e. their land management practices. Seven participants initially committed to the group, though ultimately five people partook: two members of the traditional irrigation community (eventually members of the modern irrigation community), a local environmental activist, an owner who refused to make the transformation, and an INTIA technician who led the village's involvement in the *concentraciones de tierras* and the resulting land redistribution process.

Throughout the focus group, which lasted around 6 hours, I attempted to ensure a balance between participants' potential views concerning modern irrigation. I also remained cautious of possible confrontation between participants, since there was uncertainty and tension in the village concerning the distribution of re-classified lands across affected farmers. I considered carefully the impact of participants various views on particular topics, and the potential exposition of vulnerable individuals to others. I spoke with each participant in advance, to help him or her feel more comfortable during the focus group. Additionally, I sent an email beforehand including the program and list of participants, which allowed them to consider issues and the opportunity to reflect on possible responses for the discussion (Barbour 2005).

As the location of a focus group can influence the discussion (Barbour 2005), I tried to find a neutral location. Thus, the public library of Miranda de Arga was selected, as none of the participants had differential attachment to the place. I invited a master's student and a friend to take notes and help facilitate the focus group, while I moderated the unfolding discussion. Analysis of the material was very similar to the second round of interviews; I transcribed the workshop and then coded a hard copy by hand.

3.3.5. Document analysis and participant observation

In addition to the data collected through interviews, the survey and the focus group, I collected data from key policy documents and media concerning the case study prior, during and after the fieldwork. These documents provided very rich information about the irrigation project's goals, and agricultural challenges and opportunities. Most of these documents were sourced from online newspapers, inter-scale government websites, websites of other associations, and the affected individuals themselves. They are cited throughout the dissertation as appropriate.

Finally, in social science and ethnographic research, participant observation is often cited as a complementary method to interviewing (Bryman 2004; Denscombe 2003). Ethnographies imply researchers' emersion in people's lives for an extended period of time, making regular observations about their behaviour, participating in conversations and interviewing informants on issues which are not directly amenable to observation. Ethnographies are often used by sociologists and social anthropologists to ascertain the specifics of social behaviour in a particular culture (Bryman 2004: 292-294).

Informal conversations with households and observations of people's daily activities were documented during a five-month period. Active participation took place, primarily during one week in December 2013. I visited different types of managed plots, including some multi-functional organic farms, where I helped manually harvest olives. Famers described to me other connected activities they conducted, such as rural tourism, environmental education, or natural pollination of their plots. I had the opportunity to share meals with several of the interviewees over the four months I was conducting the survey, allowing for informal conversations and insight to how community households managed their natural resources, perception of future rural development, and viewpoints on how the modern irrigation project influenced their livelihoods.

When I participated in workshops about irrigation, I tried to engage in social activities surrounding these events. For example, I actively participated in the annual meeting of *Nueva Cultura del Agua* in May 2012, as well as a seven-day kayak experience along the Ebro River with this group in July 2012, and other local meetings in the winter of 2013. Whenever possible, I attended formal and informal talks ranging in topic from modern irrigation and how the reform of the CAP affected farmers and nitrate water pollution in Navarre. I was also present at the plenary when the *concentraciones de tierras* were presented to owners in the village of Larraga.

Participant observation and interviewing is critical within ethnography, initiating access to local settings, local households and people's lives. As noted earlier, interviews allowed me to establish contacts with the NGO *'La Nueva Cultura del Agua'*, which allowed me to meet other social actors and key individuals. One of the NGO members helped me find a house during the fieldwork period, and the owner of the house then introduced me to several farmers. Participating in farming events and talking to farmers in the village bar was interpreted as a sign of respect and admiration for rural life and their customs, which increased farmers' confidence with me.

During the first round of interviews, I contacted one of the major cooperatives, where many area farmers are involved, 'Cooperative of Artajona', which also allowed for rapid access to its members. Gaining access to farmers not enrolled in the cooperative was more difficult and time-consuming, and only became possible through the database of certified organic farmers published online by Navarre's government.

Figure *3.8* summarises the research preparation and fieldwork periods, and includes detail on the methods used, sample size, and the chapters that the resulting data inform.

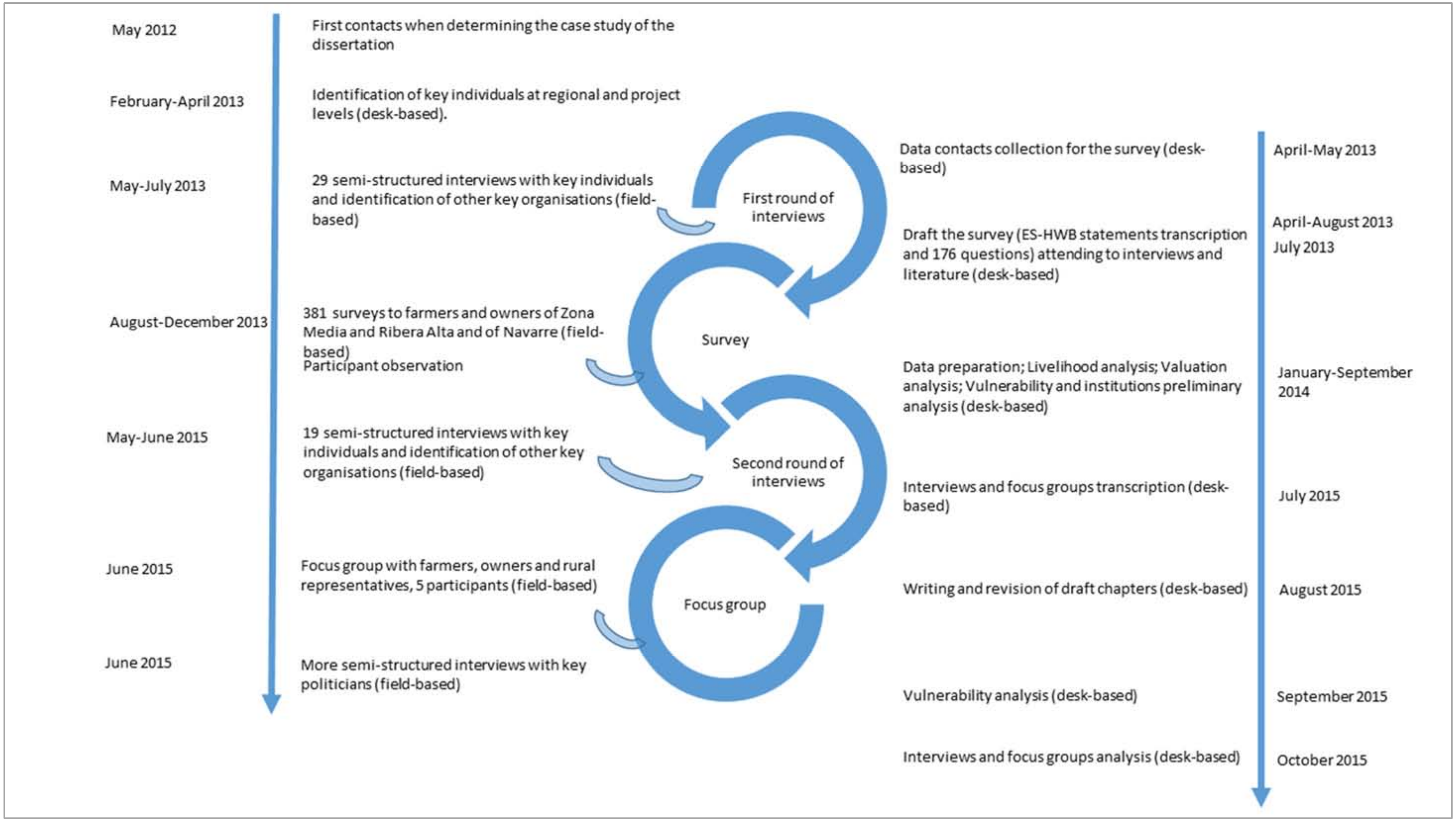

Figure 3.8 Desk-based and fieldwork periods

Table 3.1 Summary of methods used in each chapter

	Chapter 4: Livelihoods in Navarre	**Chapter 5: Perception and valuations of agrarian ES**	**Chapter 6: Vulnerability analysis in rural Navarre**	**Chapter 7: Institutional analysis to understand rural vulnerability**
Interviews and surveys	First round of semi-structured interviews and survey	First round of semi-structured interviews and survey, (Likert scale and Pebble method valuation)	First round of semi-structured interviews and survey	Second round of semi-structured interviews, focus group and survey
Target	Key informants and farmers	Key informants and farmers	Farmers	Key informants and farmers
Sampling method	Snow-ball and stratified random	Snow-ball and stratified random	Snow-ball and stratified random	Snow-ball and stratified random
Size of the sample	29 and 381	381	381	19 and 5
Combination of approaches	Triangulation of literature review, interviews and survey	Triangulation of literature review, interviews and survey	Triangulation of literature review, interviews, survey and participant observation	Triangulation of literature reviews, interviews, survey and participant observation

3.4. Research ethics

As researchers, we have individualised styles of approaching the scientific process, as influenced by our experiences and perspectives. This inevitably affects the data we produce (Scheba 2014) and it is thus imperative to reflect on our role and identity as researchers and how these influence the knowledge we seek and produce.

During field research I considered myself a student; conducting fieldwork in rural Navarre for my PhD studies at the Universitat Autònoma de Barcelona and the Basque Centre for Climate Change (BC3) in Bilbao. This, however, was not always how villagers perceived me. Sometimes, given the questions asked, they identified me as a government officer on an irrigation control routine. Often, women mistrusted my intentions and discouraged their husbands to participate in the survey. When initial contact was made via telephone, many people were impatient and rushed to hang up before I could finish introducing myself. I had to be skilful in my communication abilities to evade these situations, and was much easier when approaching farmers in person.

As it was a divided society (in favour and against modern irrigation), I tried my best not to align myself with either position, whether verbally or through my actions. For example, I did not disclose where I was staying overnight and tried to maintain a low profile in the village. Over time, most of the participants viewed me as a PhD student conducting research. Some of them were willing to cooperate based on their own son or daughters' similar experiences. After five months visiting villagers I developed a friendship with some individuals. In most of the workshops I participated in, some affected stakeholders were clearly positioned against irrigation, whereas certain friends I had made were involved in local political parties, and openly showed their affiliation. Although I attempted to remain ideologically neutral when participating in village affairs, a few villagers may have associated me with certain political positions. I tried to counteract this by not supporting specific parties during political discussions, by intentional conversation, and creating relationships with people from all parties and backgrounds during my fieldwork period.

Ethical considerations are vital to any research as the rights and interests of research participants must be respected and protected throughout the research period (Newing et al. 2011; Scheba 2014). During fieldwork, the main ethical concerns was transparency regarding research objectives, ensuring farmers provided informed consent, and offering a guarantee of confidentiality and anonymity. It was also key to ensure that farmers understood they had the right to drop out the interview or the survey at any time. I explained to each interviewee that all information collected was to be used for my PhD studies, and that nobody else would have access to the data. As noted earlier, it was emphasised that recording some personal data was useful for future contact. Whenever I made the survey or conducted participant observation I explained to villagers that they had the right to withdraw, skip questions or not participate at all.

The fieldwork stage was my best experience during the PhD process. Getting to know rural inhabitants' testimonies on how modern irrigation was experienced, how it affected livelihoods, or how rural development policies have evolved over time in Navarre was an incredibly enriching experience. During fieldwork, one of the most difficult tasks I encountered was organising research assistance team for survey administration. It required a lot of time in organisation, mentorship and supervision. I also realised too late the importance of asking 'just' the necessary questions to shed light on the overarching research questions. During the first few months, I tried to cover too much. Most interviews extended beyond what were strictly necessary, which provided me with more knowledge but complicated data analysis. I also realised, quite late into the process, that the survey was too long and interviewees got tired quite easily. It contained too many qualitative questions, which were time consuming during administration, processing and analysis.

Budget limitations and lack of awareness about possible unexpected delays made fieldwork less pleasant than it could have been. I did not have enough time to mentally and physically recover in between village visits, which left the research assistance team and me rather exhausted after fieldwork. I also did not account for aspects such as the fact that much of the surveyed population, with hearing difficulties, could be slow in understanding the interview and survey questions, which inevitably translated into lengthier and thus more tiring conversations.

3.5. Summary

This chapter has presented the research strategy and the methods employed to answer the research questions. The research adopts a case study approach and utilises a combination of qualitative and quantitative methods. These methods are suitable to capture farmers' values of ES, and to perform the vulnerability and institutional analyses proposed in the theoretical framework.

Semi-structured interviewing allows the researcher to involve a range of individuals and organisations within the research process, and to obtain information related to survey design and contextual factors relevant to interpreting the results. Semi-structured interviews are complemented by document analysis, in both policy and project contexts, and by participant observation at the community level. Household surveys are the core tool for analysis, and are used to understand the types of livelihoods co-existing in the study area, how participants value the agrarian ES, and to what extent they are vulnerable to current stressors affecting their livelihoods. A second round of interviews and the focus group exercise allowed me to gain a better perspective of *why* and *how* land management intensification affects rural socio-ecological systems.

The next empirical chapters document how the process of land management intensification induced by the modern irrigation project in the study area shapes local livelihood strategies, influences farmers' perceptions and values of ES, determines local vulnerability and adaptive capacity, and results in new water management institutions that benefit some farmers more than others.

CHAPTER 4

"Livelivelihoods beyond income"

Fernando Hernandez Espino

4. Livelihoods in rural Navarre

4.1. Introduction

This chapter highlights and discusses farming livelihood characteristics in the case study site. It addresses Research Question 1, i.e. *What combination of capital assets is associated with particular livelihood strategies in Navarre?* The chapter examines the different means of subsistence, economic activity and social composition of the case study households and demonstrates how farmers respond to markets and to a new agricultural technology, i.e. modern irrigation. The chapter also highlights how livelihood assets are connected to land use and management intensities and how such connections mediate farmers' agricultural strategies. Specifically, the chapter illuminates how farmers respond to irrigation through their livelihood strategies choices.

Adding to the abundant literature on SLA (see Section 2.2), this chapter contributes to debates of how natural, financial, man-made, human and social assets are transformed strategically by different types of farmers and whether technological changes lead to asymmetrical environmental and social outcomes among the existing livelihoods. I clarify the configuration of the different livelihoods present in *Zona Media and Ribera Alta* of Navarre, contributing to the debates about rural development through modernisation associated with intensive transformative processes. The data mobilised in the chapter are largely drawn from the quantitative survey described in Section 3.3.2. These quantitative data enable to assess numerically the differences and similarities of livelihoods characteristics within the sample, in the case study region under transformation.

First, as **Figure 4.1** illustrates, I contribute with a general description of the five assets (Section 4.2) identified in this case study and some brief insights of the current institutions shaping access to the assets (Section 4.3). The livelihoods strategies are analysed in Section 4.4, with a focus on land management. Section 4.5 describes the classification of livelihoods according to land management strategies, while the livelihood outcomes related to modern irrigation adoption are also analysed and Section 4.6 contributes to the discussion of the existing strategies and their alignment with current institutions promoting the modern irrigation model. Finally, in Section 4.7, some key messages are drawn regarding the way modern irrigation infrastructure is determining the type of livelihoods and land management strategies.

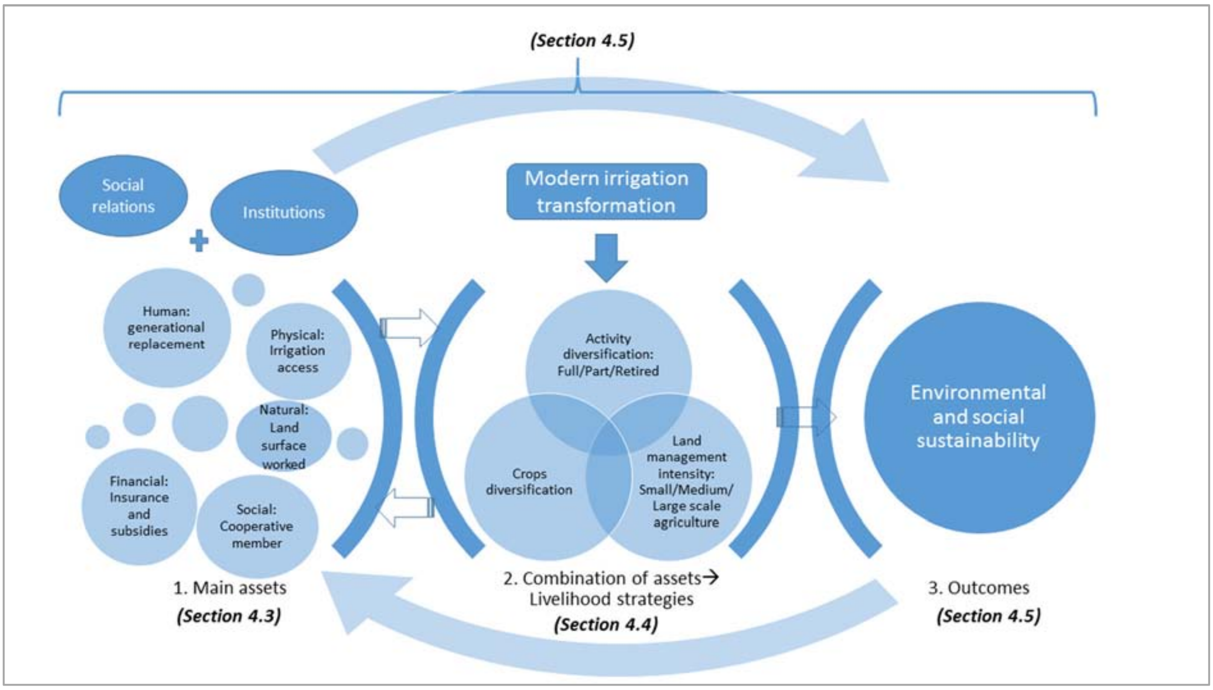

Figure 4.1 Steps of the analytical process

Figure 4.1. expands what was shown in **Figure 2.3** of the conceptual framework and synthesises further the SLA analytical framework. The combination of the five assets (human, financial, physical, natural and social) and context-dependent features (step one) influence the existing livelihood strategies. Livelihood strategies also affect those assets, e.g. a new technology introduction may require less human capital and more financial investment. Thus, I consider assets and strategies as holding bi-directional interactions. Livelihood strategies (step two) are compiled by stakeholders' labour diversification, crop diversification and the level of intensification of land management practices. As a result, livelihood sustainability can be assesed in terms of enviromental sustainability and social security (step three). This last step is assessed through land tenure shifts. This information is all combined in Section 4.5.

4.2. Socio-demographic features, assets and institutions in the study area

In this section I quantitatively characterise the diverse socio-demographic variables and assets by means of different proxy variables. The aim is to briefly describe the main features of the inhabitants of this area who participated in the survey. Appendix VI compiles a list of tables with this information in a more detailed and disaggregated way.

4.2.1. Socio-demographic characteristics

Before describing the five livelihood assets (human, financial, physical, social and natural), I briefly characterise some socio-demographic features relevant for livelihoods development. Age, gender and residence of farmers are aspects that may strongly influence the capacity of agents to put their assets into action (Swyngedouw, 2009). For example, age and gender strongly influence farmers' participation in social networks (Antwi-Agyei et al., 2013; Campos, et al., 2014). Location of the village may also determine farmers' alternative income sources as being closer to large cities or towns with factories can present higher employment prospects in other sectors. The majority of the farmers in the area were older (66% were older than 55 years) men (95%), similarly distributed over the whole case study area; they belonged proportionally to the northern, mid and southern areas of *Ribera Alta* and *Zona Media* of Navarre.[24] **Table 4.1** summarises the variables used to describe the socio-demographic features and categorises the five capital assets measured in the case study.

Table 4.1 Socio-demographic and capital assets

Socio-demographic		Description
	Age	Farmers' years
	Gender	Whether the house-head is male or female
	Residence location	Village respondents belong to
	Capital assets	
Human	Knowledge	Level of studies
	Work experience	Years farming
	Total number of members in the household	Number of people living in the same household
	Generational replacement	Whether sons or daughter will keep farming in the future
	Number of member working in the farm	Number of people belonging to and working in the farm
	Number of members economically dependent	Number of people in the household who depend on the head in economic terms
	Number of member who had emigrated	Number of people who used to live in the household but moved to another country / city
Financial	Subsidies	Economic aids
	CAP	European subsidies given per land area
	Modernisation	Navarre government subsidy to modernise the farms
	Irrigation	Navarre government subsidy to install modern irrigation
	CUMA	Cooperative to share agrarian machinery

[24] This is due to a methodological construct already explained in chapter 3, Section 3.3.4 'Household survey design'.

	Cooperative	Organisation to store crops, sell them, get advice and buy agrarian inputs at a better price
	Insurance	Coverage under a contract in which one party agrees to compensate another for a loss
	Integral	Insurance that covers a variety of events such as climatic stressors, animals attack etc.
	Hail	Insurance that covers hail damages
	Others	Other kind of insurances
	Financial aid from family / friends	Borrow money from family or friends
Physical	Irrigation access	Whether farmers can irrigate (traditional, modern or any other way)
	Modern irrigation installation	Whether farmers have adopted modern irrigation in their lands
	Machinery	Whether farmers own or rent machinery
	Internet	Whether farmers access and use Internet with agrarian aims
Social	Cooperatives	Whether farmers participate in agrarian cooperatives
	Agrarian workers' union	Whether farmers participate in agrarian syndicates
	INTIA advice use	Whether farmers use INTIA's advice services
Natural	Land Owned Rented	 Ownership of land Payment made to the owner of land for the right to use it
Rural livelihood strategies		
Time investment	Farmer profile	Whether farmers employ full tim to farmng or whether they have other income sources in the household
Commercialising type	Work for agro-industry	Whether farmers access this kinds of agro-contracts
Land management	Fertilisation type	Type of fertiliser used: organic, mineral
	Irrigation system	Whether they irrigate crops or not
	Type of crop	Hectares of each crop
Social outcomes		
	Buy more lands after irrigation	Land purchasing outcomes
	Rent more lands after irrigation	

4.2.2. Human capital

Regarding education, most farmers in the case study (63%) held basic education. Of these, 50% were full time farmers, while 30% were retired. Thirty-five percent of the farmers had coursed higher education degrees, 16% in agrarian related studies. Work experience also contributes to agrarian knowledge. In this regard, 40% of the farmers had been working in the sector for over 30 years.

I also considered the number of skilled workers in the farm. This is influenced by the dependency ratio and their health status (Hahn et al., 2009; Notenbaert et al., 2013; Ifejika Speranza et al., 2014). I found that 55% of the farmers had at least one family member who was economically dependent on the household. Ten percent of the respondents stated that a member of their family had migrated to work outside the country. In line with other studies (Gómez-Limón et al. 2009), the case study sites are characterised by low generational replacement rates in agriculture; farmers may not be able to depend on their sons and/or daughters to continue with farming activities. Although 69% of families surveyed had between two and four members in the household, 64% reported they could not depend on generational replacement, 21% reported their sons/daughters would continue farming and about 15% did not know what their children would choose to do in the future. This follow-up of their activity strongly determines households' rural strategies such as the type of financial inversions made.

4.2.3. Financial capital

In Navarre, as in the rest of Europe, agricultural subsidies are very important for the maintenance of agrarian livelihoods. Eighty-two percent of survey farmers reported receiving Common Agricultural Policy (CAP) subsidies. Most of the farmers were not aware of receiving FEAGA or FEADER[25] funds, only that they received money per farmed hectare. However, they did recognise whether they received subsidies aimed at modernising their farm or adopting irrigation, which are managed and disbursed by Navarre's government. These subsidies were accessed by 29% and 48%, respectively. Some cooperatives also offered economic aid, similar to those offered by banks, but often with better interest rates (approximately 1.4% in Larraga sector (II.2)). [26] However, just 2% of the farmers stated access to them. Subsidies provided to the cooperatives in order to encourage machinery-sharing (CUMAs[27]) and those for young farmers[28] were received by 5% of the surveyed households. Four percent of the farmers also reported other less common subsidies.

Hail and integral insurances[29] were the most common agricultural insurances contracted in the study area. The integral insurance covered climatic problems such as drought, flood or hail, as well as natural

[25] FEAGA are the Spanish acronyms for Fondo Europeo de Garantía Agraria, Agrarian Insurance European Fund. FEAGA's goal is guaranteeing crops and livestock products and farmers' complementary incomes from the market.
FEADER are the Spanish acronyms for Fondo Europeo Agrícola de Desarrollo Rural, Rural Development Agrarian European Funds. FEADER's objective is preserving the environment meanwhile agrarian economy diversification (Sanjuán and others, 2013).
The name of the subsidies have been changing over the time with the multiple CAP reforms but those terms were shown as understandable in the survey.
[26] Calculation determined from personal communication of the credit in Larraga sector.
[27] Spanish acronyms stand for Cooperativas de utilización de maquinaria agrícola (CUMA).
[28] Young farmers' subsidies are financial aids given to those who install in the sector for the first time.
[29] Integral insurance cover climatic and other kind of hazards such as animal attacks etc.

fires and damage caused by wild fauna (MINECO, 2010). The latter was contracted by 35% of the interviewees, while 42% were covered only by hail insurance. The remaining did not contract any insurance. Overlaps occurred when some stakeholders contracted both insurances. Finally, when farmers were asked if they would approach other family members (outside of the household) or friends for funding in case of need, 82% indicated reluctance in doing so. Responses varied broadly from 'I would not ask for it' or 'I don't trust they would give it to me'.

4.2.4. Physical (man-made) capital

Survey results show that 50% of the farmers already had irrigation systems in place prior to the most recently deployed system based on dripping and aspersion systems. In the past, farmers had relied on traditional irrigation infrastructure (old canals from which fields were flooded and irrigated by gravity), as well as on water wells and ponds (Baldock et al., 2000; Appendix V).

Sixty-five percent of the surveyed farmers reported they had installed a modern irrigation system. 32% reported that they had placed between 10 and 50 hectares under the new irrigation system. This was followed by farmers (25%) working small-irrigated lands (0-1 hectares). However, such small farming plots may indicate two possible situations: respondents may have joined neighbours to keep their land under modern irrigation, or they kept traditional irrigation systems. Among the 65% who had installed modern irrigation, 35% stated they had yet to pay for the connection of the plots to the main drainage infrastructure (such as plot piping system or sprinkler installation). Many of them stated that they were not going to install it in the future. This means they were paying for the possibility of accessing modern irrigation, even though they did not intend to use it. They explained they preferred to pay and preserve their lands rather than being relocated to rainfed lands.

Sixty-two percent of those who adopted the modern irrigation technology relied on a sprinkling system, 50% on drip, and 25% on other types of technology. Citing more than 100% results refers to farmers who relied on more than one type of irrigation scheme. From those who had installed the new irrigation infrastructure, 6% had to share the irrigation water tank with another neighbour (typically no more than one). In doing so, they shared water as well as investment and maintenance costs.

The level of agricultural mechanisation was high among the surveyed households. It was common for tractors to be used in the area for ploughing or harrowing, although not all farmers owned the required machinery. Forty-three percent of the survey respondents rented at least the harvester. Finally, 69% reported having access to Internet, but only half used it to get information about agrarian issues.

4.2.5. Social capital

Regarding farmers' reliance on social networks in learning additional information or techniques on agriculture and related issues, 69% of respondents stated a high or very high grade of agrarian information shared with neighbours or friends. The most remarkable social networks found in the study area were the cooperatives. The influence they have over villagers' agrarian practices and extended social networks was evident during fieldwork. Participation at the cooperatives often influenced communication between neighbours, allowing them to be cognisant of others' situations and choices.

There are several types of cooperatives in the study area: (i) those that store crops and sell seeds, fertilisers and other goods to both farmers and other 'working cooperatives', and (ii) 'working cooperatives', which function similar to enterprises: there are employees who work the members' lands and bring crops to traditional cooperatives to be stored and sold. These types of cooperatives were perceived as a solution to the increasing number of older farm-owners with no generational replacement, and who were unwilling to sell their lands. With regard to cooperatives partnership, 85% of surveyed individuals belonged to one or more cooperative, but only 34% stated active participation within the cooperatives. Finally, 56% of the farmers belonged to an agrarian workers' union and only 8% reported contributing to the union in an active way (in a high or very high degree), e. g. participating in management activities and political decision-making. Eighty-five percent were members of UAGN[30] while the remainder were primarily EHNE[31] syndicates.

4.2.6. Private property that allows control over natural capital

Ninety percent of the farmers owned at least part of their cultivated lands; 30% were full owners, while 60% reported that they partially owned the land they cultivated. Thirty-four percent fully owned between ten and fifty hectares, followed by farmers owning less than one hectare. These data on fully owned and/or managed landholdings and the interviews confirm that Navarre's farmers typically inherit land. Twenty-five percent rented between 10 and 50 hectares of land, while 32% rented less than one hectare. The extension of shared land was typically around 44% and corresponded with plots smaller than one hectare. Rented land was often reported as communal land. Part time farmers and retired farmers were those working the smallest plots, while full time farmers and farm workers worked larger farms (over ten hectares in 80% of cases).

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[30] UAGN Spanish acronyms stand for Union de Agricultores y Ganaderos de Navarra; farmers and ranchers from Navarre Union.

[31] EHNE Basque acronyms stand for Euskal Herriko Nekazarien Elkartasuna; farmers from the Basque Country Union.

4.3. Institutions regulating irrigation water and communal land

As indicated in Section 2.5, institutions regulate the access to assets within the SLA framework, which clarifies the differences in farmers decision-making when securing their assets (Blaikie, 1985; De Haan and Zoomers, 2005).

Institutions are mechanisms by which humans attempt to shape the incentives and constraints governing their interactions with each other and the natural word (Ostrom, 2005). Institutions are therefore social practices based on 'the rules of the game', which is often referred to throughout the literature; but also include common discourses to understand and address the issues at stake, agree with the appropriate behaviour and routine activities to live in community (Young, 2002a).

In this case, I briefly describe the institutions to access communal lands and the private use of public good - water for irrigation. Renting communal land is a common strategy among Navarre's farmers. Access to such land differed depending on the village's location. In general, applicants must be registered in the city council for a certain period and must prove they can work the land (through access to machinery) (Personal communication by farmer #SI1-2). Once they apply for the land, the council distributes sets of plots of varying dimensions (hectares) and for a certain amount of years that varies depending on whether it is rainfed land or an area with access to modern irrigation. If there is land surplus after the villagers' applications, the council normally establishes an auction among neighbours, where anyone may participate.

Modern irrigation transformation was often reported as an important factor to explain the changes in common land availability and the institutions regulating the correspondent access. Village councils were in charge of land attribution. Councils had greater economic aid than farmers for the installation of modern irrigation, so neighbours living in municipalities with large communal landholdings and whose council had invested in the transformation had greater chances to access irrigated lands in the modern system. However, this access was not equal for all the villages since a higher share of land area, as well as larger plots, were attributed to young farmers and full time farmers. The Councils' investments in modern irrigation had also translated into an increase in the rent price and an extension of the time period of the assigned communal lands to the same applicants so that rotation of communal lands among villagers was lower.

In the traditional irrigation system, water for irrigation was accessed according to whose lands were located in the flood area, i.e. the water concession holder owned the land to which the water was allocated to, which meant that the irrigation communities had therefore a collective use right (Water Law, 2001). There were also some communal lands of the council. The river Ebro watershed confederation provided a given amount of water that was controlled through turns, which irrigators had to respect, as not all of them could irrigate simultaneously. These alternations typically began uphill and passed downward.

With the modern irrigation system, a water concession was given to a concessionarie enterprise, after the approval of at least half of the irrigators owning the correspondent land.[32] Sprinkling or dripping automatic systems were generally installed and irrigation could be programmed so that land did not require taking turns, at least during the time in which the survey was performed. Access was dependent on whether they were willing to invest in installing the new system on their plots. This in turn, was sometimes dependent on the extension of land available, since there was a minimum of five hectares to access a hydrant. Thus, financial assets were crucial to invest in buying or renting more lands based on their livelihood strategies. In at least seven villages (Larraga, Berbinzana, Miranda de Arga, Tafalla, Beire, Satacara, Murillo del Fruto (Personal communication by farmer #SI1-13, representing AguaCanal) the adoption of modern irrigation presumed the removal of traditional system access. There may be more villages, though it is still uncertain how the transformation will be made in the extension of the canal.

4.4. Livelihood strategies in Navarre case study

Based on Zoomers' (1999) original work, De Haan and Zoomers (2005) distinguish four categories of livelihood strategies: *accumulation*, *consolidation*, *compensatory* and *security*. *Accumulation strategies* involve establishing a minimum resource base and preparing for future expansion. Such strategies are usually guided by a long-term strategic view of future gaining income (De Haan and Zoomers, 2005). They often include migration, land acquisition and labour recruitment. After achieving a certain level of desired affluence, households might apply *consolidation strategies,* which involve investments to stabilise the household's wellbeing and to improve the quality of life in the short-term. In this scenario, households are typically well-established, with surplus to invest. *Compensatory strategies*, in turn, are executed by farmers coping with a sudden shock, or unexpected impact of a stressor, and poor farmers dealing with managing a structural shortage of land or labour power. These farmers strive to maintain their subsistence through migration, economising, selling capitals, and borrowing and trading, often while using the aid of family and social networks. Finally,

[32]In the case of the enlargement of the irrigation area, the concession was initially given to Navarre governement who later transferred the concession to the general irrigator community when this was not still representative of the owners of the lands transformed. Only a posteriori was this general community representative of the owners holding more than the half of the irrigated area. There is an appeal initiated because of this initial Water Law default.

security strategies include diversification by multiple cropping and multi-tasking, exploring non-agricultural opportunities, sharecropping and stockpiling.

During the survey, I asked direct questions about whether the farmers diversified their labour throughout various activities, specific questions characterising their land management intensity, and also market strategies pursued by Navarre rural inhabitants. Regarding labour diversification, only 10% of the farmers were registered as full time farmers; for over half of farmers (sixty 60%) agriculture was not their only income source in the household. Some of them reported their partner also worked elsewhere. In other cases, (28%) farmers combined agriculture with other jobs such as industry or services. Elderly farmers (17%) reported also receiving pension payment, while others indicated a combination of incomes.

Participants reported that rainfed cereal and irrigated maize occupied surfaces between 500 and 1000 hectares, as maize extensions require larger rotation areas than other cereals. The survey revealed that irrigated maize was the most widespread crop after the irrigation conversion. **Figure 3.5** shows a distinctive increase in the area under maize cultivation from 2006, when the conversion to irrigation began. The majority of respondents recognised that this crop, in addition to requiring large amounts of water, demands high quantities of fertilisers and pesticides. Vineyards and winter-wheat benefited in particular years when certain policies promoted those crops[33] and are also influenced by the increases and decreases over the time as a consequence of market price fluctuations. Cereal crops are predominant under rainfed systems (72%), vineyards can be found in both systems in similar proportions (15%) while maize is almost always irrigated via modern systems, as grown by 53% of the respondents. Other crops, from vegetables to olive trees, are generally grown under irrigated systems.

The conventional compound of fertilisation (mineral nitrogen, phosphorus and potassium (NPK)) was predominant under irrigated systems, followed by a mixed fertilisation using both conventional and organic (including slurry and sludge) fertilisers. Under rainfed systems, conventional fertilisation remained predominant, although organic fertilisers were used more often than in irrigated systems. For both irrigated and rainfed systems, rotations of winter-wheat and barley were exposed to conventional fertilisation two times more frequently than mixed fertilisation, and twenty times more often than the organic fertilised fields. A similar situation occurred with vineyards and maize crops,

[33] For instance, the Spanish Government promoted wine production in 2008 via the *Real Decreto 1244 /2008, de 18 de julio, por el que se regula el potencial de producción vitícola. Art. 19*. Consulted in April 2015 at <http://www.magrama.gob.es/es/agricultura/temas/regulacion-de-los-mercados/real-decreto-1244-2008-consolidado_tcm7-321955.pdf>.

though vineyards were much less fertilised and the difference between conventional and mixed fertilisation was not as large.

Fourteen percent of the interviewees reported working for agro-industry. Most farmers (76%) used cooperatives to commercialise their crops, whereas 24% made direct sells. From those who directly sold to domestic consumers, half sold between 0-25 % of their production and the other half sold more than 75% of their products.

4.5. Linking capital assets, livelihood strategies and livelihood outcomes

This section combines the descriptive information provided in previous sections to classify existing livelihoods. This is developed through the performance of a Hierarchical Cluster Analysis (HCA) (see next Section 4.5.1 and an explanation of this test in Section 3.3.2.2), which allowed me to identify four distinctive groups of farmers and owners who deliver different land management choices.

The correlation of the resulting groups with the described assets (see following Section 4.5.2) allows describing the clusters in socio-demographic terms. This classification recognises differential livelihoods based on tangible, classifiable and quite stable variables, which in turn allow decision-makers to foresee how rural policy should be oriented (Allison and Ellis, 2001; Eakin and Luers, 2006). For instance, the approach and terminology of a given policy may differ depending on its targeted demographic: either conventional farmers with a clear market-oriented production or elderly retired farmers holding small-scale subsistence farming. This may be considered when drafting differential policies or a policy that accounts for the multiple rural livelihoods co-existing within a given context. Classifications allow researchers to extract information about how assets are associated to each other, when accessing one type of capital where another capital is typically accessible by stakeholders. These combinations grant possibilities that create different livelihoods, and allow research to then identify which types of capitals are normally related.

4.5.1. Typologies of livelihoods according to land management

As indicated in Section 3.3.2.2 a multiple correspondence analysis (MCA) was developed across land management variables to make the information more workable, and then a hierarchical cluster analysis (HCA) was applied to the factors obtained. HCA provides a convenient, intuitive method to identify distinct groupings that seem meaningful in interpreting different land management strategies in the rural *Zona Media* and *Ribera Alta* of Navarre.

Table 4.2 contains information about class, mode, p-value and v-test, and allow the interpretation of the performed HCA. To understand HCA results, I first selected only the variables with a p-value lower than 0.05 (less than 5%), as per variables in

Table 4.2 This means that the categories within a given variable were significantly different among the livelihoods in 95% of the cases. In this way, each cluster is represented by some variables that are significantly different across livelihoods. For example, if we look at the first cluster and the first row of the

Table 4.2, we can infer that the first cluster, *small-scale diversified* farmers, is linked to the category of not having irrigated maize. This can be explained by looking at the value of Cla/Mod, which reveals that 65% of farmers who have not irrigated maize belong to the cluster of *small-scale diversified* farmers. Furthermore, the Mod/Cla indicates that the 92% of the farmers in this cluster do not have irrigated maize. Thus, this information explains that the farmers not holding irrigated maize are overrepresented in this cluster.

Table 4.2 Characterisation of the clusters regarding farmers' land use management (N=364)

Key variables to characterise clusters	Cla/Mod	Mod/Cla	p-value	v-test
Conventionally fertilised irrigated maize (No)	64.80	92.80	0.00	12.72
Conventionally fertilised irrigated cereal (No)	75.00	76.80	0.00	12.11
Irrigated maize (0 Ha)	64.50	87.20	0.00	11.66
Rainfed cereal (0 Ha	74.51	60.80	0.00	9.94
Irrigated 'others' (0-5 Ha)	69.51	45.60	0.00	7.42
Irrigated cereal (0 Ha)	47.23	88.80	0.00	7.33
Conventionally fertilised and irrigated 'others' (Yes)	64.20	39.69	0.00	5.86
Organic fertilised rainfed cereal	100.00	68.18	0.00	9.56
Organic fertilised rainfed vineyard	100.00	40.91	0.00	7.05
Rainfed vineyard (0-5 Ha)	23.53	36.36	0.00	3.57
Organic fertilised irrigated maize	50.00	18.18	0.00	3.42
Organic fertilised irrigated 'others'	23.08	27.27	0.00	2.98
Rainfed vineyard (>5 Ha)	23.81	22.73	0.01	2.74
Mixed fertilised rainfed cereal	83.05	56.98	0.00	10.81
Mixed fertilised irrigated maize	67.95	61.63	0.00	9.71
Rainfed cereal (75 Ha)	60.61	46.51	0.00	7.23
Irrigated maize (>50Ha)	63.33	22.09	0.00	4.81
Conventionally fertilised irrigated maize	81.82	61.83	0.00	11.11
Conventionally fertilised rainfed cereal	64.20	79.39	0.00	10.21
Conventionally fertilised irrigated cereal	85.71	50.38	0.00	10.18

Rainfed 'others' (0 Ha)	42.47	96.95	0.00	6.04
Irrigated maize (10-50 Ha)	55.10	41.22	0.00	4.52
Irrigated maize (5-10 Ha)	69.23	20.61	0.00	4.42
Rainfed cereal (10-50 Ha)	54.02	35.88	0.00	3.93

Note: The mode is the value that appears most often in a set of data, in this case Cla/Mod refers to the part of total population that is in the cluster.
Mod/Cla refers to the most recurring value in the cluster.
If the v-test (last column) is positive, it indicates that the category is over-expressed for the category; if the v-test is negative, it means that the category is under-expressed for the category. The v-test number indicates the size differences between class and mode; such that the bigger the number, the higher the presentation of that variable is in the given cluster (in comparison to other clusters).

Hence, four types of livelihoods are identified: (a) *small-scale farming diversified* livelihoods; (b) *medium-scale organic-farming* based livelihoods; (c) *large-scale intensive* farming livelihoods and (d) *medium-scale intensive farming livelihoods*.

a. *Small-scale diversified* livelihood is composed of 34% of the farmers, who are distinct in that the majority of them do not grow the most general crops found in the area of study: irrigated maize and rainfed and irrigated rotations of winter-wheat and barley. Instead, they grow small plots (0-1 hectares) of 'other crops' under traditional irrigation systems. 'Other' crops generally consist of vegetables and woody crops such as olive and almond trees.

b. *Medium-scale organic livelihood* is the smallest livelihood within the whole sample (6%). This livelihood primarily grows cereals and vineyards under rainfed systems using organic fertilisers. Although the water demand system varies depending on the crop, the fertilisation used by these farmers is usually organic and the cultivated extension is quite small (0-10 hectares).

c. *Large-scale intensive* livelihood (24%) grow large extensions of rainfed cereals and irrigated maize, mixing organic and conventional fertilisers. The plots grown are frequently large, greater than fifty hectares.

d. *Medium-scale intensive* livelihood is the largest group of the four (36%). They are intensive farmers growing cereals and maize under irrigated systems while using conventional fertilisation. Some cereals are conventionally fertilised under rainfed systems. They do not have rainfed vineyards, or other rainfed 'other crops'. Plots vary from 5-50 hectares.

4.5.2. Socio-demographic characterisation of farmers' livelihoods in Navarre

Following farmers' livelihoods are described arrending to the results of Sections 4.2, 4.3 and 4.4. I performed a chi-square test, when both compared variables (the livelihood typology and the socio-demographic variable) were categorical; only those that are significantly different among the livelihoods are explained in Appendix VI. There, the socio-demographic features, assets, other pursued strategies and outcomes of modern irrigation that are significantly different among the existing livelihoods (p-value < 0.05) are presented.

Small-scale diversified **farmers** can be grouped as they are the most different ones with respect to others farmers in the case study area. This group of farmers has the lowest level for all the categories assessed, with the exception of age, as this group has the largest number of older individuals in comparison to the other livelihoods. **Figure 4.2** displays all the livelihoods and their socio-demographic features. In this figure, *small-scale diversified* farmers are represented by one 'petal' of the flower diagram- only the 'petal' representing age is present in the case of *small-scale diversified* farmers group. This is because all the rest of the categories are zero when compared to the rest of the farmer livelihood groups. Petals show the relative valuation with values scaled between zero and one.

The ***small-scale diversified*** group of farmers is characterised by older owners (60% are older than sixty-five years), including part time farmers and retired farmers who still work their own lands. Thus, their income is not solely derived from agriculture but also from retirement subsidies or other funding sources. These farmers are found predominately in the northern area. They have no agrarian studies and low or non-existent participation in cooperatives or syndicates. Female-headed households are also represented in this group. This type of farmers do not stand out for having high financial investments, since it is atypical for these individuals to contract agrarian insurances (approximately 80% did not). They do not receive access to financial aid through subsidies (only 30% received CAP and 88% do not gain access to modernisation/irrigation subsidies in comparison to the rest of the groups). They do not have access to credit loans.

This group of farmers holds small plots (0-1 hectares) and work their own land (highest percentage of full ownership) under traditional irrigated systems, since most (approximately 60%) reported not having installed modern irrigation. *Small-scale diversified* farmers do not generally seek technical advice (from INTIA) for land management and do not work for the agro-industry. After the modern irrigation transformation, they did not acquire new lands. I can also distinguish two types of farmers: 'active farmers', who still work their land despite being retired, and 'passive farmers' who have left their lands to work with cooperatives.

The *medium-scale intensive* group of farmers encompasses younger farmers fully dedicated to agriculture and with substantial financial and social assets. Their widespread participation in cooperatives and syndicates (>60% held a high or very high participation) has helped these farmers to access subsidies (around 95% accessed CAP subsidies and 74% received irrigation subsidy). Additionally, this group of farmers has the highest level (60%) of agrarian insurance, and also the highest rate of access to bank credit for agrarian development projects (greater than 60% of stakeholders). During the survey, these *medium-scale intensive* farmers demonstrated frequent contact with INTIA technical officers to receive information about land management related topics. They acknowledged that decisions regarding land fertilisation, seeds and irrigation were highly influenced by this organisation.

Farmers in this group are partial owners of large land properties (greater than fifty hectares), and 83% have installed modern irrigation infrastructure. Most of them are full time farmers, and 20% of them work for agro-industry (the highest rate compared with the rest of groups). These farmers benefit from irrigation in terms of accessing more land through buying or renting. This is also the largest group in terms of crop diversification, as 65% have diversified their crops' portfolio.

For this farmer group age, gender and access to land facilitate their opportunities to integrate within agrarian cooperatives and syndicates, whereas a high level of formal education enables them to utilise those features in a more productive way. Participating in agrarian cooperatives appears to be a secondary advantage obtained through a combination of human and natural assets. Thus*, intensive* farmers seem to use their primary assets (human and natural) to gain access to social assets (syndicates and cooperatives), which ultimately increases their access to financial (subsidies), and physical (modern irrigation installation) assets, as well as to their natural assets (enlargement of their cultivated lands).

The medium-scale rainfed organic group of farmers is characterised by young to medium aged farmers (70% around 35-55 years) who hold agrarian studies (22%) and substantial financial assets. *Medium-scale rainfed organic* farmers do not connect to cooperatives and farming unions as much as *intensive* farmers do (around 45% do not participate or do so in a limited way). Farmers' technical advice acquired from INTIA is also lower when compared to *intensive* farmers. Their expenses on agrarian insurances are on average lower compared to the other groups, while this group has access to the highest rate of subsidies: primarily irrigation (77%) and modernisation subsidies (55%). Although most of the organic rainfed winegrowers and cereal growers belong to this group, there are also farmers who fertilise their crops in an organic way. They are characterised by holding lands between 10-50 hectares under partial ownership. Fifty percent of these farmers have accessed bank credit for agrarian purposes. This group's features are similar to the most *intensive* farmers in terms of gender, age and human assets. Specifically, holding agrarian studies is highlighted since those with agrarian studies are characterised by holding extreme opposing land management strategies, i.e. they orient their management towards high intensive practices or focus on organic fertilisation and low levels of water demanding crops.

The majority of households in this group have opted for an industrial agriculture model. However, a small number of them have opted for an alternative organic model. Personal values, entrepreneurial potential, labour diversification and land tenure availability influence farmers to undertake large-scale crop production of *intensive* farming or small-scale but more quality focused approach of *organic* farming. These farmers use their human assets to diversify their labour and to develop a land management strategy that is not as broadly supported by existing local and regional organisations.

The low number of farmers observed in this group may reflect the difficulty of going against the mainstream agricultural model in the area, which is even more difficult under the current transformation process and its cross-scale ecological effects (e.g. cross-border pollution from pesticides in intensively managed plots). Farmers' lack of interest in existing agrarian cooperatives can be explained by the fact that most cereal cooperatives do not differentiate between organic crops and conventionally fertilised crops, among others, so that *organic* farmers reject to mix their yield with the rest. Moreover, the advantages offered by cooperatives in terms of accessing fertilisers at competitive prices, for example, do not fit organic farmers' necessities. The case of winegrowers is however different as their cooperatives account for 'ecologically certified' products.

The *large-scale intensive* group of farmers has similar characteristics to the *medium-scale intensive* group*,* but involves some older and retired farmers too. Most of these individuals labour 10-50 hectares of arable land, and 55% of this group of farmers have diversified their crops. The *large-scale intensive* livelihoods are mostly located in the southern area of *Ribera Media.* The geographical distance to the capital seems to have encouraged this type of farmers to engage in more intensive-oriented agrarian practices and ultimately more market-oriented agriculture than farmers belonging to *small-scale diversified livelihoods*.

This group shares a similar livelihood, which characterised by substantial land renting and acquisition, particularly in areas where modern irrigation has been adopted. They have a lower level of formal education and their participation in cooperative and syndicates also differs in comparison to *medium-scale intensive* farmers. Their participation in cooperatives is very high (60%) whereas in syndicates is lower (40%), and most rely on INTIA's advice. However, farmers' access to financial assets such as bank credit and some insurance, although lower, is similar to *medium-scale intensive intensive* farmers, with 42% having access to bank credit and around 95% to CAP subsidies.

Livelihood outcomes[34] are assessed through resultant asymmetrical livelihood strategies[35], where proxies such as income stability or income level are used to assess livelihoods sustainability. Although uncommon, some authors have also used crops diversification and land tenure shifts as indicators of rural livelihoods feasibility (Gómez-Baggethun et al., 2012; Kaye-Zwiebel and King, 2014).

In this research, I identify accumulating lands in the form of land rents or purchases as a function of livelihoods persistence over time, as land access is a vital asset in the configuration of rural livelihoods. I concluded this after performing the first round of interviews, which provided insights to identify these critical indicators when pursuing a sustainable strategy. Modern irrigation implementation is justified as a means to reach crops diversification (up to 56 new products (INTIA, 2015)) and greater extensions of cultivated lands that presumably increase the income level and its stability. By assessing those indicators, I am also evaluating those assets in an indirect way. However, in the survey only 51% of the surveyed farmers reported an increase in the number of crops. Specifically, 30% had added three new crops, while 50% had increased just in one or two new crops.

Regarding land tenure shifts among rural inhabitants in this zone, I found that 34% of the respondents have bought new lands in the transformed area. The majority of those (26%) had bought between two and five hectares of irrigated lands. Nine percent of the respondents sold their lands or part of their lands. Those sold lands areas were of approximately one to two hectares in most of the cases. Twenty-two percent had rented new lands in the modern irrigated system zone.

Figure 4.2 presents flower diagrams showing all the livelihoods and their socio-demographic and assets access features. The ranges of petal sizes are scaled mean from zero (petal absent, indicating a low value for the agrarian service) to one as a large petal (indicating a high value for the service).

[34] Livelihood outcomes typically refer to whether the existing livelihoods will be sustainable, both in social and ecological terms.
[35] This section links with chapter 7 which will further assess the processes of dispossession, accumulation and differentiation among the existing livelihoods with the adoption of modern irrigation.

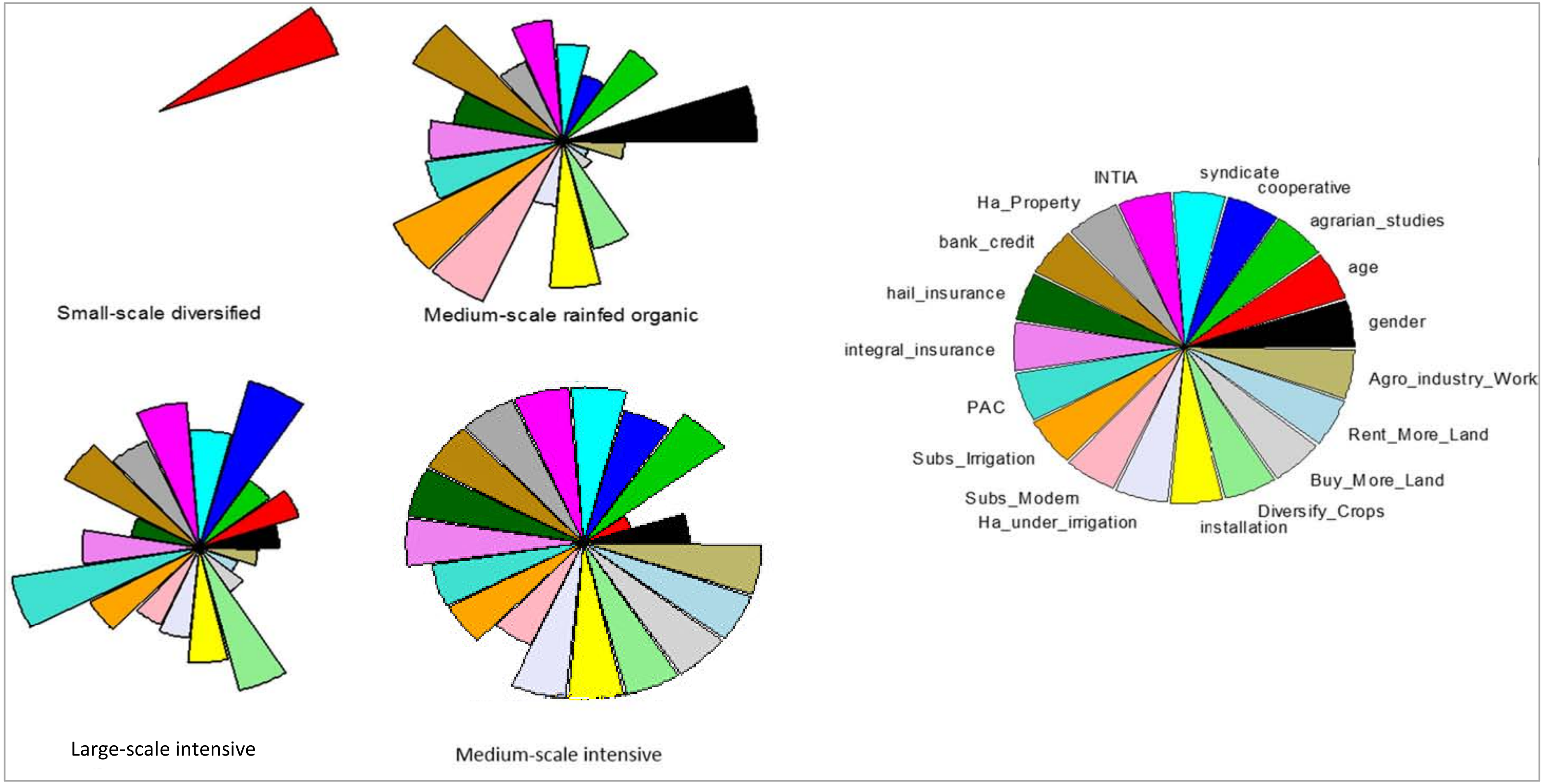

Figure 4.2 Scaled mean variables represented in the flower diagrams represent socio-demographic features and asset differences among farmer livelihood typologies

4.6. Discussion

This section discusses the differences between the livelihood profiles that have incorporated irrigation and have intensified their practices (increased use of mineral fertilisers and water as well as larger surface of laboured lands) and those farmers with less intensive livelihoods (smaller arable surfaces as well as less water consumption and organic fertilisers' utilisation). Results are considered in a broader institutional context, which is expanded in Chapter 0.

4.6.1. Four livelihoods in the *Itoiz-Canal de Navarra* case study area

Intensive farmers *(medium-scale intensive* and *large-scale intensive* groups of farmers*)* and *medium-scale rainfed organic* farmers follow a strong market-oriented strategy that can be classified as an *accumulative* strategy. These farmers seek to increase the flow of income and stocks of physical, social and financial assets (Masanjala, 2007). They accumulate financial assets through bank credit and diverse subsidies to invest on physical assets such as irrigation infrastructure, seeds and fertilisers. They are also characterised by an increased efficiency in the use of their physical assets, such as the type of fertilisation and irrigation methods. However, these facts may simultaneously indicate a reduction in the individuals involved in farming. In line with Allison and Ellis (2001), this chapter discloses that as a result of intensive farmers' strategies, there may be a tendency to displace other livelihoods from the agricultural sector. Furthermore, it may cause part-time farmers to work full-time in an effort to repay loans and to increase their earnings for a sufficient return on the increased investment.

Medium-scale rainfed organic farmers, alternatively, pursue a similar strategy but do not use cooperatives and syndicates as key platforms through which to reach their productive aims. Instead, they use their own knowledge and financial capital. Farmers who have diversified their crops after installing the modern irrigation system have consequently adhered to a combination of *accumulative* and *adaptive* strategies. These farmers diversify their labour and delegate the responsibilities of being the producer, carrier and merchant simultaneously. However, their age and higher education degree contributes to explain their entrepreneurship, which in turn allows them to take advantage of the financial assets delivered by formal institutions in the form of subsidies. Their characteristics regarding farm size and the type of used fertilisers align with the results of Clay et al. (1998).

Old farmers within the *small-scale diversified* livelihood follow a *consolidate* strategy (De Haan and Zoomers, 2005), which is common after achieving certain level of desired affluence. Land management for *small-scale diversified* farmers differed among them, i.e. there was not a clear tendency towards conservative or intensive agriculture. However, there were common strategies applied such as forecasting the meteorology, storing crops individually instead of through cooperatives and rationing their sows. Being agriculture the only income source in the household is not a significant difference among the existing livelihoods. However, fieldwork revealed that *extensive* farmers (*small-scale diversified* and m*edium-scale rainfed organic* farmers) are associated with more diversified income sources.

It should be noted that this analysis lacks information on the relationship between the level of non-farm income and total income. The survey disclosed that for part time and retired farmers' agriculture was not the primary economic source, as was the case for *intensive* farmers. Income diversification may not be always a positive feature. In some cases, it may be performed through unskilled labour or overflow time allocation that does little to reduce household risk exposure, or to increase expected income or human wellbeing (Barrett et al., 2001). Information about this is lacking in the current dissertation.

These strategies, *consolidate*, *adaptive* and *accumulative*, evolve over time. For instance, the *accumulative* strategies followed by younger stakeholders might be transformed into a *consolidating* strategy in the future (De Haan and Zoomers, 2005). Part time *extensive*, full time *intensive* and *organic* farmers' strategies happen simultaneously as they are exclusive and follow divergent agrarian paths. Such strategies are determined by farmers' land access, knowledge, off-farm opportunities and personal aspirations. Thus, it is not an evolving phase strategy, but rather a reflection of a differentiated and multi-task portfolio that coexists in Navarre.

4.6.2. Livelihoods outcomes due to modern irrigation introduction

Current formal organisations and their related institutions are promoting modern irrigation in this area through multiple types of subsidies and technical assistance at different scales. Land concentration and irrigation conversion in the area has been clearly oriented to promote agribusiness and biofuels production as well as new possibilities of implementing new crops (De Vries, A, and Garcia M., 2012). Still, farmers have not diversified their cropping systems as much as the irrigation promoters expected. A possible answer to why diversification remains constrained, even after adopting irrigation, is that some farmers were accustomed to extensive cereals and several had never used these methods of irrigation before. Some farmers' aversion to irrigation and its embedded risks may be due to (i) their self-reported conservative character; (ii) the low generational replacement rate and/or (iii) some bad experiences described during the survey. In southern areas with a traditional vegetable market orientation, growers' strategies became difficult after the canning industry almost disappeared and quotas over certain crops, such as tomatoes, were established by EU regulations. Farmers have shifted to irrigate maize and other crops linked to livestock such as alfalfa and forage.

Farmers with *intensive* livelihoods (*large-scale* and *medium-scale intensive livelihoods*) follow land management strategies that are supported by institutions at different scales. Moreover, these farmers are able to invest in modern irrigation installation and agrarian insurances due to their relatively greater financial liquidity, which is facilitated by their better access to credit and remittances through banks and institutional subsidies. For example, the EU's CAP subsidies are higher if the targeted land has an irrigated rather than a rainfed system in place (Carricondo and Peiteado, 2010). Navarre's government also offers irrigation and modernisation subsidies and other financial and technical help that are facilitated by agrarian cooperatives. In sum, the larger land area under irrigated systems, as well as the higher transformation of mechanisation and modernisation of the farms, the more funds farmers can receive. One can infer that current official organisations funds promote therefore water consumption.

Intensive livelihoods also reported a high or very high consultation to agricultural technicians in comparison to the other *extensive* livelihoods. It may prove beneficial to investigate INTIA's advice to villagers, since farmers have demonstrated trust in this organisation in particular. In contrast, current policies seem to be ignoring *small-scale diversified livelihoods* existence who, due to their *consolidate and multi-task security strategies*, were uninterested in this agrarian transformation. Consequently, early outcomes may already be observed through an exploration of the early effects of land tenure change (German et al., 2011). This sheds some light on the security of *intensive* livelihoods, which may in turn endure at the expense of other extensive livelihoods. For this reason, *small-scale diversified households'* sustainability is questioned within this context in which *intensive* farmers, buy and rent more lands.

However, *small-scale diversified* farmers have an important role in maintaining agrarian land, regardless of the reasoning behind preserving it (e.g. farming as 'hobby', family commitment or identity concerns). They try to keep traditional practices, such as old system irrigation, alongside present technologies and regulations. Therefore, the adoption of modern irrigation may be obscuring aspects connected to identity, tradition, and other cultural values as well as factors influencing the sustainability of the socio-ecological system in terms of oil, water and fertilisers increased dependency (Oteros-Rozas et al., 2012). Furthemore, *small-scale diversified* farmers contribute to raise awareness and promote understanding of how smallholder agricultural production and livelihood choices interact with broader, non-agricultural economic opportunities, which might prove useful for developing more appropriate smallholder policies (Koczberski and Curry, 2005).

4.7. Summary

In this chapter I have discussed the different types of livelihoods of farmers within the *Itoiz-Canal de Navarra* case study area. In doing so, I have characterised four main types of farmers each sharing a similar livelihood with respect to the way they manage land and hold different assets: *small-scale diversified, medium-scale rainfed organic* and two differentiated degrees of *intensive* farmers, namely *medium-scale intensive* and *large-scale intensive* farmers. *Accumulative* strategies relate to *intensive* livelihoods, adaptive strategies to *organic* livelihoods and *consolidate* as well as *adaptive* strategies to *small-scale diversified* livelihoods.

The chapter has also analysed the combination of capital assets associated with particular land management intensities and how such connections mediate farmers' agricultural strategies. It has found that human capital, particularly education, gender and age, in combination with the access to agrarian land are vital to pursue productive options, and are significantly different across different types of livelihoods in rural Navarre. *Intensive* farmers with a clear market-oriented agriculture have mainly adopted modern irrigation, and some *organic* farmers have also done so.

The chapter has also argued that current institutions are not paying sufficient attention to how local farmers make their living and the diverse assets they draw upon in the process (Bebbington, 1999). It has disclosed that *small-scale diversified* farmers are clearly connected to the notion of 'rural livelihood' while the rest of farmers, although also rural, are more related to an 'agrarian livelihood' focused on increasing income. As with similar case studies looking at small-scale practices (Allison and Ellis, 2001), it seems that agrarian policy in Navarre has viewed farming as a full time occupation seeking higher levels of efficiency. However, this aspect leads to the misinterpretation of how people conduct their lives, and discounts policies which may fit with cross-sectorial livelihood strategies pursued by *small-scale diversified* farmers and *medium-scale organic* farmers (Allison and Ellis, 2001).

The next chapter draws on the four livelihood typologies identified in this chapter to analyse whether agrarian intensification influence people's perception and valuation of multiple agrarian ES.

CHAPTER 5

"Ecosystem-based conservation without cultural considerations is not only insufficient, it risks producing unaccounted negative impacts to communities and misses an opportunity to build culturally meaningful alternatives"

Poe et al, 2013

5. Unraveling the socio-cultural values of ecosystem services

5.1. Introduction

As indicated in the previous chapter, I addressed diversity of the rural livelihoods within the case study area. The adoption of modern irrigation has strongly influenced the evolution of some of the local livelihoods, resulting in more *intensive* land management strategies overall. According to the type of land management adopted, I found contrasting *small-scale diversified*, *medium-scale rainfed organic*, *large-scale intensive* and *medium-scale intensive* livelihood strategies. For the first two classifications, the utilised strategies correspond with *consolidated* (solid and secure strategy) and *multi-task range of activities* (diverse sources of household income arising besides agrarian activities). Farmers holding *intensive* livelihoods follow agro-industry oriented and *accumulative* strategies (characterised by a high rate of capital and labour use per unit land area).

I hypothesise that the adoption of modern irrigation does not only influence land and water access but also villagers' perceived values of ES. In this vein, this chapter contributes to answering the second research question*, i.e. Does agrarian intensification influence people's perception and valuation of multiple agrarian ES*?

Since agrarian ES contribute to human wellbeing and agrarian management practices influence the co-production of ES (De Haan and Zoomers, 2005; Seppelt et al., 2011), I aim to contribute towards better theorising of ES valuation frameworks through farmers' valuation of ES, and its relation to livelihood profiles and related explanatory variables.

Disaggregated ecosystem service valuation is a way of recognising legitimate differences between farmers' preferences (Costanza et al., 2007; Gómez-Baggethun and de Groot, 2010; Pascual et al., 2014). Moreover, enhancing certain ES (such as in this case, through recent policies that foster large-scale *intensive* practices) may deny the enjoyment of other type of ES by other interested parties (Castillo et al., 2005; Martín-López et al., 2012; Norgaard, 2010). For this reason, making agrarian ES trade-offs visible (Salafsky and Wollenberg, 2000; Hartel et al., 2014; Klain et al., 2014), and emphasising how cultural services are affected by modern farming practices such as through *intensive* and technified irrigation, is of crucial importance. This information would allow for identifying whose values may be challenged by the current agrarian transformation.

The current chapter is organised in four main sections. Following the introduction, Section 5.2 qualitatively explores farmers' perceived connections between agrarian ES and human wellbeing, supported by interviews with key informants in the case study area. Section 5.3 focuses on farmers' agrarian ES valuation. For this, I rely on data from a quantitative survey. I employ a socio-cultural valuation approach (Martín-López et al., 2012; Oteros-Rozas et al., 2013; Palomo et al., 2014) (see Section 3.3.2.1). This section also discusses how farmers' land management choices influence their perception about ES co-production (Diaz et al., 2015; Palomo et al., 2016; Seppelt et al., 2011). Section 5.4 discusses the uncovered trade-offs between tangible/material services that have a wide social recognition, such as provisioning services, and other services which are less tangible such as cultural services (Daniel et al., 2012b; Howe et al., 2014; Norgaard, 2010). Finally, Section 5.5 discusses the previous findings and Section 5.6 discloses the key messages resulting from previous analysis.

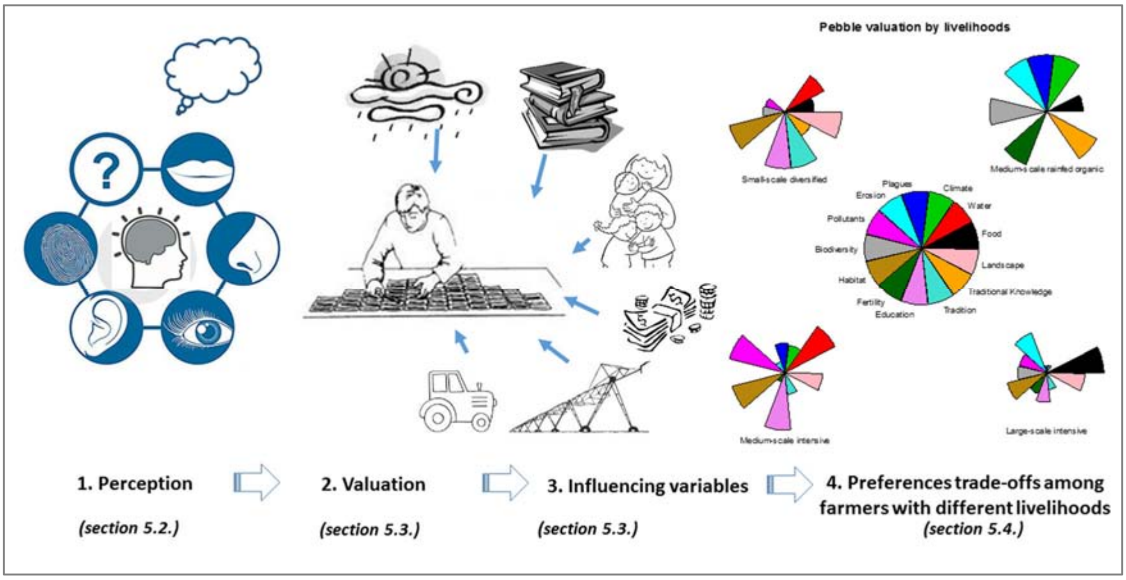

Figure 5.1 synthesises the analysis process followed in this chapter.

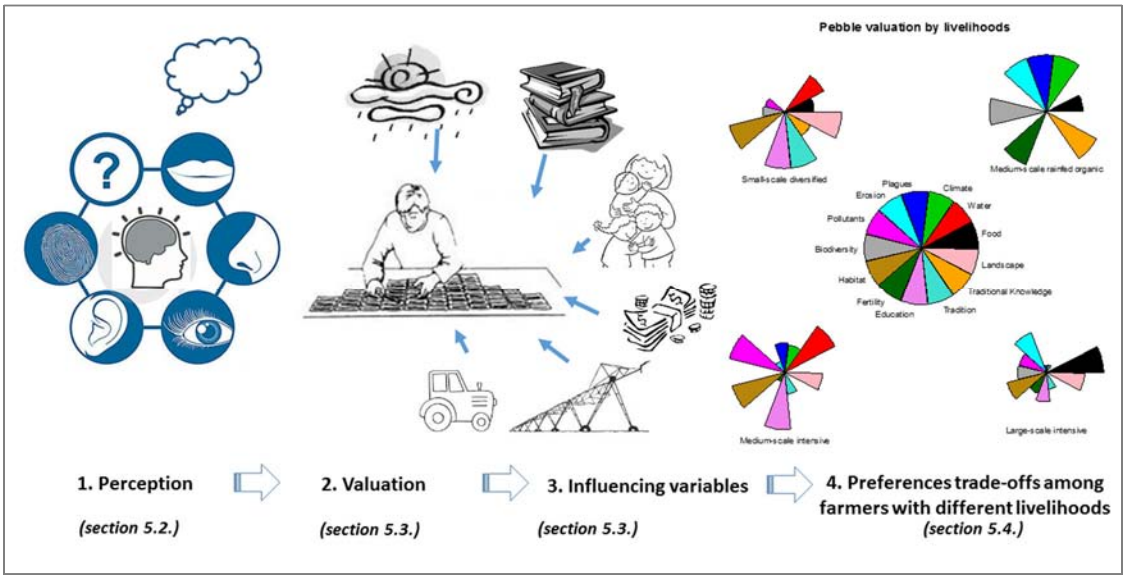

Figure 5.1 Steps of the analytical process of Chapter 5

5.2. Local perceptions of agrarian ecosystem services for human wellbeing

Semi-structured interviews of informants from varied backgrounds (e.g. scientists, farmers, politicians, NGO members) provided 18 statements which connected agrarian ES with six dimensions of human wellbeing including security, basic material for a quality life, health, social relations, freedom of choice and action and subjective happiness. Through this, individuals were able to express which type of agrarian ES they recognised, as well as to identify why such ES had to be maintained or enhanced. Cultural ES were the most commonly reported services (seven cultural services were identified), followed by regulating (six), supporting services (three) and provisioning (two).

As shown in Section 3.3.2.1, I first summarised the interviews and extracted the statements that linked agrarian ES and human wellbeing. Additionally, I conducted a broad literature review on ES that served as a reference, and used this information to order and classify the pre-defined statements. I did not include services that did not appear during the interviews such as pollination or soil formation. However, other services that were not covered during the literature review on ES but appeared during the interviews were included (e.g. self-fulfilment).

After a revision of the existing ES classifications (Costanza et al., 2007; De Groot et al., 2002b; Dominati et al., 2010), I adapted the MEA (2005)[36] classification with contributions of Chan (2012); Summers et al (2012) and Klain (2014) to organise the interviews' statements.

[36] See Section 2.3 for further information about the importance of MEA and its evolution over time.

Regarding wellbeing, Summers et. al (2012) emphasised the importance of the freedom-to-choose and identified another sixth dimension: 'subjective happiness'. The authors explain that happiness can be separated into approximately three categories. The first is referred to as solastalgia, which ascribes to the distress produced by environmental damage which is exacerbated by a sense of powerlessness or lack of control over the unfolding change process. Albrecht et al., (2007) argue on the opposite feeling –i.e. the psychological or existential comfort caused by the experience of connecting to nature. The second category is topophilia, which is related to one's affection to their hometown, which often becomes mixed with the sense of cultural identity among certain peoples and a love of particular aspects of such a place (Ogunseitan, 2004). The final category is the affection and respect concerning one's sense of belonging to a given environment.

Table 5.1-5.4 show the statements that connect agrarian livelihoods in the study site and ES with human wellbeing dimensions. Although the statements refer to 'soils', in some cases 'soil' is rather translated as 'land' or 'agrarian ecosystem'. These fuzzy concepts were used on purpose as local farmers used them interchangeably. The tables also provide information about i) the type of ecosystem service and ii) the scale at which it is delivered; iii) the type of benefits[37] connected to ecosystem service (fourth column **Table 5.1**) and iv) the human wellbeing dimension to which ecosystem service contributes; v) whether the importance attached to the services is in favour of individual or collective benefit (labelled 'scale' in the tables); vi) if the benefits perceived are considered direct or indirect ('indirect' refers to a longer or more difficult cognition process required to perceive the service effect) and vii) the information source (whether statements are mentioned in the interviews, the literature or both).

5.2.1. Links between cultural ecosystem services and human wellbeing dimensions

Among cultural services, there is the *cultural heritage* service which is often associated with identity, and defined as the legacy of biophysical features, physical artefacts, and intangible attributes of a group or society inherited from past generations, adopted in the present and maintained for the benefit of future generations (Daniel et al., 2012a). *Recreation and tourism* expand the opportunity of enjoyment to a broader range of people and provide many benefits such as physical exercise, aesthetic experiences, intellectual stimulation, inspiration and other aspects connected to psychological wellbeing. *Spiritual and religious significance* is reflected as a subcategory of cultural ES. *Local ecological knowledge* is transferred over generations and

[37] In the case of benefits I follow Klain et al., (2014) classification explained in Section 2.2.2.

regenerated through practical engagements with ecological components. *Social relations* are organised and maintained by cultural practices and common understanding of a community (Kitayama and Markus, 2000).

Table 5.1 illustrates that cultural ES were the most frequently mentioned services, compared to the rest of services categories described by the survey participants, with seven cultural services identified. Those services provide aesthetic, inspiration, knowledge, social cohesion, spiritual and identity benefits (fifth column of **Table 5.1**). The wellbeing dimensions attached to these services were: subjective happiness, social relations and freedom, and health benefits derived from enjoying agricultural management and self-produced quality food, respectively.

Table 5.1 Cultural services and their connection with human wellbeing

Type of service	Statement	Ecosystem service Scale	Benefit	Human wellbeing dimension to which ecosystem service contributes	Human wellbeing Scale	Effect	Source	
							Literature	Interview
Outdoor recreation	Agrarian soils are important because they offer a relaxing and leisure space: for walks, birds tourism	Landscape	Activity	**Subjective happiness** Solastalgia (distress by environment)	Individual	Direct	(Calvet-Mir et al., 2012; Klain et al., 2014; MEA, 2005a; Swinton et al., 2007)	√
Outdoor recreation	Agrarian soils are important because they offer unique and attractive landscapes	Landscape	Aesthetic	**Subjective happiness** Solastalgia (distress by environment)	Collective /Individual	Direct	(De Groot et al., 2002; Kremen, 2005; MEA, 2005a; Swinton et al., 2007; Zhang et al., 2007)	√
Artistic	Agrarian soil is important because it offers an inspiration source (art, culture…)	All	Inspiration	**Subjective happiness** Solastalgia (distress by environment)	Individual	Direct	(Calvet-Mir et al., 2012; Klain et al., 2014; MEA, 2005a)	√
Education and cognitive development	Agrarian soil is important because it offers an ideal source of education (about natural cycles etc.)	All	Knowledge	**Subjective happiness** Affection and respect: being part of environment **Freedom to choose**	Collective /Individual	Direct	(Calvet-Mir et al., 2012; K. Chan et al., 2012; MEA, 2005a)	√
Education through traditional knowledge	Agrarian soil is important because it keeps and exposes traditional land activities, there is a culture, richness and knowledge	Landscape	Knowledge and identity	**Subjective happiness** Affection and respect: we are part of environment; **Social relations** Mutual respect; Ability to help others	Collective /Individual	Direct	(Calvet-Mir et al., 2012, MEA, 2005b)	√

Place for creating and enhancing social relations	Agrarian soil is important because it creates social relations	Landscape	Social capital and cohesion	**Social relations** Social cohesion; Mutual respect; Ability to help others	Collective /Individual	Direct	(Calvet-Mir et al., 2012;	**√**
Self-fulfilment	Agrarian soil is important because it makes you surpass yourself, it is constructive, it gives illusion and strength to keep working	Plot	Spiritual and identity	**Freedom to choose**	Individual	Direct		**√**
Food quality	Soil quality is important since food quality depends on it	Plot & landscape	Material	**Health** Access to clean food and water	Individual	Direct	(Calvet-Mir et al., 2012)	**√**

Subjective happiness includes the comfort that the environment provided to the survey participants, for example through the landscape beauty appreciation (Albrecht et al., 2007). It also relates to personal creative *inspiration* and to the pleasure derived from; such as strolling between crops fields of labouring the land. According to participants, such services provided direct and individual benefits, although occasionally it was indicated that they could also lead to collectively perceived benefits (e.g. landscape appreciation and affection and respect through education).

Agrarian cultural services were often mentioned by NGO members and local and regional agents. Instances of reported *self-fulfilment* was mainly shared among farmers. They referred to the act of fulfilling one's ambitions, desires, etc., as being achieved through one's own efforts, e. g. their land labouring. Typically, this concerned individual and direct perceived benefits.

Additionally, participants manifested a strong sense of place or *topophilia*; mixed with the sense of *cultural identity* and affection of certain aspects of such a place (Summers et al., 2012). This was enthusiastically described regarding local identities and traditional knowledge passed through generations, sometimes as a family tradition. This was also mainly perceived among farmers but it was shared among the rest of participants (local and regional officers, NGOs and other local organisations such as cooperative and syndicate workers).

An individual’s wellbeing is strongly influenced by their ability to develop a system of understanding and practices, as well as mutual relations with others (Kitayama and Markus, 2000). Interviews demonstrated how education, traditional knowledge and the direct maintenance of social relations were of key importance for the interviewees’ wellbeing in terms of keeping social cohesion, sharing mutual respect and cultivating the ability to help others (Hartel et al., 2014). The importance of social relations was only remarked by farmers.

The *freedom to choose* dimension is central to the nature of wellbeing (Hausman, 1994). Education and self-fulfiment services are included within this dimension of wellbeing; the former as an asset which provides potential capabilities and the latter typically involves investment in ones self, which in turn can promote a higher freedom to choose and therefore, subjective happiness. The spiritual connection to nature, which is closely connected to labour farming, was also associated with this dimension, and again was only principally mentioned by farmers.

Table 5.1 complements the current knowledge on cultural ES (Calvet-Mir et al., 2012; K. Chan et al., 2012; K. M. Chan et al., 2012; Hartel et al., 2014). It further incorporates examples of links between agrarian ES and human wellbeing. The data is enriched by the specificity of the type of ecosystem on which it is based, its multi-scalar dimensions and the incorporation of self-fulfilment, is not commonly included in ES classifications.

5.2.2. Links between provisioning services and human wellbeing

The provisioning services identified by participants were connected to security, health and basic materials for a good quality of life. Food and raw materials were perceived as basic means to develop a livelihood (Schwartz, 1994). Both are direct material benefits for individuals and collectives (Fisher et al., 2008). Accounting for these services implies acquiring food for the biophysical necessities and security for material necessities. However, in the case study context, food provisioning or fibres are not always basic material to live since most participants in the survey do not develop subsistence agriculture. Nevertheless, food production is a basic source of income and employment. As expected, provisioning services were identified by all interviewees.

Table 5.2 Provisioning services and their connection with human wellbeing dimensions

Type of service	Example of related statement to provisioning service	Benefit	Ecosystem service Scale	Human wellbeing dimension to which ecosystem service contributes	Human wellbeing scale	Effect	Source: Literature	Source: Interview
Food	Agrarian soil is important although not essential since technology makes possible crops without soil	Material	Plot & landscape	**Basic material for good life & Security** Food; Access to goods	Collective & Individual	Direct	(De Groot et al., 2002b; MEA, 2005a; Swinton et al., 2007; Zhang et al., 2007)	√
Raw material	Agrarian soil is important because it provides with raw materials for industry and cattle	Material	Plot & landscape	**Basic material for good life & Security** Access to goods	Collective & Individual	Direct	(De Groot et al., 2002b; MEA, 2005a)	√

5.2.3. Links between regulating services and their connections with human wellbeing

Regulating services were considered not only by people from specific profiles such as government workers and academics, but also by *organic* farmers and a few conventional farmers. These services are not as tangible as provisioning services (McMichael et al., 2005). In fact, water and climate regulation, erosion prevention and pollutant control are indirect benefit of a desirable state of agrarian soils. In general, such services were recognised mainly by local and regional organisations; pollution related services were also strongly perceived, as both desirable and undesirable, by some farmers. These services are connected to the health and security dimensions of human wellbeing. All of them Additionally, these services have provided indirect collective benefits, since they influence the sustainability of the studied ecosystem, as well as 'higher' linked ecosystems and interact with agrarian soils as well as with neighbouring aquatic ecosystems (Fisher et al., 2008).

Table 5.3 Regulating services and their connection with human wellbeing dimensions

Type of service	Example of related statement to provisioning service	Benefit	Ecosystem service Scale	Benefit	Human wellbeing dimension to which ecosystem service contributes	Effect	Source: Literature	Source: Int.
Climate regulation	Agrarian land is important because it captures CO_2 and it helps to mitigate climate change	Existence / Option	All scales	**Security** Secure resource access; Security from disasters	Collective	Indirect	(De Groot et al., 2002b; Kremen, 2005; MEA, 2005a; Weber, 2007; Zhang et al., 2007)	√
Biological regulation	It is important when there are insects in the agrarian soil because of their biological regulation function. They contribute to balance in the system	Existence / Option	Microscopic	**Security & Health** Secure resource access (clean food and water); Security from disasters	Collective & Individual	Direct	(Barrios, 2007; Daily, 1997; De Groot et al., 2002b; Kremen, 2005; MEA, 2005a; Sandhu et al., 2010; Weber, 2007; Zhang et al., 2007)	√
Water quantity regulation	Many agrarian soil cannot filtrate water properly and they don't help on water quantity regulation	Existence / Option	Plot	**Security** Secure resource access; Security from disasters	Collective & Individual	Direct	(Barrios, 2007; De Groot et al., 2002b; Kremen, 2005; Lavelle et al., 2006; MEA, 2005a; Sandhu et al., 2010; Zhang et al., 2007)	√
Water quality regulation	Agrarian soil is important because it acts as a filter that cleans water, and contributes necessary salts	Existence / Option	Plot	**Security & Health** Secure resource access (clean food and water); Security from disasters	Collective & Individual	Direct	(Kremen, 2005; MEA, 2005a; Swinton et al., 2007; Weber, 2007; Zhang et al., 2007)	√
Erosion prevention	Agrarian soil is important because it regulates the erosion caused by water	Existence / Option	Plot & landscape	**Security** Secure resource access;	Collective & Individual	Indirect	(Barrios, 2007; De Groot et al., 2002b; Kremen, 2005;	√

Type of service	Example of related statement to provisioning service	Benefit	Ecosystem service Scale	Benefit	Human wellbeing dimension to which ecosystem service contributes	Effect	Source	
							Literature	Int.
				Security from disasters			Lavelle et al., 2006; MEA, 2005a; Sandhu et al., 2010)	
Pollutant regulation	Agrarian soil is important because it absorbs wastes that otherwise may be problematic	Existence / Option	Plot & landscape	**Security & Health**	Collective & Individual	Indirect	(Calvet-Mir et al., 2012; Daily, 1997; De Groot et al., 2002b; Kremen, 2005; MEA, 2005a)	√

5.2.4. Links between supporting services and their connection with human wellbeing

Finally, while supporting services were related primarily to security dimensions, there were also some supporting services attached dimensions of subjective happiness. Participants stated how important the intrinsic value of biodiversity and habitat were and how these services made them feel better, regardless of perceiving a direct use for them. They also noted how crucial these services were for stabilising and maintaining the health of agrarian ecosystems. Most examples referred to trophic chains regarding the necessity of biological control to avoid plagues. The security dimension refers to the possibility of using those ES in the future, known as 'option' or 'bequest' value.

Those statements were then presented to farmers and owners affected by *Itoiz-Canal de Navarra* modern irrigation transformation project for an absolute valuation using Likert Scale. A simplification of them was also used for relative valuation using a total of 13 agrarian ES to be valued through Pebble Method (see 3.3.2.1.)

Table 5.4 Supporting services and their connection with human wellbeing dimensions

Type of service	Example of related statement to supporting service	Benefit	Ecosystem service Scale	Benefit	Human wellbeing dimension to which ecosystem service contributes	Effect	Source: Literature	Source: Int.
Life	Agrarian soil is important because it supports terrestrial life	Material / Existence / Option	All	**Security & Basic material for life**	Collective & Individual	Direct	(Turner and Daily, 2008)	√
Habitat	Agrarian soil is important because it is a shelter for fauna	Material / Existence / Option	Landscape	**Security & Basic material for life**	Collective & Individual	Direct	(De Groot et al., 2002b; MEA, 2005a; Weber, 2007)	√
Fertility	Agrarian soil is important because its nutrients make possible the crops	Existence / Option	Plot & landscape	**Security & Basic material for life**	Collective & Individual	Direct	(Calvet-Mir et al., 2012; Kremen, 2005; MEA, 2005a)	√

5.3. Valuation of agrarian ecosystem services and awareness of their co-production

Once I had gathered the 18 statements linking five types of agrarian ES with the six dimensions of human wellbeing, I focused on understanding how those connections are evaluated by farmers themselves and who were affected by *Itoiz-Canal de Navarra* irrigation project. The aim is to ascertain whether and to what extent the management practices may influence such valuations by farmers. To do so, I conducted an empirical valuation of the social importance of agrarian ES (see Section 5.3.1) using two different socio-cultural valuation methods (explained in Section 3.3.2.1). Differences among the existing livelihoods are later assessed (Section 5.3.2). Section 5.3.3 and 5.3.4 inform about co-production awareness registered in the survey and differences on this perception among the livelihoods, respectively.

5.3.1. Values and perceptions

To explore which ES were the most and least valued (and to what extent) by respondents, both Likert (absolute) scale and Pebble (relative scale) methods were used. In employing the Likert Scale, 18 statements were presented to participants for an absolute valuation. Participants in the survey then had to rate each statement between 0 and 5, to indicate if they strongly agreed (5) or strongly disagreed (0) with it. In the case of the Pebble relative valuation, participants had to distribute 15 stones among 13 image cards that represented links between AES and HWB dimensions (see Section 3.3.2.2) for further explanation of scales in each method).

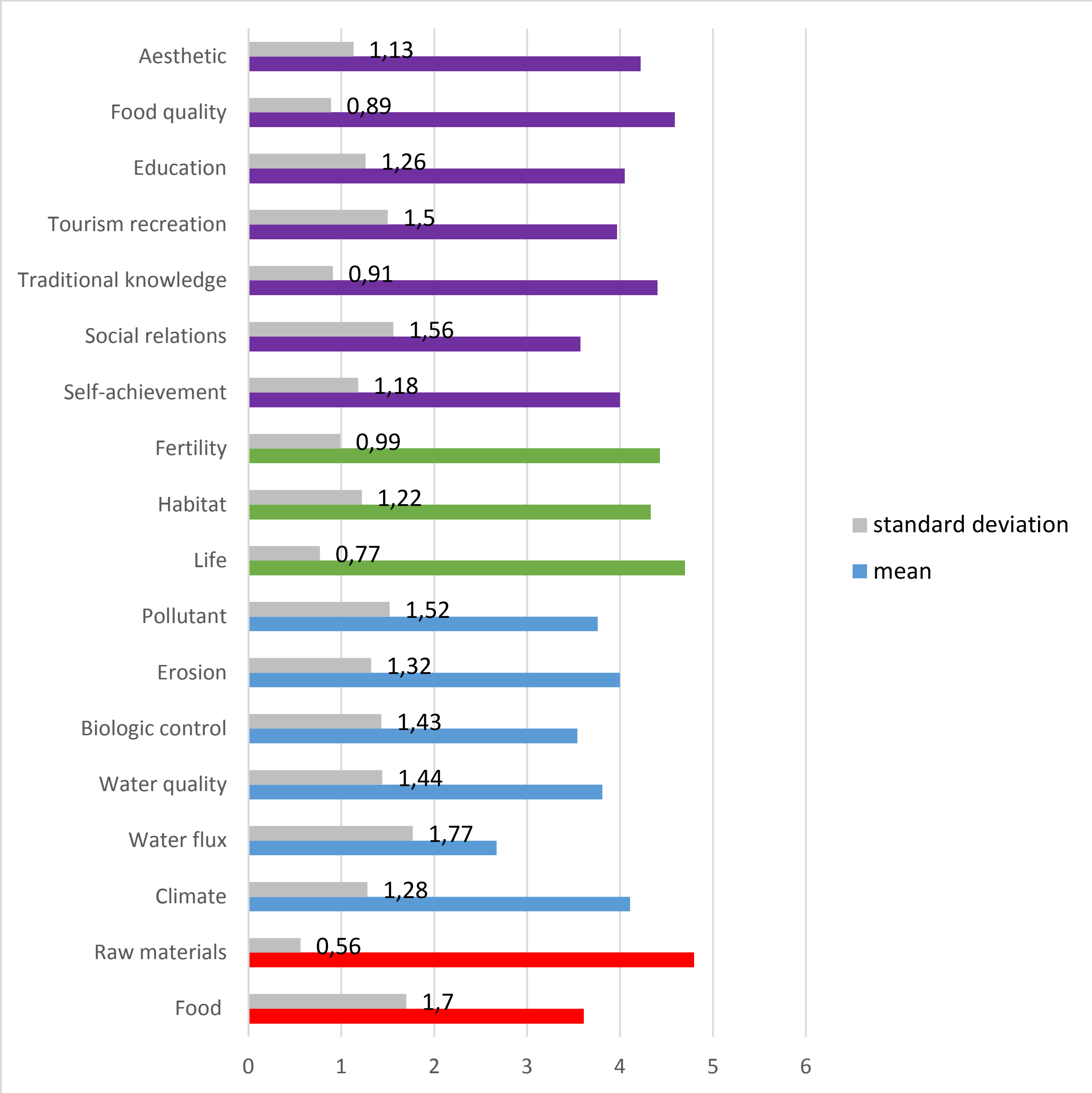

Figure 5.2 Absolute valuation of ES based on a Likert Scale (0, min -5, max)

Figure 5.2 shows absolute valuation of ES. It can be observed that, non surprisingly, provisioning services such as source of raw materials scored the highest values. Life support was the next service with the highest value, followed by food quality, fertility and traditional knowledge (which is simultaneously connected to the identity importance). Farmers' responses differed significantly in regard to their valuation of water regulation capacity, representing the highest variance in answers, followed by food provisioning. A detailed statistics table can be seen in Appendix VII.

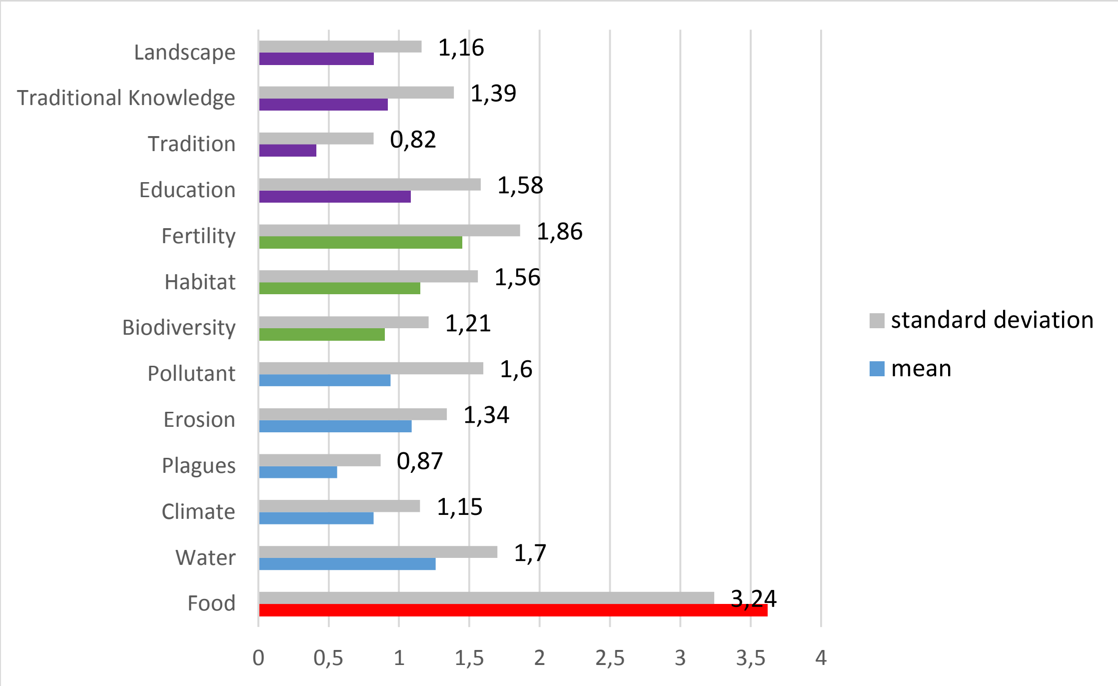

Figure 5.3 Relative values of ES relative valuation (mean values) using the Pebble Method (0, min - 5, max)

Figure 5.3 refers to relative valuation. Here, results were in line with the absolute valuation regarding provisioning services, along with supporting services such as fertility, habitat and the importance of water regulation. Provisioning services (food), followed by supporting (fertility and habitat) and water regulating service were the most valued services. Agrarian traditions (agricultural festivities) and some regulating services such as land's ability to buffer against plagues and its role in climate regulation were the least valued services. Food supply service also presented the highest variance in the valuation exercise.

5.3.2. Differences between absolute and relative valuations across farmers' livelihood profiles

The Kruskal Wallis test (Section 3.3.2.2) discerned between existing groups of farmers with regard to their valuation of ES. P values were adjusted following the False Discovery Rate control approach to avoid spurious significance due to multiple comparisons.[38]

[38] For further explanation about the FDR methods and why it is applied in this case see Section 3.3.2.

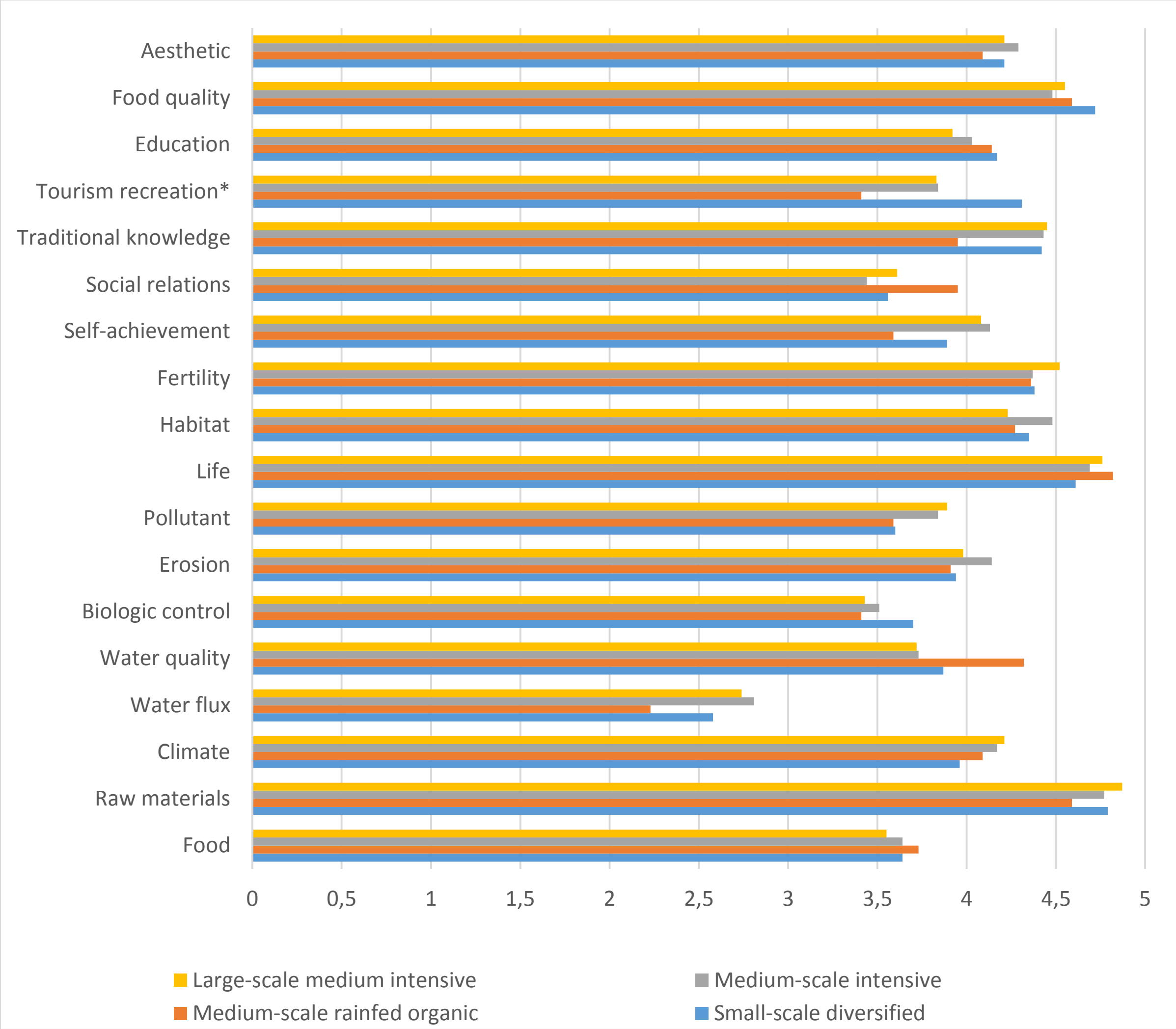

Figure 5.4 Adjusted absolute (Likert Scale) difference in valuation across existing livelihood profiles[39] (0, min -5, max)

Figure 5.4 presents the results obtained when farmers valued ES using the Likert scale method. The values refer to the mean value given by farmers holding different livelihoods (*C*hi square test mean value), being each of the farmers groups: *small-scale diversified* farmers*,* second *medium-scale rainfed organic* farmers and third *medium-scale intens*ive farmers and fourth *large-scale intensive* farmers. The p value is denoted via the presence of asterisk(s) after the labelled service.

Thus, I found that *small-scale diversified* farmers valued the capacity of agrarian ecosystems for tourism recreation significantly higher.[40] This is in contrast with the other livelihood profiles, who are

[39] One asterisk (*) after the service means that those categories are significantly different at a 90 percent significance, whereas two asterisks (**) denotes that those statements are significantly different at a 95 percent significance. This is repeated all over the rest of Figures.

[40] See Appendix VII, Table VII.2.

more dedicated to agriculture, and regarded this service (provided by the agrarian ecosystem) to have a lower value.

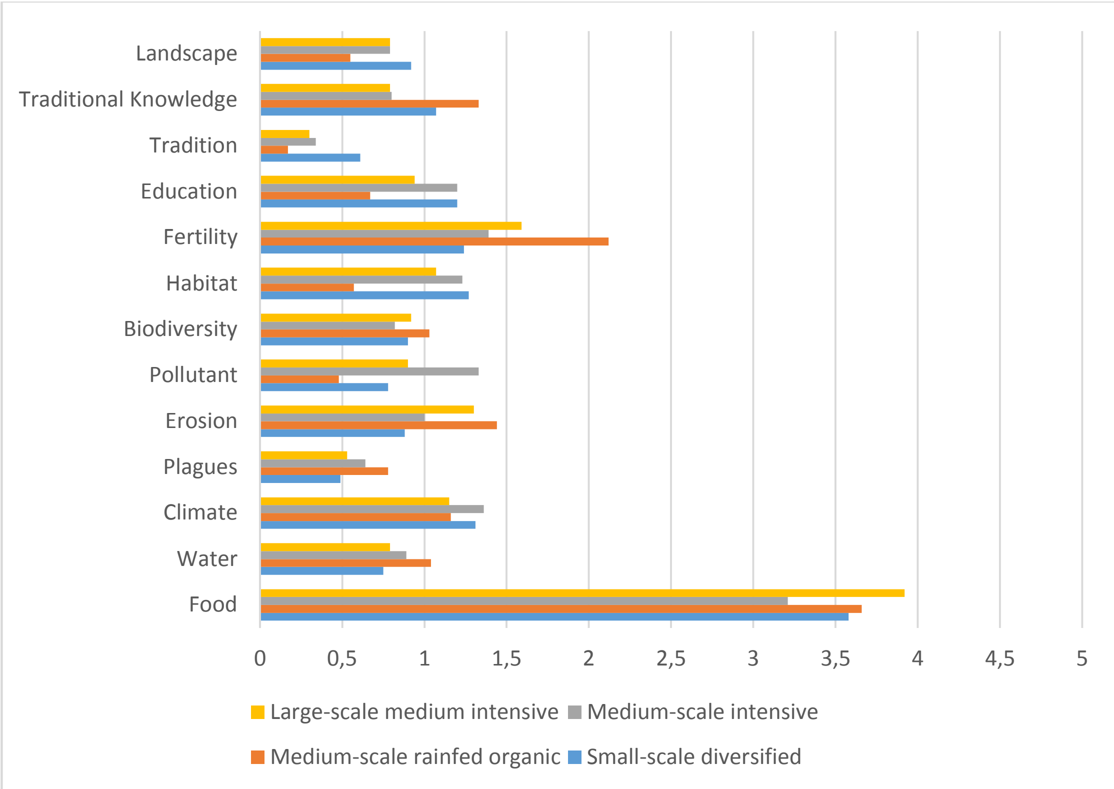

Figure 5.5 Adjusted relative (Pebble) difference in valuation across existing livelihood profiles (0, min -5, max)

Figure 5.5 displays the results of the relative valuation, which is considered a more appropriate way of valuation[41] (Matson et al., 1997) (see also Section 3.3.2). However, when utilising the Pebble method, I did not find any significant difference across livelihood profiles when p values were adjusted, which is an absence of asterisks after the services names.

5.3.3. Co-production awareness

As explained in Section 2.3, co-production is understood as the contribution of farmers' labour on the delivery of agrarian ES (Seppelt et al., 2011). During fieldwork, when participants were asked about

[41] Pebble valuation obligues participants to choose among the ES and this represent a more realistic situation regarding land management practices effects over agrarian ES. Moreover, although Likert is designed for valuation, in practice I found responses focused on the perception of agreement/disagreement with presented statements typically assigning extreme values to the sentences. Therefore, the relative valuation through the Pebble method provided richer information since clearer preferences were revealed.

agrarian ES, many of them highlighted that their labour practices strongly influenced the production of the commented services and/or disservices. Although participants showed difficulty in understanding regulating services ('Don't know' answers were more frequently attributed to this type of services than to others) and thus were normally scored as low, some participants highlighted the importance of management practices in the production of such services. This awareness was not measured using a scale of five categories, but as a dichotomy variable of being knowledgeable or not in regard to this aspect of co-production.

As **Figure 5.6** indicates, interviewed farmers were conscious of the fact that their tillage practices and use of fertilisers and pesticides had an influence on the presence of plagues, the level of soil fertility and water regulation. Interestingly, they also expressed how their practices had a strong influence on some cultural services, such as rural traditions, aesthetic services (including landscape configuration), and feelings of self-achievement.

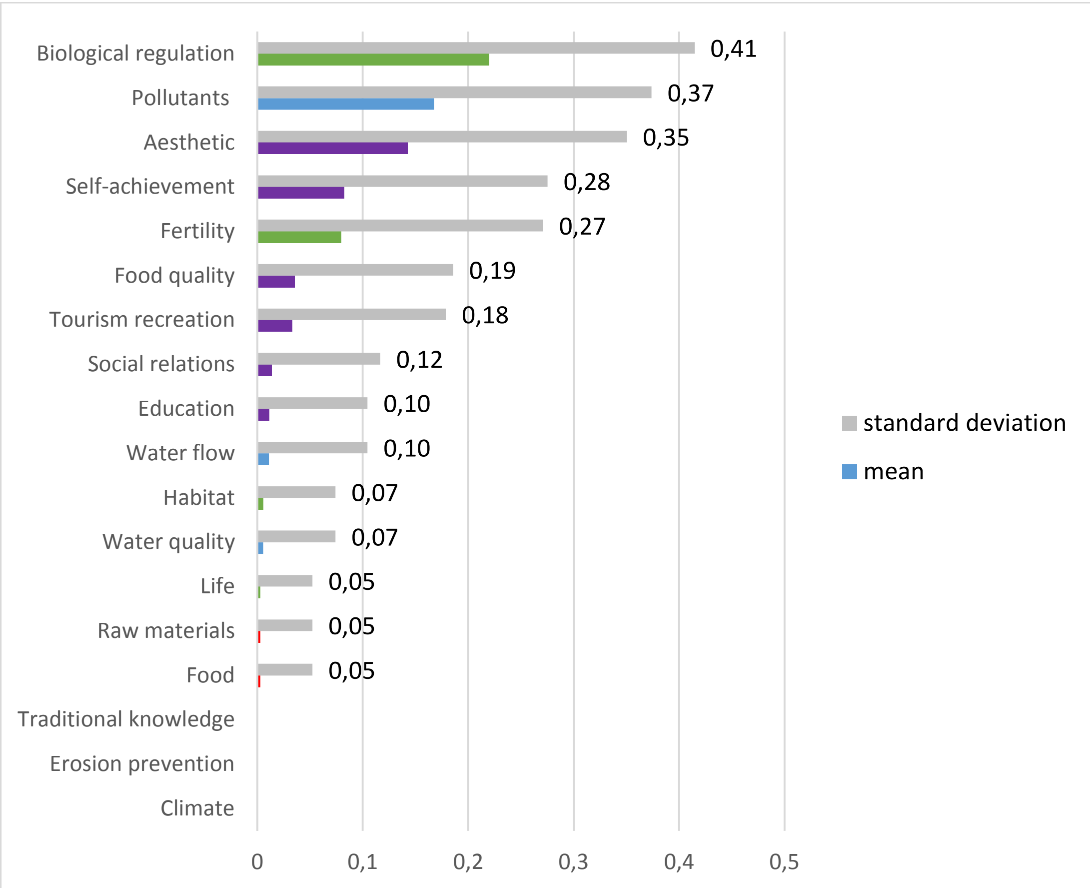

Figure 5.6 Co-production awareness on each ecosystem service calculated through the stated times mean over all the services valued (0, min -0.28, max)

Figure 5.7 presents chi square test mean value results; the p value is denoted via the presence of asterisk(s) after the labelled service. The bars represent the share or proportion of respondents answering the yes/no question regarding whether they thought their own land management practices influenced the services discussed. Scale of the horizontal axis from 0 to 0.28 represents the number of times each services was perceived by the farmers as co-produced through their management strategies. *Small-scale diversified* farmers significantly emphasised the importance of their practices for the quality of the food produced. When discerning whether awareness of co-production differed across existing livelihood profiles; I found only food quality as significantly different aware and this occurred at a 95% of significance (p<0.05) after adjusting the p values.

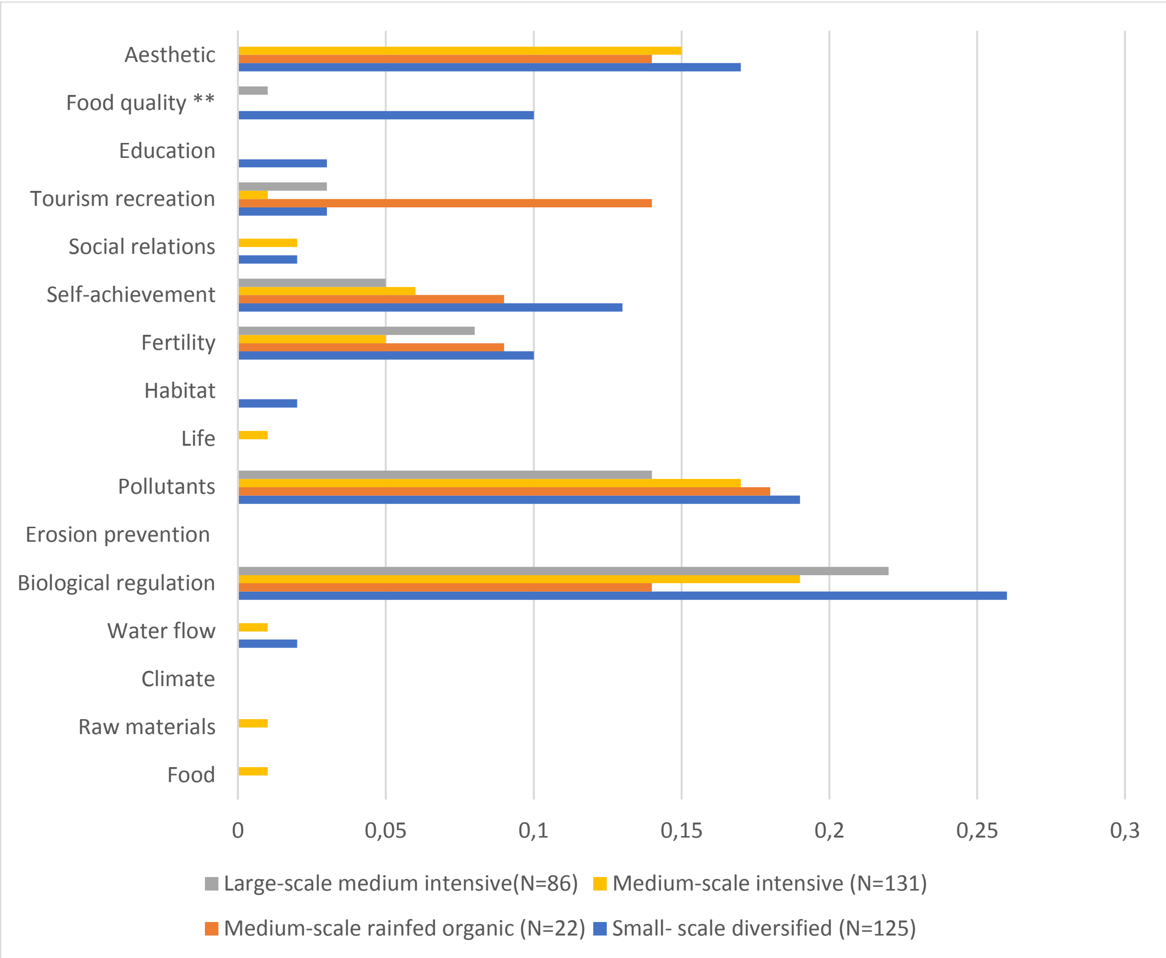

Figure 5.7 Adjusted co-production awareness differences among existing livelihoods

5.3.4. Access to capital assets influences the perception of ecosystem services values

Chapter 0 concluded that age, land access, gender and education were key variables for gaining access to other important capital assets such as participation in cooperatives and financial investment on agrarian insurance systems, for example. Although the classification of the exiting livelihoods in Navarre are based on their management choices and those variables are also significantly different across the livelihood typologies, this section analyses if these key socio-demographic variables have a significant influence on the relative valuation of agrarian ES when assessed separately. Non-parametric tests were used to understand their significant differences. I used the Kruskal-Wallis (K-H) test for discrete variables and variables with non-normal distribution, the Wilcox test for dichotomic variables and the Spearman (S) test for continuous variables without a normal distribution (see Section 3.3.2.2).

To demonstrate this relationship, the bars in the following figures indicate the farmers' perceived value of such services. Bars oriented to the right indicate that farmers with certain features hold a higher value regarding different ES. When the bars are oriented to the left, this demonstrates a lower perceived value of such services by farmers holding the same livelihood features.

As **Figure 5.8** shows, farmers with access to large land areas valued land as a climate regulation source and pollutant absorber higher than traditions ($p=0.02$) and traditional knowledge ($p=0.02$). This result aligns with findings that *intensive* farmers (which typically work larger areas) value the capacity of land to absorb pollutants higher than less intensive farmers, as well as have higher awareness of plagues than other farmers. This is a logical finding, since maize and other cereals crops that demand high fertiliser inputs normally occupy large irrigated extensions. Furthermore, these farmers often reported the use of treatment system sludge and commented how some potential hazard components of sludge were retained by agrarian soils.

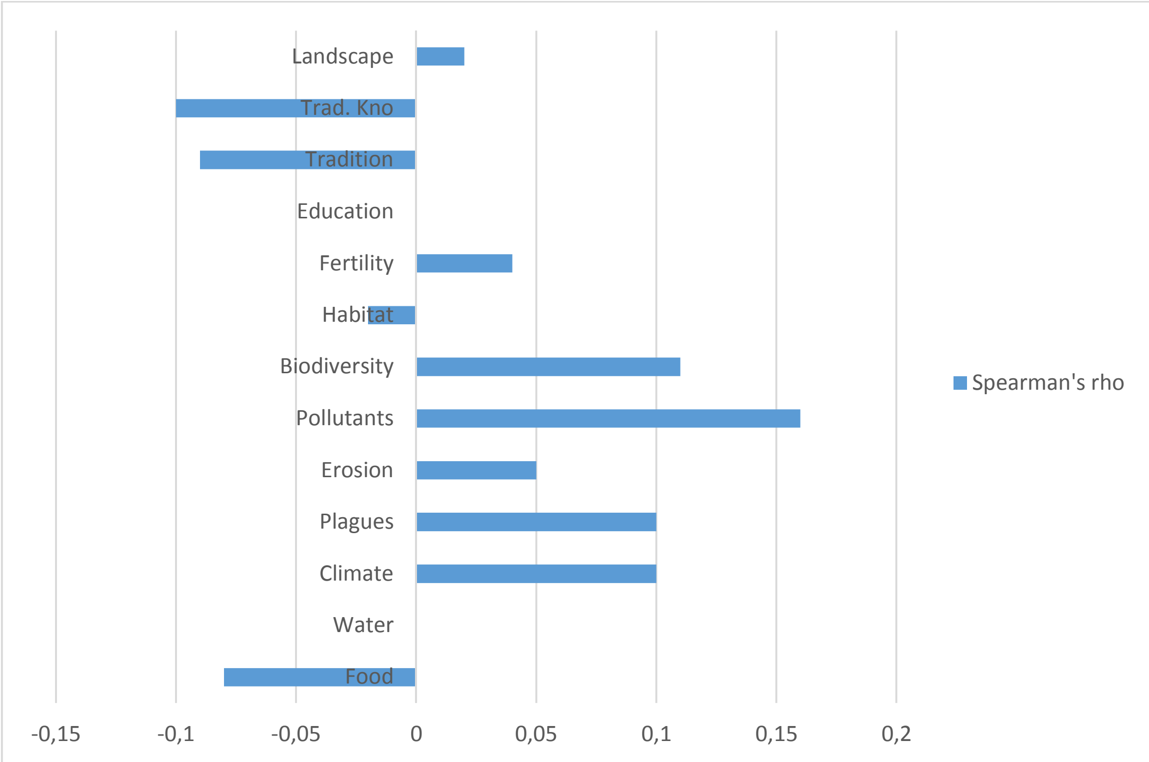

Figure 5.8 Valuation differences regarding cropped land areas (-0.1, min -0.16, max)

Figure 5.9 informs that those farmers adopting modern irrigation valued higher the capacity of land to absorb pollutants (p=0.03) and regulate plagues (p=0.01) than the rest of farmers. Appendix VII shows that women valued habitat and education services higher than men (p=0.06 and p=0.02). Age also influenced valuations. While older farmers gave higher importance to the role of land with control erosion (p=0.04), younger farmers were more conscious about the importance of land as animals' habitat (p=0.01). Education was also a relevant variable to understand differences in valuations. Respondents with more advanced levels of study assigned higher importance to the animal habitat as a supporting function of agrarian landscapes (p=0.05), while designated a lower score to traditional knowledge (p= 0.09) and education services (p= 0.06).

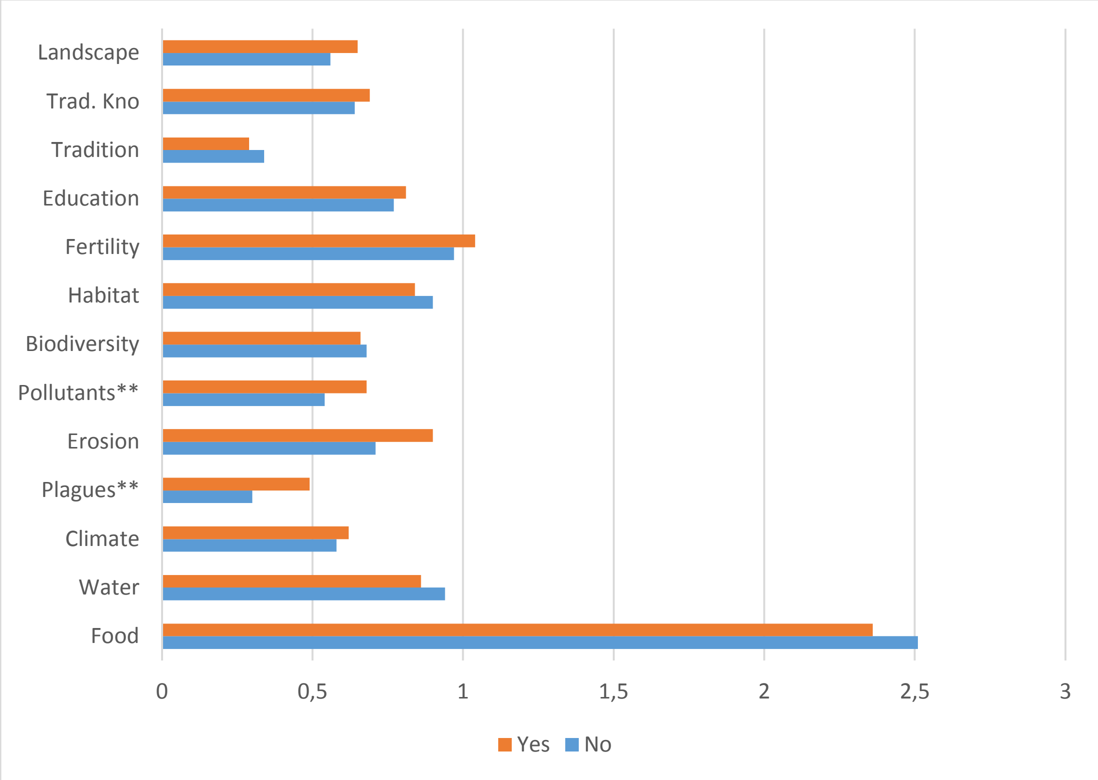

Figure 5.9 Valuation differences regarding access to modern irrigation (0.3, min - 2.51, max)

5.4. Agrarian ecosystem services trade-off analysis

Since stakeholders perceive different benefits from the same ES, sometimes their valuations can be difficult to compare. For instance, some services may be recognised by some and not by others, so those who do not acknowledge them do to attach any value to them. In other cases, individuals may have a different understanding of the relevance of agrarian ES; certain services may be conceived as a key element towards wellbeing, whereas others do not consider those services essential (Turner et al., 2003; Brondízio et al., 2010; Pascual et al., 2013).

Trade-off analysis can be done through a principal component analysis (PCA) and can depicted with a simple but equally intuitive petal flower diagram (**Figure 5.11**). PCA was applied to the data from the Pebble relative valuation (Matson et al., 1997). PCA summarised overall valuations into six components, which explained 57% of the variance with two factors (one representing food versus the rest of services and the second one representing the cultural services) explaining 23% of the variance. The PCA of the 13 ES used in the Pebble exercise illustrated that the factor analysis was multi-dimensional (i.e. services were differently valued and therefore required six factors to meet the Kaiser criterion (Kaiser, 1960) by having an eigenvalue higher than one. However, only the first three factors are described (33%of variance explained), since the remaining factors account for low variance (<9%)[42].

I labelled the first factor (F1) as *Food versus supporting and regulating services*, since the factor reflected that when regulating and supporting services were highly valued, the relative importance of food production diminished. This is reflected in **Figure 5.10** attending to factors one and two (F1 and F2). The food provisioning service is represented in the 'X' (F1) axis (left side of the figure), while almost all supporting and regulating services appear on the right side of this axis. Thus, when an interviewee attached importance to provisioning services, they typically valued the supporting and regulating services less than other services[43]. Only food provisioning service had high and negative contribution to F1, while most of the supporting and regulating services had positive contributions (with exception of pollutant absorption, which was negative but with a very low contribution towards F1). Only *small-scale diversified* farmers differed from the rest of farmers typologies regarding awareness of their practices and its effect on food quality. This reflects that those farmers' main objective was food production, which is manifested through their main crops: olive and almond trees, vegetables, etc. These farmers held partially subsistent agriculture, whereas other farmers' had a primary objective of income generation for the household. **Figure 5.11** shows that the most *intensive* group did not attach much importance to food. *Organic* farmers valued higher regulating and supporting services and valued food production lower than when compared to *large-scale intensive* and *small-scale diversified* farmers.

[42] This information can be found in Table VII.5 in Appendix VII
[43] Table VII.5 (in Appendix VII) shows the same through the weight and the signs of each variable to explain Factor 1.

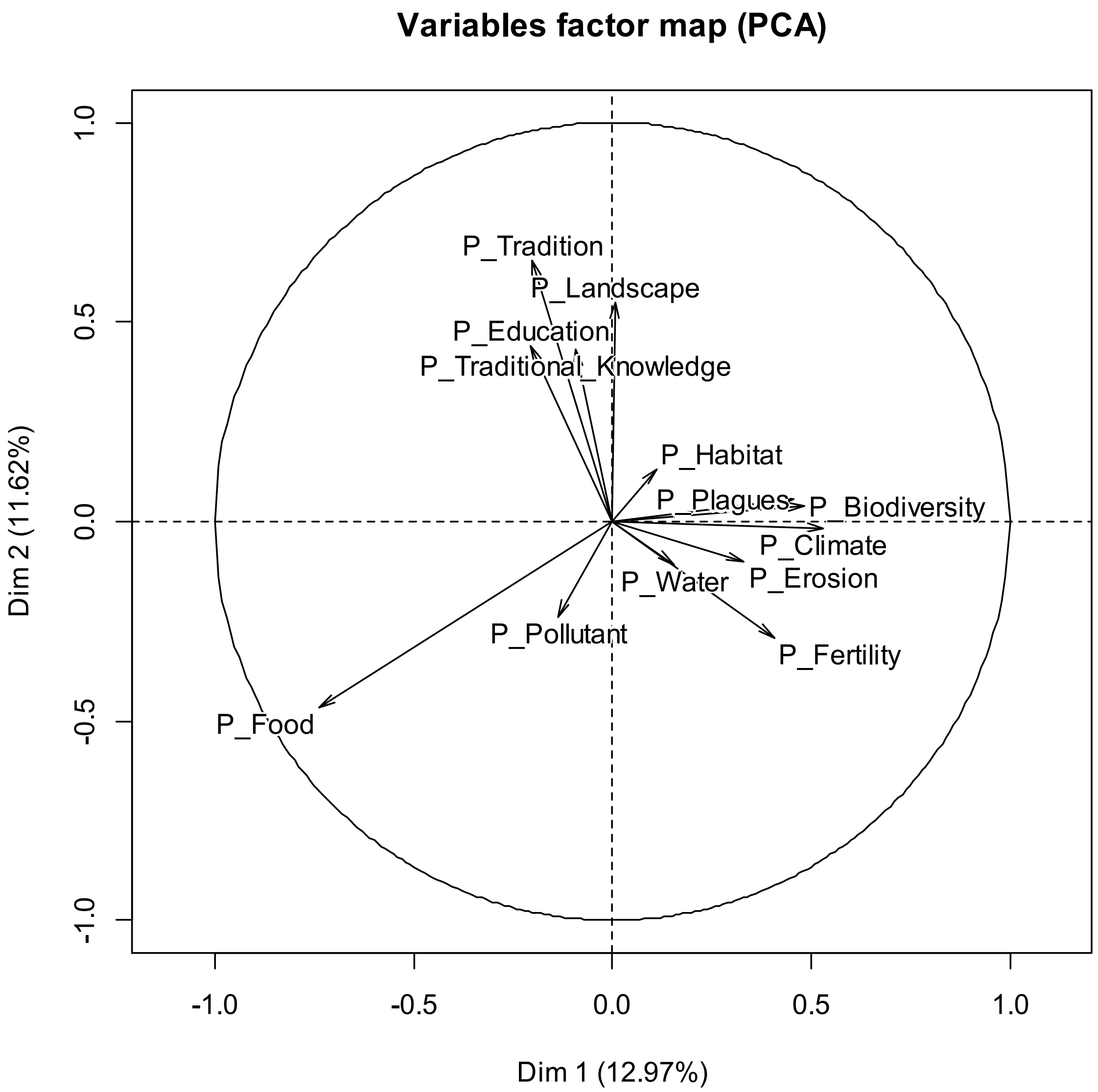

Figure 5.10 Trade-off analysis of agrarian ES valuation using Principal Component Analysis (PCA)

Factor 2 (F2) reveals the importance attributed by interviewees to agrarian ES for cultural reasons, which explains why I labelled it as the *cultural services* factor. This factor is represented by traditional knowledge and agrarian festivities maintenance (traditions) as well as landscape configuration[44]. Those variables have a positive sign and show highest weights on agrarian services valuation. Agrarian ecosystem as an educative mean was also high and positively scored. In **Figure 5.10**, axis 'Y' (F2) exhibits the variance regarding cultural services enhancement (upper left quadrant), food provisioning (bottom left quadrant) and supporting and regulating services (right two quadrants). This means that when interviewees attributed a relatively high importance to tradition, education and landscape, they often underplayed the food provisioning service, even rating the latter below other services such as

[44] This information can be found at Table VII.5 in Appendix VII.

fertility, climate regulation capacity and biodiversity. This second trade-off is not as clear as the one indicated by F1 (12.97%) but still explains 12% of the total variance in ES' valuation.

The perceived value of food provision (and in a much lower scale water and erosion regulation) as well as biodiversity and fertility services contributed in an opposite way to the *cultural services* factor. The value of the rest of the services was very low (e.g. climate, erosion, habitat and pollutant absorber capacity). This only reflected that they rarely contributed to this factor. This finding is also reflected in **Figure 5.11**, where *small-scale diversified* farmers' stated a higher preference towards some cultural services in comparison to other livelihood profiles.

Finally, factor 3 (F3), labelled *life vs. filter system*, provided information that can be connected to the findings when separate capital assets were analysed (Section 5.3.4). Moreover, it is also connected to the existing valuations of livelihoods and whether the adoption of modern irrigation influences these valuations. In regard to the values of F3, there was a clear trade-off between the importance attributed to land as habitat (0.57), biodiversity source (0.41), as food provisioning service (0.30) and land as a pollutant absorber (-0.56). Thus, this factor compared farmers who attribute low importance to land due to its capacity to absorb pollutants in contrast to those who attributed high importance to this function; which is clearly correlated with the notion of fertility (-0.39), as F3 shows. Agrarian ecosystems, by definition, are grown to produce food and fibres. As Section 4.2.3 outlined, for half of the participants it was their only source of household income, and for most of them it was an important part of their livelihood and global economy. As it is intuitively perceived, when attaching importance to food, habitat and biodiversity, the capacity of land to absorb pollutants was not scored high. However, this provisioning service exaltation contradicts the more *intensive* livelihoods, which were composed of the majority of participants in the study (217 people, the sum of farmers holding m*edium-scale intensive* and *large-scale intensive livelihoods*), who valued land's capacity to absorb pollutants significantly higher than others (see Section 5.3.4). These results may reflect that, on the one hand, participants' responses differed depending on whether their crops were for human consumption or for biofuels or animal feeding. Moreover, it may also reflect that if *small-scale diversified farmers* did value the option of their land to absorb pollutants, an over-use of land for this purpose could imply polluting all their lands; which is why farmers typically attached a lower value to this kind of agrarian services.

Drawing on Raudsepp-Hearne (2010), **Figure 5.11** below presents the results of ES valuation across livelihood profiles using flower diagrams, in which the petal length reflects the relative importance attributed to the correspondent service by the interviewees.

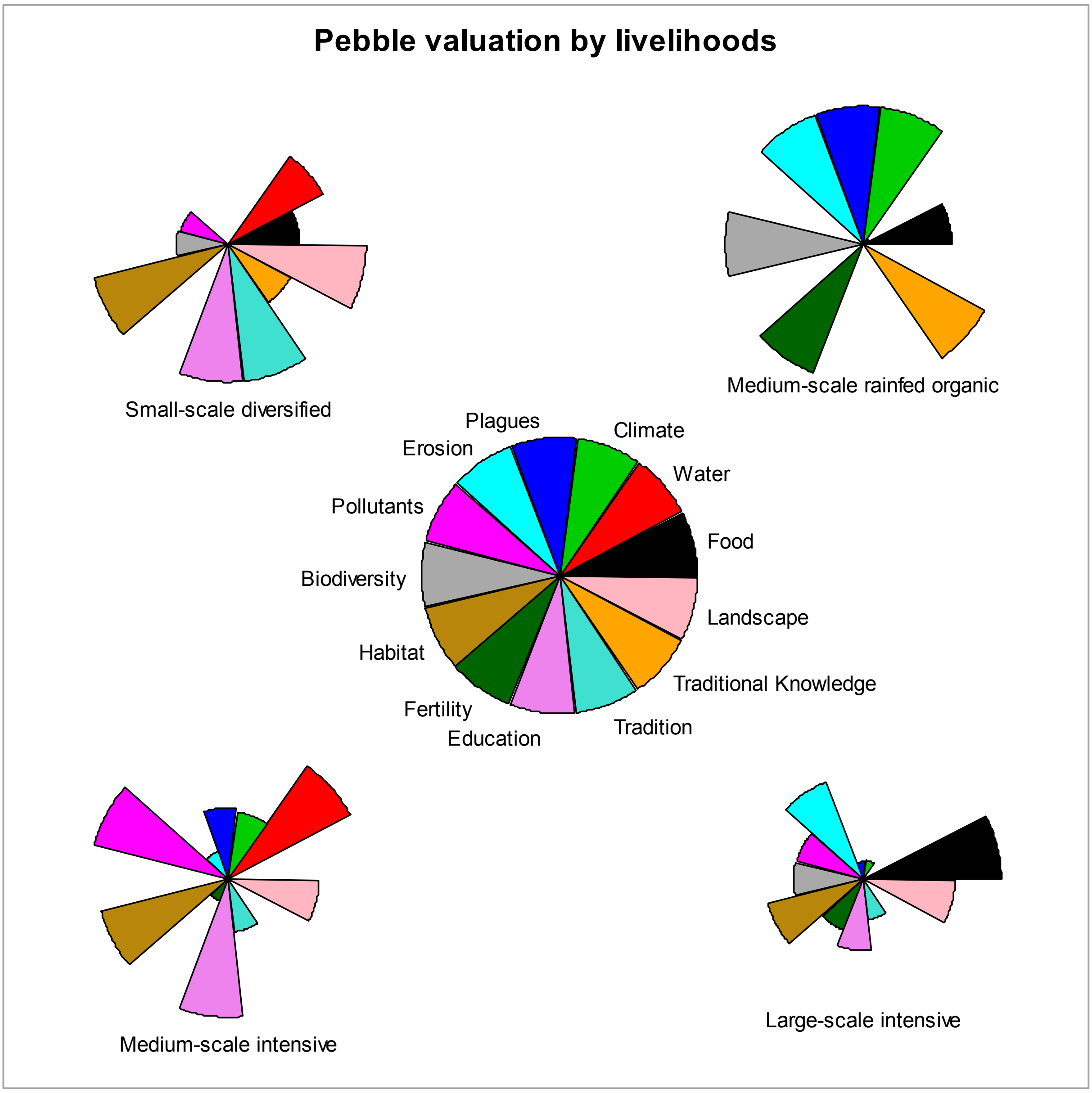

Figure 5.11. Trade-off analysis of agrarian ES valuation among existing livelihoods

Note: Flower diagrams showing the relative value of each stated preference for each agrarian ecosystem service by type of livelihood. Petal sizes range are a scaled mean from zero (petal absent, indicating a low value for the agrarian service) to one as a large petal (indicating a high value for the service). Each colour refers to a different kind of agrarian ecosystem service.

The flower diagrams depict a reflection of trade-offs and synergies across existing livelihood groups; a base point of various sets of preferences associated with livelihood trajectories. It can be seen, in the top right of **Figure 5.11**, that *medium-scale rainfed organic* farmers assigned higher importance to regulating services such as climate, plagues and erosion regulation, biodiversity, fertility and traditional knowledge. *Small-scale diversified* farmers (top left) placed a higher value on education, tradition, landscape, and habitat; water was also quite valued by this group. *Medium-scale intensive* farmers (bottom left) have a low representation of food production as they do not value it as highly when compared to the other livelihood typologies. However, *medium intensive* farmers place high valuation on water, pollutants regulation, habitats and education, whereas *large-scale intensive* farmers (bottom right) have clearly designated food as the highest value.

Although comparing livelihood profiles did not yield significant differences across the relative valuation of agrarian ES, it did however generate an understanding of coherent valuation tendencies regarding land management choices and the kind of services that are valued (i.e. the farmers' practices *a priori* promoted the services they valued). This is, those who did not perform such *intensive* practices appreciated regulating and supporting services (*medium-scale rainfed organic* farmers) higher than other farmer groups, while knowledge and traditions were more highly valued by *small-scale diversified* owners and farmers. Additionally, the analysis also demonstrates that *intensive* farming (in this case through large-scale modern irrigation) also influences valuation. The more land extension under irrigated system, the higher a farmer values the capacity of land to absorb pollutants and its capacity for biological control. *Intensive* farmers also valued traditions and traditional knowledge services less than other farmers holding different livelihoods.

5.5. Discussion

The discussion of the results presented so far in the chapter is divided in two subsections. Subsection 5.5.1 discusses how farmers' valuation of ES as related to their livelihood profiles contribute towards a better theoretical understanding of ES valuation frameworks found in the literature. Findings confirm that agricultural intensification influence farmers' perceptions about agrarian ES. This chapter's findings indicate that while an across-livelihoods comparison may not reveal significant differences, focusing on separate variables linked to intensification does disclose richer information. Subsection 5.5.2 centres in an assessment of the provisioning and cultural services trade-offs and the implications of disregarding cultural ES values. Furthermore, this section also clarifies how land use intensification influences farmers' perception about food production.

5.5.1. Understanding how livelihood profiles effect ecosystem services values

In Chapter 0, I outlined the analysis design of classifying Navarre farmers into different livelihood profiles. Their strategies were categorised in a virtual gradient of land management intensity regime which was developed according to the type of crops grown, fertiliser used, how the land was worked and the type of irrigation system. Although not ideal, these aspects were the only variables which provided insights into the distinct agricultural management strategies present in the study region. The clusters generated were not solely composed of the farmers with these characteristics, though a majority of participants within these groups held these features.

I hypothesised that farmers' management practices are related with the values they attribute to agrarian ES; i.e. farmers' decisions about their land management practices are connected to the importance in which they attribute to use, non-use, option and bequest values associated with different ES. However, as shown in Section 5.3.2, this hypothesis only held significant for *small-scale diversified* farmers and for one typology of services. This group attached significantly higher values to the recreation services provided by agrarian ecosystems than the other three groups.

Small-scale diversified farmers' land management practices consisted of the cultivation of small plots (less than one hectare) of diverse woody and vegetable crops using traditional irrigation and mineral, organic or mixed fertilisers. These farmers placed a higher value to the immaterial benefits connected to the subjective happiness dimension of human wellbeing which are provided through recreational services, and also embraced option and bequest values. The farmers within this livelihood placed a higher value on tourism recreation, which may be because some of the respondents within this typology were previously dedicated to rural tourism and associated businesses when the survey was performed.

This observation led me to realise that their land management strategies seemed not to respond solely to their perceived values, but also to the circumstances for which they decided to follow one strategy or another. As mentioned in the Chapter 0, all livelihoods were dynamic and related to the current stage of farmers' life. In other words, personal attributes such as age, experience, gender, etc. influence the values held by each individual towards ES; values and circumstances are not two independent factors explaining management styles. Thus, one could think that some of *small-scale diversified* farmers could follow *intensive* agricultural practices if their situation changed, such as not having an additional income source which would thereby affect renting and land buying decisions. In fact, *small-scale diversified* farmers presented mixed features of irrigation adoption and fertiliser use, which means that they were not very different from *intensive* farmers, except from the size of the cultivated lands and the cropping patterns. Such profile could thus reflect more to their current age or previous decisions on their livelihoods than to the values attached to the ES. In contrast, *medium-scale rainfed organic* group involved farmers who had made a conscious decision about how to produce their crops differently and the weight of attached values are presumably higher in this case. In their case, circumstances in terms of age, gender, experience etc. were similar to *intensive* farmers, but their values led them to choose a different land management strategy.

On the contrary, when attending to individual features directly connected to modern irrigation transformation, such as the type of installation and the size of the irrigated lands, I found significant differences in agrarian ecosystem service valuations. Those with a modern irrigation installation valued land capacity to regulate plagues (p=0.01) and its capacity to absorb pollutants (p=0.03) higher. Moreover, those with larger irrigated farms not only valued those two services more (p=0.06 and p=0.00 respectively), but they also valued traditions (p=0.02) and traditional knowledge (p=0.02) associated to agrarian ES significantly lower. In general, cultural services valuation trends shown in the trade-off analysis performed in the PCA and depicted through the flower diagrams disclosed that, although not significant, *small-scale diversified* farmers valued highly cultural services. Moreover, farmers within this livelihood are more conscious about the importance of rural traditions and traditional knowledge. This was exampled in the case in Iniesta-Arandia et al. (2014) where farmers not only contributed to food provisioning, but also to the delivery of those type of services.

There may be a possible connection between farm size and the knowledge and identity benefits perceived by stakeholders. This seems plausible, as practices performed in large farms are typically associated with heavy machinery and automated irrigation and fertilisation systems, all of which involve a different connection between the farmer and the ecosystem. This is, small-scale traditional agriculture is often characterised by manual labour and the farmers' knowledge of land quality, crop cycles and climate, which are crucial elements and subjected to heritage traditions. Due to the direct contact the farmer has with the land and the implicit reflective process on obtaining profit without damaging the ecosystem, there is a stronger link between the ecosystem and the farmer.

Agricultural intensification leads to the emergence of new landscapes that may contribute to the loss of identity to the original landscape. Irrigation transformation implies land concentrations with the consequent simplification of landscapes, the disappearance of micro-elements (hedges, borders, slopes, woods etc.) and the introduction of new elements such as irrigation infrastructure (De Vries, A, and Garcia M., 2012).

Furthermore, these results also inform about co-production awareness, which provides opportunities for beter policy planning. Here, I do not only identify which agrarian services are greatly valued, but I also inform about which services are perceived to influence farmers' labour practices. Fertility was valued highly and simultaneously perceived as a co-produced service through farmers' labour. The promotion of land management practices that improved fertility would be welcomed by farmers. Regulating services such as biological control, pollutant regulation and climate regulation (although perceived as co-managed services), were not particularly valued by farmers. These could be conflicting viewpoints when adopting potential regulating service enhancement measures. Again, *small-scale* *diversified* farmers were the only group who were significantly more mindful about their management effects on the quality of food.

5.5.2. Agrarian ecosystem services trade-offs

PCA has allowed me to discern that supporting services (on which the rest of services depend), regulating services (necessary for long term sustainability), and cultural services (that encourage individual roots and help determine social behaviour) are eclipsed by short-term, direct use food production. These results align with previous studies (Carpenter et al., 2009; Martín-López et al., 2012b; Palomo et al., 2013) that indicated the existence of two confronting aims: environmental conservation and rural development. In this case, this common trade-off occurs as it is not only an issue of provisioning services related to food and other regulating and supporting services but also to cultural services. These types of trade-offs have been widely acknowledged, and within several scales using other methodologies (Chan et al., 2012; Iniesta-Arandia et al., 2014). However, I have been unable to find any study in 'developed countries' which assesses the potential trade-offs of agrarian ES under transformation due to a technological change, such as irrigation. Moreover, insignificant trade-offs among livelihoods and significant trade-offs across separate variables provide reflection when considering the results of other studies. I also found that even food production seems to be undervalued by the most *intensive* livelihoods, disclosing that appreciation is not necessarily placed with the act of producing food, but instead with the income generation through the growing of crops, regardless of the products final use.

It is true that the majority of participants placed a higher value on provisioning services, revealing an agreement that food provisioning service is fundamental. *Value conflict*[45] is found in regard to regulating services such as climate and pollutant regulation and some cultural services. Fieldwork revealed that participants did not equally understand the functions behind those services, and consequently, did not attach the same value to them, which in turn was reflected as a *value conflict*.

On the other hand, cultural ES (traditions, landscape and traditional knowledge) were the least valued services. In MA terms, such cultural services are 'memories' from past cultural ties. If the farmers who value these services recede, future generations may people might not be exposed to the possibilities such legacy could have offered. Consequently, this could influence the decisions we make regarding what to remember and what to forget (Henle et al., 2008). So, if *intensive* land management becomes the dominant landscape and socio-cultural structures cease, alternative models with a higher value of

[45] When parties involved do not agree on the basic understanding of the issue discussed, what values are at stake and which should be given priority to (Vatn, 2007).

cultural services might dissipate over time. Human wellbeing dimensions (happiness, social relations, freedom and health) connected to cultural services are linked to livelihood and can help determine an individual's worldview and attitude (Poe et al., 2013). Thus, they are pivotal within the maintenance of ecological functions. The motives of cultural ES valuation depend upon moral, aesthetic and other cultural perspectives of the stakeholders involved (Hein et al., 2006; MEA, 2005a). The low valuation of those services could be partially attributed to their poor recognition in policy and science (Díaz et al., 2015a) and the consequent poor communication of their value to farmers (lack of incentives such as subsidies and technical aid). Legitimacy of politics and academic works can influence farmers' perceptions, which over time can be incorporated and accepted as facts (Vatn, 2007).

Although food provisioning was categorised as the most valued ES, I also found that *medium-scale intensive*-type farmers valued these services significantly less than of the other livelihood profiles (**Figure 5.11**). The decline of traditional farming in Europe is an issue that transcends the local scale. This result parallels research by Iniesta-Arandia et al. (2014) and provides an explanation which could clarify these findings. As Foley et al., (2011) also found, an important part of younger farmers' production (which is over-represented within the *intensive* livelihood typologies) is not devoted to direct consumption markets, but to animal feed, bio-energy and other industrial products such as fibres. Although the percentage of agriculture dedicated to non-human market is not registered in this case study, fieldwork suggests that a large part of the reported crops was used for biodiesel production and animal feed. Additionally, the market orientation for income generation may be working against farmers' perceived importance of food quality. Only *small-scale diversified* farmers upholding more traditional practices were significantly more conscious about their co-production on food quality, which can be explained by the mere orientation of the production toward supplying local food markets, friends, relatives and their families.

Irrigation transformation promotes an *intensive* farming model that is proposed by the government and its linked technical organisations such as INTIA. These institutions presented modern irrigation as an opportunity for increasing provisioning services quantities, therefore household income, and job opportunities for future generations. In contrast, farmers with livelihoods outside of the current agro-industry were propositioned to sell their lands, move to other lands in a rainfed area, or convert to the promoted *intensive* model. These were the three options offered by Navarre Government to the farmers who revealed their preferences towards food and cultural services. Moreover, cultural services are the outcome of the human-ecological interactions and the foundation which sets the preferences towards the rest of ES management (K. M. Chan et al., 2012). Time will reveal whether *small-scale diversified* and *medium-scale rainfed organic* farmers co-exist under a more *intensive* land management regime or whether intensification will suppose those kind of livelihoods disappearance.

In this case, we may be facing an irreconcilable situation. Although they both refused to convert into an *intensive* livelihood, they may not be able to maintain their practices due to the influence of intensive practices surrounding them. Cultural services such as landscape and traditions would also be threatened if the institutions promoting *intensive* land management regimes ignore them when establishing agrarian policies. The results of this work are aligned with the results of Chan (2012) regarding the importance of making an appropriate valuation which includes cultural dimensions that enable decision-making, and is ecologically appropriate and socially just.

5.6. Summary

This chapter has set out that modern irrigation influences the farmers value system, as they may only pursue services linked to such land management practices. This chapter has shown that farmers with access to large irrigated land areas placed a higher value of the land's pollution absorption capacity and its biological control service than other kind of services. In contrast, *small-scale diversified* farmers' who value more cultural services in comparison to the rest of groupf of farmers. However, I did not observe any significant trade-offs in the way groups of farmers sharing different livelihoods valued ES.

Chapter 0 provided evidence of an imbalance of land and water resource distribution as an outcome of the different livelihood strategies. Farmers that follow an iintensive livelihood profile were acquiring new lands through purchase and rental agreements. Chapter 0 has furthered this fact by informing about other potential impacts on ES promoted by modern irrigation, intensification and thus through different livelihood profiles, which in turn are associaded with potentially different valuations of ES. As a consequence of modern irrigation, a loss of mosaic landscape is occurring, along with the detachment from traditional knowledge and connected heritage traditions, as well as recreational, aesthetic, and spiritual benefits (De Vries, A, and Garcia M., 2012). Those services and benefits are the least valued in general by all the farmer groups with exception of *small-scale diversified* farmers. Those farmers are not gaining access to either land or water resources. Furthermore, they may be losing their access to those valuable services.

Next, it is questioned whether the present institutional structures are poorly suited for ensuring long term sustainability for *small-scale diversified* farmers and their preferences. I postulate that this is and will continue being the case as long as the financial gain is the basic motivator driving the system. Private interest is the source of the found tendencies (Zhang et al., 2007) and it is a reflect within the effects of large-scale economies on small-scale societies. These reflections are answered in Chapter 0.

Next Chapter 6, explores farmers' uneven vulnerability to multiple rural stressors and the role that adopting modern irrigation has on it.

CHAPTER 6

"Ecological arguments are never socially neutral any more than socio-political arguments are ecologically neutral"

David Harvey

6. Farmers' vulnerability to external stressors

6.1. Introduction

The previous chapter showed insignificant differences on the relative valuation of agrarian ES across farmers with different livelihood profiles. Classifying farmers according to their land management intensity regime does not reveal diverging valuations. However, certain variables connected to land management intensity (e.g. area of farmland and whether or not farmers had installed modern irrigation) suggest that farmers who adopted modern irrigation attribute greater importance to the capacity of land to absorb pollutants and to control plagues than other farmer typologies. These farmers also place a lower value on traditions and traditional knowledge than other farmer typologies. Overall, these findings suggest that these farmers prefer the private benefits derived from agricultural intensification over other type of benefits, even if such benefits are realised at the expense of overexploiting the soil's pollution absorption capacity and neglecting other cultural services associated to identity and knowledge sharing.

This chapter turns now to investigate the adoption of modern irrigation from a different standpoint: it examines if the access to modern irrigation increases or decreases farmers and landowners' vulnerability to external stressors and shocks. The chapter contributes to answering Research Question 3, i.e. *Which livelihoods are more vulnerable to (1) climate variability and drought and (2) crop price volatility and why this may be the case?* I investigate the main stressors and shocks faced by rural livelihoods and identify which farmers and landowners are more exposed to such threats, as well as which assets contribute to farmers' sensitivity and adaptive response capacity. I focus on the role that modern irrigation plays in determining farming households' vulnerability.

According to the IPCC (2014), climate change is likely to result in an increased reduction in water availability from rivers and groundwater sources. The combination of increased water demand (e.g.

irrigation, energy and industry, domestic use) and reduced water drainage and runoff due to increased evaporation, can result in several risks for many countries and economic sectors worldwide, but particularly in southern Europe. This evidence, however, was not evident in the case study region, where the majority of interviewed farmers (66%) manifested a lack of concern about future water availability and, in fact, were in favour of endorsing modern irrigation to increase water consumption and increase their competitiveness, regardless of potential investment for the long term. In this context, I hypothesise that modern irrigation in Navarre might negatively impact the livelihoods of some farmers and jeopardise the capacity to adapt to external stressors such as climate and market changes. Further I also hypothesise that modern irrigation installation might instead lead farmers to mal-adaptation.[46]

There is no consensus in the literature over the efficiency of modern irrigation (Berbel and Mateos, Cabello et al., 2015; Tarjuelo et al., 2015) or to which extent it reduces or increases rural households' vulnerability to drought (Wilhelmi and Wilhite, 2002). For instance, Edwards et al. (2010) show that long droughts in Australia were not solved by the introduction of irrigation. Berbel and Mateos (2014) assess the expansion of cultivated lands in Spain (north of Aragon and Andalusia) and demonstrate that, counter-intuitively, modern irrigation results in higher water consumption and an increased dependency on water for farming. In contrast, Tarjuelo et al., (2015) argue that modern irrigation in Spain has increased water-use and energy efficiency. In this dissertation, I sustain that such arguments about efficiency mask other unintended consequences of modern irrigation, such as increased indebtedness and strong dependency in increasingly fewer crop markets (see e.g. Dumont et al, 2013).

The analysis carried out in this chapter is time and scale specific; therefore, the results do not capture changes over time, assuming that adaptive capacity, sensitivity and exposure to external drivers are constant (see also O'Brien et al., 2004; Vincent, 2004). Consequently, the study might be blind to longer-term evolutions of social, political and environmental factors. As developed in Chapters 2 and 3, the analysis is based on the development of a vulnerability index, which in turn relies on the livelihood analysis of Chapter 0, and it is also informed by additional data collected through interviews and focus groups.

Figure 6.1 illustrates the reasoning behind the analytical process developed in this chapter, which is structured in seven sections, including the introduction. Section 6.2 reviews the three main dimensions of vulnerability following IPCC guidelines (IPCC, 2001): exposure, sensitivity and adaptive capacity. Section 6.3 discusses the main stressors faced by farmers in the case study area. Insights

[46] "Mal-adaptation occurs when a short term response inadvertently leads to an increase in future vulnerability" (Barros et al., 2014, p.214).

from semi-structured interviews are used to identify such stressors, which are then ranked by farmers according to their own perceived importance. Then, statistical data of the highest ranked stressors (price and climatic fluctuations as well as drought shocks) are used to calculate the farmers' current exposure. Overall, these two sections correspond with the left side of **Figure 6.1**.

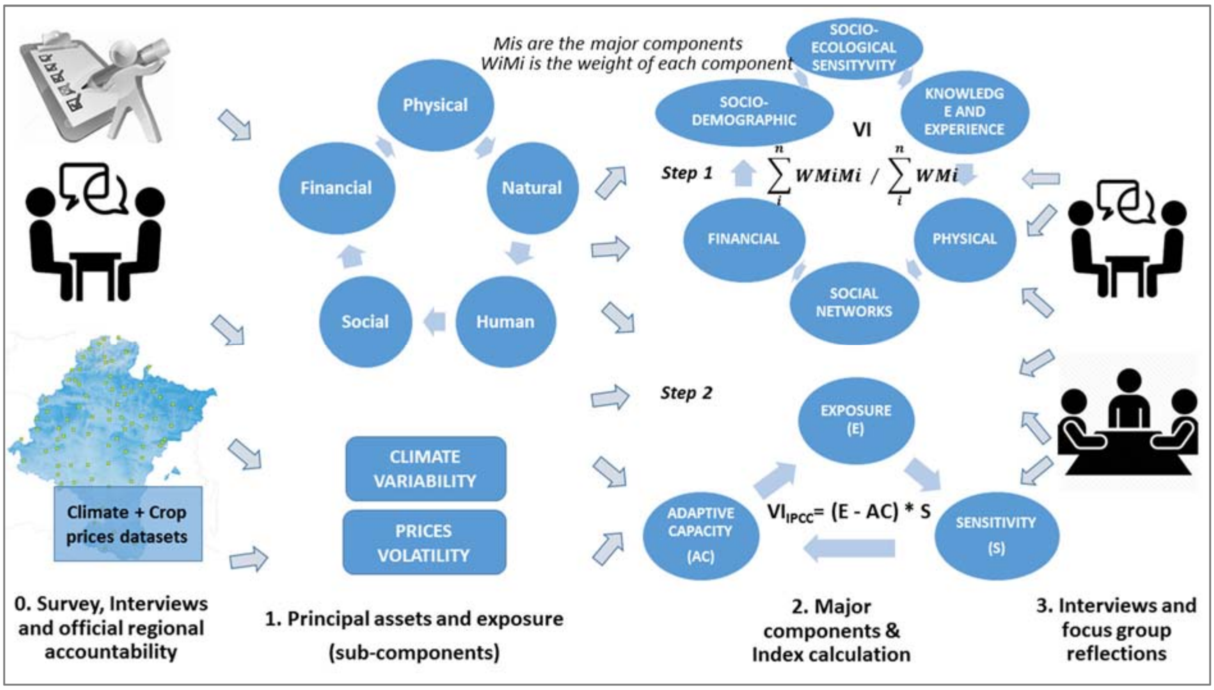

Figure 6.1 Line of reasoning for the analytical process in Chapter 6

Section 6.4, identifies data collected through surveys which provide approximate information regarding the assets and socio-demographic features influencing the sensitivity and adaptive capacity of farming households to the selected stressors. First, principal components of vulnerability are calculated (see Section 3.3.3) based on capital assets and socio-demographic features. This calculation illustrates disaggregated data regarding how household assets influence vulnerability patterns and also permits disclosing potential asset combinations that can decrease such vulnerability. Next, in alignment with the IPCC vulnerability definition, the information is aggregated in an index (hereafter VI). Assets are grouped into the IPCC's three contributing factors to vulnerability (IPCC, 2001): exposure, adaptive capacity and sensitivity (Hahn et al. 2009). Such index is represented in the bottom right side of **Figure 6.1**, and it identifies the most vulnerable farmer typologies (Eakin and Bojórquez-Tapia, 2008).

Finally, Section 6.5 discusses the chapter findings and highlights if there are 'double exposed' vulnerable livelihoods (*sensu* O'Brien and Leichenko, 2000); i.e. if the same farmer groups are simultaneously vulnerable to climate variability, including drought, and the volatility of crop prices. This section also draws on interview and focus group material to further contextualise the results. Reflections about the strengths and weaknesses of vulnerability indexes are also included here. **Table 6.1** synthesises the type of data sources used in this chapter, the demographic of each source and the purpose for which the data is used.

Table 6.1 Summary of the data sources used for the analysis of farmers' vulnerability

Data source	Demographic	Purpose
Qualitative interviews	29 interviews randomly selected including farmers, scientists, policy-makers, NGOs, cooperative workers, consumer groups and water management companies' officers	Identification of perceived rural stressors faced by farmers in the last decade and other contextual information
Quantitative household survey	381 households randomly selected from the 22 villages affected by *Itoiz-Canal de Navarra* project	Analysis of the weights farmers attributed to the previously mentioned factors of stress and identification of the assets that composite households sensitivity and adaptive capacity - components of the vulnerability indexes
Qualitative interviews	19 stratified sample of farmers in the village of Miranda de Arga	Analysis of farmers' perceptions about the importance of assets influencing their own vulnerability and adaptive capacity
Focus group	5 individuals intentionally selected: farmers and landholders from Miranda de Arga, a local environmental activist, and an INTIA technician	Analysis of farmers' perceptions about the importance of assets influencing their own vulnerability and adaptive capacity

6.2. Applied theories about exposure, sensitivity and adaptive capacity

6.2.1. Exposure to climate variability, drought and crop price volatility

Agriculture is considered a risky economic activity. Exogenous factors, such as the changing costs of production inputs and the uncertainty of weather, pests, and plant diseases, act as factors that can influence the phases of the agricultural cycle. These latter risks might intensify with anthropogenic climate change and globalisation-induced price volatility[47] (Isakson, 2014). When assessing vulnerability, *what* someone or something is vulnerable to should be considered; i.e. identifying the stress factors affecting farmers' livelihoods (Birkmann and Wisner, 2006; Cutter, 2016). In this research, and as noted in Section 2.4, farmers' vulnerability is assessed with respect to two locally identified stressors, climate variability and crop prices fluctuations[48], and a shock, i.e. drought. To analyse exposure to climate variability and drought, climatic station data were used (see Section 3.3.3). In order to assess farmers' exposure to price volatility, data was used from official sources examining the primary crops produced and their prices in the study area, i.e. cereals (wheat and barley), maize and vineyards[49] (see Section 3.3.3).

6.2.2. Sensitivity to climate variability, drought and crop prices volatility

Sensitivity can be described as the degree to which a system (e.g. social, economic) is affected by or is responsive to external stimuli (Brooks et al., 2005; Stocker et al., 2013). Generally, a household's sensitivity to a given stressor is a function of combined factors, including the household's structure (e.g. the number of family members who are economically dependent) and the existence of a broader livelihood portfolio – i.e. the availability of alternative non-farm income as complementary strategies to buffer vulnerability (Antwi-Agyei et al., 2013).

Additionally, the sensitivity of rural households to different stressors is influenced by the type of the crop, which influences investment levels and labour requirements, land tenure and land availability, which also affect financial and human investment behavior, and the level of farmers' income diversification, which determine farmers' bargaining power and exposure to risk. Prior experiences with large-scale investments (e.g. resulting in distinct levels of awareness at the negotiation stage) and contract terms (e.g. input provision arrangements, transparency, barriers to exit), and diversification of market outlets (German et al., 2011) can also influence households' sensitivity.[50]

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[47] Prices volatility refers to variations in economic variables over time (FAO and UNCTAD, 2011). Not all variations are problematic but become challenging when considerable and cannot be anticipated and, as a result, create a level of uncertainty that increases risks for producers, traders, consumers and governments (FAO and UNCTAD, 2011).

[48] Stresses are pressures that are continuous and cumulative, predictable and negative while shocks are impacts that are typically sudden, unpredictable and traumatic (Luers et al., 2003b).

[49] It was not possible to account for vegetables and woody crops export-import balance since they were registered in an aggregated way during fieldwork. This is a study caveat that has consequences for the analysis of *small scale diversified* farmers' vulnerability, who are usually those that grow these crops.

[50] See Appendix VIII, Table VIII.2 and Table VIII.3.

6.2.3. Adaptive capacity to climate variability, drought and crop prices volatility

A household's adaptive capacity can be defined as the household's capabilities that enable it to alter or structurally reorganise its activities, in order to reduce current livelihood threats while simultaneously enhancing its ability to counter new risks (Eakin, 2005). Therefore, a household's capacity to address the risks of multiple stressors has been described as a function of indicators measuring various types of capitals. These capitals can include access to information, technology, wealth and finance, and institutional resources (such as subsidies or other forms of external support) (Eakin and Bojórquez-Tapia, 2008). Therefore, the capacity of the households to access and put their assets into action will determine their ability to adapt, anticipate or react.[51]

Education is a crucial human capital asset that helps to increase adaptive capacity. Increased literacy can improve access to information about key stressors and thus potentially enhance people's capacity to buffer against their potential impacts (Antwi-Agyei et al., 2013). Households may also be able to increase their adaptive capacity when they have access to social capital, including participation in social networks (Eakin and Bojórquez-Tapia, 2008; Hahn et al., 2009), family-based interactions, and through cooperative ties, which can provide support that transcends socioeconomic factors (Antwi-Agyei et al., 2013).

Farmers can shift their land management to a less vulnerable condition (Luers et al., 2003a). Age, disability and health status, which are determinants of human capital, are key indicators that can shape adaptive capacity of individuals to climate and non-climate related hazards (see IPCC, 2014a from Campos, et al., 2014). In addition, financial assets are widely recognised as enabling anticipatory coping strategies, including insurance and post-event responses to a shock or stress (Vincent, 2004). Furthermore, individuals with access to physical assets are able to maintain their livelihoods, hence widening the range or intensity of hazards for which they can cope (Vincent, 2004).

Although its is debated if modern irrigation may be a mal-adaptive measure and under which conditions this might be the case, this dissertation considers that the adoption of such technology may promote adaptation to adverse climatic change effects in the calculation of the index (Mendelsohn and Seo, 2007; Deressa et al., 2009). Irrigation is hence included as one component of physical assets in the VI calculations, and it is thus related to farmers' adaptive capacity (Section 3.3 and Appendix VIII). Throughout the chapter, I evaluate the adoption of modern irrigation to understand how it relates to other assets and its potential effects on farmers' sensitivity and vulnerability.

[51] See Appendix VIII, Table VIII.2 and Table VIII.3.

6.3. Rural livelihoods' exposure to multiple threats

During the first round of interviews (see Section 3.3.1 and Appendix I), farmers reported drought and their lack of control over crops' selling price as key risks to their livelihoods (for similar findings see Eakin and Bojórquez-Tapia, 2008; Hahn et al., 2009; Isakson, 2014; Campos, et al., 2014). Participatory observation also revealed concerns about climate variability. Surveyed farmers reported the absence of institutional support as an important factor of stress, but to a lesser degree. **Table 6.2** shows farmers' assessments of each stressor and shock reported during the survey.

Table 6.2 Valuation of rural stressors and shock, ordered from most (5) to least (0) important

Stressors	**mean**	**sd**
Price Volatility	4.07	1.61
Drought	3.35	1.91
Lack of institutional support	2.84	1.90

Source: author's survey data analysis.[52]

When asked to evaluate the shock and stressors in a scale from zero to five (zero as insignificant and five very important), 82% of the survey respondents assigned the highest importance to not having control over crops' selling price, - they explained that external factors in which they had not control such as oil prices made crop prices fluctuate – they thus perceived price volatility as the most relevant stressor.

Data provided by the Department of Agriculture of Navarre revealed that the volatility of the dominant crops' price has been higher during the 2000-2010 decade than in the previous two decades. Since 2006, all assessed crops have experienced considerable price volatility. Prices rose sharply in 2006 and 2007, peaking in the second half of 2007 for some products (Gobierno de Navarra, 2015). **Figure 6.2** illustrates the volatility of the affected crops.

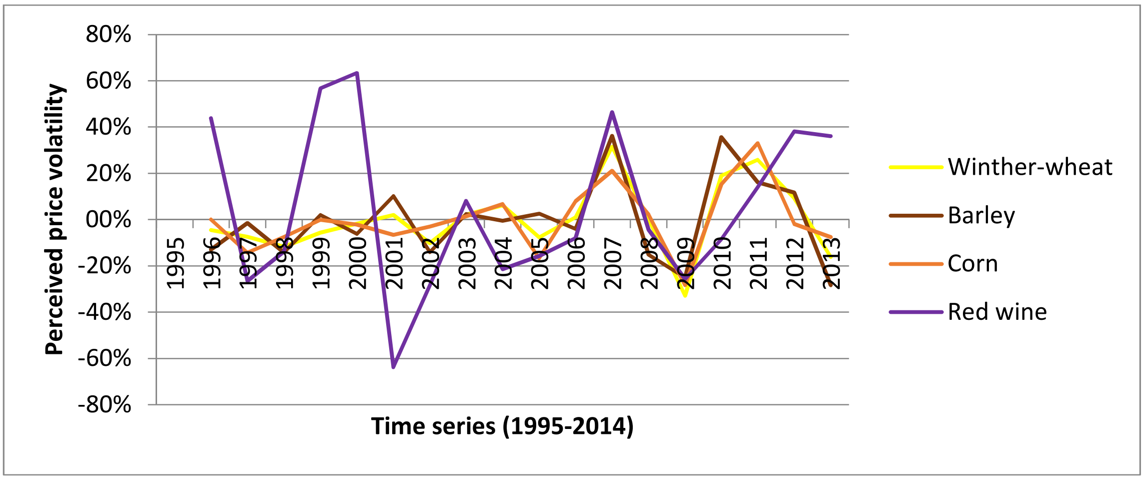

Figure 6.2 Price volatility for the period (1995-2014) by farmers in Navarre

[52] Tables not showing a source means that they are derived from the author's survey data analysis.

Future projections also point to increases in the volatility of food prices worldwide. Growing population and rising disposable income in emerging and developing countries add to the increasing demand for food, which coupled with the growing demand for feed crops and biofuels, will exert further pressure on commodity prices (FAO and UNCTAD, 2011). In the future, situations such as low crop stocks due to climatic factors are predicted to happen more often (FAO and UNCTAD, 2011). Agricultural commodity prices are also becoming increasingly correlated with oil price (through the price of fuel and fertiliser, for example). Potentially, high and volatile oil prices could therefore contribute to higher and more volatile agricultural prices. This could occur due to higher input costs, an increased demand for the commodities used in the production of biofuels (sugar, maize, vegetable oils) and through competition for land (FAO and UNCTAD, 2011). The IPCC (2014) also warns that periods of rapid food and cereal price increases following climate extremes in key producing regions indicate a sensitivity of current markets to climate extremes.

Information gathered through interviews suggests that farmers with a more market-oriented profile, e.g. the *intensive farmers*, were completely dependent on such international markets. One of these farmers noted the following:

> *'Regarding price there is no chance we can act upon. There is a grain bag traded daily. Wheat and barley prices are determined by traders... If you look at the Madrid stock exchange, these prices are changing every minute. This and the cost of energy (oil, transport) determine the price! If we talk about cereals, producers are in Argentina, Russia, Australia, and Europe. Cereals are exported from these places, we consume them. In Navarre, we have a negative balance. If I bring cereal from EEUU here, the price will be assigned by the stock market, plus the cost of transport: the ship to get here, crops transfer to the port, truck costs to get to my factory. This is globalisation, the global economy. This happens to all products!' (I2.4)*[53]

Perceptions such as this one above were shared by at least 30% of the respondents, and were also frequent during the interviews and focus group discussion.

Sixty percent of the surveyed farmers also considered drought as an important shock to their livelihoods. However, variance[54] was high for this stressor, which might be explained by differences in

[53] Quotation not indicating a source means they are derived from the author's interviews data analysis and are self-translated.

[54] Although I tried to make clear I was referring to agronomic drought (e.g. humidity deficit in the land following a meteorology drought thus negatively impacting crops production) results suggest that some survey respondents may have misunderstood this explanation.

memory recall and by the climatic differences existing between *Zona Media* and *Ribera Alta,* where the former is wetter than the latter.

Finally, 45% of the respondents believed that institutional support from formal organisations was insufficient and that such organisation did not provide enough subsidies to make most farming livelihood economically viable. Institutions regulate access to key assets that can impact the vulnerability of farmers, such as *medium-scale organic farmers* (Adger, 2006; IPCC, 2014). As farmers reported institutions to be unsupportive, they characterised this to be a high stress factor. The high standard deviation of responses in this case may be associated with varying levels of comprehension regarding the questions provided. This stress factor is not analysed in this chapter, but deserves attention in Chapter 0.

The importance attributed to the different stressors significantly differed according to the farmers' distinct livelihood portfolios (**Table 6.3**). *Small-scale diversified* farmers considered price volatility and drought as the least important stressors, and in doing so they highly contrasted with *intensive* farmers. This result confirms that *small-scale diversified* farmers are not characterised by a strong market-oriented profile and that this livelihood profile does not typically depend solely on agriculture-based income. *Medium-scale rainfed organic* farmers were the most concerned with the absence of institutional support and argued for increasing public support to improve their land management practices and crop commercialisation capabilities.

Table 6.3 Differences among existing livelihoods regarding their perception about stress and shock factors (index from 0 min to 5 max.)

Adjusted Likert valuation method					
Stressors valuations	***Small-scale diversified***	***Medium-scale rainfed organic***	***Medium-scale intensive***	***Large-scale intensive***	**(p.value)**
** Price Volatility	3.35	4.18	4.70	4.27	(1.68e-05)
** Drought	2.68	2.86	3.74	3.79	(1.30e-04)
* Lack of institutional support	2.64	3.45	3.07	2.75	(1.08e-01)

* When stressors are perceived significantly different at a 90% of significance by farmers with different livelihoods

** When stressors are perceived significantly different at a 95% of significance

6.4. Measuring vulnerability

As introduced in Section 6.1 and illustrated in **Figure 6.3** and **Figure 6.4**, the vulnerability index (VI) is structured around three analytical dimensions: exposure, sensitivity and adaptive capacity of vulnerability. Each of these, in turn, has a set of components (level 3 in **Figure 6.3** and **Figure 6.4**) and sub-components (level 4 in **Figure 6.3** and **Figure 6.4**) that bring together the analytical variables corresponding with the five types of capitals and other socio-demographic variables (see Section 3.3.3).

Farmers' vulnerability to climate variability was calculated according to climate characteristics and its fluctuations over time and farmers' explanatory components of exposure, sensitivity and adaptive capacity to such stressors (see **Figure 6.3*Figure 6.4***). Exposure to price volatility was determined by the number of crops farmers grow in the study area, the cultivated land area, as well as crops' price volatility from previous years (see **Figure 6.4**).

Sensitivity[55] encompasses three analytical variables that differ to those used when referring to vulnerability to market prices stressors. Adaptive capacity encompasses five components: human, socio-demographic (e.g. gender, age), financial, physical and social (at level 3), which are neither composed of the same analytical variables (level 4) in **Figure 6.3** and **Figure 6.4**. Such components are selected based on literature review and availability in the survey.

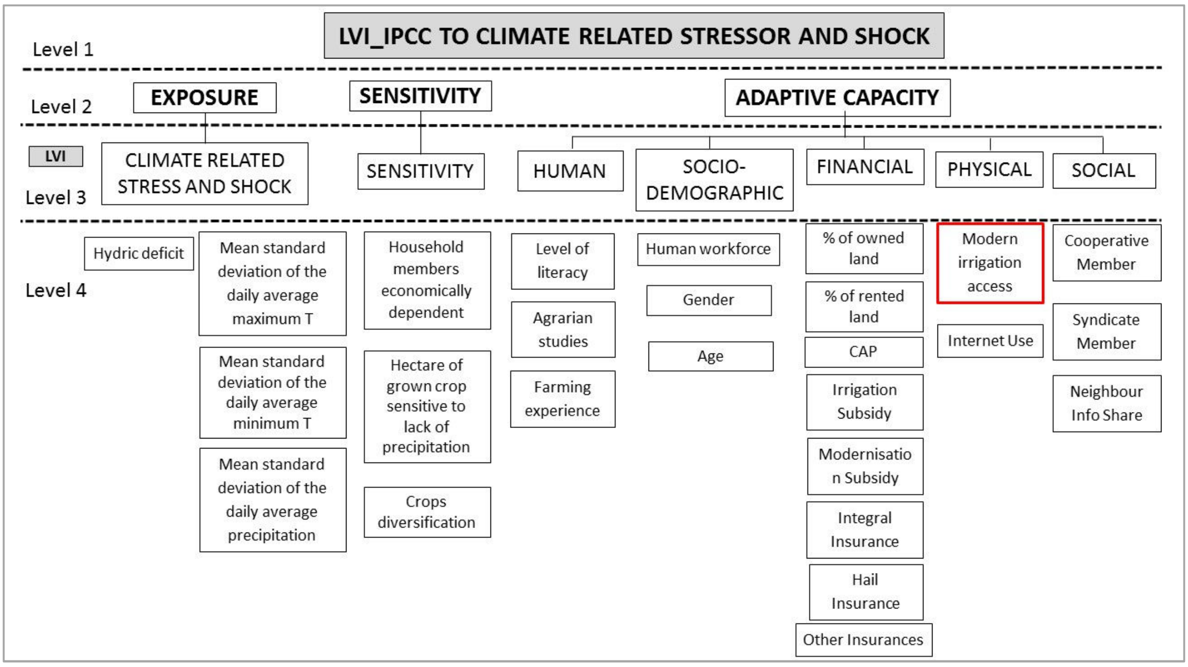

Figure 6.3 Categorisation of analytical variables, components and contributing factors from the IPCC vulnerability definition for climate connected stressors and shocks

[55] The word 'sensitivity' is used twice at level 3 and level 2 (see Figure 6.4).

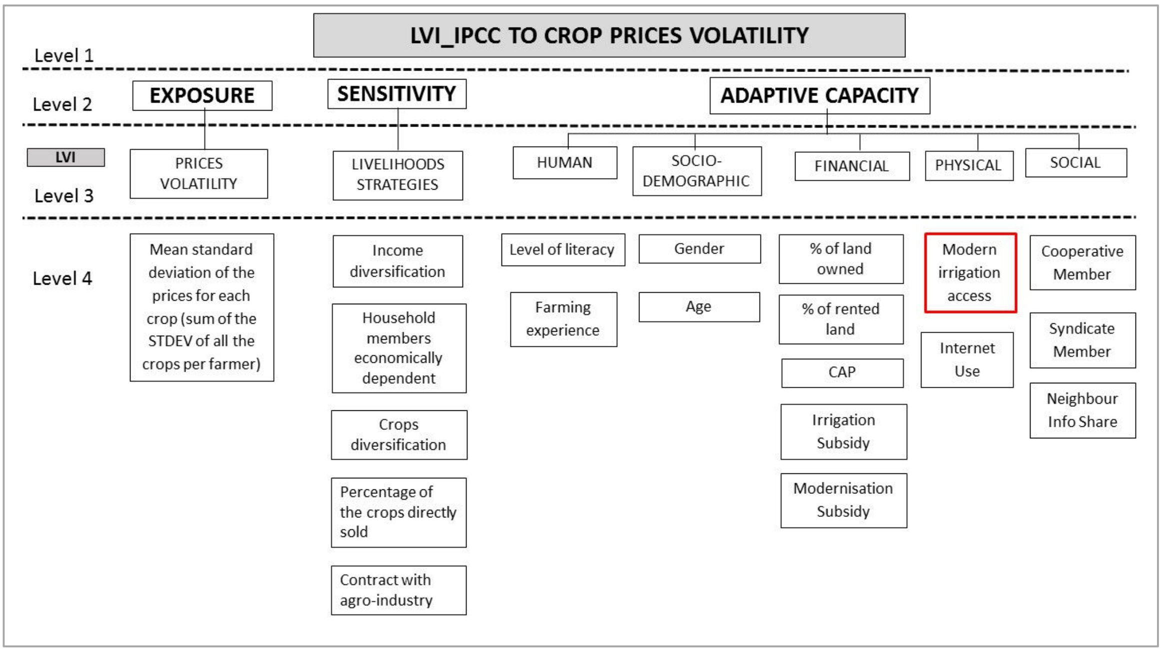

Figure 6.4 Categorisation of analytical variables, components and contributing factors from the IPCC vulnerability definition for crop prices connected stressors

6.4.1. Vulnerability to rainfall variability and drought

This section calculates the VI to analyse farmers' vulnerability to climate variability and drought. Unsurprisingly, this stress and this shock affect the case study farmers differently (**Table 6.4**). Index values should be interpreted as relative values to be considered within the study sample only. The VI to climate variability and drought (VI_climate) is on a scale from -0.10 (least vulnerable) to 0.24 (most vulnerable). These values were the minimum and maximum results of VI_climate for each household. I established thresholds of vulnerability dividing households in four groups into four quartiles (0-25, 25-50, 50-75 and >75%) of the total result. Intervals were then divided into very low [-0.10,-0.003]; low (-0.003,0.01]; high (0.01,0.03] and very high (0.03-0.24] vulnerabilities.

Overall, the VI_climate analysis shows that *small-scale diversified* farmers (0.035) and *medium-scale rainfed organic* farmers (0.015) are the most vulnerable groups, whereas *intensive* farmers (0.007 and 0.005) are less vulnerable.[56]

[56] See Table VIII.4 in Appendix VIII for supplementary data.

Table 6.4 VI to climate variability and drought contributing factors for the four types of livelihoods (IPCC, 2001)

IPCC contributing factors	Small-scale diversified farmers	Medium-scale rainfed organic farmers	Medium-scale intensive farmers	Large-scale intensive farmers
Sensitivity	0.13	0.16	0.17	0.12
Adaptive capacity	0.39	0.52	0.56	0.52
Exposure	0.65	0.62	0.61	0.56
VI_climate	**0.035**	**0.015**	**0.007**	**0.005**

Figure 6.5 shows a *vulnerability triangle or radar*, which plots the contributing factor scores for exposure, adaptive capacity, and sensitivity. The triangle in the figure illustrates that *small-scale diversified* and *medium-scale rainfed organic* farmers are more exposed to climate variability whereas *intensive* farmers are less exposed and also have a higher adaptive capacity. Among *intensive* farmers, *large-scale intensive* farmers are less sensitive to climate than *medium-scale intensive* farmers; thus, coupled with their low exposure, they are considered the least vulnerable group.

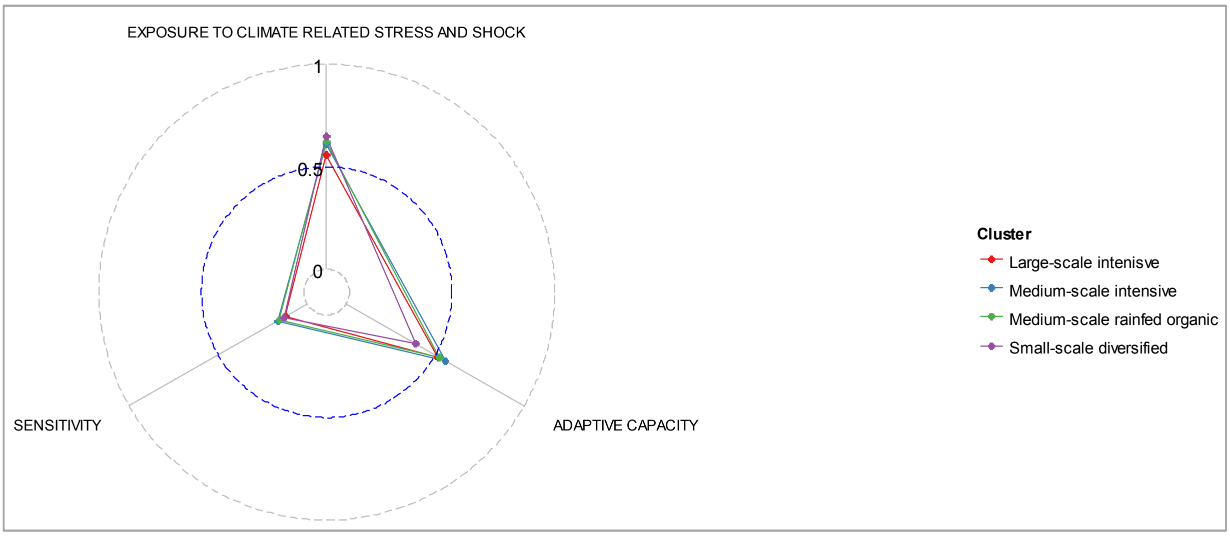

Figure 6.5 Vulnerability triangle of the VI_climate for the four types of livelihoods when exposed to climate linked variability

However, the level of variable aggregation (level 4) within **Figure 6.5** does not facilitate understanding of the explanatory causes behind the observed degrees of adaptive capacity and differences in exposure and sensitivity. **Figure 6.6** below addresses this problem by also incorporating the components (level 3) that composited the VI_climate. The scale of the diagram ranges from 0 (not vulnerable) at the centre of the web, increasing to 1 (most vulnerable) at the outside edge. It can be observed, in contrast with **Figure 6.6**, that sensitivity is similar for all farmer groups. However, *medium-scale intensive* farmers are more sensitive due to a few factors: 1) households fully depend on agricultural income; 2) the number of economically dependent family members is higher; 3) their crops diversity is lower, and; 4) the amount of land dedicated to maize cultivation is the largest.[57] Their adaptive capacity, however, is the highest compared to other farmer typologies.

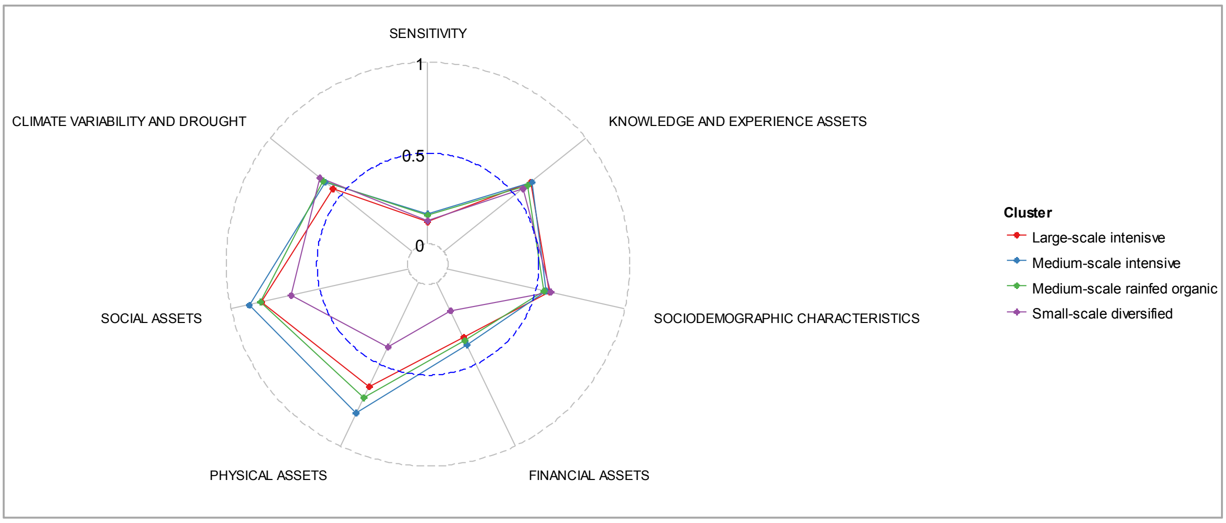

Figure 6.6 Vulnerability radar diagram for the four types of farmer groups when exposed to climate variability

Figure 6.6 shows that the differences of adaptive capacity to climate related stressors and shocks among farmer groups are more notorious than those of sensitivity or exposure. Although Navarre is characterised by its heterogeneous climate, meteorological stations are distanced at most 50 kilometres from each other. Exposure to climate variability is similar for all farmer groups. This figure also reveals the existence of a trade-off between sensitivity and adaptive capacity. *Intensive* farmers are typically fully dedicated to large-scale agriculture, which is often characterised by crops with a high demand of water and other inputs. These farmers have been able to counter climate related hazards by installing modern irrigation systems, accessing all available subsidies, acquiring insurance and also using cooperative networks services. *Small-scale diversified* farmers, thus, were more vulnerable in comparison to other farming livelihoods, due to their lack of physical, financial, social and technical knowledge-related assets.[58]

[57] See Table VIII.4 in Appendix VIII.
[58] See Table VIII.4 in Appendix VIII.

6.4.2. Vulnerability to price volatility

The VI is now applied to analyse farmers' vulnerability according to price fluctuations of their most important crops. ***Table 6.4 VI to climate variability and drought contributing factors for the four types of livelihoods (IPCC, 2001)*****Table 6.5** shows that *small-scale diversified* farmers, followed by *large-scale intensive* farmers are the most vulnerable groups to this stressor. *Large-scale intensive* farmers are more vulnerable, as they grow the largest amount of crops and therefore their exposure to crops' prices volatility is higher. This VI_prices is on a scale from -0.48 (least vulnerable) to 0.062 (most vulnerable). These values were the minimum and maximum results of VI when related to the price volatility stressor.

Table 6.5 VI to price volatility contributing factors for the four types of livelihoods (IPCC, 2001)

IPCC contributing factors	***Small-scale diversified farmers***	***Medium-scale rainfed organic farmers***	***Medium-scale intensive farmers***	***Large-scale intensive farmers***
Sensitivity	0.44	0.46	0.48	0.43
Adaptive capacity	0.48	0.61	0.63	0.59
Exposure	0.01	0.02	0.07	0.05
VI_price	**-0.20**	**-0.27**	**-0.27**	**-0.24**

Figure 6.7 illustrates the three dimensions of vulnerability when farmers are exposed to the volatility of crop prices. *Medium-scale intensive* and *medium-scale rainfed organic* farmers are the least vulnerable despite their high exposure and sensitivity in comparison to *small-scale diversified* farmers. However, they still have the highest adaptive capacity. The low exposure of *small-scale diversified* farmers is due to the fact that those farmers mainly cultivate 'other crops' and this category, which was collected in an aggregated way encompassing several types of crops, was assigned a zero value in its standard deviation (see Section 3.3.3) since they were normally reported as self-consumed crops during the fieldwork. This was considered a realistic approach since farmers in this livelihood group do not typically commercialise their crops, but instead sell their harvest locally or use them for household consumption. The observed high exposure of *medium-scale rainfed organic* farmers was anticipated given that the majority of these farmers grow vineyards and grapes, which have recently experienced very unstable market prices (see **Figure 6.2**). In this case, the most *intensive* group is quite sensitive but their adaptive capacity makes them the least vulnerable group.

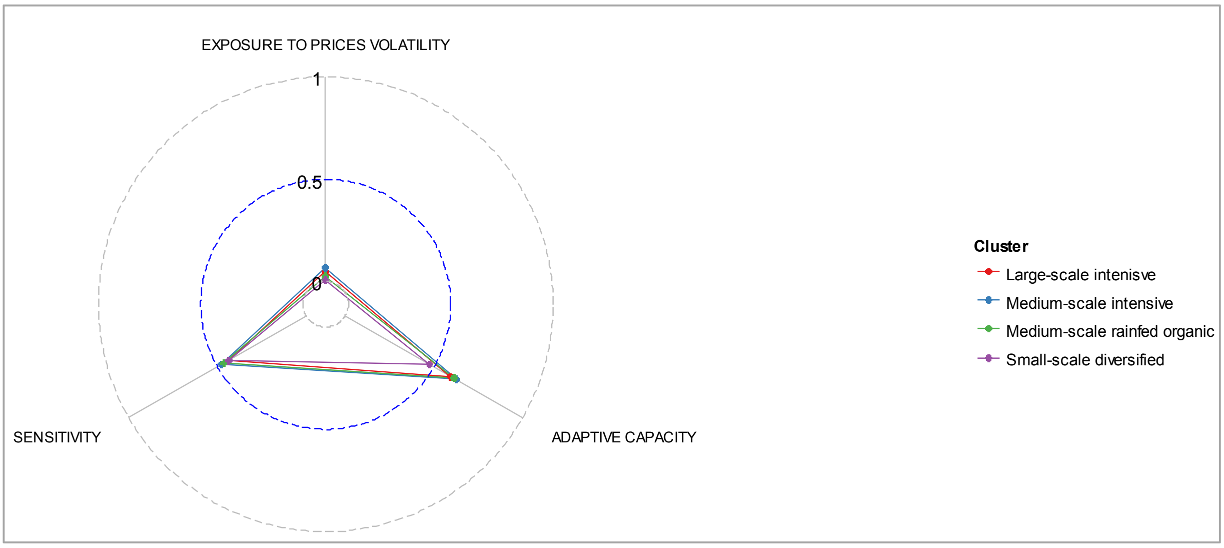

Figure 6.7 Vulnerability trainagle for the four types of livelihoods when exposed to price volatility

Figure 6.8 provides more information in understanding what drives vulnerability relative to crop prices' fluctuation. Again, *intensive* and *organic* farmers are the most sensitive groups and also had higher adaptive capacity in terms of physical, financial and human assets. *Small-scale diversified* farmers are in a clear disadvantage in this regard, since their socio-demographic features and human assets are lower than the rest of farmers.

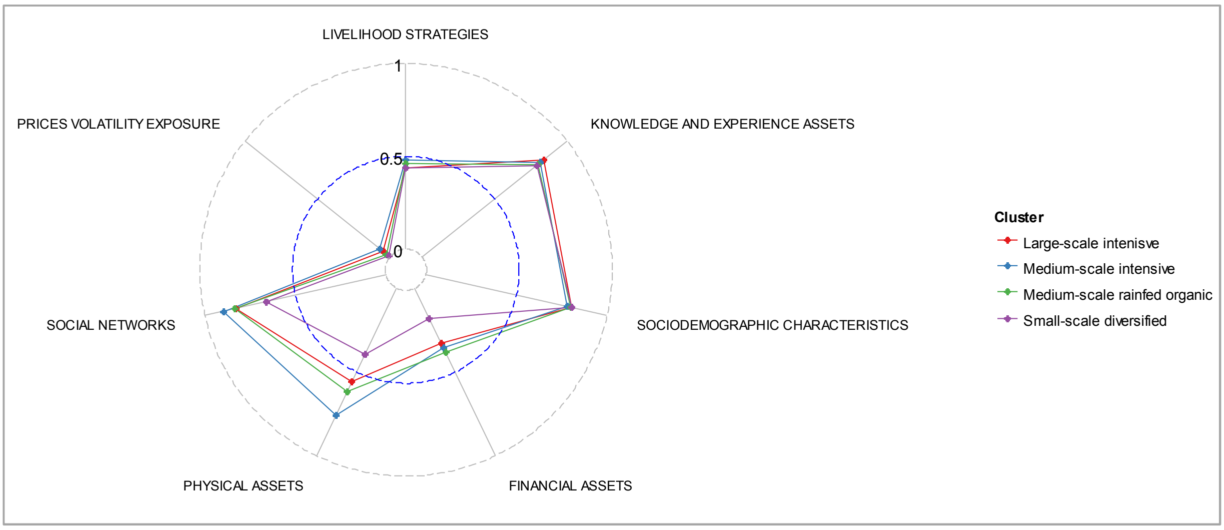

Figure 6.8 Vulnerability diagram of the major components for the four types of livelihoods when exposed to crop price volatility

6.5. Discussion

This section discusses the main results of this chapter, complemented with information derived from interviews and the focus group discussion. The argument focuses on how modern irrigation shapes farmers' vulnerability, and it also reflects the utility of vulnerability indexes.

6.5.1. Farmers' vulnerability and the role of modern irrigation technology

The vulnerability analysis above suggests overall that *small-scale diversified* farmers are the most vulnerable group in the case study region. They are the most vulnerable group to both climate variability and drought, since they have not adopted modern irrigation and thus, most have lost their traditional irrigation rights (revealed through participatory observations, see Chapter 0). Contrary to what has been shown in other research (Eakin, 2005), small-landholders of this case study region have been disinterested in adopting modern irrigation as a means to enter markets and diversify into increased-value, higher-yielding crops.

Additionally, and contrary to my expectations, they were also the most vulnerable to crops' prices volatility, even if they do not tend to commercialise their crops. This can be explained by the fact that their low sensitivity and exposure (represented as two single sub-components to explain households' sensitivity and exposure) do not have much importance when compared to their available adaptation options. Further, the VI results do not distinguish across relative levels of crops' commercialisation, since a variable to reflect so was not included in the index. The lack of adaptive capacity of these farmers is grounded primarily on their constrained access to financial assets, technology and social networks, which are key factors when addressing socio-economic and environmental change. The VI calculations for both climate-related and price factors reflect the inability of *small-scale diversified* farmers to accessing modern irrigation (physical asset) and the latter's related subsidies (financial assets) and water management cooperatives (social assets). In turn, the inability to access to these key assets negatively affects their capability to participate in emerging agrarian institutions linked to large-scale production (IPCC, 2014). *Small-scale diversified* farmers, thus, base their livelihoods on the self-consumption of their crops and a diversified household economy.

Within the study area, farmers following principles of *organic* agriculture are the second most vulnerable group to climate variability, but are not particularly vulnerable to prices volatility. Their vulnerability is due to their high sensitivity (i.e. a high level of family-based dependency). Although these farmers have the financial options to adapt, their social networks with mainstream organisations are nearly non-existent. Moreover, the literature also suggests that their agency is lower due to the high investment they make to plant their crops (often vineyards), including the necessary time to reach fruition (Dwiartama and Rosin, 2014). This exposes these farmers to significant financial risks during initial stages of vineyard establishment (Dwiartama and Rosin, 2014). The indexes utilised within this dissertation do not accurately account for this issue, and thus do not reflect that *intensive* agriculture can have cross-scalar negative impacts over *organically* managed fields, rendering their land management procedures impractical. This insight was obtained through interviews and participatory observation. Additionally, the management practices of this farming group are misaligned with those promoted by existing institutions implementing modern irrigation. Despite being young, educated and with access to financial subsidies, these farmers remain a minority, are not well-connected with the existing local cooperatives, and furthermore, seem to lack influential power over regional rural strategies and policies.

Finally, I found that the most *intensive* farmers were the least vulnerable farmers to climate variability, drought and prices volatility. Their high adaptive capacity is associated with a particular collection of key resources, including access to large tracks of land (owned or rented), education, relevant cash flows and social connections (aligned with Eakin, 2005). Their adoption of the modern irrigation system involves higher financial benefits through subsidies (e.g. CAP, modernisation and irrigation subsidies). Interviews revealed that those adopting modern irrigation not only accessed most of the available subsidies but also received higher amounts of such subsidies, precisely as a result of adopting irrigation.

In fact, VI calculations reveal that these subsidies become a stable income supporting the livelihoods of *intensive* farmers' and provide them with the means to counteract income variability. This is driven by crop price volatility or fluctuations of crop production due to adverse climatic conditions. Moreover, participatory observation disclosed that the access to common lands by these farmers is particularly facilitated if they are young or full-time, which are common characteristics of *intensive* farmers. Additionally, interviews revealed that their affiliation to cooperatives and farming unions allows them to acquire discounts for insurance, oil and fertilisers. Such financial incentives buffer crop price fluctuations allowing them to store their harvest until selling prices become profitable.

Interviews and participatory observation also helped me to understand that farmers who belong to cooperatives also receive better advice on agro-industry contracts, which include contracts between farmers and the regional enterprises that transform crops into tinned food, feed, forages, and so on. These contracts are common among the *intensive* farmers, as the VI_prices revealed. The VI results also make evident that the direct selling of crops (thus circumventing intermediaries) and outgrower schemes[59] are also a common feature among *intensive* farmers. As Eakin (2005) points out, these resources do not assure that the households will effectively manage the shifting patterns of climatic and market risks, but they may offer those farmers an opportunity to flexibly negotiate new challenges as they arise and evolve.

Throughout the interviews, survey responses, and the focus group, it also became evident that irrigation had increased farmers' yield security. Overall, with exception of *small-scale diversified* farmers, the VI results suggest that modern irrigation plays a crucial role when facing both climate variability and price volatility stressors. Aligned with Wilhelmi and Wilhite (2002), in most cases, particularly during a short-term drought, irrigation farming provides increased security for crop growers. Therefore, farmers who adapted modern irrigation are less vulnerable to both climate variability and prices volatility. However, such technology shift is making *small-scale diversified farmers* doubly vulnerable to climate variability, drought and prices fluctuations, which makes me suggest that modern irrigation may indeed be a mal-adaptative option in the long term.

The analysis presented in this chapter also revealed an interesting trade-off related to climate-driven vulnerability. Results suggest that when farmers increase their adaptive capacity, especially through modern irrigation adoption, this causes them to become more sensitive to climate variability and crop prices linked stressors and drought shock. The sensitivity of *intensive* farmers' is directly related to their larger plots of water-demanding crops, such as maize. Because they specialise in this kind of agriculture, they have less diversified sources of income. Additionally, *intensive* farmers usually have more family members who are economically dependent from the household head.

6.5.2. Strengths and weakness of using a vulnerability index

There are at least two important benefits of using an index such as the VI used in this chapter for a better understanding of rural vulnerability to global change. First, and at a theoretical level, an index contributes to the operationalisation of vulnerability theory by accounting for the interdependencies of global (e.g. global market influences and climate change) and local mechanisms that create social vulnerability (Lin and Polsky, 2015). Moreover, an index is useful to understand both the impacts and the social capabilities in response to anticipatory or reactive modes (adaptive capacities) to reduce

[59] Also known as *contract farming.* Through these contracts, the farmers' crop harvest will be sold to large-scale agribusinesses (German et al., 2011). Farmers and future buyers agree on a price for the harvest, which may be either above or below future market price, so farmers may either lose or win money. They accept the potential loss because they are guaranteed the purchase of the harvest.

their sensitivity and exposure to threats (Eakin and Bojórquez-Tapia, 2008; Hahn et al., 2009; Lin and Polsky, 2015).

Secondly, an index reveals useful information for policy-making. An index is a first step of recognising farmers' exposure to global stressors and shocks, and is helpful for understanding the suitability of government actions to deal with such stressors (O'Brien et al., 2004). Specifically, in this case study, the index used permits to reveal trade-offs between sensitivity and adaptive capacity in the implementation of modern irrigation, which allow policy-makers to better understand the co-lateral risks (increased sensitivity) that accompany technology adoption.

Moreover, an index allows for comparisons across farmer types. It indicates which livelihoods are in a more disadvantaged position when reducing vulnerability and contending with certain stressors if they have not adopted irrigation technology. Whereas some livelihoods (*small-scale diversified* farmers in this case study) might degrade, others might increase their assets. Such patterns are expected to be observed repeatedly across the European rural landscape (Rivera-Ferre, 2008). Without enough land and a relatively stable source of subsistence, *small-scale diversified* farmers appear unlikely to enter a large-scale agrarian model of production. The diversity of rural livelihoods is seemingly decreasing; transitioning to a more intensive agriculture, leaving behind other alternatives such as subsistence and organic farming or rural tourism.

However, the development and calculus of a vulnerability index is likely to be characterised by some methodological flaws and caveats. For example, in this particular study, the index used does not reflect the high investment made by *intensive* farmers and the uncertainty about whether government will maintain economic aid to install modern irrigation and keep water prices quotas low. This could have been addressed including in the index, for example, information about farmers' income (e.g. salary), expenditure (e.g. monthly water bills[60]) and investments, since participatory research revealed uncertainty about their capacity to cope with the increasing financial commitments and loans associated to the adoption of modern irrigation. However, this was not done because I found them too personal questions.

I finally considered including other cognitive indicators (e.g. farmers' views about their self-confidence, trust to join other farmers etc.) that could disclose multiple degrees of difficulty when

[60] Fieldwork revealed the continual increase of the water quota. The following source supports this, reporting that Canasa agreed on a 60% increase of the water irrigation tariff over a five-year period. Part of this increase (15%) had been previously applied in 2015. (Diario de Noticias de Navarra, 2016 < http://www.noticiasdenavarra.com/2016/02/18/economia/canasa-decidira-el-proximo-23-de-febrero-las-tarifas-que-se-aplicaran-a-los-usuarios-del-canal-de-navarra>).

adapting or discarding modern irrigation. Although I obtained some information through the survey, I was unable to include it in the VI calculation due to their incomparability feature. Such information was so subjective that I could not include it within the index to compare different household-types. Such qualitative information is rather integrated through the insights of interviews and focus groups.

6.6. Summary

The findings in this chapter have made evident that farming livelihoods are unevenly exposed to climate and market-related stressors and show differentiated abilities to adapt, with the most powerful farmers (*intensive* farmers) being able to shift climate and market prices related threats to less powerful groups (*small-scale diversified* farmers).

Small-scale diversified farmers are doubly vulnerable to 1) *climate variability and drought* and 2) *crops' price volatility*, while *intensive* farmers are the best equipped to deal with such stressors. The latter are more sensitive but are much more able to adapt to changing circumstances given their participation in the modern irrigation project and their access to the project's related benefits (i.e. subsidies, access to social networks, etc.).

The chapter has also argued that a vulnerability index is a helpful tool to provide key information to policy-makers and to evaluate the risks of new agricultural technologies from a vulnerability and adaptation perspective. For example, an index can predict the disappearance of certain livelihoods at the expense of the advancement of other livelihoods, a process that can be accelerated with the adoption of such technologies (modern irrigation in this case).

The following chapter takes and institutional approach to assess how modern irrigation changes existing norms that may further explain and exacerbate existing vulnerabilities of different farmers' groups.

CHAPTER 7

"Often by confronting difficulties and details you confront reality"

Werner Herzog

7. An institutional approach to understand farmers' vulnerability

7.1. Introduction

The previous chapter showed that *small-scale diversified farmers* were the most vulnerable group of farmers to both climate variability and drought and crops' price volatility in the case study area. The chapter also showed that other farmer groups were less vulnerable to such stressors because they had adopted modern irrigation and they could mobilise key financial and social assets in times of need.

As explained in Chapter 3, the Navarre's government and other national organisations promoted modern irrigation as as means to increase the territory's competitiveness in a 'free market' context. Modern irrigation and its associated intensive land management practices (Diez et al., 1997) are geared towards obtaining higher yields. However, such transformation may also alter farmers' access to water and communal lands, particularly of the most vulnerable farmers (Vásquez-León et al., 2003; Ford et al., 2007), potentially leading to socially unfair outcomes.

This chapter addresses Research Question 4, i.e. *In which ways has the development of modern irrigation transformed the ASES, especially in terms of the norms and rules-in use regarding irrigation water, and in consequence farmers' vulnerability?* When certain groups of affected farmers and other social actors are not recognised within irrigation related institutions and their participation in decision-making is uneven, conflicts or behaviours related to lack of participation, free riding and rent seeking may deteriorate social relations, which in turn can influence the adaptive capacity of such farmers and consequently their vulnerability (Vatn, 2005; Barnett and Adger, 2007; Kloos et al., 2013).

Focusing on the village of Miranda de Arga, the chapter uses an 'institutional robustness' approach (Ostrom, 1990; Anderies et al., 2003) and the lenses of equity and legitimacy (Corbera et al., 2007a; McDermott et al., 2013) to explore these issues and respond to the chapter's overarching question. Specifically, it examines assess if and how *intensive* farmers[61] - favoured by the dominant institutional

[61] This consideration is due to intensive farmers' livelihoods alignment with the public policy push for modern irrigation.

context - are able to exploit such circumstances for their own private benefit and if, in contrast, other farmers become more vulnerable as a result of the institutional changes driven by modern irrigation.

Miranda de Arga is considered a representative example of the villages affected by the *Itoiz-Canal de Navarra* project because there are both rainfed lands that have been transformed into irrigated lands and there also traditionally irrigated areas that have been modernised (as it was the case for more than 60% of the survey's participants). Miranda de Arga is located in a semi-arid zone and encompasses the majority of crops and livelihoods existing in the rest of the study area (to see location see **Figure 3.2** in Section 3.2.2).

The introduction of modern irrigation has had important effects over existing and new legal institutions arbitrating the use of natural resources in this village and the study area as a whole (see Section 3.2.2). Modern irrigation is transforming traditional water irrigation norms and therefore it is critical to understand how the access mechanisms to assets (natural, financial, social), and particularly irrigation water, vary so that some farmers are more vulnerable to specific climate shocks (e.g. drought) and stressors (e.g. climate variability and crops' price volatility) than others. This can be attributed to, for instance, monitoring changes, lack of rights to organise or inappropriate/absence of mechanisms to resolve conflicts over water use (Vatn, 2005; Adger, 2006; Paavola, 2007).

Methodologically, the chapter relies on secondary data, primary data through 22 semi-structured interviews, and a focus group discussion with five key stakeholders, representing different interests of Miranda de Arga's farming population (see Section 3.3.1 and Appendix III and IV about semi-structured interviews and Section 3.3.4 and Appendix IX for the methodology on focus groups).

It is structured as follows: the next section characterises the traditional and modern irrigation systems so that the main features regarding water and land management practices can be understood. Section 7.3 introduces the socially alleged reasons behind the expansion of modern irrigation in Miranda de Arga and Section 7.4 compares the robustness of traditional versus modern irrigation systems as a result of the changes in the norms over access and use of irrigation water. Such analysis takes into account the results of Chapter 0 and the overarching policy context (see Marsden et al. (2002)), to understand how institutional changes may unevenly affect the different types of farmers in Miranda de Arga. Section 7.5 focuses on the economic, social and ecological consequences of the modern irrigation project, based on what has been experienced by farmers from Miranda de Arga, and it highlights who actually benefits from irrigation water, through what processes, and in what circumstances. Not only outcomes are considered but also procedural fairness in terms of how and who is marginalised. Section 7.6 begins by assessing the arguments in which the project's legitimacy is grounded. It discusses whether its legitimacy is due to legality arguments, participative customs or persuasive and powerful group strategies. These reflections permit disclosing pre-existing and newly emerged features that benefit the modern irrigation adoption. It also discloses existing differences in decision-making participation among the diverse farmers. Second, the equity dimension is assessed. Some procedural mechanisms are discussed, but primarily the discussion focuses particularly on equity of outcomes. Finally, the coupled dimensions of equity and legitimacy are compared to other studies and some observations of their interactions are explored. As in previous chapters, Section 7.7 provides a summary of the chapter key messages. **Figure 7.1** illustrates the analytical approach pursued in this chapter.

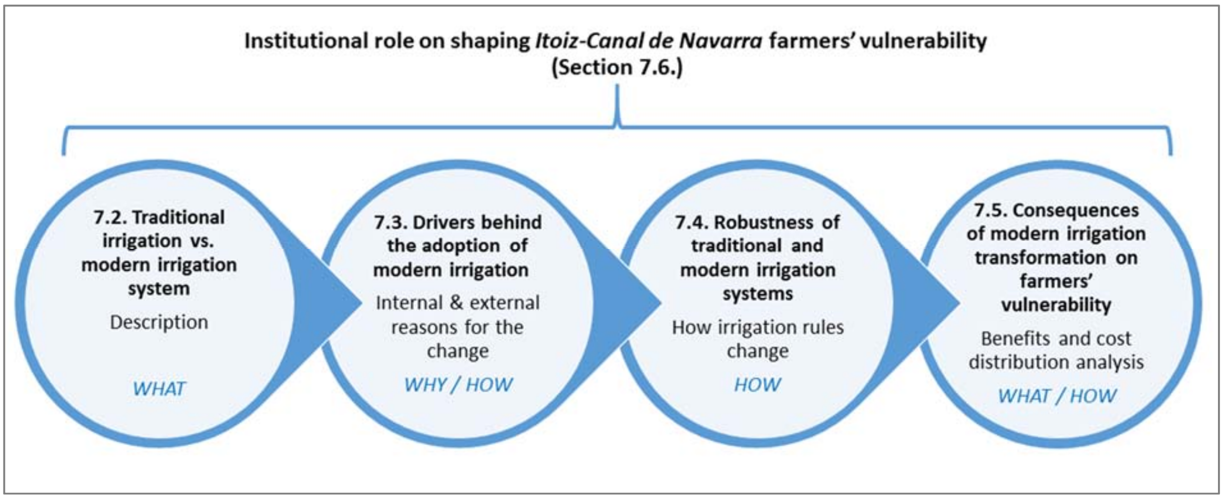

Figure 7.1. Line of reasoning for the analytical process

7.2. The traditional and modern irrigation systems in Miranda de Arga

Traditional irrigation in Miranda de Arga and across the larger study area consisted of a century old system that captured water from the river and was transported via small canals (*acequias*) and used to flood agricultural land through a gravity-fed system. [62] After irrigation, water surplus returned to the riverbed by percolating through the soil. The placement of water capture points depended on the particular village and geomorphological locations. In the case of Miranda de Arga, the *acequia* passed below the '*Mina'*, a tunnel built in the 13th century used to transport the irrigation water from the Berbinzana municipality to Miranda de Arga. Starting at the most elevated zones, irrigation water was transported through the *acequias* and farmers controlled the amount of water flowing into their plots

[62] See Appendix X, Figure X.1

by operating lock-gates manually. At the time of the interviews, villagers did not access water through this traditional system because the tunnel had sunk.

The Water Law (Royal Decree 1/2001) and the Hydraulic Public Realm Rules (Royal Decree 9/2008 amending the Hydraulic Public Domain rules) establish what should be included in traditional irrigation norms. When the irrigator communities were created, they proposed their own irrigation norms, but these norms had to be approved by a national government organisation –the Spanish River Basin Agency, or the CHE[63] in this case. The CHE established the amount of water that could be used in each village and any modification of such irrigation norms had to be approved by the agency.

In the traditional system, irrigators were organised through irrigator communities at village level. Local irrigators formulated a committee comprised of a president, a maintenance person, and an administrator. It established simple written norms detailing irrigators' rights and duties, including advocating respect for each other's irrigation turns and formulating maintenance procedures of the *acequias*. Each irrigator was in charge of the maintenance of the *acequia* next to their plot. The role of the maintenance person is to ensure proper rotation of turns, maintain the state of the *acequias* and some communal canals, and to communicate potential rule breaking situations to the irrigator committee and to also provide solutions to possible conflicts over the use of the irrigation water, which had to be aligned with the community norms. A system of graduated sanctions was applied. The level of sanctions depended on the severity and context of the offense. More than half of the interviewees expressed that they were autonomous to self-organise and they highlighted that they could make decisions at a local level for all issues.

The design of the plot determined the distribution of water when irrigating; if the area were not flat, the distribution of water would not be uniform, leading to flooded zones after irrigation. According to some interviewees this caused the land to become compacted, particularly when land had a higher composition of clay. Consequently, the crops growth was negatively affected, resulting in lower yields than those possible with modern irrigation. Traditional irrigators paid the River Basin Agency a low fee for a long-term water use concession. Such historical fixed concession lasted for approximately 75 years. Small-scale farmers explained that such period was long enough to guarantee the continuity of their agrarian livelihoods.

The modern irrigation system, which has completely substituted the traditional system in Miranda de Arga as well as in most villages within the study area, consists of a network of new irrigation canals

[63] CHE is the acronym for Confederación Hidrográfica del Ebro, translated to Ebro River Basin Agency. It is a national government organisation, controller and maintainer of water and irrigation of the Ebro basin (northeastern Spain). It was the first institution created in the world with the aim of managing an entire river basin unitarily.

distributed across a defined set of agrarian fields, including rainfed and traditionally irrigated lands. Instead of collecting water directly from the river, these canals collect water from a main canal (e.g. *Canal de Navarra*), which simultaneously departs from the *Itoiz* dam (see Section 3.2.2.2). Water for irrigation is delivered to land plots that encompass at least five hectares.

INTIA, who designed the canal and placed hydrants in the land plots, is a public company affiliated with the Navarre Government. These hydrants are equipped with a computer that allows farmers to program irrigation as they wish (see Appendix X). With this new technology, farmers are now able to check the correct water supply by remote control. Pressure sprinklers are the most widespread practice to irrigate crops, but a drip irrigation system may also be installed when appropriate (e.g. with crops such as vegetables, vineyards or trees). The farmers who did not adopt this new technology and thus did not access water through the *Itoiz-Canal de Navarra* are now unable to access irrigation.

As in other villages farmers who obtain water through modern irrigation tend to be organised in communities with farmers from several other villages. This is in contrast to the traditional system, which consisted of one irrigation community per village. There is also a general irrigation community for the entire *Itoiz-Canal de Navarra* area. For modern irrigation farmers, it is now unnecessary to take turns to irrigate and maintain canals. When there are issues to discuss, complaints are directed to the local community president, who represents them in the general community. Then, each president conveys these decisions made by leaders in the general society/population (other presidents representing each sector) back to their local irrigation farmers.

In the modern system, water consumption is measured through a meter located next to the hydrants, and farmers pay for the water consumption and for the maintenance and conservation work carried out by Aguacanal[64], the concessionaire enterprise. The government committee invoices irrigators' for their water consumption levels. As most of the interviewees commented during fieldwork, they were unhappy about how expensive the water quota was and that in the past, when there was no meter, they had paid a very low rate for the water concession. Now they have to pay not only the fixed quota but also for water consumption, the maintenance service and the canal construction.

Additionally, the *concentración de tierras*[65] allows for an enlargement of the land plots being managed, which facilitate in turn the cost-effective use of heavy machinery. With widespread application of modern irrigation, larger infrastructure along with an increased amount of synthetic fertilisers and pesticides are being adopted. Consequently, average yields are higher; winter-wheat increased on

[64] Aguacanal shareholders are composed of seven companies. Acciona, a large construction group, holds the 35% and AGBAR, an international water management company, holds another 35%.

[65] *Concetración de tierras* refers to the grouping of several plots belonging to different owners which are unified.

average 5900 Tm between 2013 and 2014 in the whole Ribera Alta (Gobierno de Navarra, 2016),[66] but irrigation is more expensive when compared to the traditional method. This type of modern irrigation requires high investment, although it has been strongly subsidised by the introduction of the *Foral Law 7/1999, Navarre Irrigation Plan* and the *Foral Law 1/2002,* regarding agrarian infrastructures which established that the farmers willing to adopt this system would have part of their investment cost covered (approximately 40-50% of an investment of 3900 euros/hectare)[67] by the Navarre government.

7.3. Drivers of the modern irrigation project

This section explores why the modern irrigation system has been adopted by an increasing number of farmers in the study area[68], despite its early and ongoing controversies (see Section 3.2.2).

Research in the context of this dissertation has revealed that the introduction and spread of modern irrigation by Navarre's government has been presented as a key rural development strategy (see also De Vries, A, and Garcia M., 2012; MAGRAMA, 2013; INTIA, 2016), supported by legal frameworks (see Section 3.2.2.2). The Navarre's government and related official organisms, such as INTIA and local agrarian cooperatives, concur with the view that Navarre had under-utilised hydric resources until very recently and that modern irrigation would untap such hydrological potential and facilitate rural development (De Vries, A, and Garcia M., 2012; Parlamento de Navarra/Nafarroako Parlamentua - Noticias Presidencia, 2015).[69] This view reinforced the view that the *Canal de Navarra* was a critical infrastructure.

However, other groups such as some political parties (e.g. EH-Bildu)[70], EHNE union and some of the local small-scale farmers have contested such arguments and complained that the modern irrigation would result in unexpected outcomes, such as an increase cost of water and a lower variety of crops (interview SI2-18). Those against modern irrigation also used NGO reports (e.g. Greenpeace), expert

[66] This data should be taken with caution since during the fieldwork some farmers explained that this amount varied between years, and despite that farmers were now able to have two crops per year, it was difficult that both were abundant. Moreover, they added that they were not permitted to cultivate as many crops as they wanted since agro-industry set limitations to the crops they were able to buy. Furthermore, some years the rainfed system was more profitable regarding costs and benefits.
[67] Amounts were decreasing from one year to another.
[68] Information is generalised to the whole case study area by using information from the represenative village of Miranda de Arga.
[69]Arguments consulted in May 2016 at <http://www.intiasa.es/es/comunidad-de-regantes/areas-de-interes/itoiz-canal-de-navarra/aspectos-generales.html>.
[70] EH Bildu is a left-wing Basque nationalist and pro-independence political coalition active in the Spanish autonomous communities of Basque Autonomous Community and Navarre (Ugarriza, 2014).

advice (SEO, CSIC, Consejo de Europa) (Beaumont, 1997) and academic publications (Brinquis et al., 2012) to build their own legitimate arguments against modern irrigation.

In the following paragraphs, I dissect such arguments in further detail, drawing on collected opinions during the interviews and the focus group workshop performed in Miranda de Arga. There I found divergent views regarding the motivations behind the development of the *Itoiz-Canal de Navarra* modern irrigation project. Understanding such motivations is useful to shed light on the social legitimacy of the *Itoiz-Canal de Navarra* project. Within this dissertation, these viewpoints are classified in two main categories: *external and global* motivations (such as international market prices); and *internal and local* motivations, which refer to drivers proceeding at the community level-Miranda de Arga. Some of these local motivations cannot be extrapolated, as they are specific to that village. Following, in this and successive sections of the chapter (i.e. Sections 7.3, 7.4and 7.5) I present the interviews and focus group data analysis.

In reference to the question: **'***What socio-economic factors are the precursors of modern irrigation?'* (self-translation), approximately 30% of the interviewed farmers, who held distinct livelihood profiles, expressed that globalisation, climatic features and water use efficiency were the main external drivers of the irrigation project.[71] Globalisation and climatic issues confirm Chapter 6 results regarding the main stressors farmers faced in this area.

> *"The main cause for modern irrigation introduction here is the progress. Nowadays, we are competing with countries that manage large extensions of crops and that obliges us to have large extensions of lands" (SI.2-10)*

Regarding the internal and local discursive arguments behind the adoption of modern irrigation, 30% of interviewees and a majority of the focus group participants explained that large-scale farmers had demanded modern irrigation and lobbied for it. Moreover, such interviewees added that one of the primary reasons of modern irrigation in Miranda de Arga was due to the modification of the project for *Itoiz-Canal de Navarra* Phase One. Since the construction proved to be more expensive than expected and INTIA had decided to modify the original project and extend modern irrigation to the western side of the area. One interviewee noted that:

[71] Globalisation was reported by 35% of the interviewees but it was recognised as a share impression during the fieldwork; climatic reasons were reported by less than 20% of the interviewees and water efficiency by a 20% of the interviewees.

> *"They have a financial deficit and they need to sell water so, what have they done? They have decided to extend the first phase, which is much cheaper than building the second phase... but they are selling water where there is already water, in the traditional irrigation area" (SI.2-2)*

The third local reason to install modern irrigation was related to the breakdown of the old traditional irrigation system (see Section 7.2), was a shared argument in all the interviews and focus group discussions. They explained that the '*Mina'* had sunk on several occasions and the irrigation farmers had long been asking for a solution that would modernise the traditional irrigation system. However, a long-term solution was not reached between Miranda de Arga irrigation farmers and the Navarre government.[72] Irrigation farmers kept restoring small sections of the old system until it was not worth repairing it being very expensive with no guarantee of endurance. Discussions in Navarre's Parliament (Parlamento de Navarra/Nafarroako Parlamentua - Iniciativas, Tramitación, 2013) and a few interviewees revealed that the last collapse of the old tunnel was due to the modern irrigation transformation in the former dry lands. The humidity in these areas was the cause of the land movements in lower regions. Miranda de Arga had no water to irrigate for nearly a year when *Itoiz-Canal de Navarra* project was proposed and it was this situation that influenced a positive vote from the farmers regarding the modern irrigation project.

The fourth and final local motivation reported by a minority of interviewees and a few focus group participants referred to uneven power relations emanating from the top-down character of the modern irrigation project. In this regard, several examples were given with specificity to the particular occurrences happening only in Miranda de Arga. The former mayor of Miranda de Arga's village council[73] explained that all proposed alternatives to repair the destroyed tunnel (the Mina, see Section 7.2) had not been considered in recent years, as the *Itoiz-Canal de Navarra* project had already been approved at higher administrative levels. Additionally, several interviewees noted that the first referendum held in the village in 2013 to explore farmers' willingness to adopt modern irrigation already demonstated that the modern irrigation project was going to be implemented regardless of local views. The statement considered in the referendum illustrates this fact:

> "*Now that a branch of Canal de Navarra <u>is arriving to the traditionally irrigated lands and the communal lands of Miranda de Arga are proposed to be transformed</u>, my position is: 1) I keep with the traditional system; 2) I choose to adopt the new irrigation system of Canal de Navarra" (self- translation; underlined emphasis added)*

[72] They asked for subsidies to restore the 'Mina' but their claims were denied.
[73] This was discussed during the workshop and documented in parliamentary debates, (Parlamento de Navarra/Nafarroako Parlamentua - Iniciativas, Tramitación, 2014).

Most residents of Miranda de Arga voted in favour of maintaining the traditional system (i.e. position 1 above). However, and despite the referendum results, the Miranda de Arga village council voted in favour of modern irrigation installation. In December 2014, the irrigation community implemented a second referendum that this time resulted in favour to the introduction of modern irrigation. Participants clarified that although all irrigation workers could participate, their votes did not count the same; the larger the land area an individual held, the higher the value of that person's vote. Approximately half of the participants, both interviewees and focus group participants, emphasised that if the local council, who accounted for the communal land area, had not adopted a favourable decision in 2013, modern irrigation would not have been implemented in Miranda de Arga. Moreover, complaints about the land size based approach to votes' value reveal legitimacy concerns as this system furthered the preferences of landowners with larger plots of land.

Nearly half of the focus group participants and interviewees claimed there had been lack of transparency and incomplete information when asked to vote. In contrast, the other half of participants argued that the process was acceptable; otherwise the proceeding would be too long if every decision had to be taken to assembly. A few interviewees also complained about INTIA consultation periods, *concentración de tierras* and land re-distribution processes. As an example of such complaints, I note below the views of an interviewed farmer:

> *"When land was re-distributed, after the "concentraciones de tierras", not all the neighbors were treated equally. If the quality of land that person owned was not high enough, INTIA did not oblige owners to take part in this project. But when your land was good enough… they tried to convince you. If possible, INTIA misled you (attempting to make an exchange with you for worse quality and a less amount of land) otherwise they directly expropriated your lands. This was notable when owners were older. They explained to elderly people the situation to the extent they wanted to. In this way many people gave up resisting an undesired transformation and adopted it. You know, 'divide and rule'. That strategy was used here" (SI.2-20*)

A few interviewees also believed that the *Itoiz-Canal de Navarra* infrastructure was just a way to enrich certain politicians and enterprises. They explained that this was evidenced by the contracts made to politicians in such enterprises after retiring from their political careers. Examples included the creation of CANASA[74], which is the public company affiliated with the Navarre Government that designed the canal. One of these interviewees argued that:

[74] The Company "Canal de Navarra, SA" (CANASA) is the result of the collaboration agreement between the Ministry of Agriculture, Food and Environment and Navarra for Navarra Canal construction.

> *"The Itoiz-Canal de Navarra project was not promoted by farmers. Indeed, there are other kinds of interests of other stakeholders... The canal is being payed through a* 'shadow payment'*system*[75] *for which we are paying more than if the Government had asked a credit to a bank. In order to manage this payment there is a concessionarie enterprise and I do not think it is by chance that the president of such enterprise is the Navarre government council (omit name). There are placed these politicians, in revolving doors" (SI2-12).*

From the perspective of the interviewees, construction companies and electric companies were two key lobby interest groups. Also, the previously mentioned water management companies were interested in water privatisation for a business venture. Water privatisation and speculation over water and lands were vigorously discussed themes during the focus group workshop. INTIA representative argued that water concession did not mean privatisation and the enterprise was considered a service enterprise for the maintenance of the canals. In response, an ecologist representative and some community members in favour of the traditional system argued that now that farmers had to pay for their consumed water rather than a fixed quota, those in control of the canal would make sure to increase their own benefits. The focus group participants were not in agreement to whether there were already investors buying lands in the transformed area:

> *"In the modern system land is treated as money. You can be a mere investor searching for benefit regardless of the consequences of your actions on the land" (FG-4)*

Table 7.1 summarises the reasons provided by interviewees and focus group participants. It includes an assessment of the level of (dis)agreement for each motivation (second and third columns). The fourth column summarises which actors hold the correspondent viewpoint and the last column explains how such reasons might influence farmers' vulnerability.

[75] Shadow payments are a type of payments made by the government to a private company that utilises private funding to construct and maintain infrastructure. The government pays these funds in installments with high interests.

Table 7.1 External and internal motivations driving the modern irrigation project and their influene over farmers' vulnerability

Socio-ecological reasons	External	Internal	Representative profiles with such view	Links between the social-ecological components	Contribution to farmers' vulnerability
Economic globalisation	●		All stakeholders*	External socio-economic change	One of the stressors assessed in Chapter 6
Climate variability and drought	●		All stakeholders*	External biophysical disruption	One of the stressors assessed in Chapter 6
Water efficiency	●		Opposite views between small-scale farmers, ecologists and some scholars and large-scale farmers, INTIA and some scholars	Between public infrastructure (physical and institutional infrastructure –i.e. the canal possibilities and the rules to use water) and users (irrigators)	Indirect influence on the natural basis of the social-ecological system
Financial deficits		●	Some small-scale farmers, ecologists, some syndicates and political parties	Between resource users (irrigators), infrastructure providers (government) and public infrastructure (canal)	Farmers and Government financial capacity decreases
Partial local demand		●	All farmers	Between users (irrigators) and public infrastructure providers (government)	Large-scale farmers benefit through technological, financial and social assets whereas small-scale farmers lose their traditional right to water and access to communal lands
Traditional irrigation system collapse		●	All farmers	Between users (irrigators) and public infrastructure providers (government)	Small-scale farmers cannot longer access water to irrigate and their adaptive capacity decrease
Power interests Referenda participation		●	All farmers	Between users (irrigators) and Miranda de Arga Council (government)	Small-scale farmers less power to decide compared to large-scale farmers

Socio-ecological reasons	**External**	**Internal**	**Representative profiles with such view**	**Links between the social-ecological components**	**Contribution to farmers' vulnerability**
Nested enterprises to benefit powerful agents		○	Few small-scale farmers, EHNE syndicate, some ecologists and scholars	Between public infrastructure providers (government) and infrastructure (physical and institutional)	Farmers lose access to lands and water and political elites gain power
Water and land speculation		○	Few small-scale farmers, EHNE syndicate, some ecologists and scholars	Between infrastructure providers (government) and infrastructure (physical and institutional)	Farmers lose access to lands and water and political elites gain power

Based on the shared opinions, a qualitative estimate of relevance of the reasons is provided through the following symbols:
○ Shared by a minority, less than half of the participants

● Shared by approximately half of the participants; and

⬤ Shared by the majority (interviewees and focus group participants).

* 'All stakeholders' refer to every kind of farmers and owners, politicians, syndicates, scholars and ecologists.

7.4. Comparing the robustness of traditional and modern irrigation systems

The confluence of these reasons eventually led to the implementation of modern irrigation in Miranda de Arga. Through the comparison of the traditional system *vis–à–vis* the modern system norms, it is possible to examine the consequences of such transformation for the robustness of the ASES under study (see Section 2.5). Among the principles necessary for a system to be robust, there were several which became evident during the interviews and the focus group: 1) the necessity to clearly define the boundaries of the resource system; 2) the establishment of proportional benefits and costs that a user is allocated; 3) collective-choice arrangements that individuals use to modify rules; 4) monitoring and sanctioning means to secure proper use of resources, and; 6) conflict-resolution mechanisms amongst users or within relationships of users and officials.

First, for ASES to be considered robust, there should be *clearly defined natural resource boundaries,* as it allows for users' rights and limits of resources appropriation to become more evident (Acheson, 2006; Agrawal, 2001; Anderies et al., 2004a; McKean, 2000; Ostrom, 2009a). In the Miranda de Arga case, irrigation norms (both traditional and modern) are clearly defined as well as the area in which irrigation can be used. Such area is determined by the existing infrastructure to distribute water, e.g. *acequias* in the past and the current pipe-irrigation system. However, in quantitative terms, interviewees revealed that they were more aware of the total water volume given by the CHE (see Section 7.2) in the past than with the modern system. Nevertheless, in the modern system, financial capital seems to gain importance since irrigation water is measured and paid for; thus consumption is restricted according to the price of water. Consequently, only those farmers able or willing to pay such costs have access to irrigation water.

A second principle behind the robustness of our ASES is the establishment of *balanced benefits and costs of water for irrigation* (Acheson, 2006; Anderies et al., 2004a; Ostrom, 2009a)*.* Farmers adopting modern irrigation stated that the increase in crop yields compensated the newly acquired irrigation-borne expenses (e.g. cost of modern irrigation installation and water quota). All participants added that the traditional system did not allow commercialising crops in international markets due to insufficient yields. However, the situation changed with the introduction of modern irrigation that now allows farmers to compete more effectively in international markets. This was a shared impression during the interviews and acknowledged by all participants in the focus group. However, modern irrigation replaced the traditional access to water and those who did not or could not invest in modern irrigation lost their water concession rights. This finding also allows for a better understanding of results in Chapter 6, which suggested that *small-scale diversified* farmers were the most vulnerable group to climatic and market related stressors. With the refusal to adopt modern irrigation, this group of farmers has relinquished their historic water concession and consequently they can no longer access irrigation water.

Small-scale farmers also stated that with the implementation of the new system, they had lost other cultural services linked to the traditional land management practices, such as local traditional knowledge and other benefits connected to their identity (see Chapter 0). In this regard, the distribution of costs and benefits was rather skewed. Consequently, farmers who valued ES beyond market-oriented ones were marginalised.

ASES's robustness principles also encompass *monitoring* –i.e. the control of bio-physical conditions and users' behaviour (Agrawal and Chhatre, 2006; Anderies et al., 2004b; Gibson et al., 2000; Nee, 2005; Ostrom, 2009b). As noted in Section 7.2, monitoring is quite different in both systems. A few participants complained about the fact that the maintenance person used to avoid conflict, and this led some users to break norms.[76] Focus group participants expressed that having external monitoring could be translated into improved fulfillment of norms due to the lack of personal involvement of those in charge of monitoring. Additionally, they also perceived higher control of water consumption due to the meters and the new enterprises in charge of proper functioning of the irrigation systems.

Such examples suggest that in the past, positive social relations with other community members might have allowed some farmers to take advantages from resources (Ribot and Peluso, 2003). Easier access to authorities, and negotiations via friendship, trust and reciprocity influenced farmers' water access and management. As revealed in Chapter 6, social networks are crucial for social adaptive capacity and reduction of vulnerability. Such social networks seem to have been more relevant in the past than within the current situation. Among the existing livelihoods, *small-scale diversified* farmers already lacked social networks (within syndicates and cooperatives), so this effect may have a stronger influence on these farmers.

Fifth, users need to have the capacity to plan their own institutions in the long term (Agrawal, 2001; Anderies et al., 2004b; Gibson et al., 2000; Ostrom, 2009b). In the modern system, decision-making are not community decisions and this could endanger potential collective action in the future (Anderies et al., 2003; Dakos et al., 2015). Some of interviewee farmers perceived bureaucracy as a barrier to deal with immediate and envisioned obstacles:

> "*Irrigators do not have the same power as before. For example, to make this modern irrigation extension we had no option to say how we wanted it*" *(SI2-14)*

[76] Statements provided by interviewees, citing the non-existence of sanctions, evidenced this. Some of the interviews explained that sanctioning was not necessary since users always paid the water quota and turns worked adequately.

Lastly, it is necessary to establish *conflict-resolution mechanisms* among users or within relationships of users and officials (Acheson, 2006; Anderies et al., 2004a; Gibson et al., 2000; Ostrom, 2009b) for ASES robustness. In this regard, nearly half of the interviewees expressed that in the past, there were few conflicts and they were often due to not comply with irrigation turns, especially during drier months. To solve these problems, dialogue was the primary method utilised and formal complaints were avoided. In the modern system, participants were uncertain about how conflicts may be monitored and addressed by the external company. This uncertainty also referred to other potential conflicts in the future: for example, whether there would be enough water or pressure to irrigate, as the initial design was misaligned with the current situation and water quota price was continuously increasing.[77]

Table 7.2 summarises the principles[78] to assess whether irrigation system was more robust with the traditional system or after the transformation to modern irrigation.

[77] The quota had been tripled in the last three years without justification and the farmers believed it was abusive. Despite the complaints, they did not explain which mechanisms they had used, if any, to protest a change in fee.
[78] Only the principles that were identified as relevant by the interviewees and focus group participants within this case study are reported.

Table 7.2 Comparison between robustness of modern and traditional irrigation systems

Principles	Traditional system	Modern system	Implications
1. Natural resources boundaries			
Physical boundaries (-)	Water directly accessed from the river, close to the place it was used (<10 km)	Water coming from Itoiz dam	Physical boundaries are clear in both systems. Water volume boundary is blurred in both systems since in the past consumption was not controlled and in the modern system since its consumption would be restricted to an established price
Water volume (=)	Volume: 1200-3000 m3/seg for about 75 years	Water consumption is paid	
2. Equivalence between benefits and costs			
Financial (+)	Very low cost, low yields	Higher cost, higher yields	In financial terms, benefits and costs are balanced in both systems – i.e. if they invest more, they gain more. Traditional system did not allow large-scale farmers yields commercialisation. Modern system suppress some cultural services and leads to the abandonment of some small-scale farmers who lose their previous access to water
Cultural (-)	High level of cultural services	Lack of cultural services	
Market options(+)	No option to compete at international market level	They can compete in international markets	
Irrigation water access by some farmers (-)	All kind of farmers had access	Small-scale diversified farmers lose their access	
3. Monitoring and graduated sanctions			
Surveillance (+)	A local surveillance and maintenance person at village level	External company at regional level	Access to authority was easier in the past and hence benefitted from easier water access. However, this could mean inadequate use of water. The scale at which water management is monitored increases along with the technology and employment of human resources
Control (+)	No consumption meter boxes	Consumed water measured	
Sanctions (+)	Sanctions were not made	Higher control perceived	
4. Recognition of rights to organise			
Autonomy (-)	Higher local autonomy	Top-down bureaucratic functioning	Although local institutions are not removed, their decision-making autonomy is reduced
5. Conflict resolution mechanisms			
Mechanisms (-)	Dialogue was used when infractions occurred. They normally adopted strategies of reciprocity	External notification and legal processes when infractions occur	The mechanisms seem to be equal in the traditional and modern system and large-scale farmers are benefitted in both cases

Note: Symbols in the 'principles' categories refer to whether the new situation is more robust (+), less robust (-), equal (=) or unclear (?) after modern irrigation introduction

7.5. A qualitative undertanding of the effects of modern irrigation on farmers' livelihoods

All interviewed farmers expressed that modern irrigation would have uneven impacts on farmers. Approximately half of the interviewees and most of the focus group participants remarked that the *Itoiz-Canal de Navarra* project had left a 'bitter taste' between small and large landholders. This was a shared impression during fieldwork conversations. Differences regarding the distribution of irrigation water and communal land, if perceived unfairly, may lead to social conflict[79] (Barnett and Eakin, 2015). Uneven power relations and injustice are seen as fundamental drivers of vulnerability and insecurity (Kloos et al., 2013). Additionally, farmers' vulnerability may increase according to the quality of resources and denied access to such resources which are important to sustain certain livelihoods (Barnett and Adger, 2007).

The majority of the interviewees admitted that *intensive* farmers' situation had improved under the modern system since the harvests were larger, sometimes with two harvests per annum, which translated into higher economic returns. A few even stated that modern irrigation was the future of the sector in the area and without this transformation the sector would collapse. Moreover, during the focus group discussions, people agreed that, in contrast, traditional irrigation did not permit large-scale farmers compete in the international market and this made those farmers more vulnerable in an economic global context.

> *"I can understand some landholders don't want Itoiz-Canal de Navarra, but that cannot condition profitability for all the rest of farmers. In the past there was only cereal, wheat and barley because that was all you could do at a reasonable cost" (SI2-4)*

Modern irrigation, though, seemed to make other types of farmers more vulnerable to market and climate-related stressors. Among other reasons, modern irrigation causes an uneven access to communal lands by farmers, thus diminishing small-landholders' access to natural assets, one of the crucial capitals in vulnerability analysis. Around half of the interviewees explained that one condition the council had for getting a higher subsidy to install modern irrigation in communal lands was to allocate those lands to priority farms.[80][81] Consequently, in the new situation a larger percentage of communal land is distributed among those farmers fully dedicated to the agrarian activity because of;

[79] "A range [of] negative interactions that encompass mild verbally-expressed discord and cold interstate relationships, as well as hostile acts or declarations of war "(Kloos et al., 2013).
[80] Priority farms are those whose owners are professionally engaged in agricultural activity, with revenues sourcing primarily from this activity, and who have a land hold of sufficient size to provide work for a person full time (see Foral Decree 150/2002, of July 2nd, which approves the Foral Law regarding agrarian farms register in Navarre).
[81] A revision of the communal land norm modification confirms this (Boletín oficial de Navarra, 2015).

1) rents of communal lands were higher since council wanted to recover the investments made to install modern irrigation and 2) those accessing these lands had longer contracts than in the past.

As a consequence of changes in communal land norms, the vast majority of the interviewees reported the abandonment of agrarian activity by *small-scale diversified* farmers. Such abandonment was also due to the industrialisation and the aging-out process of the remaining farmers (the majority of farmers were older than 50 years)[82], but modern irrigation transformation had accelerated the process of relinquishing their lands. Several interviewees indicated that the number of landowners is decreasinsg exponentially in the region. One interviewee explained that, "*The land has gone from 60 to 6 plots. Moreover, before the average area was 0.6-0.5 hectares and now the average is around 7-8 hectares*" (SI2-1). Another interviewee (SI2-14) provided an internal list of Miranda de Arga irrigators that showed that the number of landowners had decreased by 80 individuals in only one year. In the words of one interviewee:

> "*In the end, multinationals will end up buying all the land. It is an industrial design that is already happening in other places. The company that sells you the seed, fertiliser, herbicide- is the owner of the land and the farmers, the few that remain, will be paid just for their labour*" *(SI2-22)*

About half of the interviewees did not welcome this new situation, arguing, for example, that "*It is not in the general interest when only a quarter of landowners remain*" (SI2-2). Furthermore, they stressed that small-landholders, due to modernisation, had to refuse their rights to irrigation water that were not going to be recovered. Consequently, they would be more vulnerable during dry periods, if still wanted to cultivate their lands.

Some focus group participants and interviewees pointed out that there were still unrevealed co-lateral effects of *small-scale diversified* farmers' abandonment of agriculture. For example, they explained that some owners, who were unwilling to adopt modern irrigation, had decided to rent their land or leave it to cooperatives under long-term contracts. Such decisions could encourage an over-exploitation of land by cooperative members; the land would be returned when infrastructure was obsolete and owners might have lost their work capacity (due to aging, machinery sold, loss of traditional knowledge and experience). These concerns are reflected in the potential increase in vulnerability by those (and their descendants) who are not willing to adopt modern irrigation:

> *"If my daughter wanted to become a farmer in the future, she would have access to three hectares, but that is not enough to be competitive in comparison to others having 300*

[82] Thirty-seven percent of the population in Navarre in 2013 was older than 50 years. (Instituto de Estadística de Navarra. URL: http://www.cfnavarra.es/estadistica/redie.asp?qry=01 Last access 26/03/2014).

> *hectares. It can be said that I have access. Legally I have it, but access to what? We are talking about another thing not about new entrepreneurs' possibilities" (SI.2-18)*

A third outcome of the uneven access to water and lands was the deterioration of social relations, an impression shared just among a few of the interviewees. One individual gave relevant examples:

> *"Large-scale irrigators agreed on a price to buy good lands as they knew owners would sell them anyway" … "I was told: If you don't sell your land, you will be isolated there. We all are going to do large-scale agriculture irrigating and fertilising and your land will be flooded as a consequence. And you know what happens if land is flooded? Epidemics! You will not be able to raise anything!"* (SI.2-20)

Informal institutions, such as reciprocity and mutual understanding, are clearly deteriorated by such personal threats, which may lead to the weakening of cooperative arrangements. Such weaking may in turn lower adaptive capacity.

There were other relevant points highlighted in the interviews, though not directly linked to the norms modifications, but that influenced social relation weaknesses. A few interviewees explained that shifting to more intensive and irrigated land management may lead to cross-scale impacts, including pollution of organic plots by intensive farmers' practices. An interviewee indicated:

> "*I cannot afford an ecological garden if another person is fertilising with sulphates all the time next to my plot. These products end up in my land. I need barriers; otherwise I will not be able to sell my products as ecological products*" (*FG.1*)

A fourth outcome, which is related to the previous idea, is that only a few interviewees highlighted the negative environmental effects of modern irrigation. Those who did, however, mentioned the disappearance of small plots full of vegetation and animals, which can also lead to an important change of landscape and biodiversity. Moreover, although studies were conducted to delimit adequate zones for irrigation[83], field observation and local testimonies revealed concerns regarding the suitability of converted areas due to land flooding. These fears indicate a vulnerability concern related to the ecological dimension of the ASES. Moreover, such new practices associated to modern irrigation imply higher input necessities, which influence farmers' financial capacity so that their adaptive capacity to deal with stressors and shocks is also influenced by these facts.

[83] This information is in the 'Delimitation of potential areas irrigated and currently under irrigation of the Mediterranean slopes of Navarre' developed by the Institute for Soil and the ´Study of the demand of water for irrigation in 1986´ and the ´Irrigated areas of Navarre´ by the Institute for Territorial Studies and Riegos de Navarra, S.A. (Beaumont, 1997).

Finally, there was a shared perception of uncertainty regarding farmers' and the state's financial situation after the adoption of modern irrigation. On the one hand, the current chapter reveals that investments under modern irrigation systems were high, whereas Chapter 6 showed that global markets' prices volatility put large-scale intensive farmers' activities at risk, since they normally specialise in fewer crops and their exposure increases due to the large amounts of yields they produce. Therefore, despite holding large surfaces of land and yields, they have no guarantee their crops would be profitable.

Modern irrigation infrastructure funding was based on a non-compulsory agreement for only the first phase of the project, but the second phase and the extension were not mentioned in such agreement. Additionally, the study developed by Brinquis (2011) stated that *Itoiz-Canal de Navarra* project was not profitable if the necessary time for revenues and the discount rate on investments were considered. Furthermore, Beaumont, (1997) and syndicates meetings discussed that this project was denying other irrigation cheaper and more local alternatives (alternatives for the cessation of Phase Two) leading to 'rigidity traps'[84] (Robards et al., 2011). In contrast, supporters of the project argued that toll payments allowed the government a 'margin of manoeuvrability' to invest in other aspects. To address this, opponents to the canal explained that the first phase of the project supposed an expenditure of 483.5 million euros, with an additional cost of 500 million euros. The irrigation zone costs would be through 'shadow payments' and the Navarre government would have to pay 8.5 million euros per year for 30 years. Combined with the 13 million per year of the first phase, this adds to 21.5 million per year, meaning the depletion of the public budget for other agrarian purposes.

7.6. Farmers' vulnerability through the lens of legitimacy and equity

I use the lenses of legitimacy and equity to further discuss the effects of modern irrigation on farmers' vulnerability. Equity and legitimacy have been largely absent in debates about agrarian intensification and modern irrigation technology, which have focused instead on cost-effectiveness water use efficiency arguments (Corbera et al., 2007b; McDermott et al., 2013). When farmers perceive decision-making as legitimate and outcomes fair, it is more probable that such decisions will be effectively implemented and conflicts avoided (Barnett and Eakin, 2015).

I do not assess participants' perceptions of equity and legitimacy here but instead I try to understand the context and the mechanisms used by farmers to access natural resources and make decisions regarding how such resources should be managed and distributed (see Section 2.5). I postulate that

[84] When institutions tend to remain highly connected, self-reinforcing, and inflexible despite changing circumstance, limiting the ability of actors within the system to reorganise (Robards et al 2011).

those most vulnerable are typically unable to take part in decision-making, or are not recognised by irrigation-related norms, and consequently their values and preferences are underrepresented, potentially leading to conflicts and an increase in their vulnerability condition.

At government policy level, modern irrigation decision-making grounds its legitimacy in the existing legal framework, i.e. through the different norms that support the implementation of the *Itoiz-Canal de Navarra* irrigation project. Since the construction of the dam, the modern irrigation project sought to rest its legitimacy upon constitutional and legal processes at both the national and regional level (see Section 3.2). A brief contextual review demonstrates that there are several formal norms (e.g. *Real Decree 22/1997* regarding the necessity of dam construction, *Foral Order 186/2011* and *Foral Order 185/2015* about pressure irrigation financing investments) that are used by organisations (e.g. Navarre's government and its agencies in charge of building and managing the canal) to persuade farmers and other social actors to get involved in such project. Such legal backing fits with the cultural expectations and interpretations of what should be considered legitimate, where legitimacy is equated to legality. Therefore, legality becomes a powerful argumentative tool for those both defending and contesting the irrigation project.

In addition to the legal backing framework, both the state and regional governments, along with local cooperatives, support and materialise the modern irrigation project on the grounds of financial and employment motivations. Those orgnisations defend that this infrastructure will improve water urban supply, develop agrarian sector through modernistaion, advance the flood control and produce hydroelectric power. Therefore, there already existed economic, political and social arguments in favor of modern irrigation made by powerful organiations, whereas opponents lacked legal support and social networks to substantiate their arguments.

At local (village) level, participation in decision-making forums and processes related to the modern irrigation project diverges across the different farmer typologies co-existing in the study area. Although there was local participation in nearly all the steps advancing towards the change in the irrigation system, findings from previous section demonstrate that some farmers, particularly *small-scale diversified* ones, were unhappy about the project's top-down nature and the lack of opportunities to adequately voice their concerns. As Forbes, (2008) points out, the improvement of information, transparency and accountability arises as a key challenge in the fostering of trust and the improvement of adaptive capacity by all farmers and owners in Navarre, but primarily for *small-scale diversified* farmers. Consultation should go beyond informing stakeholders and farmers should be included in the preparation of irrigation-related norms. With that aim, broad advertising and scheduling should favour all stakeholders' in attendance, as those mechanisms are key elements to recognise stakeholders' diversity and make their participation possible.

This chapter, as well as Chapter 6, findings also suggest that affiliation with powerful social networks (e.g. cooperatives and syndicates) can determine some type of livelihoods' hegemony over others, i.e. *intensive* farmers' aims may eclipse those of *small-scale diversified* farmers. According to Adger (2003), this confirms that the powerful actors within a society can maintain their privileged position by legitimising it through a system of norms. Moreover, in line with Swyngedouw (2004), I focus on power and strategies pushed through state-led modernisation projects, and align with Marsden et al., (2002) in the recognition that there is social exclusion within development programmes, mechanisms and policy implementations; at times exclusion is used by local elites to reaffirm the legitimacy of their development discourses.

My findings make evident also that older owners and less educated landholders are at a disadvantage due to their lack of access to 'privileged' information, (i.e. education or social connections), which limits their ability to participate effectively in the development of irrigation norms (Ribot and Peluso, 2003). An owner's report also discloses coercive[85] claims. Such claims are made by powerful groups of farmers whose institutional discourses and practices influence other farmers' behaviours making the latter sell their land.

Furthermore, the conditions established by Navarre's government concerning communal land access and their related subsidies to install modern irrigation clearly benefit large-landowners and richer farmers and promote a less frequent rotation of communal lands. Such an approach marginalises small-scale farmers who are often older and less educated. Likewise, in regard to the referenda, *small-scale diversified* farmers were again at a disadvantage in comparison to large landholders (as they had lower levels of recognition and inclusion in the process), being therefore an unfair distribution of decision-making power.

From an outcome distributional perspective (equity), findings reveal an uneven distribution of costs and benefits from modern irrigation in the area. Large-scale farmers accessing modern irrigation get increasing yields that permit them to be more competitive in international markets. Simultaneously such technology facilitates their land management and their access to communal land is also improved, since larger extensions of transformed lands that small-landholders cannot access become available to them. Consequently their natural capital, a crucial asset in rural livelihoods, increases. This, in turn, increases their adaptive capacity.

In contrast, *small-scale diversified* farmers do not perceive any benefit but rather several costs. Modern irrigation adoption does not fit with their *consolidate* and *adaptive* livelihood and for this

[85] Coercion is understood as 'the injustice that can arise when people buy and sell things under conditions of severe inequality or dire economic necessity' (Corbera, 2015, p. 156).

reason they do not invest in such modern irrigation system and lose access to traditionally irrigated water. The fact that several of them decidd to sell their lands precludes the access of their future generations to the rural landscape, including communal lands.

Therefore, access to land and water rights of small-landholders and how future opportunities would be distributed among the farmers is an apparent challenge blurred by economic and development narratives of the rural sector in Navarre. These threats contribute to reinforcing existing power structures, inequities and vulnerabilities and therefore, modern irrigation institutions are perceived as deficient for local decision-making arrangements.

I acknowledge that 'there are multiple principles of equity such as principles of desert (i.e. who deserves to win or lose), equality, or need' (Adger et al., 2005, p. 84). In consequence, and considering that *large-scale intensive* farmers' income is sourced solely from agriculture, one could infer that they deserve such technological improvement more than *small-scale diversified* farmers (whose livelihood is already *consolidate*[86], see Section 4.5.1*)*. However, if we consider equality and need priciples, the involvement of the maximum possible quantity and diversity of stakeholders would be prioritised, and one could alternatively infer that the modern irrigation project should be more sensitive to the needs of the disadvantaged – i.e. the double vulnerable group of *small-scale diversified* farmers (Corbera et al., 2007a). However, the findings of this chapter and Chapter 6 demonstrate that modern irrigation introduction, as a means to foster economic development and climate adaptation, reinforces inequalities in access to water and land and do little to alleviate underlying vulnerabilities.

Overall, a legitimacy and equity perspective has deepened our understanding of the effects of modern irrigation on farming groups, and has revealed striking differences in terms of participation and distribution of costs and benefits across farmer groups. Considering such differing social and farming profiles and power relations in the contexts where modern irrigation unfolds should be regarded as a first critical step to avoid conflicts and guarantee a more socially just and environmentally responsible technology adoption process. In the specific case of Miranda de Arga and the region affected by the *Itoiz-Canal de Navarra* project, fostering more legitimate processes and a fairer distribution of modern irrigation costs and benefits through action-research and public policy is urgent. This will require the transformation of existing practices in a way that are more attentive to social diversity and cultural values, and facilitate the co-existence of multiple types of farming livelihoods.

[86] Consolidate here refers to those farmers who are no longer seeking the accumulation of assets, but are instead living from assets previously generated.

7.7. Summary

This chapter has shown that the *Itoiz-Canal de Navarra* modern irrigation increases farmers' water consumption control at the expense of them becoming more dependent on nested enterprises that control irrigation water, which might be translated as an overall increase in farmers' vulnerability due to their decreases in adaptive capacity. In relation to the legitimacy of modern irrigation introduction in the area and the distribution of natural resources and project-related information, this chapter has demonstrated that small-landholders (elderly, retired or multi-income farmers) have been partially excluded from the decision-making process of introducing modern irrigation. Consequently, land is being transferred to larger-scale *intensive* farmers along with the privatisation of farmers' previous water-use rights, which is increasingly controlled by the state.

Intensive farmers' adaptive capacity to climate and market fluctuations, assessed in Chapter 6, cannot therefore be characterised as successful because it is affecting the ability of other farmer typologies, i.e. it is increasing the vulnerability of *small-scale diversified* farmers. For this reason, modern irrigation may be interpreted as a mal-adaptation. This chapter has also shown that within the context of rapid economic growth and global economic integration, the current agricultural transformation pathways create new vulnerabilities in populations that are either excluded from such growth, or whose economic activities suffer as a consequence of such globalising trends.

CHAPTER 8

"Imaginar la realidad sigue siendo tan importante como construirla"

Gioconda Belli

8. Conclusions

This PhD dissertation has analysed the social, ecological and institutional effects of agrarian intensification by studying the adoption of modern irrigation in Navarre, Spain. In this last chapter, I summarise its main findings, theoretical and methodological contributions, and I highlight key areas of further research.

8.1. Summary of findings

8.1.1. Four typologies of farming livelihoods

In addressing the first research question, i.e. ***What combination of capital assets is associated with particular livelihood strategies in Navarre?****,* this dissertation has shown that the rural livelihoods in the study area are diverse and dynamic. The research has uncovered four distinct groups of farmers regarding their land management practices: 1) *small-scale diversified*; 2) *medium-scale rainfed organic*; 3) *medium-scale intensive,* and 4) *large-scale intensive* farmers. These groups are associated to different combinations of available capital assets.

Medium-scale rainfed organic and *medium-scale intensive* farmers are mostly young farmers with higher levels of education and with access to financial assets (e.g. subsidies). Both groups of farmers are similar in such aspects, but their land management strategies diverge in terms of water consumption and type of fertilisers used. Both follow an *accumulative* strategy and welcome modern irrigation. *Rainfed organic* farmers also grow rainfed vineyards and always apply organic fertilisation, whereas *medium-scale intensive* farmers mainly grow maize under highly irrigated and mineral fertilised systems. The main difference between the two groups is that *intensive* farmers participate primarily in the existing rural networks (agrarian cooperatives and syndicates), whereas *organic* farmers do not, since they do not find any appeal in such social networks. Existing cooperatives and the main rural syndicate support *intensive* farming practices, also promoted by the government of Navarre. In contrast, *small-scale diversified* are older and their land management also differ within the group. These farmers are also associated with more diversified income sources and they are the only group who has not adopted modern irrigation. Furthermore*, small-scale diversified* farmers lack access to social networks and financial assets.

Regarding the impact of modern irrigation on livelihoods, the research has revealed that *small-scale diversified* farmers are displaced from the agrarian landscape, since some of them have sold their lands, partially due to their lack of land area. Both facts (lack of large plots and their tendency to sell the small plots they have) influence their ability to adopt a more competitive strategy of agricultural practices. The absence of social networks and financial assets also negatively impinge on the adaptive capacity of this group. *Small-scale diversified* have been unable to improve their livelihoods, and defend their existing assets effectively. In contrast, *intensive* livelihood farmers increased their purchased and rented lands (survey data). Such reaffirmation of *intensive* livelihoods can be most likely related to the decline of *extensive* livelihoods, since the former are buying the latter's lands. This justifies the need to further investigate the implications of a new technology for rural competitiveness.

8.1.2. Divergent perceptions and values of agrarian ecosystem services

This thesis has also shown that the access to key assets is vital for farmers' land management strategies and that such access determines their valuation of agrarian ES and their cognisance of their own co-production of such services. In responding to the research question, i.e. ***Does agrarian intensification influence people's perception and valuation of multiple agrarian ES*?**, the thesis has demonstrated that *small-scale diversified* farmers place a higher value on the recreation services provided by agrarian ecosystems and attach greater importance to the benefits derived from knowledge and identity compared to other farmers. Moreover, only s*mall-scale diversified* farmers are significantly more aware of the effects of their land management on food quality. In contrast, farmers who have installed modern irrigation systems place a greater value on the agrarian ecosystem's capacity to regulate plagues and absorb pollutants. Those with larger irrigated farms assign a lower value on traditions and traditional knowledge associated with agrarian ES. These results are in line to those of Kull et al. (2015), who state that converting to more intensively managed land may jeopardise multifunctional agrarian land management and cultural services, such as those related to traditional knowledge, landscape and traditions.

Additionally, the research has shown that *small-scale diversified* and *medium-scale rainfed organic* farmers value cultural (traditions, landscape and traditional knowledge) and regulating (diseases, erosion, climate and water regulation) services respectively more than *intensive* farmers. Sustaining the livelihoods of such small-scale farmers could determine the continuity of these agrarian ES since these two groups are the most conscious about the key role played by these services in ecological and socio-cultural terms. If these two types of farmers disappeared from the region – as Chapters 4 and 7 suggest might happen in the near future -, the absence of cultural and regulating agrarian services may be mistakenly taken for granted or disregarded by future generations.

8.1.3. Double vulnerable livelihoods and trade-offs between vulnerability dimensions

In addressing the third research question, i.e. ***Which livelihoods are more vulnerable to 1) climate variability and drought, and; 2) crop price volatility and why this may be the case?**,* the dissertation has shown that *small-scale diversified* farmers are vulnerable to both climatic factors and crops' price volatility. The older age and lower level of formal education of some of these farmers complicate the access to technologies, social networks and knowledge, which negatively impact their ability to adapt to the combined effects of socio-economic and environmental changes. Other farmers' strategies (within the *small-scale diversified* livelihood*)* are grounded on multiple income sources but also lack social networks and financial assets. Consequently, *small-scale diversified* farmers' adaptive capacity is the lowest, despite not being as sensitive to climate and market-related fluctuations as other farmer groups.

Medium-scale rainfed organic farmers are also highly vulnerable to climate-related stressors. They have a high sensitivity because they have on average more economically dependent members in the household, and although they have financial options to aid in adaptation, their connections to mainstream agricultural organisations are weak. *Large-scale intensive* farmers are the second most vulnerable group (after *small-scale diversified* farmers) because they manage the largest areas of cash crops and are thus highly exposed to commodity price volatility and climate variability. The research has also revealed a trade-off between sensitivity and adaptive capacity. *Intensive* farmers grow large extensions of water demanding crops, such as maize, and they have less diversified income sources which renders them more sensitive to climate-relate stressors or price volatility. However, their access to technology, subsidies, insurance products and cooperatives to manage stressors and shocks are the highest in comparison to the rest of farmer groups.

The above results confirm the mal-adaption hypothesis, which refers to the actions taken to avoid or reduce vulnerability that adversely impacts other systems, sectors or social groups (Barnett and O'Neill, 2010, p. 211): modern irrigation negatively affects the most vulnerable farmers. Furthermore, initial access to abundant resources, such as irrigation water, might reduce incentives to mitigate and adapt; for example, by encouraging unnecessary dependence on water or by stimulating rent-seeking behaviour. Such potential outcomes are also considered maladaptive. Moreover, as Robards et al. (2011) suggest and became apparent through fieldwork, large infrastructural development typically commits capital and institutions to trajectories that are difficult to change in the future (rigidity traps); for this reason, modern irrigation may be again considered a mal-adaptation option.

8.1.4. Modern irrigation institutions increase the vulnerability of non-adopters

In addressing the last research question, i.e. ***How has the development of modern irrigation transformed traditionally irrigated systems and influenced irrigation regulation and farmers' vulnerability?***, this research has demonstrated that the robustness of the locally studied social-ecological system varies depending on the system's robustness principle one focuses on and on the farmer's typology. Chapter 7 reveals two different trade-offs. First, there is a trade-off between effectiveness and equity. Modern irrigation allows increasing yields, which in the short term means that the new system is effective in improving the productivity of large-scale farmers. However, it also diminishes *small-scale diversified* farmers' values regarding cultural benefits that are strongly associated with the traditional irrigation system, which disappear with modern irrigation.

There is a second trade-off between the increased control of water consumption, which accompanies modern irrigation, and a lower level of self-organisation mechanisms in the new institutional context. Farmers adopting modern irrigation become more dependent on the state (e. g. CHE and the government's agriculture department) and related enterprises that control irrigation water when stress factors such as market and climate fluctuations affect them. The increase in bureaucracy associated with modern irrigation translates into a centralisation of decision-making, which shifts from the local level to higher organisations such as the national state. This institutional change makes the plural views concerning irrigation water and the management of communal lands existing in the case study area invisible to civil society and policy-makers.

The research has also found that small landholders (older, retired or multi-task employment farmers) have been partially excluded from decision-making processes during the introduction of modern irrigation. For instance, in the Miranda de Arga referendum, the value of the vote was linked to the farmer's landholding size, which considerably reduced the power of small-scale farmers in comparison to large-scale ones. Moreover, the village's local council has taken a favourable stance to adopt modern irrigation and to implement the removal of the traditional system, ignoring what the majority of farmers – who were mostly small-scale- expressed in first referendum.

Modern irrigation has also brought about an unfair distribution of benefits, particularly among *small-scale diversified* farmers and *medium-scale rainfed organic* farmers. It has been revealed that access to communal land and water, and how future opportunities (e.g. land purchasing or organic farming performance) would be distributed among farmers is a challenge incompatible to rural development and competitive agriculture. Modern irrigation, as a state-driven modernisation process, lacks a strategy that would prevent benefits being distributed only to certain types of farmers, and it does not include the means for *small-scale diversified* farmers to remain in such evolving agricultural landscape.

Overall, this research has confirmed that large-scale agriculture finds the means to prosper with the support of the state apparatus and at the expense of small-scale farmers, who become marginalised. Current powerful institutions and existing organisations reward *large-scale intensive* farmers, resulting in the remaining farmer groups and their related values being excluded from the modern irrigation project. This critique however, is not incompatible with the recognition that some rural actors can also benefit from the intensive land management practices that accompany modern irrigation adoption, including an increased household income, higher rent extraction from common lands, and the strengthening certain land management skills, among others.

8.2. Theoretical and practical implications

This dissertation revealed, first, the importance of acknowledging different social groups within a context in order to recognise livelihoods diversity (White, 2016) and value pluralism. On one hand, the dissertation, in line with Van der Ploeg et al. (2000), has demonstrated that rural livelihoods can generally be classified following two dichotomies: modernisation vs. rural development and industrial agriculture vs. organic or small-scale agriculture. Such recognition is important for policy making as a first step to account for the different profiles of farmers and to discern that rural pluri-activity represents a new form of social capital and makes it possible for farmers to remain in business (Chapter 4).

Second, and in agreement with Chan et al., (2012), the research has also illustrated that more comprehensive awareness and understanding of cultural and social values of ES is needed. Discoveries regarding preferences and co-production awareness may increase the likelihood of engaging farmers' participation in behavioural change (Chapter 5). As Gómez-Baggetum and Kelemen (2008) suggest, this research finds that as a consequence of modern irrigation, there are unbalanced effects over farmers' values, such as the potential decrease of key cultural services (Eakin, 2005). Organisations (e.g. INTIA) and policies promoting intensive agriculture deserve more attention since they may be unwillingly influencing farmers' sense of stewardship and belonging to agrarian landscapes. In line with Orenstein and Groner (2014), the research has also shown that cultural services, such as emotional attachment and cultural meanings, strongly influence local residents –particularly small-scale and organic farmers- but have not yet been given the attention they deserve in academic and policy areas.

Third, the dissertation has also paid attention to the extent to which socio-demographic and production strategies influence agrarian ES valuation by farmers (Chapter 5). This issue is important at least from two perspectives. One the one hand, following Orenstein and Groner (2014), the research has advocated for a greater role of social approaches in ES assessment and it has argued for a more careful integration of farmers' views and preferences over ES in rural planning and policy (Mulder et al., 2015). On the other hand, at a methodological level, the dissertation has provided an innovative approach to analyse trade-offs of agrarian ES through stakeholders' stated preferences.

Regarding social vulnerability and institutional theory, the dissertation has found that there are critical factors that can decisively enhance or decrease social vulnerability. Technological, financial, social networks and natural assets are key assets allowing farmers to be less vulnerable to stressors and/or subsequently adapt (Chapter 6). In line with Eakin and Luers (2006), the research has also shown that the control that political elites exercise over community organisations inhibits the development of the forms of social capital necessary to reduce *small-scale diversified* farmers' sensitivity to climate and market-related stressors (Chapter 7). Regarding the latter issue, the dissertation has highlighted the importance of legal support and social networks to legitimatise large-scale agrarian projects and decision-making processes, as part of stakeholders' expectations. The research has found a path dependency on existing norms and social organisations that obstruct other rural alternatives, which are unable to flourish in such an unfavourable context (Chapter 7).

The dissertation has found that the most vulnerable group of farmers to climate and market related fluctuations might not be able to sustain their livelihoods (Chapter 6). As Dakos et al., (2015) indicates, the decline of famers' diversity is prone to increase the vulnerability of the social-ecological system. If those disappearing are the ones valuating other agrarian ES beyond yields and income, critical traditional knowledge may be severely impacted, thus potentially augmenting the overall system vulnerability in the long term.

As regards vulnerability, the dissertation hints at the fact that policy-oriented publications typically attend to response (*what to do*) rather than causality (*why the socio-ecological system is at risk*), as if causes were not a part of redressing vulnerability and its production causes and consequences. As Ribot (2014) argues, policy-making blindness to existing vulnerabilities would imply that the causes of risk are not understood. Considering 'why' also addresses the complexity and cost of short versus long-term solutions to vulnerabilities. For this reason, this kind of approach may not be welcome by those who have a role of responsibility and those benefitting, passively or actively (Ribot, 2014).

Regarding the notion of equity, the dissertation has attempted to shed light on the contested nature of the concept, but also on the analytical value of its application in the case study context. One should understand the mechanisms that explain why some farmers are not recognized as subjects of policy and, consequently, do not participate in decision-making. Furthermore, the existence of diverse livelihoods (and values) requires more attention in policy planning and this thesis has shown that this has not been the case so far in the *Itoiz-Canal de Navarra* irrigation project, where the conditions and values of *small-scale diversified* and *organic* livelihoods have been marginalised. Indeed, the irrigation transformation process has not accounted for local understandings of what is traditionally considered to be fair, and has responded instead only to short-term economic criteria.

These findings suggest that Eurocentric scientific and political worldviews about intensification are subordinating farmers who are not aligned with this perspective. As McDermott et al. (2013) also suggest, large-scale farmers are aided by existing legal norms -e.g. irrigation and communal, in addition to existing local, regional and state organisations- that enable them to control and maintain access to water and land by influencing others' ideas and by shaping institutions and practices that further influence behaviours (Chapter 7). Thus, *small-scale diversified* farmers' low adaptive capacity is explained by their specific demographic and socio-economic features, as well as by a set of new institutions that inhibit their access to common natural resources and therefore impede the decision-making capabilities of these farmers.

8.3. Future research directions

Modern irrigation effects on ASES, and more generally technological shifts that endorse agrarian intensification are aspects that require further scrutiny by scholars interested in agrarian systems and sustainability science. First, there is a need to conduct more research on the relationship between agrarian ES and human wellbeing, particularly in contexts where farmers are adopting new technologies (e.g. irrigation, GMOs) that can substantially transform their land management practices and even their worldviews. Although I have illuminated aspects of farmers' perception about agrarian ecosystems, including the influence to their wellbeing and awareness regarding farmers' co-production over agrarian ES, the interactions between agrarian practices and human wellbeing have not been directly assessed in this dissertation. However, I have indirectly measured the effect of farming intensification on human wellbeing through vulnerability analysis.

Second, it is important to go beyond the study of farmers' vulnerability and combine it with analysis of ASES *resilience*. Many immediate responses to vulnerability might only result in short-term, potentially maladaptive outcomes, since there is a risk of locking in a pathway that decreases vulnerability in the short term but that it may increase it in the long term. Equally, a long-term response to build resilience or transform may not provide rural people with sufficient adaptive capacity in the short-term, although it may avoid maladaptation (Luers et al., 2003b; Maru et al., 2014). Understanding and analysing vulnerability as performed in this dissertation essentially involves an actor-oriented and short-term approach, which disregards the mid/long-term socio-ecological dynamics (e.g. climate and market fluctuations) in which households are embedded. To counteract this caveat, resilience thinking suggests a more system-level and long-term focused analysis with a target on adaptive capacity and maintaining the ability to deal with future uncertain change. A resilience approach recognises that vulnerability is inherent in the systems and rather than trying to eliminate it, the challenge resides in identifying acceptable levels of vulnerability. Adopting a broader spatial-temporal scale can thus be useful to investigate social-ecological systems' vulnerability instead of social vulnerability only. This dissertation has focused on a single-sector analysis of agrarian intensification, thus providing an incomplete understanding of the general drivers of change (De Groot et al., 2010).

Third, another area of further research enquiry concerns the scientific-policy nexus regarding how policy-makers and farmers can make better and more informed rural development decisions in the context of land-use systems, while seeking to optimise their services and avoid undesirable consequences at the different geographical scales. At a global scale, the IPCC (2014) emphasises the importance of including land systems planning, but much needs to be done. Adding agrarian ES information and exisiting rural vulnerabilities to IPCC scenarios will make more tangible projections possible, by better understanding the land-use and climate feedbacks at different geographic scales.

8.4. Final remarks

In response to the central objective of this PhD thesis which is to inform about the implications of agrarian intensification for ES and social vulnerability, I postulate that the usually assumed positive synergies between modern irrigation and rural development should be treated with due caution. If modern irrigation is to help rather than hinder sustainable development, this kind of technology first needs to recognise the competing views and diversity of stakeholders involved in rural livelihoods decision-making. Moreover, the tendency to adopt more intensive land management practices as those farmers embracing modern irrigation do and who were revealed to care less about cultural services, suggests a potential long-term impact on the multi-functionality of ASES. However, this research has made evident that modern irrigation, at least in Navarre, has been a blunt instrument with respect to issues such as equitable inclusion and distribution of environmental outcomes leading certain farmers to a highly vulnerable condition.

The market-oriented nature of large-scale modern irrigation projects preclude them from paying enough attention to local characteristics, ambiguous resource management conditions, and building the necessary institutional arrangements to make agrarian productivity and other rural alternatives compatible. It also limits local ability to increase the levels of representation and inclusion of the diversity of existing farmers' views and needs, in strategic decision-making at the local level in a way that challenges existing institutional hierarchies.

Although it is still too early to fully evaluate the contribution of modern irrigation to rural development in Navarre, it is critical that policy-makers, practitioners and researchers reflect on the implications of this type of large-scale techno-projects for environmental justice and the precautionary principle. Researchers may continue to investigate the role that new technologies in agriculture are likely to have in rural people's lives and in the ecosystems they live in. This may be a process of continuous knowledge co-production through a never-ending process of observation, critical enquiry, reflective action, and so on. Rural studies scholars might like to consider how it is possible to move towards a more socially equitable and ecologically sustainable world. If the institutional mechanisms to achieve such aims are not in place or they are based on the wrong premises, such scholars have a duty to acknowledge it.

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Appendixes

I. Template for the first round of semi-structured interviews[87]

Hello, my name is Amaia Albizua and I am developing a PhD about agrarian ecosystem benefits. This PhD program is coursed at the Institut de Ciència i Tecnologia Ambientals (ICTA), Universitat Autònoma de Barcelona (UAB) and developed in the BC3 (Basque Centre for Climate Change), in Bilbao.

The PhD study encompasses two goals: 1) understanding agrarian ecosystems' contribution to human wellbeing, and 2) a vulnerability assessment of Navarre's farmers and how such vulnerability is influenced by modern irrigation.

The information obtained from the interviews will be used confidentially. Only myself will have access to the data and the interview contents will not be published online. Your personal information is only retained for potential follow-up procedures in the future, if necessary. The interview will last approximately one and a half hours. I ask for your permission to record the interview. Thank you.

Interview number:	Sector:	Place:

Could you please tell me?

1. Your name and birth year (I also indicated gender):
2. Literacy level of number of years studied:
3. Your profession:
4. How do you connect your work to the agrarian sector?
5. How long have you been working in the agrarian sector?
6. How would you classify farmers in this area?
7. Could you tell me four types of agrarian practices common in the area?
8. How happy would you say you are regarding your livelihood? Why?

(Self-esteem / security / happiness / stress / vulnerability / power / exclusion)

[87] Though the interviews were conducted in Spanish, I am publishing the final questions as translated to English. If interested in reviewing the originals, they are available via the author.

Agrarian ES perceptions and link with HWB

9. Have you ever heard about ES?
10. Could you tell me, apart from crops, the other benefits that the agrarian ecosystem provides you with?
11. For every identified service, could you tell me how it affects your wellbeing? How are those services useful in your life? How do they benefit you?
12. Why are those benefits important for you? (the mentioned services)

Vulnerability analysis and identification of key institutions

Stress factors

13. Please tell me about main problems within the rural sector (processes, changes, challenges) you have had to face in the last decade
14. Would you consider climatic stressors to be especially important, such as floods, droughts, rainfall volatility?
15. Please, specify the frequency, intensity, length and main effects on the land and farmers (such as crop lost)
16. Please tell me which are the two or three most important stressors from what we have discussed; why do you consider these the most important?

The following questions are linked to the two or three most important stressors mentioned:

Exposure and sensitivity

17. How often do stressors occur? (Length of the phenomena/magnitude/scope) (If relevant)
18. Do these problems affect all the crops equally? Which stressors are more impactful for cereals and vineyards?
19. From the previous classifications regarding farmer typologies within the zone, which type of farmer would you say is most exposed to the aforementioned challenges?
20. Would you say farmers with land in irrigated systems are less exposed? Which farmers are more sensitive? Why?
21. For the different types of farmers discussed, what were the outcomes of the stressors? Would you say those changes affected the existing relationships among the different farmers?
22. Do you know if affected farmers received any kind of help (financial, physical) to face the impacts of the stressors? If so, who gave this aid? What was this aid for, exactly?

23. Do you know if some of those climatic or environmental changes were beneficial for the communities? Why or why not? Can you provide an example?

Adaptive response

24. How did you react against those challenges? Could you avoid their effects? (selling, buying, emigrating) If so, how did you resist? (intensifying practices, diversifying crops, buying insurances, joining cooperatives, syndicates, asking for a credit)
25. Did you use rural knowledge to avoid being affected by stressors? Can you give me an example?
26. Have you started any additional activity (entrepreneurial) to absorb or ameliorate stressor's effect? Which one(s)?
27. Would you like to change any of your current activities to be less affected by the mentioned stressors?
28. Do you think that adopting modern irrigation could improve your situation? How? (More crop production and therefore higher economic gains, stronger social networks) Why? Could you tell me differences (accessing the market, legal rights and general advantages) between having either rainfed or irrigated systems?
29. Was adopting modern irrigation autonomous/assisted; automatic/planned; active/passive; a strategic reaction?
30. Did you foresee the problem (e.g. stressors)? How did you react once it had happened?
31. Do you think your reaction was effective? Efficient? Fair for you and for the rest of farmers?
32. Do you think your actions and modern irrigation have effects on the environment and for other people living in his area? Which effects and why? (Trade-offs)
33. Do you think some of the mentioned actions and modern irrigation could be mal-adaptation measures? Why? (Examples to prompt discussion: Do you think this may displace some farmers? Do you agree with your current cost of water? Do you think this transformation is displacing less costly, better options? Do you think modern irrigation creates more dependencies such as technological dependencies?)

Adaptive capacity

34. Which factors determine your actions? Are they determined by ecological features such as soil type? Personal knowledge and skills? Personal problem formulation? Social networks? Family? Personal financial situation (savings, debts, subsidies)?

35. From the aforementioned factors, which one do you think is the most important one? Can you mention other crucial assets to adapt?
36. On what does access to the mentioned assets and resources depend? (Access to the mentioned assets and resources), are there formal organisations establishing conditions to get access?
37. Which type of obstacles do you find when trying to adapt to the previously mentioned stressors, or when searching for your livelihoods sustainability? (Examples of obstacles: age, emigration/immigration, globalisation, market introduction, land attachment, others)
38. Do you consider modern irrigation to be an obstacle or an aid to be able to adapt to the mentioned stressors?

Institutions

39. Which organisations do you consider of key importance to solve rural sector problems? Would you highlight any practice, mechanism?
40. Who decides how to resolve problems within the rural sector? Are they individual/social decisions? Are there differences between those under irrigation and those under rainfed systems?
41. What are the main discussion themes? How are decisions made? Is there any assembly mechanism to make decisions? How often are those topics discussed? How those meetings are disseminated in order farmers notice and are able to participate in them?
42. Are there any organisations that you miss in the area? Why or why not?
43. Can you identify the main organisations and institutions that enhance modern irrigation? Which type of agriculture would you say is strengthened? (Intensification?)
44. How is water for irrigation managed? How can you be part of modern irrigation? What would you add, change or erase from modern irrigation operation?
45. Has this institution always existed? Is it substituting other one? Do you think it reaches its aims?
46. Are property rights different under irrigated or rainfed systems? How does modern irrigation influence property rights? (if relevant)
47. How do you think modern irrigation influences land labour and market access?
48. How can you get access to a bank credit? Is it easily accessible? What were the minimum requirements?
49. Is there financial aid connected to modern irrigation?
50. What rate of uncertainty exists in this sector change? Why might there be uncertainty?

51. Is modern irrigation and the subsequent access to irrigation water a discussion topic in the area? Between the existing livelihoods? Are there any conflicts linked to this topic? Why are there conflicts? Which parties are involved and what are their positions?
52. How do you think modern irrigation influences farmers' vulnerability to climatic and other types of stressors?

Extra questions if time permits

How is land redistributed, after the concetración de tierras?

How the definition of the irrigated zone was initially made?

Please tell me your opinion about the questions; what would you change and why?

Who else would you suggest to speak with?

II. Participants in the first round of interviews

The following Table describes the participants' profiles of the first-round interviews. Listed first are diverse farmers, followed by mixed stakeholders' profiles. Farmers were selected according to time invested in agriculture, type of crops, management approach, gender and age. 'Other' stakeholders were selected in relation to their involvement within the transformation to modern irrigation.

	Age	**Gender**	**Area/zone**	**Profile**	**Land management system (If applicable)**
I.1	Middle	Female	Southern Zone	Part-time; cereal ecologic system	Rainfed
I.2	Middle	Male	Medium area	Full-time; wine farm/vineyard	Irrigated and rainfed
I.3	Young	Male	Northern area	New farmer	Irrigated and rainfed
I.4	Middle	Male	Northern area	Full time	Irrigated and rainfed
I.5	Middle	Male	Northern area	Full time	Irrigated and rainfed
I.6	Old	Male	Northern area	Full time	Cooperative president
I.7	Middle	Male	Northern area	Part time	Irrigated system without installation
I.8	Middle	Male	Southern area	Full time	Irrigated
I.9	Old	Male	Southern area	Retired	Small plot
I.10	Middle	Female	Medium area	Part time	Rainfed
I.11	Middle	Female	Medium area	Part time	Traditional irrigated system
I.12	Middle	Male	Southern area	Full time	Conventional and ecological farming under irrigated and rainfed systems
I.13	Young	Female	n/a	n/a	Technician of AguaCanal
I.14	Middle	Male	n/a	n/a	Responsible of lands concentration of INTIA
I.15	Middle	Female	n/a	n/a	Responsible of agrarian farms training of INTIA
I.16	Middle	Male	n/a	n/a	Responsible of Projects and direction of canal work
I.17	Middle	Male	n/a	n/a	Head of agricultural production (I+D) of INTIA
I.18	Middle	Male	n/a	n/a	Technician of the negotiated of soils and climatology of Navarre Government

	Age	Gender	Area/zone	Profile	Land management system (If applicable)
I.19	Middle	Male	n/a	n/a	Head of re-parceling negotiation of Rural development and environment department of Navarre Government
I.20	Middle	Female	n/a	n/a	Member of Nueva cultura del agua NGO
I.21	Middle	Male	n/a	n/a	Manager of Artajona cooperative
I.22	Middle	Female	n/a	n/a	Technical head of the CPAEN Ecological Agriculture Council of Navarre
I.23	Middle	Male	Northern area	Part time	Worker of a city council, councilor of agriculture
I.24	Young	Female	n/a	n/a	Member of a consumption group
I.25	Young	Male	n/a	n/a	Member of a consumption group
I.26	Middle	Male	n/a	n/a	Technician of UAGN agrarian union in Navarre
I.27	Middle	Male	n/a	n/a	Technician of EHNE agrarian union in Navarre
I.28	Middle	Female	n/a	n/a	Member of a traditional irrigation community
I.29	Middle	Male	n/a	n/a	Agrarian economist professor at the University of Navarre

<35: Young; 35-55: Middle-aged; >55: Old

III. Template for the second round of semi-structured interviews

Introduction[88]

Hello, my name is Amaia Albizua and I am developing a PhD about agrarian ecosystem benefits. This PhD program is coursed at the Institut de Ciència i Tecnologia Ambientals (ICTA), Universitat Autònoma de Barcelona (UAB) and developed in the BC3 (Basque Centre for Climate Change), in Bilbao.

In one of the chapters, I am researching the governance and access to irrigation water. I analyse the evolution of the traditional irrigation to new irrigation from the Navarre Canal and the determinants of this transformation, as well as the effects of the Canal on irrigators and non-irrigators' livelihoods.

The information obtained from the interviews will be used confidentially. Only myself will have access to the data; they will not be published online. Your personal information is only retained for potential follow-up procedures in the future, if necessary. The data will be utilised as part of the doctoral thesis and to further understand the role that institutions have on the vulnerability of socio-ecological systems. The obtained information will be potentially published in a scientific journal which addresses these issues. The interview will last approximately one hour. I ask for your permission to record the interview Thank you.

Interview Questions

In the following questions I aim to understand how the system of irrigation in Miranda de Arga has changed over time; what are the causes of this evolution and the effects that it has on the farmers and/or affected owners' lives.

1. Please tell how the access to water has changed with the new modern irrigation system compared to the traditional one (20 min)
    a. Are the same people obtaining access to water (resource and users boundaries)?
    b. How many users (before and now); for how long time do they have the concession; which is the main use given; what are the conditions for access to modern irrigation water? Is there any relevant change you would mention?
    c. How were/are the irrigation costs and benefits?
    d. How are water-use decisions made (in both systems)? (Is there any assembly?)

[88] Though the interviews were conducted in Spanish, I am publishing the final questions as translated to English. If interested in reviewing the originals, they are available via the author.

    e. How was/is the surveillance of the proper use of resources performed? Are there sanctions in case of infractions?
    f. Who does the water originally belong to? Who manages it?
    g. How were/are conflicts solved? (before and currently)
    h. How were/are existing enterprises nested? (Irrigation community, AguaCANAL, INTIA, CHE etc.)
2. What socio-economic factors have addressed the change into modern irrigation?
    a. Why have these changes been adopted, instead of an alternative?
    b. Which other processes/external institutions, have enhanced the shift from traditional irrigation to modernisation?
    c. What are some advantages and disadvantages of the transformation to modern irrigation? (Who are the beneficiaries? Who are disadvantaged?)
    d. Why is there conflict in the village? Could you explain contrasting narratives/viewpoints?
3. Which implications do those changes have on the farmers and owners' vulnerability?
    a. What are some of the effects/changes have on your life, on your land management practices, on your yield, to your family structure…
    b. Which other factors (global) affect your livelihood sustainability
        i. Crop selection and climate, price fluctuations, exposure
        ii. Financial assets (insurances, subsidies, on property and rented land); knowledge (literacy and working experience)

Interview tools

Table III.1 was used as an aid while stakeholders reported traditional and modern irrigation differences regarding the management of the organisations in charge and also concerning the rights and duties of the irrigation farmers.

Table III.1 Notes used to aid interview conversation

TRADITIONAL IRRIGATION	MODERN IRRIGATION
CREATION, AIM Origination Who defines it Who has rights to access How are norms and rules developed (statutes) What use(s) is/are given to water Conditions for the use of water Who ensures proper use of resources How are enterprises nested Water property (public, private, managed by…) How much water used, for what duration	CREATION, AIM Origination Who defines it Who has rights to access How are norms and rules developed (statutes) What use(s) is/are given to water Conditions for the use of water Who ensures proper use of resources How are enterprises nested Private property, managed by AguaCANAL How much water used, and for what duration
COMMUNITY LEADERS General board Government board Irrigation board Terms of office Voting	COMMUNITY LEADERS General board Government board Irrigation board Terms of office Voting
RIGHTS AND OBLIGATIONS OF PARTICIPANTS Right to water (how to access, how much, how are rights exercised) Voting conditions Construction, repair and maintenance, police and control costs	RIGHTS AND OBLIGATIONS OF PARTICIPANTS Right to water (how to access, how much, how are rights exercised) Voting conditions Construction, repair and maintenance, police and control costs

Interview for politicians

Interview Questions

With the following questions I am exploring the perception of the political process in the materialisation of the 'Canal de Navarra'; both the modernisation of traditional irrigation as well as the transformation of the dryland into irrigated systems. Furthermore, I am investigating how different decisions have triggered the execution of the project and whose interests are taken into account.

1. Please, tell me how you see the decision-making process
    a. Whose interests are promoted
        i. Financial, social, cultural and/or ecological interests?
        ii. Large-scale farmers' or rather small-scale owners'?
        iii. To progress (please define), modernity and efficiency claims?
    b. How did the facts take place over time? Please, mention the most important milestones for you.

i. Norms and orders declarations

1. At what scale (local, meso-level, macro-level (European and national)
2. Are subsidies/incentives included?
3. Co-lateral effects of the interventions

c. Justice vs. efficiency

i. Does the process sacrifice democratic governance at the expense of financial efficiency while maintaining the equality of the current power relations?

d. Certain groups ability to acquire benefits from resources (compared to other groups or livelihoods)

e. Restrictions and barriers identification to sustainable livelihoods opportunities

i. Delivered information (how was it executed)
ii. Time allotted for decision-making
iii. Recognition of livelihood diversity
iv. Decision-making participation (how, solely inform, voting)
v. Results of geographical conditions; technical elections and political agreements
vi. Appropriation, accumulation, transferability and resource distribution
vii. Particular actors' ability to influence others' ideas and practices
viii. Rights: ownership, heritage, use ...
ix. Individual vs. collective petitions
x. Conflict and cooperation over the benefits; previously constituted laws or resulting laws
xi. Influence over the access due to:

1. Technology
2. Market access
3. Financial capital
4. Knowledge
5. Authority (legal systems that benefit some and harm others, how are they articulated)
6. Social relations: friendship, trust, reciprocity, dependency and responsibility)

2. What is your opinion regarding the project aim and how it has actually been conducted?

3. What opinion do you think others have regarding the project? Regarding the process of the decision-making groups with opposing interests to yours (what do they think and why)

IV. Participants in the second round of interviews

The following Table describes the participants' profiles of the second-round interviews. Listed first are diverse farmers and owners of Miranda de Arga village, which correspond to the existing livelihoods. Next are multi-scale formal organisation representatives with diverse political stances toward the modern irrigation project. Farmers were selected according to the survey cluster results, which categorised participants consistent with their land management practices and diverse viewpoints.

	Age	**Gender**	**Profile**	**Position towards modern irrigation**
I.1	Young	Female	Large scale intensive farmer	In favour
I.2	Young	Male	Large scale intensive farmer	In favour
I.3	Experienced young	Male	Large scale intensive farmer	In favour
I.4	Experienced young	Male	Large scale intensive farmer	In favour
I.5	Middle	Male	Full time farmer	In favour
I.6	Middle	Male	Full time farmer	In favour
I.7	Old	Male	Retired farmer	In favour
I.8	Old	Male	Retired farmer	In favour
I.9	Middle	Female	Small scale diversified	Against and denied to sell
I.10	Middle	Male	Part time farmer	Against and displaced
I.11	Middle	Male	Part time farmer	Against and displaced
I.12	Old	Male	Retired farmer	Against and displaced
I.13	Old	Male	Part time farmer	In favour
I.14	Middle	Male	Part time farmer organic farmers	Against
I.15	Middle	Female	Former Miranda de Arga council major	?
I.16	Middle	Male	Worker of Miranda de Arga cooperative	In favour
I.17	Middle	Male	Personal in charge of the maintenance of the traditional irrigation system	In favour
I.18	Middle	Male	Member of Navarre parliament belonging to BILDU	Against
I.19	Middle	Male	Member of Navarre parliament belonging to UPN i	In favour

<35: Young; 35-55: Middle-aged; >55: Old

V. Survey template

Introduction[89]

Hello, my name is Amaia Albizua and I am developing a PhD about agrarian ecosystem benefits. This PhD program is coursed at the Institut de Ciència i Tecnologia Ambientals (ICTA), Universitat Autònoma de Barcelona (UAB) and developed in the BC3 (Basque Centre for Climate Change), in Bilbao.

I will start with an exercise to valuate ES. I will read several sentences and I ask you to give me a number between 0 and 5, being 0 a complete disagreement and 5 a complete agreement. Later we will make a relative valuation exercise in which I will show you different cards/photos and I will ask you to distribute 15 pebbles among them depending on which card has more importance for you. We will do this in two phases. I will explain this later. Afterwards questions about your livelihood (strategies, socio-demographic information etc.) and your opinion about modern irrigation project and related institutions will be made.

The information obtained from the survey will be used confidentially. Only myself will have access to the data and it will not be published online. Your personal information is only retained for potential follow-up procedures in the future, if necessary. The survey will last approximately one hour. I ask for your permission to record the conversation while filling the survey. Thank you.

[89]Though the interviews were conducted in Spanish, I am publishing the final questions as translated to English. If interested in reviewing the originals, they are available via the author.

Likert Scale valuation

Survey Number: ____**Date:** (dd/mm/yyyy):______**Sector**: ______ **Recording #**: _____ **Survey taker**: _______

Agrarian soil ES valuation

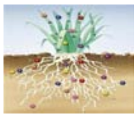
	Services	**(0-5)**
1	Agricultural land is important because it is the support of life on Earth.	
2	Agricultural land is not important to provide structure to the territory. It does not address population issues in villages nor does it offer employment opportunities in the area.	
3	Agricultural soils are important because they offer a source of inspiration (art, culture).	
4	Agricultural land is important because it gives employment to the agro-food (Not just for personal use, but also for larger-scale)	
5	Agricultural soil is important because it is the heritage of the past and the future.	
6	Agricultural land is important because it provides a source of income.	
7	Agricultural land is important because it transcends your personal needs. It is constructive, it gives hope and strength to continue.	
8	Agricultural soil is important for the regulation of pests.	
9	Agricultural land is important because it allows a direct connection to nature.	
10	Agricultural land is important because it acts as a filter that cleans the water, providing a number of necessary salts.	
11	Agricultural land is not important in the formation of ties and social relations.	
12	Agricultural land is important because it maintains and exhibits traditional rural activities, and a cultural environment of wealth and wisdom.	
13	Agricultural land is important because it absorbs waste that would otherwise be problematic. (Clarification: substances which in excess or due to their characteristics can cause damage on land. I am referring to the ability of the soil to absorb, retain, or immobilise these substances)	
14	Agricultural soils are important because they offer a place to relax and space for leisure time activities (walks, birdwatching, etc.).	
15	Agricultural land is important because it regulates erosion caused by water.	
16	Agricultural land is important because it offers a good environment for the education of children about the cycles of nature.	
17	Agricultural land is not important for the regulation of water. Water is filtered and is not retained in the soil.	
18	Agrarian soils are important because they allow freedom and autonomy for the farmers.	
19	The soil is important, but not essential for agriculture, because technology allows crops to grow without soil.	

	Services	**(0-5)**
20	Agricultural land is important because it is part of family tradition.	
21	The quality of the soil is important because quality food provision depends on it.	
22	Agrarian soils are important because they offer unique and attractive landscapes.	
23	Agrarian land is important because it provides raw material for industry and livestock.	
24	Agrarian land is important because it captures CO_2 and thus helps mitigate climate change.	
25	Agrarian soil is important because it provides a refuge for wildlife, such as Roe deer, wild boar.	
26	Agrarian land is important because it provides nutrients which ensure crop production.	
27	Agrarian land is important because its landscape tells a story, speaks of the people who live there and work it.	

Notes taken during the exercise:

- Co-production awareness
- Soil definition
- Etc.

Pebble method valuation

Provisioning	Regulating	Supporting	Cultural
 *Food*  *Financial benefit*[90]  *Employment in the sector*	 *Purifier and water flow regulator*  *Climate regulator*  *Illness and plague regulator*  *Erosion prevention*  *Waste absorber*	 *Biodiversity source*  *Wild animal habitat*  *Fertility source*	 *Basis for education*  *It gives life to festivities and traditions*  *Traditional knowledge source*  *Configures a unique landscape*  *Provides happiness to those who work it*

Notes regarding participants' indication of ES given during the exercise. The explanations given regarding to: self vs. others-oriented; individual vs. global; bio-centric vs. anthropocentric reasons.

[90] Financial benefit and employment creation were removed from the analysis after realising they were benefits rather than services.

Characterising questions: Socio-demographic, human, natural, physical, social and financial assets

General information

1	Gender	0=F; 1=M			Answers
2	Village	1= Añorbe 2= Obanos 3= Puente la Reina 4= Artajona 5= Larraga 6= Mendigorría 7= Tafalla	8= Falces 9= Miranda de Arga 10= Berbinzana 11= Olite 12= Caparroso 13= Marcilla 14= Peralta	15= San Martin de Unx 16= Beire 17= Ujué 18= Pitillas 19= Murillo el Cuende 20= Santacara 21= Murillo el Fruto	
3	Age	Nº			
4	Studies /Years of studies If university or professional studies, go to Q. 5	0= Non primary education 1= Basic and secondary education 3= Professional Training (2 years) 4= Professional Training (3 years or more) 5= University studies			
5	Are/were your studies related to agriculture?	0=No; 1=Yes			
6	Were you raised in a farmers' family? If yes, continue with Questions 7 and 8	0=No; 1=Yes			
7	From your agrarian knowledge, what percentage would you say is from your heritage or learnt at home?	%			
8	What percentage would you say is external (courses, books, magazines, Internet…)?	%			
9	How many years have you been working in this sector?	Nº			
PROFILE					
10	Employee of agriculture (T) Full-time farmer ATP (Aa) Part-time farmer (Ab) Agriculture manager (G) Owner Non-owner Retired From agrarian sector From other sector				
11	Hours per day worked at highest peak (e.g. harvesting time)	Nº			
12	Did you have to stop working last year due to health problems? (Please tell me approximately how many days)	0=None 1= 0-5 days due to minor issues (e.g. colds) 2= 10-20 days (minor) 3= More than a month (moderate)			

		4= More than two months (serious)	
13	Do you have any chronic illness(es) that may negatively affect your work?	0=No; 1=Yes	
14	Number of members in the household	Nº	
15	Is agriculture the only source of income in the household?	0=No; 1=Yes	
16	How many household members work with you in agriculture?	Nº	
17	How many household members are economically dependent on you?	Nº	
18	Has any member of the household recently emigrated in search of work elsewhere? (to another city or country)?	0=No; 1=Yes	
19	Do you have generational replacement to continue your work?	0=No; 1=Yes	
20	Total land extension of the worked land	Nº of Hectares:	
21	Are you owner of the land you work? If partially, continue to Questions 22-24 (profiles A and G)	0=No; 1=Yes; 2=Partially	
22	Percentage of worked land that you own	Nº	
23	Percentage of worked land that you rent (indicate if communal land)	Nº	
24	How many hectares do you work that are owned by others	Nº	
25	Do you have CAP rights?	0=No; 1=Yes; 2=Partially (%); -9=Don't know	
26	Do you have land that is not worked by you personally? If yes, continue with Questions 27-32 (Profiles A and G)	Nº	
27	Is someone else working that land?	0=No 1= Family or friends 2= Services enterprise 3= Cooperative	
28	Do you receive rent?	0=No; 1=Yes	
29	Do you receive a proportional benefit regarding the land area your land area transfer?	0=No; 1=Yes	
30	Do you decide which crops to grow?	0=No; 1=Yes	
31	Do you decide on the land management practices?	0=No; 1=Yes	
32	Do you invest in the infrastructure?	0=No; 1=Yes	
33	How many hectares do you own/rent in the modern irrigation transformed area? If >0, continue with Questions 35-39	Nº of hectares:	
34	Before modern irrigation installation, did you have any other source of water access that permitted you to irrigate? Which one(s)?	0=No; 1=Yes (well, raft, traditional irrigation)	
35	Have you installed modern irrigation in your plots?	0=No; 1=Yes	
36	Which type of irrigation do you perform?	1=Sprinkling 2=Dropping	

		3=Others		
37	Do you share irrigation tanks with any neighbours? If yes, continue with Questions 38-39	0=No; 1=Yes		
38	With how many?	Nº of neighbours		
39	Do you take turns to irrigate?	0=No; 1=Yes		
40	Do you rent agrarian machinery? (Profiles A and G)	0=No; 1=Tractor 2=Harvester 3=Small tools (e.g. hoe, etc.)		
41	Do you share machinery due to not owning all the necessary tools? (Profiles A and G)	0=No; 1= Tractor 2= Harvester 3= Small tools (e.g. hoe, etc.)		
42	What is your degree of participation within the cooperative?	0= Non-member 1= Very low 2= Low	3=Medium 4=High 5=Very high	
43	What is your degree of participation degree within the syndicate? If affiliated with a syndicate, go to Question 44	0= Non-member 1= Very low 2= Low	3=Medium 4=High 5=Very high	
44	To which syndicate do you belong?	1=UAGN 2=EHNE	3=UCAN 4=Other	
45	Have you applied for any of the following subsidies? Which one(s)?	0=No; 1= FEADER (Rural development European agrarian funds) (CAP) 2= FEAGA (Guarantee European agrarian funds) (CAP) 3= Subsidies for agrarian farms modernisation (Navarre Government) 4= Subsidies for inversions on modern irrigation (Navarre Government) 5= Cooperative credit aids 6= CUMAS 7= Young farmers installation aids 8= Others (specify)		
46	Do you contract any agrarian insurance? Please specify.	0= No; 1= Climatic and other insurance (integral)	2= Hail insurance 3= Others (specify)	
47	Do you sell your products directly (without intermediaries)?	0=No; 1=Yes (% of the total produced crops)		
48	Do you have any contracts with agro-industry?	0=No; 1=Yes		

IRRIGATION					**RAINFED**			
CROPS	**Ha**	**Last year?**	**Which fertiliser do you use?**		**Ha**	**Last year?**	**Which fertiliser do you use?**	
Winter cereals (winter-wheat-barley)	Ha	0=No; 1=Yes	1=Nitrates 2=Phosphates 3=Slurries	4=Sludge 5=Organic 6=Others	Ha	0=No; 1=Yes	1=Nitrates 2=Phosphates 3=Slurries	4=Sludge 5=Organic 6=Others
Vineyards	Ha	0=No; 1=Yes	1=Nitrates 2=Phosphates 3=Slurries	4=Sludge 5=Organic 6=Others	Ha	0=No; 1=Yes	1=Nitrates 2=Phosphates 3=Slurries	4=Sludge 5=Organic 6=Others
Corn	Ha	0=No; 1=Yes	1=Nitrates 2=Phosphates 3=Slurries	4=Sludge 5=Organic 6=Others	Ha	0=No; 1=Yes	1=Nitrates 2=Phosphates 3=Slurries	4=Sludge 5=Organic 6=Others
Other	Ha	0=No; 1=Yes	1=Nitrates 2=Phosphates 3=Slurries	4=Sludge 5=Organic 6=Others	Ha	0=No; 1=Yes	1=Nitrates 2=Phosphates 3=Slurries	4=Sludge 5=Organic 6=Others

81	Between irrigated and rainfed crops, which one demands a higher quantity of fertilisers?	1= More in irrigated systems; 3= Equal 2= More in rainfed systems	
82	Between irrigated and rainfed crops, which one demands higher amounts of pesticides?(quantity)	1= More in irrigated systems; 3= Equal 2= More in rainfed systems	

Changes and challenges

83 / 84	Has **irrigation** changed your life? If yes, continue to Questions 85-88 (+) / (-)	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high		85	How does the change affect your land management practices?	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high	
86	How does irrigation affect the crops production level?	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high		87	How does irrigation affect your income?	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high	
88	Do you work longer hours since the change to modern irrigation?	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high		89	Is the **absence of control over prices** an important challenge for you? If yes, continue to Questions 90-91	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high	
90	How much does the absence of control over prices affect your income?	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high		91	How much does the absence of control over prices affect your happiness levels?	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high	
92	Is **drought** an important challenge you have to face? If yes, continue to Questions 93-96	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high		93	How much does drought affect your land management practices?	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high	
94	How much does drought affect the production level?	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high		95	How much does drought affect to your income?	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high	
96	How much does it affect your happiness?	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high		97	Which years, among the last ten years, were the hardest in this regard?		
98	Is the **absence of official support** an important challenge you have to face? If yes, continue to Questions 99-100	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high		99	How much does it affect to your income?	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high	

100	How much does it affect your happiness?	0=Not at all 1= Very low 2= Low 3= Medium 4= High 5=Very high					

Adaptation strategies after modern irrigation transformation

101	Did you change your lands to a rainfed area after the transformation?	0=No; 1=Yes; (Nº Hectares)		
102	Have you decided to leave the agrarian sector to begin a new profession?	0=No; 1=Yes		
103	Have you sold all or a portion of your lands?	0=No; 1=Yes (Nº Hectares)		
104	Have you rented all or a portion of your lands? If yes, continue to Question 105	0=No; 1=Yes (Nº Hectares)		
105	Who do you rent your lands to?	1= Family / Friends 2= Cooperative 3= Others		
106	Have you partially left the agrarian sector? If yes, continue to Questions 107-108	0=No; 1=Yes		
107	Please indicate the percentage of time dedicated to land labour	0 = None 1 = Very low 2= Low	3= Medium 4= High 5= Very high	
108	Please indicate the percentage of rent obtained from agrarian land	0 = None 1 = Very low 2= Low	3= Medium 4= High 5= Very high	
109	Have you purchased new land under modern irrigation system?	0=No; 1=Yes (Nº Hectares)		
110	Have you rented new land under modern irrigation system?	0=No; 1=Yes (Nº Hectares)		
111	How much do you use INTIA advice aid?	0 = Not at all 1 = Very low 2= Low	3= Medium 4= High 5= Very high	
112	Have you diversified your crops after modern irrigation transformation? If yes, continue to Question 113	0=No; 1=Yes		
113	How many additional crops do you have currently compared to previous years?	Nº of crops		
114	Have you completed any training course to use modern irrigation?	0=No; 1=Yes		
115	Have you joined with any other organisation that provides aid for the modern irrigation use?	0=No; 1=Yes		
116	Have you joined with other farmers to create a CUMA?	0=No; 1=Yes		
117	Have you asked for credit from any bank?	0=No; 1=Yes		
118	Once the transformation is made, how much money can you save financially?	0= None 1= Very low 2= Low	3=Medium 4=High 5=Very high	

119	Have you changed land management practices in search of increased soil quality?	0=No; 1=Yes	
120	Do you have any other project in mind to improve your livelihood in a near future?	0=No; 1=Yes (If yes, please specify) -9=Don't know	

Cognitive capacities

121	*Please rate your satisfaction levels with agrarian activity.*	0= None 1= Very low 2= Low	3=Medium 4=High 5=Very high	
122	*Do you trust joining other farmers to perform agrarian activity?*	0= Not at all 1= Very low 2= Low	3=Medium 4=High 5=Very high	
123	*Please rate the level of difficulty in learning how to use the new technology.*	0= None 1= Very low 2= Low	3=Medium 4=High 5=Very high	
124	*Is age a factor when considering the adoption of new land management options, i.e. modern irrigation?*	0= Not at all 1= Very low 2= Low	3=Medium 4=High 5=Very high	
125	*Please rate your level of conservatism regarding land management practices?*	0= None 1= Very low 2= Low	3=Medium 4=High 5=Very high	
126	*Please rate the importance in which you attribute to your freedom; i.e. the power of decision-making and ability to work for yourself.*	0= None 1= Very low 2= Low	3=Medium 4=High 5=Very high	
127	*Please indicate your level of attachment toward your land* *If answered Medium, High, or Very High, please continue to Question 128*	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
128	*Does your (high) level of attachment toward your land influence your decision to sell it?*	0=No; 1=Yes; -9 Don't know		
129	*What level would you rate your trust Science?*	0= None 1= Very low 2= Low	3=Medium 4=High 5=Very high	
130	*Do you think administrative bureaucracy is an obstacle in maintaining your livelihood?*	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
131	*Do you share information regarding the climate, favourable land management practices, etc. with your neighbours?*	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
132	*Do you have Internet access?*	0=No; 1=Yes		
133	*Do you use the Internet to obtain information about agrarian related topics? (Seed prices, Climate forecasts, subsidies, etc.)*	0=No; 1=Yes		
134	*If necessary, would you trust getting financial aid from your family or friends?*	0=No; 1=Yes		

Local perception about modern irrigation transformation process

135	Do you think that the 'Canal de Navarra' modern irrigation transformation is necessary?	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
136	Do you think the transformation is being executed in an adequate way? (write down comments)	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
137	Do you agree with the Phase One extension in the traditional irrigation lands?	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
138	Do you think adopting modern irrigation is necessary to avoid becoming obsolete in the sector?	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
139	Do you think your election to use modern irrigation was influenced by outside agencies?	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
140	Do feel this decision makes you less vulnerable to climatic factors?	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
141	Do you think a consequence of modern irrigation transformation is that there are now less farmers for the same land-area? (write down reasons if commented)	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
142	Do you think this kind of transformation only benefits the 'professional' farmer?	0=No; 1=Yes; 2=to all but this one specially; -9 Don't know		
143	Are you satisfied with the concentración de tierras process?	0=No; 1= Yes; -9 Don't know		
144	Do you know what your options are if you do not agree with the concetracion de tierras process?	0=No; 1= Yes; -9 Don't know; 2= Yes, but it might not make a difference		
145	Do you think there are favouritisms in the 'concentracion de tierras' and re-distribution processes?	0=No; 1= Yes; -9 Don't know		
146	Have you missed out on procedural information regarding the process?	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
146 b	Do you feel as if you were given an appropriate amount of time to decide if you wanted to be included within the modern irrigation transformation?	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
147	From your perspective, how has agriculture changed with the introduction of modern irrigation?	Please specify.		
148	Do you agree with the modern irrigation taxes? (Specify.)	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
149	Do you think modern irrigation will make you more competitive in the market?	0=No; 1= Yes; -9 Don't know		
150	Have you had any trouble with the plots' ownership deeds when the concentracion de tierras was made?	0=No; 1= Yes; -9 Don't know		
151	Please indicate how.	1=I was the owner but I have no certificate to		

		demonstrate it (I have lost rights) 2= I paid the council to obtain my rights 3= Other	
152	Do you think it would be better if water came from another source other than the Navarre Canal? (Specify.)	0=No; 1= Yes; -9 Don't know; 2= There was no other option	
153	How long do you anticipate until you are able to see the benefits of the irrigation transformation?	0=Never 1=Short-term (1-5 years) 2=Medium-term (5-8 years) 3=Long-term (8-15 years) 4=Very long-term (>15 years)	
154	Do you think modern irrigation positively affects soil/environmental conditions? (Specify.)	0=No; 1= Yes; -9 Don't know	
155	Do you think modern irrigation negatively influences soil environmental conditions?? (Specify.)	0=No; 1= Yes; -9 Don't know	
156	How do you think modern irrigation differently influences farmers and owners within that area? (Social effects)		
157	Do you think communal land is affected in a different way? (Please specify)	0=No; 1= Yes; -9 Don't know	
158/159	Please mention the three weakest and two strongest features of modern irrigation. (Please specify)	+	-

Do you know anyone who has left the sector following the transformation to modern irrigation? (If so, please indicate how many people you have known in this situation, and provide names if possible)

Institutions

160	Due to its subsidies, do you view CAP positively?	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
161	Due to its subsidies, do you view CAP negatively?	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
162	Do you think the state government is of key importance to aid the rural sector?	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
163	Do you think the Navarre government is of key importance to aid the rural sector?	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
163	Do you think the existence of the organic agriculture board is important to commercialise these types of products?	0= No 1= Very low 2= Low	3=Medium 4=High 5=Very high	
165	Please indicate the level of involvement you perceive the agrarian syndicates have for the defence of farmers' interests?	0= None 1= Very low 2= Low	3=Medium 4=High 5=Very high	
166	Please indicate the level of trust you have for agrarian syndicates	0= None 1= Very low 2= Low	3=Medium 4=High 5=Very high	
167	To what extent do you think URA-Nueva Cultura del Agua is of key importance for farmers' interests' defence?	0= None 1= Very low 2= Low	3=Medium 4=High 5=Very high	
168	To what extent do you think INTIA INTIA helps promote the sustainability of the Navarre agrarian sector?	0= Non-member 1= Very low 2= Low	3=Medium 4=High 5=Very high	
169	To what extent do you think the role of the irrigation community plays in negotiating irrigation conditions?	0= Non-member 1= Very low 2= Low	3=Medium 4=High 5=Very high	
170	To what extent do you think the agrarian cooperative is a key representative organisation for the farmers?	0= Non-member 1= Very low 2= Low	3=Medium 4=High 5=Very high	
171	To what extent do you think CHE helps the agrarian sector?	0= Non-member 1= Very low 2= Low	3=Medium 4=High 5=Very high	
172	To what extent are you satisfied with the council you belong to?	0= Non-member 1= Very low 2= Low	3=Medium 4=High 5=Very high	
173	Do you think the village farmers are united?	0= Non-member 1= Very low 2= Low	3=Medium 4=High 5=Very high	

174	Do you think there is union between farmers from different villages?	0= Non-member 1= Very low 2= Low	3=Medium 4=High 5=Very high	
175 / 176	Please, mention the three laws, norms, organisations you consider most important for helping farmers. And the three worst? (Please specify why.)	+	-	

VI. Livelihood assets and socio-demographic features

Introduction

Table VI.1 shows the indicator variables for the five types of capital assets, context dependent socio-demographic variables and livelihood strategies collected during fieldwork. The first column indicates the type of variable. The second column, labeled 'abbreviation' is how the variable is coded for the analysis. The third column expresses the unit of each variable and the fourth column indicates whether it was used in Chapter 4 for the livelihood description.

Table VI.1 List of all the indicator variables for the five types of capital assets, context dependent socio-demographic variables and livelihood strategies collected in the fieldwork.

Indicator categorized by form of capital	**Abbreviation**	**Unit**
Educational variables:		
Farmer studies level	Studies	Illiterate, Basic, Professional training, High Professional training, University
Agrarian studies	Agrarian_Studies	Yes, No
Percentage of heritage knowledge	Inherited_Knowledge	Low < 20%, medium = 20–70%, high > 70%
Work experience	Years_Working	Very Low (0-5 years), Low (5-15 years), Medium (16-30 years), High (30-50years), Very High >50years
Farming effort	Harvesting_Hours	None (1); Low (0-5→2); Medium (5-9→3), High (9-12→4), Very high (>12→5)
Family members	Family_Members	Nº people
Number of family member emigrated	Family_Members_Emigrant	Nº people
Family structure of farms	Family_Members_Working_With_You	Nº people → high > 70%, medium = 20–70%, low < 20%
Family members economic dependent	Family_members_Economic_Dependent	Low < 20%, medium = 20–70%, high > 70%
Generational Replacement	Generational_Replacement	Yes, No, Don't Know
Health		
Missing working days due to illness	Not_Work_Illness	Nº days
Chronic illnesses	Chronic_Illness	Yes, No

Indicator categorized by form of capital	Abbreviation	Unit
Professional Satisfaction	Profession_Satisfaction	None (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
Self-barriers learning difficulty	Learning_difficulty	None (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
Self-barriers age	Age_difficulty	None (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
Conservative character	Land_management_conservative	None (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
Autonomy importance	Autonomy	None (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
Bureaucracy perception	Bureaucracy_barrier	None (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
Land affection	Land_Love	None (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
Reluctance to sell land due to land attachment	Not_sell_land_love	None (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
Cooperative participation	Cooperative_Member	Non-member (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
Syndicate participation	Syndicate_Member	Non-member (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
Information shared between neighbours	Neighbour_Info_Share	None (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
Family/Friends economic aid trust	Family_Friends_Economic_Help_Trust	None (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
INTIA services used	INTIA_Member	No member (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
Psychological variables		
Trust of association	Association_Trust	None (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)

Indicator categorized by form of capital	**Abbreviation**	**Unit**
Trust of Science	Science_Trust	None (0), Very Low (1), Low (2), Medium (3), High (4), Very High (5)
Income source(s) in the household	Unique_Income	Yes, No
Agrarian Community Policy subsidies	PAC	Yes, No
Modernisation/irrigation subsidies	Subs_Irrigg/Subs_Modern	Yes, No
Crop insurance I/Crop insurance II/ Crop insurance III	Integral_Insurance/ Hail_Insurance/ Others Insurance	Yes, No
Credit access for farming uses	Credit_Access	Yes, No
Installation of the new irrigation	Installation	Yes, No
Type of irrigation	Irrigation_Type	Sprinkling, Dripping, Others
Mechanisation	Machinery_Renting	Level of mechanisation (% renting Tractor, harvester and others)
Access and use of Internet	Internet_Use	Yes, No
Land area worked (Land tenure + Land rented)	Worked_Land_Ha	Very low (0-1Ha→1), Low (1-5Ha→2), Low Medium (5-10Ha→3), High Medium (10-50Ha→4), High (50-100Ha→5), Very High (100-200Ha→6), Very very high (>200Ha→7)
Village	Village	North (Añorbe, Obanos, Puente, Artajona, Larraga, mendi, Berbizana) Medium (Tafalla, Falces, Miranda, Olite, Beire, Ujue, San Martin Unx) South (Caparroso, Marcilla, Peralta, Pitillas, Murillo el Cuende, Santacara, Murillo el Fruto)
Average age of farmer	Age	Young < 35 yrs, Medium 35–55 yrs, Old > 55 yrs
Gender dominating farming	Gender	Male, Female
Agrarian family	Agrarian_Family	Yes, No
Land tenure Area	Ha_Property	High = 'own' land (>80%), medium = 20–80% own land, low < 20% own land
Land Rent Area	Rented_Ha	High = 'own' land (>80%), medium = 20–80% own land, low < 20% own land

Indicator categorized by form of capital	Abbreviation	Unit
Shared Land	Shared_Ha	High = 'own' land (>80%), medium = 20–80% own land, low < 20% own land (Nº Ha)
Owner of the land	Owner	Yes, No, Partial
Rules about modern irrigation		
New irrigation facilities shared	Shared_Irrigation	Yes, No
Number of people sharing irrigation	How_Many_Irrig_Share	Nº people
Necessity of turns for irrigation	Irrigation_Turns	Yes, No
Markets in practice		
Own Market Access	Direct_Sell	High = >80%, medium = 20–80%, low < 20%
Agro-industry Access	Agro-industry_Work	Yes, No
Type of crops (Ha)	Cereal (Winter-wheat and Barley), Maize, Vineyards, Others (vegetables, fruit, olive, almond trees)	0Ha, 0-5Ha→1; 5-10Ha-10→2; 10-50Ha→3; 50-75Ha→4; >75Ha→5
Irrigation system	Irrigation/Rainfed	Ha under each system
Type of fertiliser	Fertiliser_type	Conventional (N,P,K), Mixed, Organic (slurry and sludge included)
Profile	Profile	Farm worker (1), Full Time farmer (2), Part time farmer(3); Farm Manager/Owner (4), Retired Farmers (5)
Current crops diversification	Diversify_Crops	Number of crops
Displacement to rainfed lands	Rainfed_Displacement	0-1Ha→1; 2-5→2; 5-10→3
Land was sold	Sell_Land_Ha	0-1Ha→1; 2-5Ha→2; 5-10Ha→3; 10-20Ha→4; >20Ha→5
Land was rented to others	Land_For_Rent	0-1Ha→1; 2-5Ha→2; 5-10Ha→3; 10-20Ha→4; >20Ha→5
Additional land was purchased	Buy_More_Land	0-1Ha→1; 2-5Ha→2; 5-10Ha→3; 10-20Ha→4; >20Ha→5
Additional land was rented	Rent_More_Land	0-1Ha→1; 2-5Ha→2; 5-10Ha→3; 10-20Ha→4; >20Ha→5
Increased number of crops after modern irrigation	Diversify_Crops	Number of new crops after irrigation

Note: Variables in black are direct variables included in the analysis of Chapter4. Variables in grey were not used in analysis of Chapter 4 but they may be included in other chapters.

General description of Ribera Alta and Media farmers based on socio-demographic and assets summaries

Socio-demographic characteristics

Table VI.2 reflects the main socio-demographic variables assessed in Chapter 4. First column indicates the type of variable, second column the categories existing under such variable and third column such charcateristics in the case of the farmers in Itoiz-Canal de Navarra region.

Table VI.2 Main socio-demographic variables

Variable	Category	Total (%)
Sex	Female Male	5.4 94.6
N		371
Village	North Middle South	31.0 37.2 31.8
N		371
Age	<35: Young 35-55: Middle-aged >55: Old	15.9 17.8 66.2
N		370

Human assets

Table VI.3 shows the main human variables assessed in Chapter 4. This is, those related to knowledge. First column indicates the type of variable, second column the categories existing under such variable and third column such charcateristics in the case of the farmers in Itoiz-Canal de Navarra region.

Table VI.3 Main human variables

Variable	Category	Total (%)
Studies	No studies Basic education Professional education Medium Professional education High University studies	1.6 63.6 14.6 8.4 11.9
N		371
Years working in the sector	<5 years 5-15 years 16-30 years 30-50 years >50	4.4 14.5 22.2 41.4 17.5
N		367
Generational replacement	Don't know No Yes	14.7 63.8 21.5
N		367

Financial assets

Table VI.4 shows the main financial variables assessed in Chapter 4. Those encompase different types of subsidies and insurances. First column indicates the type of variable, second column the categories existing under such variable and third column such charcateristics in the case of the farmers in Itoiz-Canal de Navarra region.

Table VI.4 Main financial variables

Variable	Category	Total (%)
PAC	No	14.5
	Yes	85.5
N		358
Subs_Modern	Don't know	2.3
	No	68.4
	Yes	29.4
N		354
Subs_Irrigation	Don't know	2.3
	No	50.0
	Yes	47.7
N		354
Integral_Insurance	Don't know	4.1
	No	60.4
	Yes	35.4
N		364
Hail_Insurance	Don't know	4.1
	No	52.5
	Yes	43.4
N		364
Other_Insurance	Don't know	4.1
	No	84.6
	Yes	11.3
N		364

Natural capital and institutions regulating its access

Table VI.5 shows the main farmers' access to land features found in Chapter 4. They differentiate mainly in the land are they work and ownership feature. First column indicates the type of variable, second column the categories existing under such variable and third column provides such information for the different types of farmers in Itoiz-Canal de Navarra region.

Table VI.5 Farmers' access to land features

			Farm worker	Full-time Farmer	Part-time Farmer	Retired Farmer	Total
Ha of worked land	< 1 Ha	Count	4	20	28	18	70
		% of Total	.0	.1	.1	.1	.2
	1-5 Ha	Count	3	18	23	14	58
		% of Total	.0	.1	.1	.0	.2
	5-10 Ha	Count	2	9	15	7	33
		% of Total	.0	.0	.0	.0	.1
	10-50 Ha	Count	4	82	21	21	128
		% of Total	.0	.2	.1	.1	.4
	50-100 Ha	Count	0	33	6	2	41
		% of Total	.0	.1	.0	.0	.1
	100-200 Ha	Count	2	17	2	0	21
		% of Total	.0	.0	.0	.0	.1
	>200-400 Ha	Count	0	6	1	0	7
		% of Total	.0	.0	.0	.0	.0
	Total	Count	15	185	96	62	358
		% of Total	.0	.5	.3	.2	1.0
Owner	No	Count	4	14	11	2	31
		% of Total	.0	.0	.0	.0	.1
	Yes	Count	1	14	48	35	98
		% of Total	.0	.0	.1	.1	.3
	Partial	Count	10	158	43	27	238
		% of Total	.0	.4	.1	.1	.6
	Total	Count	15	186	102	64	367
		% of Total	.0	.5	.3	.2	1.0

Livelihood strategies in Ribera Alta and Media in Navarre

Labour diversification

Table VI.6 shows the main farmers' profiles found in Chapter 4. They differentiate mainly in the time invested in agrarian activities. First column indicates the type of variable, second column the categories existing under such variable and third column provides such information for the different types of farmers in Itoiz-Canal de Navarra region.

Table VI.6 Labour diversification strategy description

Variable	Category	Frequency	Valid %
Profile	Farm workers	15	4
	Full-time farmers	186	50
	Part-time farmers	104	28
	Retired farmers	65	17.4
	Total	370	100

Land management

Table VI.7 shows the main farmers' management strategies found in Chapter 4. They differentiate mainly in type of crop grown, whether they irrigate or not and in the d¡fertiliser used. First column indicates the type of variable, second column the categories existing under such variable and third column provides such information for the different types of farmers in Itoiz-Canal de Navarra region.

Table VI.7 Land management (crops, irrigation technology and other inputs)

Land management	Category	Frequency	Valid %
Type of Crops	Cereal	295	79.5
	Maize	199	53.63
	Vineyard	94	25.3
	Others	23	60.10
Type of system (Rainfed/Irrigated)	Irrigated Cereal	145	39
	Rainfed Cereal	268	72.24
	Irrigated Vineyard	58	14.25
	Rainfed Vineyard	58	15.18
	Irrigated Maize	198	52.99
	Rainfed Maize	7	1.35
	Irrigated others	186	49.60
	Rainfed others	69	17.71
	Total	371	
Type of fertiliser	Irrigated-Cereal-Conventional	77	20.8
	Rainfed-Cereal-Conventional	162	43.7
	Irrigated-Vineyard-Conventional	33	9
	Rainfed-Vineyard-Conventional	19	5.1
	Irrigated-Maize-Conventional	100	27.0
	Rainfed-Maize-Conventional	1	.3
	Irrigated-Others-Conventional	82	22.7
	Rainfed-Others-Conventional	21	5.8
	Irrigated-Cereal-Organic	2	.5
	Rainfed-Cereal-Organic	15	4.3
	Irrigated-Vineyard-Organic	24	6.5
	Rainfed-Vineyard-Organic	9	2.4
	Irrigated-Maize-Organic	8	2.2
	Rainfed-Maize-Organic	1	.3
	Irrigated-Others-Organic	26	7.2
	Rainfed-Others-Organic	9	2.5
	Irrigated-Cereal_Mix	2	.5
	Rainfed-Cereal_Mix	59	16.8
	Irrigated-Vineyard_Mix	9	2.4
	Rainfed-Vineyard:mix	6	1.6
	Irrigated-Maize_Mix	78	21.0
	Rainfed-Maize_Mix	2	.5
	Irrigated-Others_Mix	44	12.2
	Rainfed-Others_Mix	8	2.2

Market elections

Table VI.8 shows the main farmers' market strategies found in Chapter 4. They differentiate mainly in whether they sell directly their crops and whether they have contracts with agor-industry. First column indicates the type of variable, second column the categories existing under such variable and third and fourth columns provide such information for the different types of farmers in Itoiz-Canal de Navarra region.

Table VI.8 Description of main livelihood strategy variables

Variable	Category	Frequency	Valid %
Direct sell	Don't know	1	0
	0	284	79
	25%	32	9
	50%	9	2
	75%	31	9
	100%	1	0
	Total	358	100.0
Agro-industry contract	Don't know	3	1
	No	302	85
	Yes	51	14
	Total	356	100.0

Outcomes after modern irrigation transformation in Ribera Alta and Media, in Navarre

Crops diversification

Table VI.9 shows whether farmers diversify their crops after the installation of modern irrigation. First column indicates the type of variable, second column the categories existing under such variable and third and fourth columns provide such information for the different types of farmers in Itoiz-Canal de Navarra region.

Table VI.9 Crops diversification after the installation of modern irrigation

Variable	Category	Frequency	Valid %
Diversification	Don't know	4	1
	No	144	47
	Yes	157	51
	Total	305	100
Number of new crops added	0	18	4.9
	1	93	25.1
	2	92	24.9
	3	110	29.7
	4	48	13.0
	5	9	2.4
	Total	370	100.0

Buying and selling land

Table VI.10 shows land tenure purchases after the installation of modern irrigation. First column indicates the type of variable, second column the categories existing under such variable and third and fourth columns provide such information for the different types of farmers in Itoiz-Canal de Navarra region.

Table VI.10 Land tenure shifts after the installation of modern irrigation

Variable	Category	Frequency	Valid %
Ha displaced to rainfed lands	0 Ha	208	94.1
	0-1 Ha	4	1.8
	2-5 Ha	4	1.8
	5-10 Ha	5	2.3
	Total	221	100.0
Land area sold	0 Ha	322	91.2
	0-1 Ha	10	2.8
	2-5 Ha	12	3.4
	5-10 Ha	5	1.4
	10-20	4	1.1
	Total	353	100.0
Land area for rent	Don't know	1	.3
	0 Ha	291	89.0
	0-1 Ha	11	3.4
	2-5 Ha	9	2.8
	5-10 Ha	7	2.1
	10-20	3	.9
	>20 Ha	5	1.5
	Total	327	100.0
New land under irrigation purchased	Don't know	7	2.0
	0 Ha	222	63.2
	0-1 Ha	14	4.0
	2-5 Ha	93	26.5
	5-10 Ha	6	1.7
	10-20	4	1.1
	>20 Ha	5	1.4
	Total	351	100.0
New land under irrigation rented	Don't know	3	.9
	0 Ha	269	76.6
	0-1 Ha	9	2.6
	2-5 Ha	56	16.0
	5-10 Ha	4	1.1
	10-20	7	2.0
	>20 Ha	3	.9
	Total	351	100.0

Socio-demographic characterisation of farmers' livelihoods in Navarre

I performed a chi-square test, when both variables (the livelihood typology to which they belonged and the socio-demographic variables) compared were categorical. Only those that are significantly different among the livelihoods are presented and explained in ***Table VI.11***. The socio-demographic features, assets, and other pursued strategies and outcomes after modern irrigation are presented that are significantly different among the existing livelihood (p-value < 0.05).

Only one of the categories for each variable is represented in the ***Table VI.11***. This information endorses a broader description of the existing livelihoods. Values under each cluster represent the mean value for chi-square test so that the first row corresponding to gender for example, means that just the first livelihood ('small scale diversified farmers') are represented by females rather than males, whereas the rest of livelihoods are overrepresented by men. This is performed for the rest of significant variables.

Table VI.11 Characterisation of land management groups resulting from hierarchical cluster analysis

Assets Strategies Outcomes	Variables	X^2	p value	A) Small-scale diversified (N=125)	B) Small-scale organic (N=22)	C) Large-scale intensive (N=86)	D) Medium-scale intensive (N=131)
Socio-demographic	Gender (Males)	9.88	4.24E-02	-2.96	1.10	1.85	0.74
	Age (Old)	24.15	3.05E-03	3.19	-1.83	-3.38	0.74
	Village (North)	49.23	8.53E-04	3.80	-0.33	1.01	-4.49
Human	Agrarian studies (Yes)	6.70	7.97E-02	-2.47	0.25	1.69	0.81
Social	Participation in cooperative (High)	53.46	8.53E-04	-5.01	-1.28	5.81	0.43
	Participation in syndicate (High)	65.43	8.53E-04	-2.40	1.00	3.68	-1.39
	INTIA advice used (Very High)	113.90	8.53E-04	-5.28	0.57	5.07	0.32
Financial	Ha Property (0-1Ha)	96.62	8.53E-04	4.96	-0.60	-2.29	-2.56
	Ownership (Partial)	52.47	8.53E-04	-6.22	2.53	3.43	1.86
	Bank credit access	39.90	8.53E-04	-5.67	1.18	4.60	0.57
	Hail insurance (Yes)	23.84	8.53E-04	-4.55	-0.41	3.18	1.84
	Integral insurance (Yes)	30.18	8.53E-04	-5.26	0.42	3.54	1.80
	Other insurances (Yes)	9.38	2.00E-02	-2.69	0.27	2.40	0.37
	CAP (Yes)	32.73	8.53E-04	-5.71	0.77	2.32	3.21
	Irrigation subsidy (Yes)	62.72	8.53E-04	-7.80	2.12	3.90	3.08
	Modernisation subsidy (Yes)	32.04	1.18E-06	-5.50	2.27	2.06	2.40
Physical	Ha under irrigation (>200 Ha)	122.56	8.53E-04	-1.45	-0.78	2.26	-0.19
	Modern irrigation installation (Yes)	52.11	8.53E-04	-6.98	1.26	4.21	2.47
Current str	Profile (Full time)	97.53	8.53E-04	-8.85	1.20	6.16	2.71

Assets Strategies Outcomes	Variables	X^2	p value	A) Small-scale diversified (N=125)	B) Small-scale organic (N=22)	C) Large-scale intensive (N=86)	D) Medium-scale intensive (N=131)
	Work for agro-industry (Yes)	13.83	6.52E-03	-3.44	-0.76	1.67	2.24
Outcomes	**Purchased more lands after irrigation (10-20 Ha)**	50.16	8.53E-04	-3.16	-1.18	3.01	1.02
	Rent more lands after irrigation (>20 Ha)	49.41	1.61E-03	-2.68	-1.00	4.20	-0.61
	Crops diversification	60.26	1.31E-12	-7.49	0.25	4.77	3.06

VII. ES valuations

Table VII.1 presents in its left-hand side the absolute valuation (Likert Scale) of agrarian ES made by farmers affected by Itoiz-Canal de Navarra project. In the left-side hand, it presents the relative valuation (Pebble Method) of agrarian ES made by the same farmers. **Table VII.2** presents the same valuation but adjusted applying a method called *False Discovery Rate* (FDR) (See Section 3.3.2.2).

Table VII.1 ES: Absolute and relative valuation according to Likert Scale and Pebble Method

Likert Scale (relative valuation)					Pebble Method (absolute valuation)				
Ecosystem service	**mean**	**sd**	**min**	**max**	**Ecosystem service**	**mean**	**sd**	**min**	**max**
Food	3.61	1.70	0	5	Food	3.62	3.24	0	15
Raw materials	4.80	0.56	0	5	Water	1.26	1.70	0	15
Climate	4.11	1.28	0	5	Climate	0.82	1.15	0	6
Water fluctuations	2.67	1.77	0	5	Plagues	0.56	0.87	0	3.75
Water quality	3.81	1.44	0	5	Erosion	1.09	1.34	0	7.5
Biological control	3.54	1.43	0	5	Pollutant	0.94	1.60	0	15
Erosion	4.00	1.32	0	5	Biodiversity	0.90	1.21	0	8
Pollutant	3.76	1.52	0	5	Habitat	1.15	1.56	0	15
Life	4.70	0.77	0	5	Fertility	1.45	1.86	0	15
Habitat	4.33	1.22	0	5	Education	1.08	1.58	0	15
Fertility	4.43	0.99	0	5	Tradition	0.41	0.82	0	5
Self-achievement	4.00	1.18	0	5	Traditional Knowledge	0.92	1.39	0	15
Social relations	3.57	1.56	0	5	Landscape	0.82	1.16	0	7.5
Traditional knowledge	4.40	0.91	0	5					
Tourism recreation	3.97	1.50	0	5					
Education	4.05	1.26	0	5					
Food quality	4.59	0.89	0	5					
Aesthetic	4.22	1.13	0	5					

Table VII.2 Adjusted absolute (Likert Scale) and relative (Pebble Method) differences in valuation among existing livelihood profiles

	Likert absolute valuation					Pebble relative valuation					
ES	**SD**	**MO**	**MI**	**LI**	**p value**	**ES**	**SD**	**MO**	**MI**	**LI**	**p value**
Food	3.64	3.73	3.64	3.55	0.97	Food	3.58	3.66	3.21	3.92	0.81
Raw materials	4.79	4.59	4.77	4.87	0.75	Water	0.75	1.04	0.89	0.79	0.81
Climate	3.96	4.09	4.17	4.21	0.75	Climate	1.31	1.16	1.36	1.15	0.76
Water flux	2.58	2.23	2.81	2.74	0.75	Plagues	0.49	0.78	0.64	0.53	0.81
Water quality	3.87	4.32	3.73	3.72	0.66	Erosion	0.88	1.44	1.00	1.30	0.28
Biologic control	3.70	3.41	3.51	3.43	0.70	Pollutant	0.78	0.48	1.33	0.90	0.28
Erosion	3.94	3.91	4.14	3.98	0.75	Biodiversity	0.90	1.03	0.82	0.92	0.93
Pollutant	3.60	3.59	3.84	3.89	0.75	Habitat	1.27	0.57	1.23	1.07	0.28
Life	4.61	4.82	4.69	4.76	0.70	Fertility	1.24	2.12	1.39	1.59	0.54
Habitat	4.35	4.27	4.48	4.23	0.75	Education	1.20	0.67	1.20	0.94	0.81
Fertility	4.38	4.36	4.37	4.52	0.66	Tradition	0.61	0.17	0.34	0.30	0.20
Self-achievement	3.89	3.59	4.13	4.08	0.66	Traditional Knowledge	1.07	1.33	0.80	0.79	0.28
Social relations	3.56	3.95	3.44	3.61	0.75	Landscape	0.92	0.55	0.79	0.79	0.54
Traditional knowledge	4.42	3.95	4.43	4.45	0.66						
Tourism recreation*	4.31	3.41	3.84	3.83	0.08						
Education	4.17	4.14	4.03	3.92	0.85						
Food quality	4.72	4.59	4.48	4.55	0.66						
Aesthetic	4.21	4.09	4.29	4.21	0.90						

SD: *small-scale diversified farmers;* O: medium-scale rainfed *organic farmers;* MI: medium-scale *intensive farmers*; LI: large-scale *intensive farmers*

Table VII.3 presents the co-production of agrarian ecosystem service awareness of farmers in *Itoiz-Canal de Navarra* region.

Table VII.3 Co-production awareness of ES

Co-production awareness	**Mean**	**sd**
Biological regulation	0.21978	0.414668
Pollutants	0.167582	0.374009
Aesthetic	0.142857	0.350409
Self-achievement	0.082418	0.275378
Fertility	0.07967	0.271155
Food quality	0.035714	0.185832
Tourism recreation	0.032967	0.178796
Social relations	0.013736	0.116554
Water flow	0.010989	0.104394
Education	0.010989	0.104394
Water quality	0.005495	0.074023
Habitat	0.005495	0.074023
Food	0.002747	0.052414
Raw materials	0.002747	0.052414
Life	0.002747	0.052414
Climate	0	0
Erosion prevention	0	0
Traditional knowledge	0	0

ES co-production awareness is calculated through the stated times mean over all the services valued during the Likert scale discussions.

Table VII.4 presents the socio-demographic features that influence the agrarian ES valuation of farmers in *Itoiz-Canal de Navarra* region.

Table VII.4 Socio-demographic variables influencing significantly agrarian services valuation

	Natural		**Physical**					**Social**		
ES	**Worked land extension**		**Irrigated land extension**		**Modern irrigation installation**			**Gender**		
	X2	p value	X2	p value	No	Yes	p value	Fem	Mal	p value
Food	-0.08	0.12	-0.04	0.41	2.51	2.36	0.26	2.50	2.40	0.32
Water	0	0.93	-0.04	0.43	0.94	0.86	0.50	0.78	0.89	0.51
Climate	0.1	0.061*	0.06	0.22	0.58	0.62	0.58	0.61	0.62	0.95
Plagues	0.1	0.06*	0.1	0.06*	0.30	0.49	0.01**	0.22	0.44	0.13
Erosion	0.05	0.35	0.07	0.17	0.71	0.90	0.10	0.78	0.83	0.96
Pollutants	0.16	0.00**	0.17	0.00**	0.54	0.68	0.03**	0.44	0.63	0.29
Biodiversity	0.11	0.046	0.04	0.45	0.68	0.66	0.96	0.78	0.68	0.40
Habitat	-0.02	0.73	-0.02	0.74	0.90	0.84	0.56	1.17	0.84	0.06*
Fertility	0.04	0.46	0.02	0.76	0.97	1.04	0.53	1.06	1.02	0.74
Education	0	0.96	0.04	0.51	0.77	0.81	0.21	1.33	0.77	0.02**
Tradition	-0.09	0.09*	-0.12	0.02**	0.34	0.29	0.57	0.33	0.31	0.92
Traditional Knowledge	-0.1	0.069*	-0.13	0.02**	0.64	0.69	0.74	0.50	0.68	0.38
Landscape	0.02	0.75	0.03	0.57	0.56	0.65	0.28	0.89	0.60	0.26

p values adjusted following BH correction

	Human									
ES	**Age**				**Agrarian Studies**					
	Young	Mid.	Old	p value	No	Basic	FP1	FP2	Uni.	p value
Food	1.95	2.16	2.66	0.09*	2.00	2.46	2.07	2.13	2.77	0.52
Water	0.82	0.89	0.89	0.81	0.33	0.96	0.65	0.84	0.93	0.26
Climate	0.68	0.68	0.55	0.11	0.17	0.61	0.76	0.45	0.63	0.31
Plagues	0.45	0.43	0.42	0.81	0.33	0.40	0.50	0.42	0.47	0.82
Erosion	0.55	0.94	0.76	0.04**	0.50	0.80	1.00	0.90	0.77	0.66
Pollutants	0.64	0.64	0.60	0.81	1.00	0.63	0.46	0.61	0.74	0.63
Biodiversity	0.91	0.82	0.56	0.02**	0.50	0.62	0.80	0.90	0.79	0.51
Habitat	1.14	0.97	0.72	0.01**	0.67	0.75	1.15	0.94	1.00	0.05**
Fertility	1.05	0.97	1.06	0.93	0.33	1.01	1.06	1.06	1.12	0.54
Education	1.05	0.72	0.83	0.63	2.33	0.77	0.85	0.94	0.53	0.06*
Tradition	0.32	0.32	0.30	0.81	0.83	0.26	0.44	0.29	0.35	0.13
Trad. Kno	0.55	0.66	0.70	0.65	0.33	0.74	0.67	0.45	0.49	0.09*
Landscape	0.59	0.62	0.62	0.93	1.33	0.57	0.67	0.77	0.56	0.61

*Significant at 90%; **Significant at 95%

<35: Young; 35-55: Middle-aged; >55: Old

No studies; Basic education; FP1: Professional education Medium; FP2: Professional education High; Uni: University studies

Figure VII.1 shows the valuation differences depending on the irrigated land areas farmers hold in Itoiz-Canal de Navarra region.

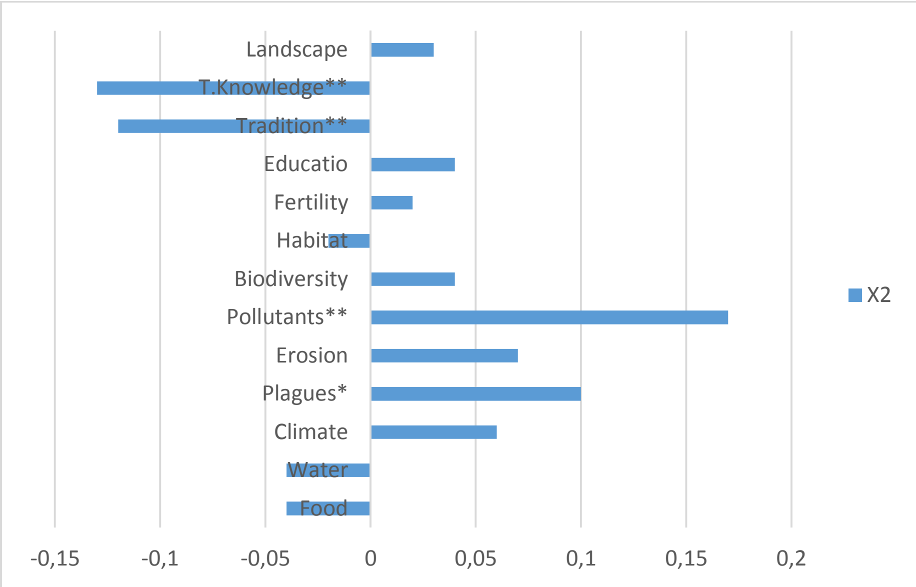


Figure VII.1 Valuation differences regarding irrigated land areas (-0.13, min -0.17, max)

Figure VII.2 shows the valuation differences in regard to gender differences in Itoiz-Canal de Navarra region.

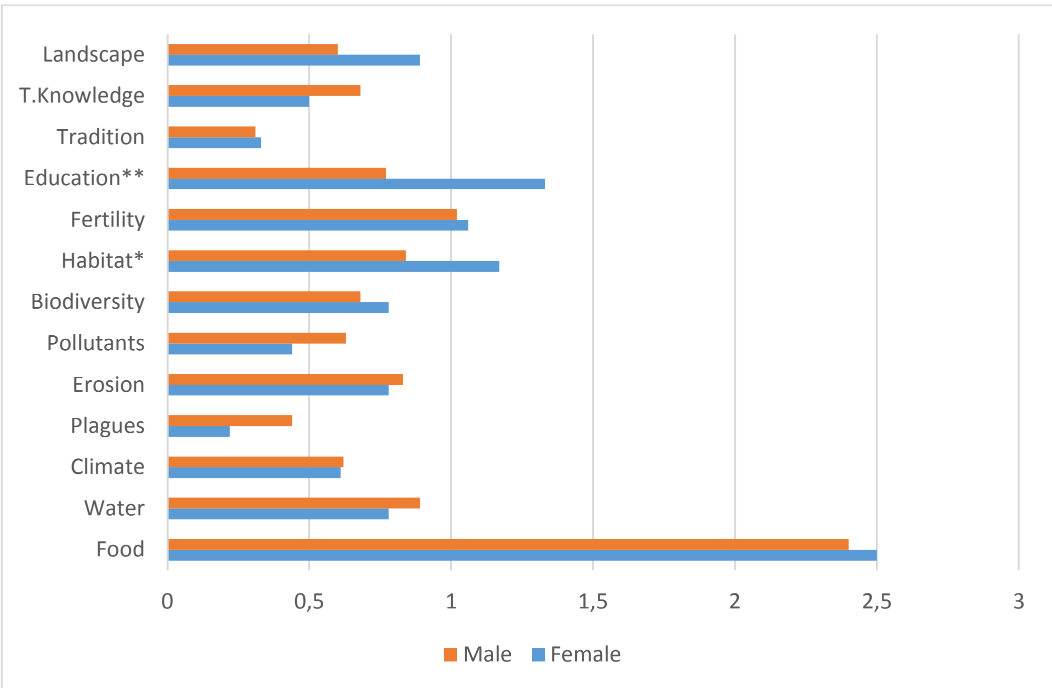


Figure VII.2 Valuation differences in regard to gender differences

Figure VII.3 shows the valuation differences in regard to age differences in Itoiz-Canal de Navarra region.

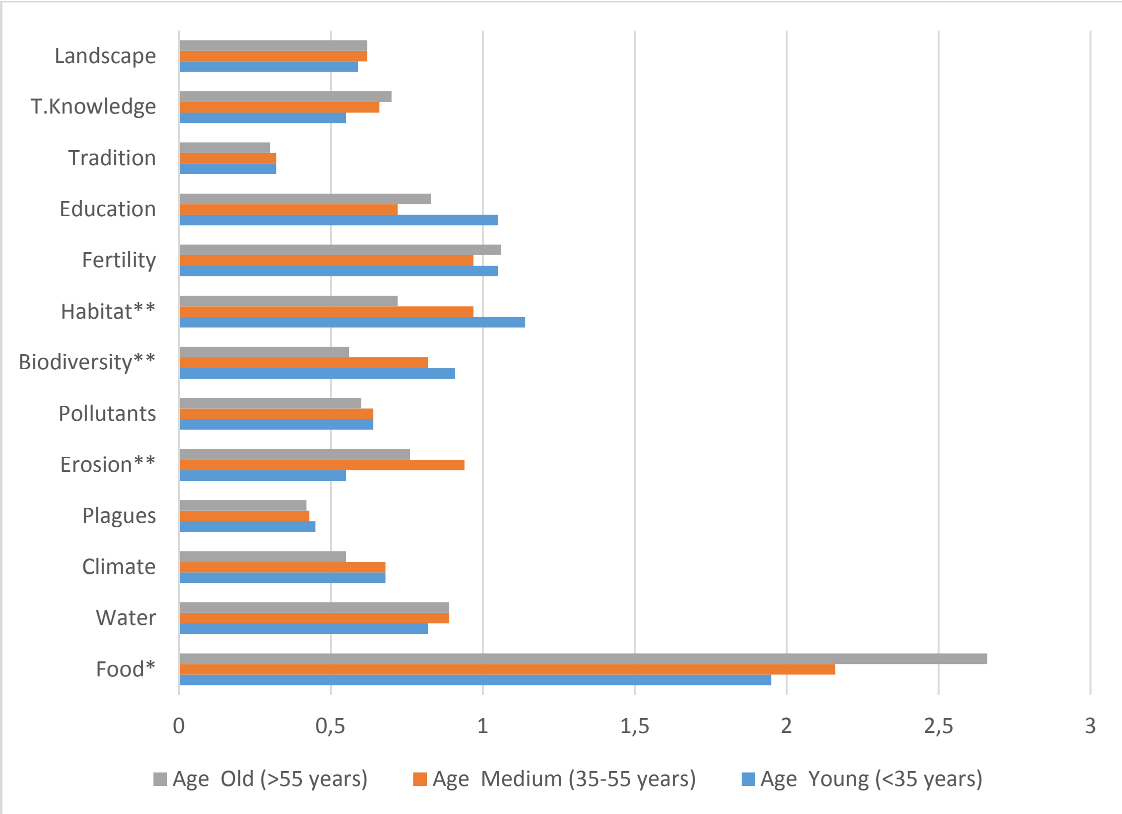


Figure VII.3 Valuation differences in regard to age differences

Figure VII.4 shows the valuation differences in regard to the level of studies differences in Itoiz-Canal de Navarra region.

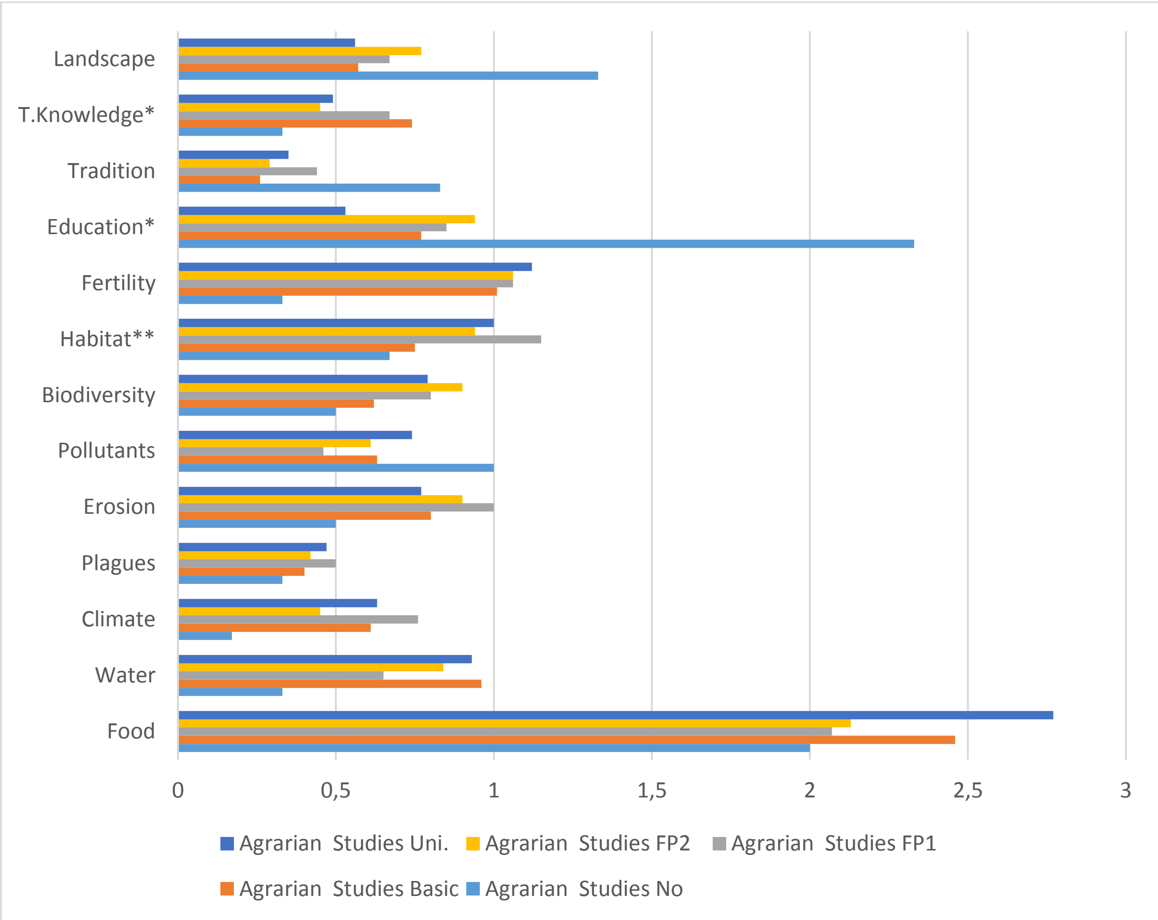


Figure VII.4 Valuation differences in regard to the level of studies differences

Trade-off analysis can be done through a principal component analysis (PCA), which was applied to the data from the Pebble relative valuation (see Section 5.4). **Table VII.5** shows the factor loadings of the PCA.

Table VII.5 Factor loadings of the PCA

Pebble AES	F1	F2	F3	F4	F5
Food	-0.73657	-0.46705	-0.31099	-0.04421	0.110138
Water	0.154569	-0.10742	0.431205	-0.58934	-0.32734
Climate	0.529963	-0.01638	0.05298	-0.17103	-0.24028
Plagues	0.456513	0.055282	-0.11236	0.011989	0.59154
Erosion	0.330717	-0.09974	-0.11268	0.401211	-0.59679
Pollutant	-0.13739	-0.23844	0.440439	0.426232	0.11622
Biodiversity	0.482271	0.040826	-0.48174	-0.11383	0.218525
Habitat	0.110473	0.131869	-0.58232	-0.08168	-0.06502
Fertility	0.406835	-0.29199	0.392123	0.216047	0.251955
Education	-0.20546	0.440789	-0.07911	-0.13619	-0.2207
Traditions	-0.20159	0.652549	0.098114	0.087013	0.11018
Traditional Knowledge	-0.09431	0.429877	0.364499	-0.33854	0.221951
Landscape	0.006282	0.549247	0.049234	0.512542	-0.08917
Eigenvalue	1.714792	1.545833	1.408337	1.19E+00	1.13E+00
Variability (%)	12.24851	11.04166	10.05955	9.16	8.69
Cumulative (%)	12.24851	23.29018	33.34973	44.37419	53.0675

VIII. Vulnerability analysis

Table VIII.1 shows in its first column the different stress factors and the shock farmers in Itoiz-Canal de Navarra region face. Second column refers to the measure unit. Third column provides a definition of each stress factor and shock followed by a further definition in the fourth column; the potential outcome for each livelihood in the sixth column and the references used are showed in the last column.

Table VIII.1 Exposure to climate variability and market prices volatility

Type of stress	Unit of meas.	Variable definition	Definition	Potential outcome for livelihood	Reference
Climate variability	Celsius	Mean standard deviation of the daily average maximum T by month between 1925-2009	What changes imply for the distribution of inter-annual agricultural productivity changes in the distributions of temperature	Food/income insecurity	(Hahn et al., 2009; Ahmed et al., 2010)
	Celsius	Mean standard deviation of the daily average minimum T by month between 1925-2009	What changes imply for the distribution of inter-annual agricultural productivity changes in the distributions of temperature	Food/income insecurity	(Hahn et al., 2009; Ahmed et al., 2010)
	Mm	Mean standard deviation of the daily average precipitation by month between 1925-2009	What changes imply for the distribution of inter-annual agricultural productivity changes in the distributions of precipitation	Food/income insecurity	(Hahn et al., 2009; Ahmed et al., 2010)
Drought	Mm	Average number of drought in the last 10 years: Mean precipitation-ETP Potential of Thorntwaite	What changes imply for the distribution of inter-annual agricultural productivity changes in the distributions of hydric stress	Food/income insecurity Conflict over natural resources	(Hahn et al., 2009; Ahmed et al., 2010; Maru et al., 2014)
Prices volatility	Eur	Mean standard deviation of the prices perceived by farmers for each crop (1995-2013) (sum of the STDEV of all the crops per farmer)	What changes imply for the distribution of inter-annual agricultural income changes in the distributions of prices	Income insecurity	(O'Brien et al., 2004; Haile et al., 2013)

Table VIII.2 presents the variables, definition and how such variables mediate the intensity of climate related stressors as well as the references where these ideas can be found.

Table VIII.2 Sensitivity and adaptive capacity to climate variability related stressors

Variable definition	**Unit of meas.**	**Definition**	**How it mediates the intensity of the stressor?**	**Reference**
Household members economically dependent (+)*	Ratio	Number of incapable people who depend on the household	The effect of the climate hazard and consequent crop lost would be higher if more people is affected	(Hahn et al., 2009; Notenbaert et al., 2013; Ifejika Speranza et al., 2014)
Ha of grown crop sensitive to lack of precipitation (+)**	Ha	Area of the most sensitive crop known in the area	The percentage of land that can be irrigated will suffer less from climate variability	(Ifejika Speranza et al., 2014)
Crop diversity (-)	Number of crops	Number of different crops each farmers has	Number of different crops planted by a household make the household less sensitive since such crop will have different responses to hazards being variable their resistance to hazards	Hahn et al (2009) Eakin and Bojorquez-Tapia (2008)

* Confusion about who is an elder dependent and how many children are dependent when both parents worked

** Type of crops already account for this differences since they have different hydric necessities

Adaptive capacity					
	Variable	**Unit of measurement**	**Definition**	**How the intensity of the stressor is mediated**	**Reference**
Human	Education: Level of literacy (+)	0= No studies 1= Primary education 3= Secondary intermediate 4= Secondary up 5= University	An individual equipped with knowledge to respond to stressors and shocks	The level of education provides tools to react to climate hazards.	(Eakin and Bojórquez-Tapia, 2008; Hahn et al., 2009; Ifejika Speranza et al., 2014) (Notenbaert et al., 2013)
	Education: Agrarian studies. (+)	No=0, Yes=1	An individual with a high level of knowledge about agricultural practices	This agrarian knowledge will better equip individuals against stressors and shocks	(Eakin and Bojórquez-Tapia, 2008; Ifejika Speranza et al., 2014) (Notenbaert et al., 2013)
	Education: farming experience (+)	Ln(Years)	Knowledge which provides a holistic perspective in response to stressors on farming	Experience in farming provides farmers with knowledge to react	(Ifejika Speranza et al., 2014)
Socio-demographic	Human workforce (+)	Number of relatives working in the farm	Human labour	The higher the number, the higher the response	(Ifejika Speranza et al., 2014)(Notenbaert et al., 2013)
	Female headed household (-)	0=F; 1=M	Recognition of the negative role that gender plays on socio-political relations within the sector; females are more severely impacted by this inequality	In a female-lead household, she may encounter more obstacles in accessing information, thus able to react to stressors and shocks	(Hahn et al., 2009) (Notenbaert et al., 2013)
	Age (-)	Ln(Years)	Age of the participant	The older an individual, the less likely it is to develop adaptation strategies	(Eakin and Bojórquez-Tapia, 2008) (Notenbaert et al., 2013)
Financial	Agrarian land ownership (+)	Percentage	Percentage of land under legal right of possession	Ownership does not necessarily facilitate freedom of decision, the percentage	(Eakin and Bojórquez-Tapia, 2008)

Adaptive capacity					
	Variable	**Unit of measurement**	**Definition**	**How the intensity of the stressor is mediated**	**Reference**
				of owned land is also important for certain decisions	
	Rented agrarian land (-)	Percentage	Percentage of rented land	Renting land decreases decision capabilities	(Eakin and Bojórquez-Tapia, 2008)
	CAP Subsidy access (+)	No=0, Yes=1	Communitarian Agrarian Policy subsides	In the event of a climate hazard resulting in crop loss, extra income allows for replacement purchases appropriate for their livelihood practices	(Eakin and Bojórquez-Tapia, 2008)
	Irrigation subsidy access (+)	No=0, Yes=1	Economic aid to promote irrigation	Economic aid to ensure farms' resistance to hazards	(Eakin and Bojórquez-Tapia, 2008)
	Modernization subsidy access (+)	No=0, Yes=1	Economic aid to promote modernisation	Economic aid to ensure farms' resistance to hazards	(Eakin and Bojórquez-Tapia, 2008)
	Integral agrarian insurance access (+)	No=0, Yes=1	Contracted coverage which protects the insured from financial loss from any meteorological hazard	Compensation in the event of a climate hazard	(Eakin and Bojórquez-Tapia, 2008)
	Hail agrarian insurance (+)	No=0, Yes=1	Contracted coverage which protects the insured from financial loss from hail damage	Compensation in the event of hail	(Eakin and Bojórquez-Tapia, 2008)
	Others agrarian insurance (+)	No=0, Yes=1	Contracted coverage which protects the insured from financial loss covering other risks affecting agricultural production	Compensation for other hazards	(Eakin and Bojórquez-Tapia, 2008)
Physical	Percentage of the area of crops irrigated	No=0, Yes=1	Modern infrastructure for irrigation	Competitive in terms of efficiency land management	(Eakin and Bojórquez-Tapia, 2008)
Social networks	Grade participation as cooperative member	0=No',1='Low',3=' Medium',4='High	Cooperatives offer assistance with accessing subsidies, cheaper feed and	Integration within the cooperative provides	(Eakin and Bojórquez-Tapia, 2008; Ifejika Speranza et al., 2014)

Adaptive capacity					
	Variable	**Unit of measurement**	**Definition**	**How the intensity of the stressor is mediated**	**Reference**
			energy, crop commercialisation, management guidance, etc.	information and decision-making competence	(Notenbaert et al., 2013)
	Grade participation as syndicate member	0=No',1='Low',3=' Medium',4='High	Syndicates defend farmers and help with access to subsidies, etc.	Integration within the syndicate provides information and decision-making competence. This membership/participation in social networks can increase other assets (insurance, subsidies)	(Eakin and Bojórquez-Tapia, 2008; Ifejika Speranza et al., 2014) (Notenbaert et al., 2013)
	Grade of information shared with friends or neighbours	0=No',1='Low',3=' Medium',4='High	Recognition that an open communication with neighbours and friends facilitates response capacity and increases social cohesion	The more information shared, the higher adaptive capacity. Information and adaptive capacity are directly correlated	Speranza et al., 2014

Table VIII.3 presents the variables, definition and how such variables mediate the intensity of crop prices volatiliy effects over farmers' vulnerability as well as the references where these ideas can be found.

Table VIII.3 Sensitivity to crop prices volatility related stressors

Variable	Unit of meas.	Definition	How it mediates the intensity of the stressor?	Reference
Income diversification *	Yes / No	Agriculture accounts for 100% of the expenses entering in the household	Those with a varied source of income are more financially protected against agricultural price volatility	Hahn et al (2009)
Household members economically dependent (+)	Ratio	Number of individuals who are dependent on the household	The higher the amount of people are impacted by potential stressors and shocks, the more sensitive the household will be.	(Hahn et al., 2009; Ifejika Speranza et al., 2014; Notenbaert et al., 2013)
Crops diversification	Number of crops	Number of different crops hold by a household	The more diverse the crops, the less sensitive the farmers will be if one crop is negatively affected (price rate, climate stressors)	Hahn et al (2009) Eakin and Bojorquez-Tapia (2008)
Percentage of the crops directly sold	Percentage	Percentage of the crops directly sold	When crops are directly commercialised (at local level), there is more stability, as international market fluctuations will only have indirect effects	(Isakson, 2014)
Contract with agro-industry **	Yes / No	Contract with agro-industry	Comparative advantage to other farmers; having the contracts and rights to grow and market particular vegetables	

*Percentage of income unknown
**We did not account for the area under contract

Adaptive capacity					
	Variable	**Unit of measurement**	**Definition**	**How the intensity of the stressor is mediated**	**Reference**
Human	Education: Level of literacy	0= No studies 1= Primary education 3= Secondary intermediate 4= Secondary up 5= University	An individual with the knowledge to anticipate price volatility and crop suitability	Education level provides tools to better react against price volatility	(Eakin and Bojórquez-Tapia, 2008; Ifejika Speranza et al., 2014) (Notenbaert et al., 2013)
	Education: farming experience	Ln(Years)	Set of knowledge that provides a holistic perspective in response to farming stressors	Farming experience provides knowledge to react	(Ifejika Speranza et al., 2014)
Socio-demographic	Female headed household	0=F; 1=M	Recognition of the negative role that gender plays on socio-political relations within the sector; females are more severely impacted by this inequality	In a female-lead household, she may encounter more obstacles in accessing information, thus able to react to stressors and shocks	(Hahn et al., 2009) (Notenbaert et al., 2013)
	Age (-)	Ln(Years)	Age of the participant	The older you are, less likely it is that you will be able to develop adaptation strategies	(Eakin and Bojórquez-Tapia, 2008) (Notenbaert et al., 2013)
Financial	Owned agrarian land	Percentage	Percentage of land under legal right of possession	Being owner facilitates freedom for decision	(Eakin and Bojórquez-Tapia, 2008)
	Rented agrarian land (-)	Percentage	Percentage of rented land	Renting land decrease freedom for decision	(Eakin and Bojórquez-Tapia, 2008)
	CAP Subsidy access	Yes / No	Communitarian Agrarian Policy subsides	If there is a climate hazard and they lose their crops their have an extra income entrance to buy new seeds or whatever strategy they follow	(Eakin and Bojórquez-Tapia, 2008)

Adaptive capacity					
	Variable	**Unit of measurement**	**Definition**	**How the intensity of the stressor is mediated**	**Reference**
	Irrigation subsidy	Yes / No	Economic aid directed to irrigation promotion	They have economic aid to make their farm more resistant to hazards	(Eakin and Bojórquez-Tapia, 2008)
	Modernization subsidy	Yes / No	Economic aid directed to modernization promotion	They have economic aid to make their farm more resistant to hazards	(Eakin and Bojórquez-Tapia, 2008)
Social networks	Grade participation as cooperative member	0= None; 1= Very low; 2= Low; 3=Medium; 4=High; 5=Very high	Cooperatives help on accessing subsidies, cheaper feed and energy, commercialize crops, management guiding etc.	The more integrated in the cooperative the more power to decide and be informed	(Eakin and Bojórquez-Tapia, 2008; Ifejika Speranza et al., 2014) (Notenbaert et al., 2013)
	Grade participation as syndicate member	0= None; 1= Very low; 2= Low; 3=Medium; 4=High; 5=Very high	Syndicates defend farmers and help on access to subsidies etc.	The more integrated in the cooperative the more power to decide and be informed	(Eakin and Bojórquez-Tapia, 2008; Ifejika Speranza et al., 2014) (Notenbaert et al., 2013)
	Grade of information shared with friends or neighbours	0= None; 1= Very low; 2= Low; 3=Medium; 4=High; 5=Very high	Recognition that an open communication with neighbours and friends facilitates response capacity and increase social cohesion	The more information shared, the higher adaptive capacity	Speranza et al., 2014

Table VIII.4 presents Chapter 6 results regarding the sub-components, components and overall VI to climate variability and drought.

Table VIII.4 Sub-components, major components and overall VI to climate variability and drought

		Small-scale diversified farmers (SDi)		**Medium-scale rainfed organic farmers (MRO)**		**Medium-scale intensive farmers (MI)**		**Large-scale intensive farmers (LI)**		**All livelihoods**	**All livelihoods**
Major comp.	**Sub-components**	**mean**	**Major comp.**	**mean**	**Major comp.**	**mean**	**Major comp.**	**mean**	**Major comp.**	**Max.**	**Min.**
Sensitivity	Family member economic dependent (number of people)	0.77		1.64		1.57		1.06		8.00	0.00
	Crops diversity (inverse of number of different crops per farmers)	0.44	0.13	0.41	0.16	0.42	0.17	0.36	0.12	1.00	0.20
	Area of land under maize (hectares)	0.52		10.68		33.16		27.81		1100	0.00
Human assets	Studies (0=no; 1=yes)	0.97		1.00		1.00		0.98		1.00	0.00
	Agrarian studies (0=no; 1=yes)	0.10	0.56	0.18	0.59	0.22	0.62	0.18	0.61	1.00	0.00
	Work experience (1= 0-5 years), (2= 5-15 years), (3= 16-30 years), (4= 30-50years), (5 >50years)	3.43		3.33		3.52		3.71		5.00	1.00
Socio-demographic characteristics	Age[91] (1)<35); (2=35-55 (3 >55 years)	4.08		3.94		3.91		4.02		4.51	3.09
	Number of family member working other than the head of the household (number of people)	0.39	0.58	0.14	0.54	0.40	0.55	0.36	0.57	4.00	0.00
	Gender (0=female; 1=male)	0.90		1.00		0.99		0.96		1.00	0.00
	Access to CAP aid (0=no; 1=yes)	0.70		0.91		0.93		0.94		1.00	0.00
	Access to modernisation subsidy (0=no; 1=yes)	0.11		0.52		0.40		0.38		1.00	0.00

[91] Expressed as natural logarithm (ln) of the value.

		Small-scale diversified farmers (SDi)		Medium-scale rainfed organic farmers (MRO)		Medium-scale intensive farmers (MI)		Large-scale intensive farmers (LI)		All livelihoods	All livelihoods
Major comp.	**Sub-components**	**mean**	**Major comp.**	**mean**	**Major comp.**	**mean**	**Major comp.**	**mean**	**Major comp.**	**Max.**	**Min.**
Financial assets	Access to irrigation subsidy (0=no; 1=yes)	0.19	0.18	0.71	0.36	0.68	0.38	0.60	0.34	1.00	0.00
	Access to CUMA[92] subsidy (0=no; 1=yes)	0.00		0.05		0.11		0.06		1.00	0.00
	Access to integral Insurance (0=no; 1=yes)	0.17		0.41		0.53		0.43		1.00	0.00
	Access to hail Insurance (0=no; 1=yes)	0.28		0.41		0.60		0.52		1.00	0.00
	Access to other insurance (0=no; 1=yes)	0.05		0.14		0.19		0.13		1.00	0.00
	Percentage of owned land (0=no; 1=yes)	0.68		0.84		0.41		0.97		66.67	0.00
	Percentage of rented land (0=no; 1=yes)	0.18		1.85		0.46		0.44		30.00	0.00
Physical assets	Internet Use (0=no; 1=yes)	0.39	0.40	0.62	0.70	0.76	0.80	0.56	0.64	1.00	0.00
	Modern irrigation installation (0=no; 1=yes)	0.40		0.77		0.84		0.73		1.00	0.00
Social assets	Information shared with neighbours (0=no; 1=yes)	0.88	0.66	1.00	0.83	0.97	0.90	0.91	0.83	1.00	0.00
	Cooperative membership (0=no; 1=yes)	0.79		0.86		0.93		0.90		1.00	0.00
	Syndicate membership (0=no; 1=yes)	0.32		0.64		0.79		0.68		1.00	0.00
Climate variability	Mean standard deviation of the daily average maximum Temp by month (ºC)	6.88	0.65	6.74	0.62	6.68	0.61	7.20	0.56	7.80	5.02
	Mean standard deviation of the daily average minimum Temp by month (ºC)	5.01		4.92		4.82		5.08		5.38	3.32

[92] Spanish acronym for 'Cooperativas de utilización de maquinaria agrícola' which means cooperatives to share agrarian machinery.

		Small-scale diversified farmers (SDi)		Medium-scale rainfed organic farmers (MRO)		Medium-scale intensive farmers (MI)		Large-scale intensive farmers (LI)		All livelihoods	All livelihoods
Major comp.	**Sub-components**	**mean**	**Major comp.**	**mean**	**Major comp.**	**mean**	**Major comp.**	**mean**	**Major comp.**	**Max.**	**Min.**
	Mean standard deviation of the daily average precipitation by month (mm)	131.0		131.1		131.6		119.8		147.20	108.10
Drought	Hydric deficit (mm)	-223.0		-223.3		-219.8		-268.5		-126.3	-325.6
VI_climate		**0.53**		**0.43**		**0.40**		**0.42**			

Table VIII.5 presents Chapter 6 results regarding the sub-components, components and overall VI to price volatility.

Table VIII.5 Sub-components, major components, and overall VI to price volatility

		Small-scale diversified		Organic		Intensive		Large-scale intensive		All livelihoods	All livelihoods
Major comp.	**Sub-components**	**mean**	**Major comp.**	**mean**	**Major comp.**	**mean**	**Major comp.**	**mean**	**Major comp.**	**Max.**	**Min.**
	Unique income	0.33		0.36		0.48		0.46		2.00	0.00
	Family member economic dependent	0.77		1.64		1.57		1.06		8.00	0.00
	Crops diversity	0.44	0.44	0.41	0.46	0.42	0.48	0.36	0.43	1.00	0.20
	Direct Sell.	0.78		0.77		0.89		0.82		1.00	0.01
Livelihood strategies	Agro industry Work	0.97		0.95		0.90		0.90		1.00	0.50
	Studies	0.97	0.79	1.00	0.80	1.00	0.81	0.98	0.83	1.00	0.00
Human	Work experience	3.43		3.33		3.52		3.71		1.00	0.00
	Age[93]	4.08	0.80	3.94	0.80	3.91	0.78	4.02		4.51	3.09
Socio-demographic	Gender	0.90		1.00		0.99		0.96	0.81	1.00	0.00
Financial	PAC	0.70	0.18	0.91	0.38	0.93	0.35	0.94	0.33	1.00	0.00

93 Log age.

		Small-scale diversified		Organic		Intensive		Large-scale intensive		All livelihoods	All livelihoods
Major comp.	**Sub-components**	**mean**	**Major comp.**	**mean**	**Major comp.**	**mean**	**Major comp.**	**mean**	**Major comp.**	**Max.**	**Min.**
	Modernisation subsidy	0.11		0.52		0.40		0.38		1.00	0.00
	Irrigation subsidy	0.19		0.71		0.68		0.60		1.00	0.00
	CUMA subsidy	0.00		0.05		0.11		0.06		1.00	0.00
	Percentage of owned land	0.68		0.84		0.41		0.97		66.67	0.00
	Percentage of rented land	0.18		1.85		0.46		0.44		30.00	0.00
Physical	Internet Use	0.39	0.39	0.62	0.62	0.76	0.76	0.56	0.56	1.00	0.00
	Information shared with neighbours	0.88		1.00		0.97		0.91		1.00	0.00
	Cooperative membership	0.79	0.66	0.86	0.83	0.93	0.90	0.90	0.83	1.00	0.00
Social	Syndicate membership	0.32		0.64		0.79		0.68		1.00	0.00
Price volatility	Exposure to price volatility	39.27	0.01	133.45	0.02	402.13	0.07	279.59	0.05	5721.71	0.00
VI_prices		**0.46**		**0.36**		**0.36**		**0.38**			

Table VIII.6 and **Table VIII.7** present Chapter 6 results regarding the sub-components, components and overall VI to climate variability and drought and crop prices volatility respectively after a standardisation process. I calculated the inverse of these variables when calculating the 7-component based VI since they counteract vulnerability. The original values, however, were used for the VI index calculation when aggregated in three components, since adaptive capacity is already included in the formula as a subtraction.

Table VIII.6 Indexed sub-components, major components, and overall VI to climate variability and drought

Vulnerability climate variability								
Sub-component	**SDi**	**Major Comp**	**MRO**	**Major Comp**	**MI**	**Major Comp**	**LMI**	**Major Comp**
Family members economic dependent	0.10		0.20		0.20		0.13	
Crops diversification (inverse)	0.30	0.13	0.27	0.16	0.28	0.17	0.21	0.12
Ha of irrigated maize	0.00		0.01		0.03		0.03	
Studies	0.97		1.00		1.00		0.98	
Agrarian studies	0.10	0.56	0.18	0.59	0.22	0.62	0.18	0.61
Working experience	0.61		0.58		0.63		0.68	
Age (log)	0.70		0.60		0.57		0.65	
Family members working in the sector	0.10	0.58	0.03	0.54	0.10	0.55	0.09	0.57
Gender	0.90		1.00		0.99		0.96	
PAC subsidy	0.70		0.91		0.94		0.93	
Modernisation subsidy	0.11		0.52		0.38		0.40	
Irrigation subsidy	0.19		0.71		0.68		0.60	
CUMA subsidy	0.00		0.05		0.11		0.06	
Integral Insurance	0.17	0.18	0.41	0.36	0.53	0.38	0.43	0.34
Hail Insurance	0.28		0.41		0.60		0.52	
Other Insurance	0.05		0.14		0.19		0.13	
Percentage of owned land	0.01		0.01		0.01		0.01	

Vulnerability climate variability								
Sub-component	**SDi**	**Major Comp**	**MRO**	**Major Comp**	**MI**	**Major Comp**	**LMI**	**Major Comp**
Percentage of rented land	0.01		0.06		0.02		0.01	
Internet use	0.39	0.40	0.62	0.70	0.76	0.80	0.56	0.64
Modern irrigation installation	0.40		0.77		0.84		0.73	
Info shared with neighbours	0.88	0.66	1.00	0.83	0.97	0.90	0.91	0.83
Cooperative member	0.79		0.86		0.93		0.90	
Syndicate member	0.32		0.64		0.79		0.68	
Mean standard deviation of daily average maximum	0.67	0.65	0.62	0.62	0.60	0.61	0.79	0.56
Mean standard deviation of daily average minimum	0.82		0.78		0.73		0.85	
Mean standard deviation of daily average precipitation	0.59		0.59		0.60		0.30	
Hydric deficit	0.52		0.51		0.53		0.29	

Table VIII.7 Indexed sub-components, major components, and overall VI to price volatility

Vulnerability price volatility								
Sub-component	**SDi**	**Major Comp**	**MRO**	**Major Comp**	**MI**	**Major Comp**	**LMI**	**Major Comp**
Unique income	0.16		0.36		0.23		0.24	
Family members economic dependent	0.26		0.33		0.18		0.20	
Crops diversification (inverse)	0.25	0.44	0.27	0.46	0.21	0.48	0.23	0.43
Direct Sell (inverse)	0.78		0.77		0.82		0.89	
Agro-industry work (inverse)	0.95		0.91		0.80		0.80	
Studies	0.97	0.79	1.00	0.80	0.98	0.82	1.00	0.83
Working experience	0.61		0.44		0.68		0.63	
Age (log)	0.66	0.80	0.44	0.80	0.68	0.78	0.56	0.81
Gender	0.90		1.00		0.96		0.99	
PAC subsidy	0.70		0.91		0.94		0.93	
Modernisation subsidy	0.11		0.52		0.38		0.40	
Irrigation subsidy	0.19	0.18	0.71	0.38	0.60	0.35	0.68	0.33
CUMA subsidy	0.00		0.05		0.06		0.11	
Percentage of owned land	0.35		0.09		0.01		0.19	
Percentage of rented land	0.18		0.06		0.37		0.21	
Internet use	0.39	0.39	0.62	0.62	0.56	0.75	0.76	0.56
Info shared with neighbours	0.88		1.00		0.91		0.97	
Cooperative member	0.79	0.66	0.86	0.83	0.90	0.90	0.93	0.83
Syndicate member	0.32		0.64		0.68		0.79	
Sum of all crops price volatility	0.06	0.01	0.30	0.02	0.05	0.07	0.15	0.05

IX. Focus group template

Introduction[94]

Thank you very much for your cooperation. I am sure each of you has much to contribute to this workshop and hopefully we can have a discussion in which we can learn from each other.

Joining me today is Imanol Okiñena, a master student and collaborator in the centre where I work, and Begoña Renteria, a social worker and friend.

The objective for the discussion is to better understand the access to irrigation water. To do this, I am interested in the different viewpoints and perspectives regarding the modernisation of irrigation in Miranda de Arga by analysing the comparison of traditional and modern irrigation.

There are rules for the discussion. It is very important to be respectful of taking turns in speaking and adhering to the objectives of the workshop. It is particularly essential to maintain compliance with all participants. Please, let us maintain an environment of respect to everyone throughout the debate.

I would appreciate if each participant can take approximately two minutes to introduce themselves and state the reason that each person is here today.

Thank you again for contributing.

Traditional and modern system characterisation

The first exercise consists of characterising each irrigation system. Please write down a brief description on the provided card focusing on the given categories:

• Monitoring, surveillance and penalties regarding the proper management of irrigation water. How is this influenced/will influence the behaviour of users/biophysical conditions and its effect on irrigation farmer relations (cooperation, dependency).

• Is the distribution of benefits and cost (rights and duties) properly balanced between irrigation farmers and/or external actors (concessionary company, Navarre Government, etc.)?

• Water consumption (efficiency and effectiveness of the irrigation system)

• Prices (commodification of land and water)

[94] All the interviews were conducted in Spanish. Here, the questions are translated to English. If anyone wishes to view the original versions, they are available via the author.

• Community, insurance-related subsidies that may potentially favour some groups

• Others

Each participant will fill out their cards and place them with the corresponding topics, in the panles of traditional and modern irrigation systems. We will compare both irrigation systems. Finally, a brief descriptive summary will be made, followed by the debate.

Advantages and disadvantages of both modern and traditional systems

Now we will discuss some advantages and disadvantages of both systems. Respective to the topics from the previous exercise, we will examine a few related variables: social, economic, environmental, cultural and political aspects (empowerment, disempowerment).

In the following panel we will document the advantages and disadvantages of the ideas discussed in the previous exercise. We must specify what kind of benefits they are (economic, environmental, etc.) and which group (among the different types of farmers) is either positively or negatively affected. Advantages and disadvantages may be related to three different types of farmers[95], which are representative of the different livelihoods in *Itoiz-Canal de Navarra* zone.

Everyone has 10 min to think and then participants will stand up to draw up your ideas (represented by cards and placed at each point you want to discuss.

Break

Summary of the debate

Discussion focus on the effect of the advantages and disadvantages among the plurality of actors involved: smallholders, intensive farmers, organic farmers.

[95] I did not distinguish between large-scale and medium-scale intensive farmers and both were discussed as belonging to the same group.

List of participants and brief description

Here are the profiles of the focus group participants who were involved.

	Name	Profile
FG.1	Jesús Mari Isturiz	Técnico de INTIA: technician in charge of the '*concentración parcelaria'*
FG.2	Azucena Zabaleta	Land-holder in favour of traditional irrigation
FG.3	Mónica Cárcar	Miranda de Arga neighbour, sustainable fluvial manager and member of the foundation *Nueva Cultura del Agua*
FG.4	Luis Mari Ibañez	Miranda de Arga *intensive* farmer
FG.5	Vitorio Tápiz	Miranda de Arga *organic* farmer

Note: This focus group was conducted in June 2015 in Miranda de Arga

X. Pictures of traditional and modern irrigation systems

Figure X.1 shows the traditional system. The upper left photograph shows the point on the river where water was diverged to the *acequias*, arriving to Miranda de Arga. At that location, there was a small submerged dam to slow the river current, which was where the water was introduced into the *acequia,* as shown in the upper right photograph. The bottom left photograph shows the manual gates used by irrigation farmers to introduce water to flood their plots. Finally, in the bottom right photograph, some traditionally irrigated vegetable gardens are displayed.

Figure X.1 Traditional irrigation system

In Figure X.2, the upper left photograph shows one of the pipes used to construct the modern irrigation system. The upper right photograph is a sign indicating the project plans and behind it excavated land can be observed as construction had begun to install the underground pipes. On the bottom left, we can see the hydrants; computers to program irrigation are inside these blocks. Finally, on the bottom right side, there is a field with pressure sprinklers in action.

Figure X.2 Modern irrigation system

XI. Glossary

Technical terms

General

Soil

Natural tri-dimensional body which is part of an ecosystem (Porta et al., 2003). It is studied through the soil profile which consists of a vertical cut of the land that permits the study of the soil as whole –i.e. from surface to original matter. Soil is generally used to refer to soil sampling for ecological indicators such as regulating services (e.g. water, climate and pests) and supporting services (e.g. biodiversity). 'Soil science' discipline is typically used at this scale.

Land

Earths' surface –i.e. a bi-dimensional body. Stakeholders, during the fieldwork for empirical data collection, refer to 'land' as the surface where they labour.

Agrarian ecosystem

It covers the interaction of multiple scales (e.g. dead leaves, land surface and soil characteristics at different horizon levels) and organisms of several size and complexity are included at those scales, from microscopic to human. It is typically used when referring to larger scales (e.g. landscape) and 'geomorphology' and 'ecology' disciplines, among others.

Agricultural area

The sum arable land, permanent crops, and permanent pastures (FAO, 2015b).

Arable land

The land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for arable land are not meant to indicate the amount of land that is potentially cultivable (FAO, 2015b).

Biofuel production (thousand kt of oil eq.)

Fuel that is produced through biological processes, including agriculture. They can be derived directly from plants, or indirectly from agricultural, commercial, domestic, and/or industrial wastes (FAO, 2015b).

Irrigated systems (Area equipped for irrigation)

Area equipped to provide water (via irrigation) to crops. It includes areas equipped for full/partial control irrigation, equipped lowland areas, and areas equipped for spate irrigation (FAO, 2015b).

Irrigated Area (%)

Percent of area equipped for irrigation that is actually irrigated in any given year, expressed in a percentage. Irrigated land that is cultivated more than once a year is counted only once (FAO, 2015b).

Price volatility

Measure of the volatility in the relative price of food in a country. The indicator is calculated from the monthly domestic food price level index using monthly consumer and general food price indices and purchasing power parity data from the International Comparison Program conducted by the World Bank (see the Relative Price of Food Indicator for more information). Month-to-month growth rates are calculated, and the standard deviation of these growth rates are calculated over the previous eight months (Eight month rolling standard deviation) (FAO, 2015b).

Fertilisers (kg/ha)

Inorganic form of the three types of fertilisers: nitrogen (N), phosphate (P205), potash (K2O) and including complex fertilisers (NP, PK, NK and NPK) (FAO, 2015b).

Organic fertilisers

Derived from animals, plants and compost (FAO, 2015b).

Mineral fertilisers

Available for farmers in solid or liquid form, and are delivered to the farm either in bulk, in bags or in pressurised containers (FAO, 2015b).

Pesticides

Insecticides, fungicides, herbicides, disinfectants and any substance or mixture of substances intended for preventing, destroying or controlling any pest; including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies (FAO, 2015b).

Wheat

Triticum spp.: common (T. aestivum) durum (T. durum) spelt (T. spelta). Common and durum wheat are the main types. Among common wheat, the main varieties are spring and winter, hard and soft, and red and white (FAO, 2015b).

Value added from agriculture (% GDP)

Agriculture corresponds to ISIC divisions 1-5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3 (FAO, 2015b).

The *agro-industrial model*,

A model upheld and reinforced by an alliance of agricultural economists and biological scientists who are still legitimating the intensification and scale economies imported from the American and Australasian modernisation project (see Drummond et al., 2000) (Marsden et al., 2002).

The *post-productivist model*

A model, alternatively, associated with the social geographers and planners' concerns of rural capacity and with the regulatory mechanisms needed for dealing with the ‘consumption countryside’ (see Lowe et al., 1997) (Marsden et al., 2002).

The *rural development* dynamic,

Although originated among the largely ‘bottom-up' initiatives associated with the integration and empowerment of ‘peripheral’ rural communities, is now a much broader and more diffuse agrarian model. It is one which may be able to recentre the significance of agricultural practices and social ecology (see Light, 1999). It holds the potential to reignite the social and environmental role of agriculture as a major agent in the sustainment of rural economy and culture (Marsden et al., 2002).

Modernisation paradigm,

Still the dominant agrarian model, consists of intensification through mechanisation, fertilisers, pesticides and water consumption, but due to its associated environmental damage, this paradigm evolved in the 1990s, into *sustainable intensification* and/or *smart climate agriculture*.

Sustainable intensification

Model based on higher yields at the aggregate level with fewer negative impacts (Tilman et al., 2011; Godfray and Garnet, 2014). However, the latter model has also been disputed from several standpoints regarding whether those aims were balanced or not. Concerns about whether it distracts attention from non-production sides; whether it is still part of the *productivist* agenda, as well as whether it suggests ecosystems substitution (Godfray and Garnet, 2014).

Rural development paradigm

Model that appears simultaneously in the 1990s but with a very different approach (Van der Ploeg et al., 2000). It encompass rural residents, not only full time farmers and it ecompasses shorter food chains and high quality products and aims of landscape and ES conservation among other goals. These different pathways are already occurring. Their sustainability however, will partly depend on the support and assistance from state policy (Marsden et al., 2002).

ES for human wellbeing: perceptions and valuations

ES

Benefits that ecosystems provide to people (Viglizzo et al., 2011).

Ecosystem functions

Intermediate processes necessary to deliver a service which is known as the final benefit provided to humans (Fu et al., 2010).

Management

Interphase between human and ecological systems through which humans influence and are influenced by ecosystems (McMichael et al., 2005).

Intensification

Management practices used to increase yield per surface and time. Intensification typically incorporates intensive tillage regimes, increased application of fertilisers, irrigation when necessary (Baldock et al., 2000) and reductions in crop diversity both in time and space (landscape) (Matson et al., 1997).

The Millennium Ecosystem Assessment (MEA, 2005),

A four-year study involving more than 1,300 scientists worldwide. These scientists developed ES classifications through proxies to understand the multiple services ecosystems can offer.

Indirect service

Cognition process required due to the fact that many services (e.g. nutrients cycling) are not intuitively perceived by humans as other services, such as food provisioning (Daniel et al., 2012a).

Co-production

The influence of farmers' labour on the delivery of agrarian ES (Seppelt et al., 2011).

Di-services

Negative effects of co-production, such as soil erosion, salinity and loss of water quality (Power, 2010; Bacon et al., 2011) .

Double-counting

Term originally used in economics to refer to the erroneous practice of counting a value more than once (Fu et al., 2010).

Self-fulfilment

Fulfilment of one's hopes, dreams, goals, etc. Here this service is understood as the energy that land ecosystem provides farmers through their labour, and allows them to feel good through a metaphysical force and/or identity connected strength.

Recreation and tourism

Cultural services that provides many benefits such as physical exercise, aesthetic experiences, intellectual stimulation, inspiration and other values connected to psychological wellbeing.

Local ecological knowledge

Cultural services transferred over generations and regenerated through practical engagements with ecological components (Kitayama and Markus, 2000).

Social relations

Human relationships that are organised and maintained by cultural practices and common understanding of a community (Kitayama and Markus, 2000).

Cultural heritage service,

Legacy of biophysical features, physical artefacts, and intangible attributes of a group or society inherited from previous generations, maintained in the present and given for the benefit of future generations (Daniel et al., 2012a).

Material benefits

Tangible products of ecosystems;

Aesthetic benefit

Cultural benefits related to beauty or appreciation of beauty;

Place/heritage benefit

Cultural benefits associated to the meaning or importance associated with a location;

Activity benefit

The intangible benefit associated with action (labouring);

Spiritual benefit

Cultural benefit related to metaphysical forces that exist beyond the individual;

Knowledge benefit

Cultural benefit that concerns theoretical and practical information and skills;

Existence/bequest benefits

Intangible non-use benefits associated to knowing that something exists or the satisfaction of preserving for future generations;

Option benefit

Cultural benefit that applies to the predicted benefit of future use;

Social capital benefit

Cultural benefit that signifies the contribution to enhance relationships among people;

Identity benefit

Ideas, relationships and sense of belonging that shape people;

Employment

Contribution to work that provides monetary income.

Human wellbeing (HWB)

Positive physical, social and mental state of a person (Collins English Dictionary, 2015; MEA, 2005b). More specifically, the MEA (2005) defines wellbeing as a multivariate state comprising of five dimensions: basic material for a good life, health, security, good social relations, and freedom of choice and action.

The *security* dimension

Secure access to natural and other resources, personal safety, and security from natural and human-made disasters (MEA, 2005).

Human security

Latest of a long line of neologisms; including common security, global security, cooperative security, and comprehensive security that encourage policymakers and scholars to think about international security as something more than military defence of state interests and territory. Although definitions vary, most formulations emphasise the welfare of ordinary people (Paris, 2001).

Solastalgia

Distress caused by environmental change, such as mining or climate change.

Topophilia,

Someone's affection to hometown, which often becomes mixed with the sense of cultural identity among certain peoples and a love of certain aspects of such a place.

Affection and respect,

Someone's sense of belonging to a given environment.

Freedom of choice and action

Ability of individuals to control what happens to them and to be able to achieve what they value doing or being.

Valuation

Process of assigning a value to a particular action or object (Farber et al., 2002).

Interest conflict

When the concerned parties have the same understanding of an issue and there is a common set of values involved (Vatn, 2007).

Value conflict,

When the parties involved do not agree on the basic understanding of the issue discussed, what values are at risk and which should be given priority (Vatn, 2007).

Use values

Direct consumptive use assets such as the value of timber, fish or other resources that ecosystems provide, and direct, non-consumptive use values such as those related to recreation and aesthetic appreciation.

Indirect-use values

Services provided by nature, such as air and water purification, erosion prevention and pollination of crops.

Non-use value

Importance attributed to an aspect of the environment in addition to, or irrespective of its use value.

Option value

Value we place on maintaining the option to use ES in the future, either within our own lifetime, or for future generations (the latter is referred to as ‘bequest value’).

Commodity

Exchangeable unit of economic wealth (‘Definition of ‘commodity’ | Collins English Dictionary,’ n.d.).

Livelihood strategies

Reactive,

Response to a stimulus, i.e. coping with stressors and shocks (Chambers and Conway, 1992).

Proactive,

Enhancing and exercising capabilities in adapting to, exploiting and creating change, and in assuring continuity (Chambers and Conway, 1992).

Agency

Autonomous and purposive actor—which is attributed solely to humans (Dwiartama and Rosin, 2014). Whereas personal agency comes from everyday decision-making processes, political agency entails the ability of humans (individuals or collectives) to affect social processes. Agency goes beyond pure intentionality, and is reliant to some extent on the actor’s relationality to the material components of society.

Vulnerability

Vulnerability

Propensity or predisposition to be adversely affected by a stressor (e.g. climate change) (IPCC, 2014).

Sensitivity

Degree to which a system is affected by or responsive to climate stimuli (IPCC, 2001, p. 894).

Socio-ecological sensitivity

Degree to which the socio-ecological is affected by or responsive to a/or multiple stressors. In this dissertation, it is measured by assessing the current state of the household and stressors´ effect on the agro-ecological system

Sensitivity of a social system

Characterised by different factors such as household structure (e.g. the number of family members who are economically dependent) and the existence of a broader livelihood portfolio, i.e. the availability of alternative non-farm income as complementary strategies to buffer vulnerability (Antwi-Agyei et al., 2013).

*Stress*ors

Pressures that are continuous and cumulative, predictable and distressing, such as seasonal shortages. Examples of stressors include declining yields of soils that degrade through salinisation, declining common property resources, or declining rainfall (Chambers and Conway, 1992).

Shocks

Impacts that are typically sudden, unpredictable and traumatic. Example of shocks are droughts, floods, pests, accidents and sudden sickness, or the unexpected death of a family member (Chambers and Conway, 1992).

Agronomic drought,

Humidity deficit in the land that comes after a meteorology drought and has negative impacts in crops production.

Exposure

Presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Adaptive capacity

Ability of a system to adjust to different hazards (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2001 p. 982).

Conflict

Range of negative interactions that encompass mild verbally-expressed discord and cold interstate relationships, as well as hostile acts (Kloos et al., 2013).

Institutions

Institutions

Formal and informal procedures, routines, norms and conventions embedded in organisational structure of political economy (Hall and Taylor, 1996).

Group theory,

Two or more people who interact with one another, share similar characteristics, and have a collective sense of unity.

Access

Ability to derive benefits from things (Ribot and Peluso, 2003).

Access control

Ability to mediate others' access.

Control

Checking and direction of action,

Access maintenance

Expending resources or powers to keep a particular sort of resources access open (Ribot and Peluso, 2003).

Monitoring rules

What is being monitored and by whom (Paavola, 2007).

Rules of exclusion

How effectively unauthorised users can be excluded and authorised resource use (Paavola, 2007).

Property right

Right to benefit from a resource or economic good (Ribot and Peluso, 2003).

Establishing clear boundaries

Clear definition of natural resources and users' rights (Anderies et al., 2004a).

Proportional equivalence between benefits and costs

Rights and duties of users and the distribution of impacts and benefits (Anderies et al., 2004a).

Collective-choice arrangements of the individual

Ability to modify the rules (Anderies et al., 2004a).

Monitoring

Control of bio-physical conditions and users behaviour (Anderies et al., 2004a).

Graduated Sanctions

Users who violate rules-in-use are likely to receive graduated sanctions (depending on the seriousness and context of the offense) from other users, from officials accountable to these users, or from both (Anderies et al., 2004a).

Conflict-Resolution Mechanisms

Users and their officials have rapid access to low-cost, local arenas to resolve conflict among users or between users and officials (Anderies et al., 2004a).

Minimal Recognition of Rights to Organise

The rights of users to devise their own institutions are not challenged by external governmental authorities; users have long-term tenure rights to the resource (Anderies et al., 2004a).

Nested Enterprises

Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organised in multiple layers of nested enterprises (Anderies et al., 2004a).

Equity

Criterion for the distribution of costs and benefits in an institutional setting and the analysis of participatory processes in such setting (Corbera, 2007).

Legitimacy

The way in which livelihoods' outcomes are negotiated, accomplished and accepted by stakeholders. This is, the extent to which decisions are acceptable to participants and non-participants that are affected by decisions (Adger et al., 2005).

Foreign languages terms

Itoiz-Canal de Navarra

Name of the area affected by the modern irrigation introduction project.

Concentración de tierras

The term can best be translated as *land consolidation* and consists of grouping small plots of an owner or diverse owners into a smaller number of plots

Acequias

A community-operated watercourse used in Spain and former Spanish colonies in the Americas for irrigation. Acequias are usually historically engineered canals that carry river water to distant fields.

La Nueva Cultura del Agua

New Culture of Water is a social movement that emerged in the mid-1990s. It promotes a change in water management policy in favour of more rational and sustainable actions. Members are professionals from various fields (business, academic, cultural, social, etc.).

Audiencia Nacional (National Court)

A special and exceptional high court in Spain.

Solidari@s con Itoiz collective

Collective born to cover a battle front of direct, public and non-violent action, within a strategy of civil disobedience in defense of land.