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EL FUTURO DE LA ALIMENTACIÓN Y RETOS DE LA AGRICULTURA PARA EL SIGLO XXI:

Debates sobre quién, cómo y con qué implicaciones sociales, económicas y ecológicas alimentará el mundo.

THE FUTURE OF FOOD AND CHALLENGES FOR AGRICULTURE IN THE 21st CENTURY:

Debates about who, how and with what social, economic and ecological implications we will feed the world.

ELIKADURAREN ETORKIZUNA ETA NEKAZARITZAREN ERRONKAK XXI. MENDERAKO:

Mundua nork, nola eta zer-nolako inplikazio sozial, ekonomiko eta ekologikorekin elikatuko duen izango da eztabaidagaia

More able to adapt but more sensitive: Modern irrigation role on social vulnerability to global change in rural Navarre

Amaia Albizua, Esteve Corbera and Unai Pascual

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Navigating spaces between the stomach and the purse: food securing, gender, and agricultural commercialization in northern Mozambique

Amaia Albizua, Esteve Corbera and Unai Pascual

Abstract

Although some literature argue that modern irrigation in Spain has increased water-use and energy efficiency, there is still no conclusion about irrigation role to improve vulnerability. In this paper, we explore if the adoption of modern irrigation in *Itoiz-Canal de Navarra* case study, in the Basque Country, north of Spain, increases or decreases farmers and landowners' vulnerability to multiple stress and shocks –i.e. (1) climate variability and drought and (2) crop price volatility. Based on the development of a vulnerability index, which in turn relies on a livelihood analysis and it is also informed by additional data collected through interviews and focus groups we find that vulnerability differs among different groups of farmers holding uneven livelihoods: a) *small-scale diversified* farmers are doubly vulnerable to climate variability and crop prices volatility; b) *small-scale diversified* farmers' adaptive capacity is much lower than the rest of farmers groups' but their sensitivity is lower than those *intensive* groups adopting modern irrigation and c) whereas some livelihoods degrade when modern irrigation is introduced, others improve their situation leading to a mal-adaptation situation.

Keywords: social vulnerability; modern irrigation; global change; sensitivity; adaptive capacity and exposure

Introduction

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). 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., 2003; Vincent, 2004). In this paper, vulnerability, is multi-dimensional and it is related to securing wellbeing (Shameem et al., 2014). This is, wellbeing requires 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).

We adopt a political ecology perspective which 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) (Vincent, 2004). 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). Therefore, 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., 2003; 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), we assume 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. This work aligns with Adger et al., (2003) who consider that understanding the current state of the agrarian social-ecological system 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).

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., 2012). 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 behaviour. 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.

Finally, the capacity of the households to access and put their assets into action will determine their ability to adapt, anticipate or react (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).

According to the Fifth Assessment Report of Intergovernmental Panel on Climate Change (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. Irrigation is often presented as an adaptation tool (Maleksaeidi et al., 2016; Varela-Ortega et al., 2016). However, there is no consensus in the literature over the efficiency of modern irrigation (Berbel and Mateos, 2014; 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 paper, we 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).

In this context, we 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 we also hypothesise that modern irrigation installation might instead lead farmers to mal-adaptation – i.e. when a short term response inadvertently leads to an increase in future vulnerability.

Methods

Study area

Our case study of *Itoiz-Canal de Navarra*, is located in the Ebro watershed, in *Zona Media* and *Ribera Alta* of Navarre, a northern region of Spain. This area entails the construction of a dam for modern irrigation as the main use of the stored water. Modern irrigation in this case, involves a number of differences on land management that leads to a more intensively managed and homogeneous landscape. For instance the cultivated land area is expanded due to the execution of *concentración de tierras* –i.e. lands concentration -, which is normally a requisite. Moreover, most of the farmers adopting modern irrigation, use sprinkler irrigation system that implies higher amounts of fertilizers and pesticides.
Itoiz-Canal de Navarra modern irrigation project has been quite controversial since its origins and it has faced the opposition of certain groups of farmers due to the loss of their traditional irrigation rights, environmental impacts of the project and other cultural related concerns whereas other groups of farmers have supported such technological transformation under the idea of increased yields and farms profitability.

This paper is based on Albizua (2106) classification of livelihoods, which founded upon the Sustainable Livelihoods Approach (SLA) discloses the existence of four main types of farmers in *Itoiz-Canal de Navarra* case study, each with dissimilar livelihoods regarding the way they manage land and mobilize assets, including irrigation water and technology. Those livelihoods are: *small-scale diversified*, *medium-scale rainfed organic* and two differentiated degrees of intensive farmers, namely *medium-scale intensive* and *large-scale intensive* farmer (for further information about the site, project characteristics and the distinction of the four groups of farmers holding uneven rural livelihoods see Albizua (2106)). This paper assesses vulnerability differences among such farmers holding uneven livelihoods.

Field methods

The research adopts a case study approach and utilises a combination of qualitative and quantitative methods. Semi-structured interviewing allows to involve a range of individuals and organisations within the research process, and obtaining information related to survey design and contextual factors relevant to interpreting the results. Semi-structured interviews are complemented by a household survey used to triangulate some of the qualitative findings with quantitative data, through the elaboration of a vulnerability index of randomly selected farmers. Focus groups discussions are also used to gather information about which are the key factors influencing farmers' vulnerability and adaptive capacity. Document analysis is also developed, in both policy and project contexts, and participant observation at the community level.

Table 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 (95% of confidence level)	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

The vulnerability index (VI thereafter) calculation is the core tool for the analysis and it is used to assess vulnerability differences among the farmers' groups. VI has been derived based mainly on the quantitative household survey information and on other elements of Table 1 and following the approach of Hahn et al (2009). Each of the three vulnerability components (exposure, sensitivity and adaptive capacity) has a set of components (level 3 in Figures 1 and 2 and sub-components (level 4 in Figures 1 and 2) that bring together the analytical variables corresponding with the five types of capitals and other socio-demographic variables (extracted from the survey performed to farmers in the area).

To analyse exposure to climate variability and drought, climatic station data were use. 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. Sensitivity and adaptive capacity analytical variables are extracted from the survey and differ depending on whether those are used to vulnerability to market prices stressors or climate related stressors.

Figure 1. Categorisation of analytical variables, components and contributing factors from the IPCC vulnerability definition for climate connected stressors and shocks

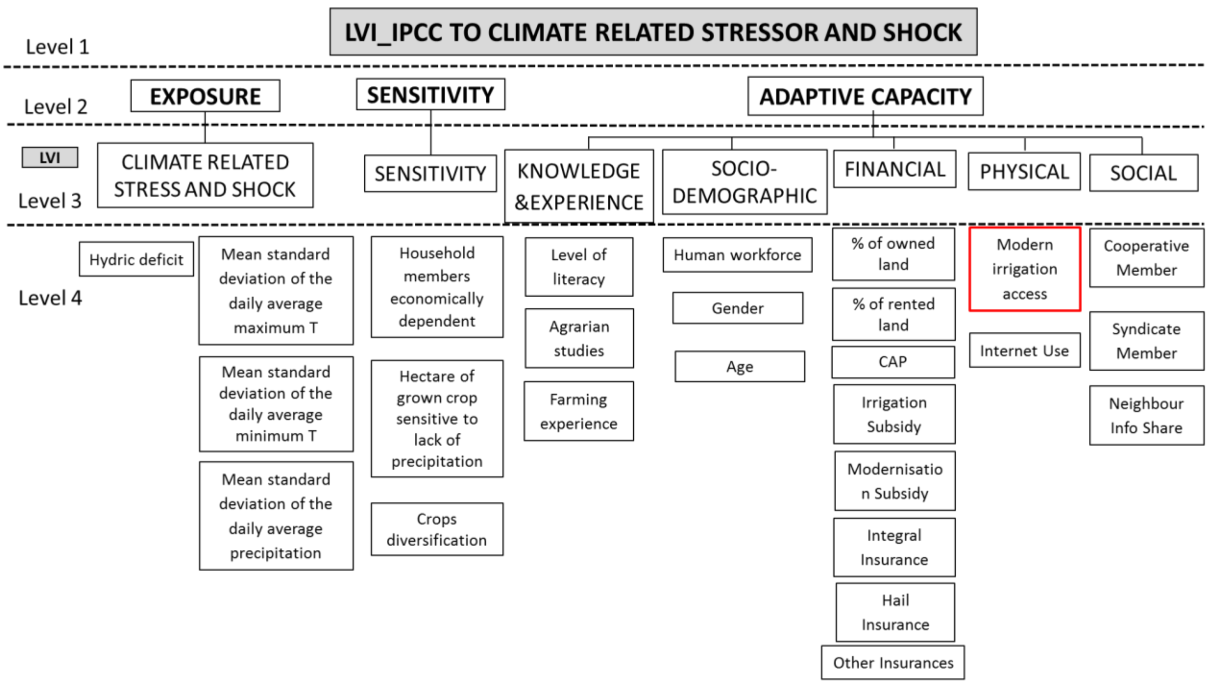
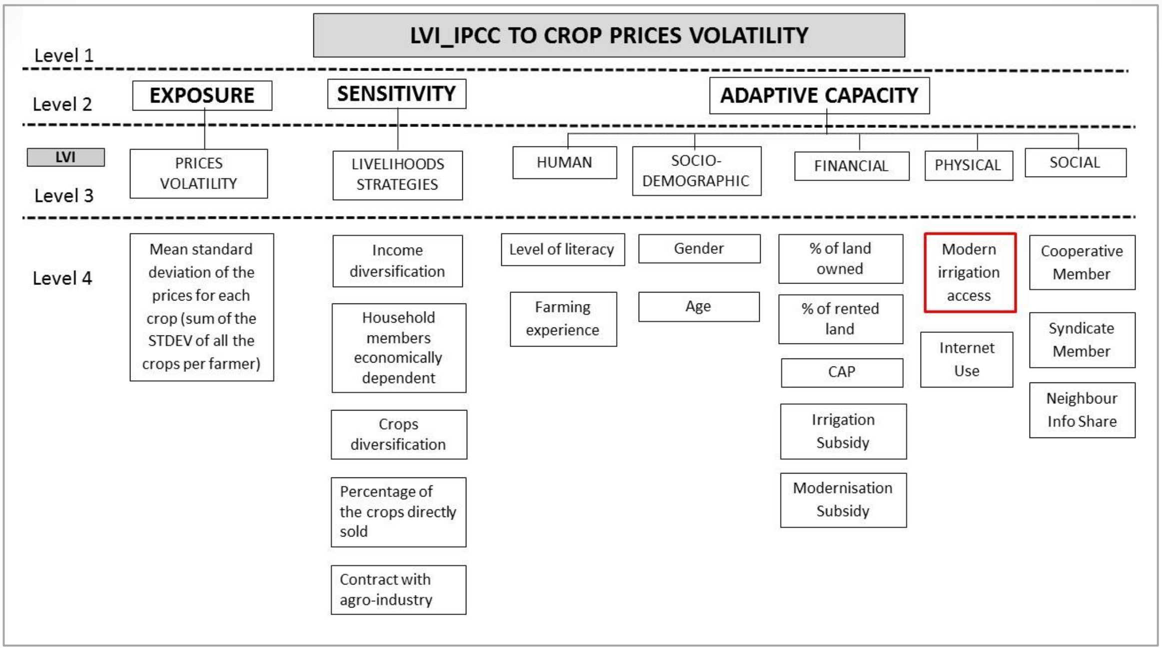


Figure 2 Categorisation of analytical variables, components and contributing factors from the IPCC vulnerability definition for crop prices connected stressors



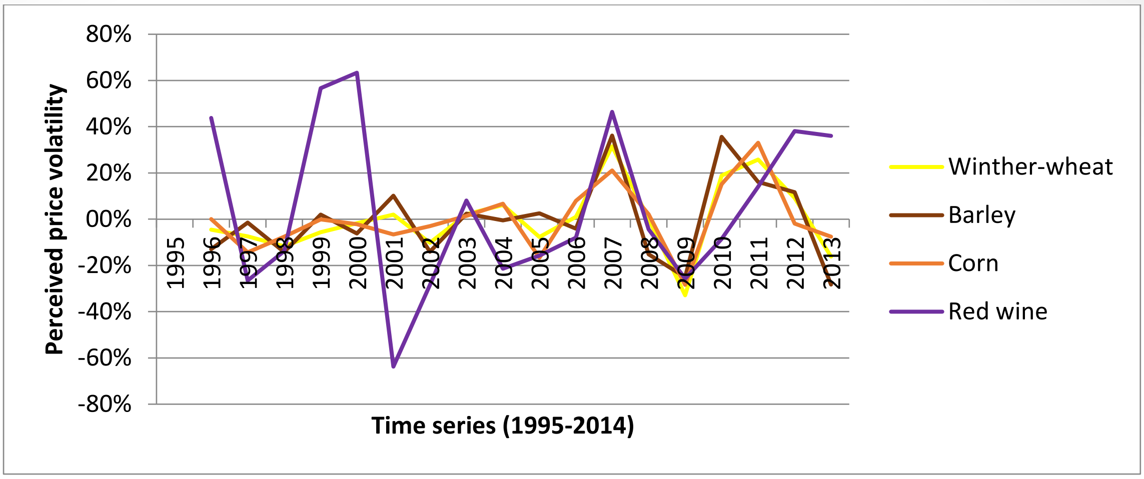
Results

During the first round of interviews (see Appendix I), farmers reported drought and their lack of control over crops' selling price as key risks to their livelihoods (for similar findings see (Campos, et al., 2014; Eakin, 2005; Hahn et al., 2009; Isakson, 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.

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 3 illustrates the volatility of the affected crops.

Figure 3 Price volatility for the period (1995-2014) by farmers in Navarre



Measuring vulnerability

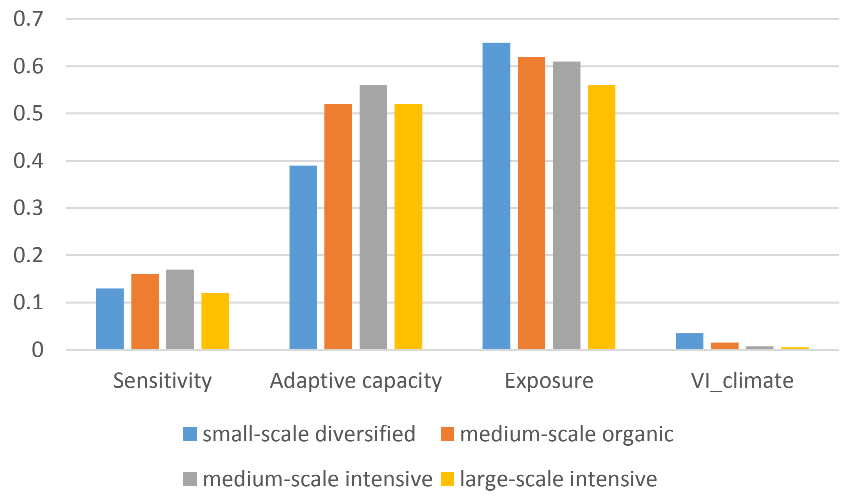
Exposure to price volatility was determined by the number of crops farmers grow in the study area, the cultivated land area, as well as crops' price volatility from previous years. Sensitivity[1] encompasses three analytical variables that differ to those used when referring to vulnerability to market 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 1 and Figure 2. Such components are selected based on literature review and availability in the survey. For more detailed of the calculation see Appendix 4.

Vulnerability to climate variability and to price volatility

This section calculates the VI to analyse farmers' vulnerability to climate variability and drought. As expected, this stress and this shock affect the case study farmers differently (Figure 4). Index values should be interpreted as relative values to be considered within the study sample only.

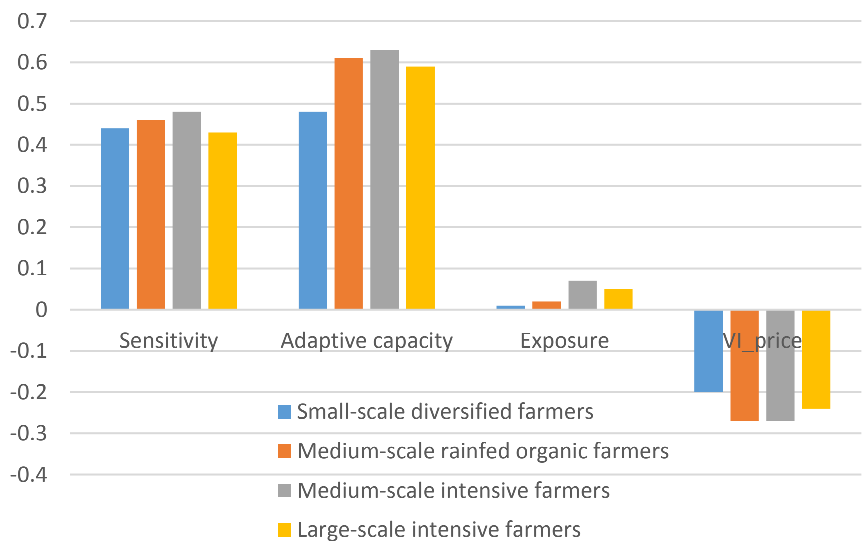
[1] The word 'sensitivity' is used twice at level 3 and level 2 (see Figure 1).

Figure 4. Vulnerability to climate stressors. 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.



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.

Figure 5. Vulnerability to crop prices volatility stressors. It illustrates the three dimensions of vulnerability when farmers are exposed to the volatility of crop prices. 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.



Small-scale diversified farmer is the most vulnerable group to both climatic factors and crops' price volatility. *Organic* farmers are the second most vulnerable group to climate variability, but are not particularly vulnerable to prices volatility. *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. An interesting finding is that the most vulnerable groups are the least sensitive but their low adaptive capacity makes them vulnerable.

To identify and understand the causes of the vulnerability we disaggregated the vulnerability index. Figure 6 identifies the contribution of each dimension of vulnerability (detailed in Figure 1) to the Vulnerability Index, when considering climate related stressors. A similar figure is obtained when assessing vulnerability to crop prices volatility (see Figure 7).

Figure 6 Vulnerability radar diagram for the four types of farmer groups when exposed to climate variability

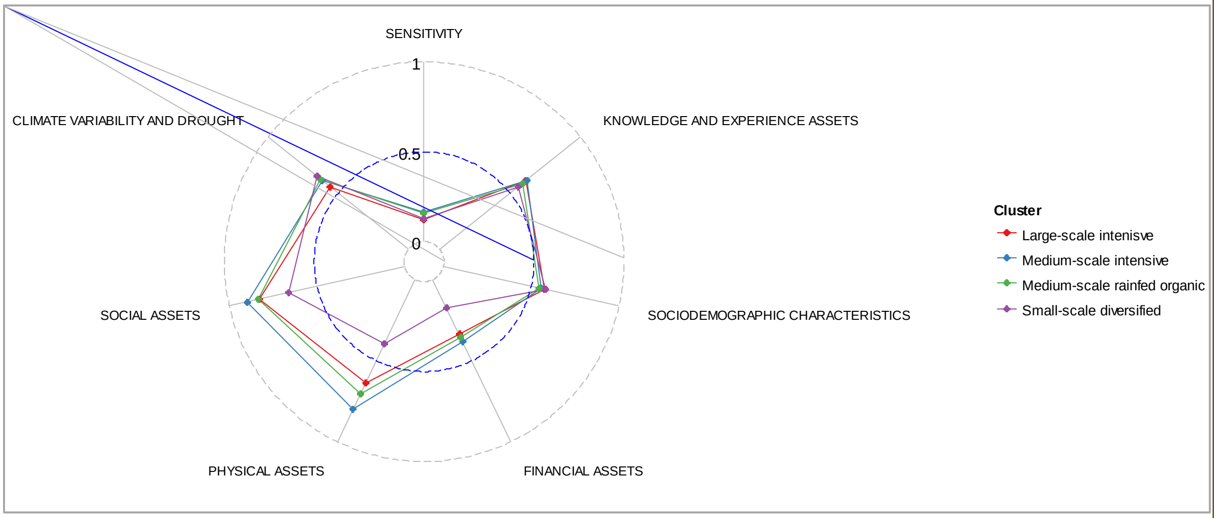
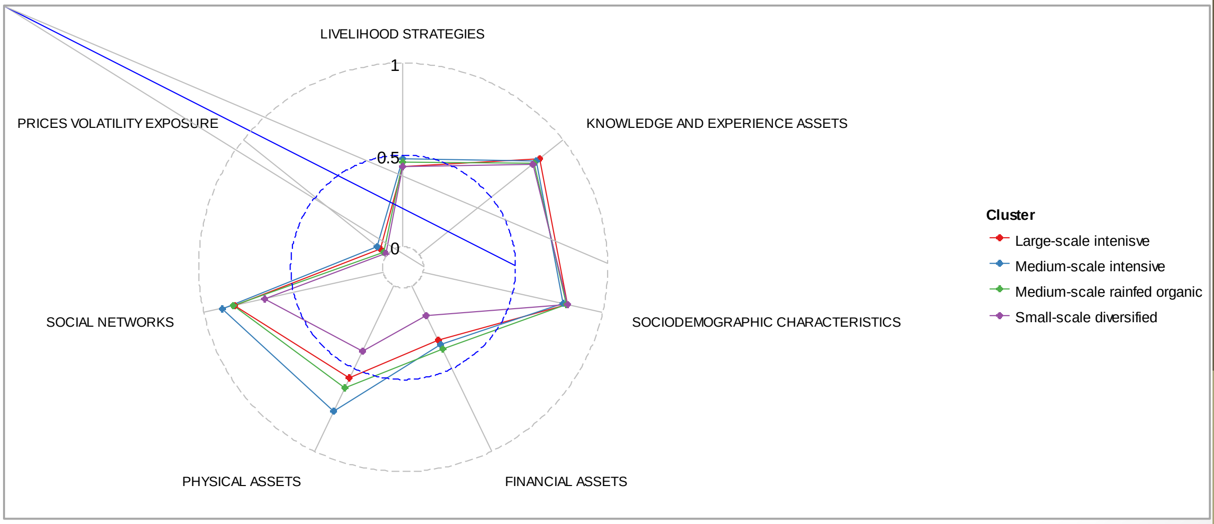


Figure 7 Vulnerability diagram of the major components for the four types of livelihoods when exposed to crop price volatility



These diagrams permits us understanding that the reasons of such low adaptive capacity of *small-scale diversified* farmers is their lack of access to technology, social networks and financial assets such as subsidies, insurances and credit.

Discussion

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 the interviews, focus groups and participatory observations). Contrary to what has been shown in other research (Eakin, 2005), small-landholders of this case study region have presented lack of interest in adopting modern irrigation as a means to enter markets and diversify into increased-value, higher-yielding crops.

Additionally, and contrary to our 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[2] 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.

These results are aligned with Plieninger and Bieling (2013) outcomes, who report on how many "high-nature-value" (HNV) farmlands have vanished, while remaining ones are vulnerable to socioeconomic changes. HNV farmland is defined as "those areas in Europe where agriculture supports or is associated with either a high species and habitat diversity or the presence of species of European conservation concern or both." Comparatively, *small-scale diversified* farmers hold the most

[2] 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.

diverse mosaic of crops (adhering almonds and olive trees, small home garden of vegetables). Normally, there are steep banks between their plots for separation that attract diverse wild plant and animal species including pollinators and pest regulator insects. As Plieninger and Bieling (2013) expound, conservation efforts for HNV farmland have focused too much on static, isolated, and mono-sectoral conservation strategies. Further, they have emphasised on resilience and adaptation, which are essential strategies for guiding HNV farmland through rapid economic and social change.

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. Moreover*, intensive* farmers low vulnerability does not mean high resilience in the long-term since as the disaggregate index shows, their current low vulnerability is due to their access to financial assets and social networks, being both promoted by existing institutions favouring farming intensification. In case this support failed, such proxies would also score lower and their relative vulnerability would change.

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.

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 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., 2004a). 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[3]) 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.

We 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 adapting or discarding modern irrigation. Although we obtained some information through the survey, we were unable to include it in the VI calculation due to their incomparability feature. Such information was so subjective that we 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.

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., 2004b; Vincent, 2004). Consequently, the study might be blind to longer-term evolutions of social, political and environmental factors.

Conclusion

The findings in this paper 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

[3] 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>).

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.). Being this technology and its related management and required assets strongly supported by existing institutions suggests that vulnerability and resilience studies should be integrated to discern short and long term conclusions since such institutional support is key for the high scores of social, technological and financial proxies compositing the VI.

This work has also revealed 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). However other key influencing factors cannot be included in such index and for this reason we recommend to complement indexes with other qualitative research tools such as interviews, focus groups etc.

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Nazioarteko Hizketaldia

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Mundua nork, nola eta zer-nolako inplikazio sozial, ekonomiko eta ekologikorekin elikatuko duen izango da eztabaidagaia

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EL FUTURO DE LA ALIMENTACIÓN Y RETOS DE LA AGRICULTURA PARA EL SIGLO XXI:

Debates sobre quién, cómo y con qué implicaciones sociales, económicas y ecológicas alimentará el mundo.

24 / 26 de Abril, 2017. Palacio de Congresos Europa. Vitoria-Gasteiz. Álava. País Vasco. Europa.

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