Vulnerability of Andalusia, Spain, to Global Change: A view towards 2050

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Table of contents

Introduction

Human activities have become a driving force of global changes. Changes in climate, biodiversity, and land use, coupled with rapid changes in social and economic systems, may lead to vast transformations of the human-environment system in the first half of the twenty-first century. However, global changes are manifested differently in local places as they are filtered through varying local conditions. Vulnerability assessments represent a useful tool to explore how future trends may impact the human-environment system. This can be achieved with a combination of qualitative and quantitative analysis to incorporate important factors for a region of interest (Luers et al., 2003; Turner et al., 2003). In this report, we present a vulnerability assessment for the Spanish region of Andalusia.

Characteristics of Andalusia

Andalusia is one of 17 autonomous regions in Spain, stretching along the Mediterranean Sea in southern Spain. Home to 7.5 million residents (approximately 18% of the national population), the region is well-known to the world for its sunny beaches and the vibrant culture of the cities of Sevilla, Córdoba and Granada. Andalusia is characterized by the varied topography of the Sierra Nevada mountain range, the fertile valley of the Guadalquivir River, Europe's only true desert near Almería, and numerous protected areas (Inman et al., 2004).

Historically, Spain was a powerful world empire in the 16th and 17th centuries, then fell behind to other European countries by failing to adapt to the mercantile and industrial revolutions (CIA, 2003). In modern times, Spain has been playing a catch-up role within Europe in modernization and economic development. The country passed from a developing to developed country in 1963, when per capita income reached $500 per year, and Spain joined the EU in 1986 (Andalucia.com, 2005a). Andalusia is a relatively poor region within Spain, with an average income 75% of the national income, and contributes approximately 13.5% of Spain's GDP (1casa.com, 2005). Employment and revenues in Andalusia are largely driven by the service sector, including tourism, trade, finance, and insurance.

Tourism is the true motor of Andalusia's economy and the principal generator of employment. About 20 million tourists visited Andalusia in 2001 for its mild Mediterranean climate, and more than 220,000 people are directly employed in the tourism sector. Almost half of the tourists go to the Costa del Sol, while only five percent cite nature as their main incentive for coming (Andalucia.com, 2005b). Tourists are the main consumers of water; an average tourist uses 200 litres per day, while luxury hotels provide 600 litres of water per capita per night (Moreno, 2005).

Agriculture also retains an important role in Andalusia both in terms of cultural importance and its relatively high contribution to GDP compared with the contribution of the primary sector at the national level (1casa.com, 2005). Agricultural production in Spain contributes 12.1% to the EU total production (behind France, Germany and Italy). Approximately 30% of the national territory is farmed or used for pastures (Figure 1). From this land, 67% of Andalusia is used for agricultural purposes, 13% of which are grassland and 54% are arable land. Spain is the world's largest producer of olive oil (Andalucia.com, 2005a), and 12.4% of the total area in Andalusia is olive farming. Non-irrigated farming area covers 22% of the total land area (European Commission, 1993). Durum is the most cultivated cereal; orchards and sunflowers are also important. The agricultural system around Almería is characterized by high intensive vegetable farming using plastic coverage and high amounts of fertilizer and plant protection products (PPP). Irrigated arable land has nearly doubled in the past two decades (6% of the total area). The current use of crop species is strongly affected by the Common Agricultural Policy and not very well adapted to the site specific conditions (soil, water, climate). Thus, the sustainability of this agricultural system is questionable (Tudela et al., 2005).

Agrosilvopastoralism has a long-term history in the Iberian Peninsula and consists of trees, crops, and pasture for sheep, goat, and cattle (also known as a transhumance network). The Andalusian transhumance network covers over 30,000 km and is one of the most complex and extensive in Spain (Ortiz Borrego, 2004). The transhumance practice is managed under the Recovery and Organization for Drove Roads Act not only for its value to livestock herding but also for its biodiversity value and function as habitat corridors for birds and other animals. One of the two main summer pasture areas is located in the Sierra Nevada at altitudes of more than 3,000 m for over 22,000 sheep (Gomez Sal and Lorente, 2004).

Protected areas (PAs) in Spain are mainly established by the State Law 4/89 for the Preservation of the Natural Areas and by the rules of each Autonomous Region (Ministerio de Medio Ambiente, 2004). Of the more than 700 PAs nationwide, 153 are in Andalusia. The establishment of PAs represents one of the most important steps towards the achievement of the Convention on Biological Diversity's 2010 target and the Millenium Development Goals (Faith, 2005). Additionally, they may provide direct benefit for local people, e.g., by creating job opportunities in ecotourism.

The most recent available figure for GDP per capita is 18882.61 US$ in 2002 (National Competitiveness Council, 2005), and income distribution inequity (the ratio of the top 20% to the bottom 20% of income) is 5.6 (NewCronos Eurostat, 2004). Similarly to the rest of Spain, Andalusia suffers from an outdated bureaucracy with poor record-keeping (making data analysis difficult) and a poor health care warning system (Díaz et al., 2005). Although the social services system has been reduced in recent decades due to budget deficits (Andalucia.com, 2005a). Andalusia benefits from modern, comprehensive transport infrastructure linking cities with roads and high-speed rail, and includes a number of airports and seaports (1casa.com, 2005).

Methods

The vulnerability assessment included the following five major sectors of Andalusia: agriculture, agrosilvopastoralism, public health, nature conservation, and tourism. Within the agriculture system we focused on four major stakeholder groups: olive growers, farmers of non-irrigated croplands, irrigated croplands, and intensive vegetable farming. The agrosilvopastoral system involves mainly transhumance herders and the regional land management association, this latter one including the hunters as well (both commercial and self-consumed) in the management of agrosilvopastoral systems of the Iberian Peninsula (Campos-Palacin, 2004). The public health system is represented by the public health administration. In the nature conservation sector, protected area management (PAM) associations and non-governmental organizations (NGOs) represent one stakeholder group, and employees in the ecotourism industry represent another stakeholder group. Finally, tourists and tour operators are the two major stakeholders representing the tourism sector. All stakeholders are using certain ecosystem functions (landscape functions; and their goods and services) or strongly depend on them respectively. Appendix 2 contains the landscape functions (after Bastian and Steinhardt, 2002), which are relevant for our stakeholder groups.

The vulnerability assessment for each stakeholder group and the associated components of the system was partially framed in the eight-step process adapted from Schröter et al. (in press). We were also inspired by the DPSIR (Driving forces, Pressures, State, Impact, and Responses) framework used by the OECD. We developed a conceptual model including four main driving forces of future changes in Andalusia: climate change, population dynamics, behavior and lifestyle changes, and policy changes. Then we developed a list of twelve key pressures in the region: temperature, precipitation, water availability, pollution, fire, erosion, invasive species, social services, urbanization, land abandonment, tourism, and subsidies. (Changes in consumer demands were initially proposed, but results are not reported here as we did not find significant vulnerabilities to this pressure). We recognize that these twelve pressures are not independent, but we selected them to include a range of mechanisms for future responses to global change.

The assessment was conducted for each stakeholder group under two scenarios of global change adapted from the IPCC SRES report (Nakicenovic et al., 2000). Namely, we considered the vulnerability of Andalusian systems under scenarios A1 (rapid economic and technological growth; economic and cultural convergence and capacity building; and less emphasis on environmental quality) and B2 (local economic, social, and environmental sustainability; diverse technological change; and social innovation at the local level). Quantitative information was available (ATEAM land use and climate database) for the following pressures in Andalusia: land abandonment up to 40% under scenario A1 (50% by 2080 projected by Rounsvell et al., 2005) and up to 20% under scenario B2, summer temperature increases of about 2°C to 5°C for both A1 and B2. The other pressures under scenarios A1 and B2 were qualitatively downscaled to the Andalusia region using knowledge of the region and projected changes gained from the literature, discussion with experts, and group discussion to come to a consensus on the direction and relative magnitude of expected changes.

Our vulnerability assessment considers the changes in availability of ecosystem goods and services caused by the different driving forces and their pressures as buffered by the adaptive capacity of the stakeholders under the conditions of Andalusia. We followed the vulnerability framework described in Figure 2, where we assessed for each stakeholder and each pressure the exposure and sensitivity (which combine to form potential impact). Potential impact may be counteracted by the adaptive capacity (including new technologies and management practices), which is a function of awareness, ability and action (Metzger, 2005). In this investigation, only likely adaptation possibilities are considered.

The exposure of stakeholder groups to A1 and B2 scenario changes was assessed on a binary scale—"yes" (exposed) and "no" (non-exposed). Sensitivity was ranked on a five-point scale in terms of potential impact ranging from very negative to very positive potential impact. Finally, vulnerability was assessed as a function of potential impact (resulting from sensitivity) and adaptive capacity (ranging from not adaptable through moderately to highly adaptable) and the outcome of the assessment was categorized as very vulnerable (double minus), vulnerable (minus), and not vulnerable (equal or greater than 0). While we did not have enough data or resources to fully quantify and weight vulnerabilities between stakeholders or pressures, we report the result of our analysis quantitatively, with the caveat that the vulnerability numbers should be interpreted with caution.

Results and Discussion

Overall

Our results for the assessment of the impact of pressures under the A1 and B2 scenarios are presented in Table 1, separated by season where applicable. In Appendix 3, we show regional changes in temperature, precipitation, and land use, while in Appendix 4 we present vulnerability assessments for each stakeholder under each scenario, with Appendix 5 showing a comparison between stakeholders in the nature conservation sector. We estimated the impacts of climate changes and pollution would be greater under A1 due to increased economic development with less focus on environmental protection. Land abandonment was projected to increase significantly under A1 as local farms are abandoned, and to remain stable under B2 due to support for regional agriculture. Fire is projected to increase more in the summer than winter for both scenarios, but to increase more under A1 due to increases in temperatures, drought conditions, and land abandonment. Urbanization increases under A1 as populations increase and cities sprawl in the absence of strong centralized planning, while B2 sees a more stable population and more planned cities which do not expand much past their current boundaries. Both tourism pressure and invasive species increase under A1 with a globally mobile, highly interconnected population, while they decrease under B2 as citizens stay closer to home and policies protect regions from invasive species.

Subsidies decrease substantially under the highly privatized A1 world, while they increase substantially under the protectionist B2 world. Finally, erosion is projected to increase equally under A1 and B2, because the increase in climate-influenced erosion in A1 is balanced by the decreased area under cultivation.

Under the A1 scenario, the most vulnerable stakeholders (based on total vulnerabilities to all pressures to which they were exposed and sensitive) were farmers in non-irrigated agriculture (with a vulnerability score of -13), protected area managers (-11), and herders (-10) (Figure 3). The pressures causing the greatest vulnerabilities across stakeholders were changes in water availability (-11), and increases in temperature, land abandonment, and fire frequency (all -10) (Figure 4). The total vulnerability score for all stakeholders under all relevant pressures was -92 (Appendix 6a).

Under the B2 scenario, overall vulnerabilities were significantly reduced. The most vulnerable stakeholders were still non-irrigated farmers, but their vulnerability was decreased to -4, a score also shared by protected area managers and ecotourism employees. Tour operators (-3) and herders (-2) were also slightly vulnerable under this scenario (Figure 3). The greatest pressures were fire (-6), followed by changes in temperature, precipitation and erosion (Figure 4). The total vulnerability was -21, over four times smaller than the total vulnerability under A1 (Appendix 6b). We discuss the mechanisms and explanations for potential impacts, adaptive capacities, and vulnerabilities for each sector in more detail below.

Agriculture

The vulnerablility of the agricultural sector depends very strongly on the scenarios (Oleson and Bindi, 2004; Metzger et al., 2004; Ewert et al., 2005; Rounsevell et al., 2005). Under the A1 scenario all agricultural stakeholder groups are expected to be highly vulnerable, mostly to land abondonment and the absence of subsidies; but also to changes in precipitation, water availabilty and urbanization. By contrast, under B2 conditions, only farmers with non-irrigated croplands are affected due to the increase in temperature and decrease in precipitation and available water.

We believe that olive plantations are tolerant to warm and dry conditions, thus land abandonment and changes in subsidies are the major threats for this sector. Land abandonment will mostly occur in areas with poor site conditions. Intensive vegetable farming systems are highly sensitive to precipitation, water availability and invasives, but there also is a high adaptive capacity that counteract these negative effects. Irrigated farming systems are affected by the same pressures. However, there is a lower adaptive capacity compared to intensive vegetable farming systems, which results in a moderate vulnerability. This stakeholder group is also highly vulnerable to land abandonment and changes in subsidies. The farmers of irrigated and intensive vegetable systems, especially in scenario A1, have the possibility to reduce the negative influences by different strategies; e.g., higher income allowing improved irrigation systems, application of PPP and fertilizer and new and adapted cultivars. Finally, the most vulnerable agricultural stakeholder group are the farmers with non-irrigated fields. This is due to their high sensitivity to both climatic and socio economic changes and their low adaptive capacity. These non-irrigated fields will be abandoned to a large extent.

Agrosilvopastoral Systems
Both stakeholder groups of the agrosilvopastoral (ASP) system are more vulnerable to changes under the A1 scenario (global economic world) and less vulnerable to changes under the B2 scenario (regional environmental world). Under the A1 scenario transhumance herders are most vulnerable to fire and invasive species, and less vulnerable to temperature increases, decrease of precipitation and water availability, increasing erosion and land abandonment, and decreasing subsidies. Under the B2 scenario transhumance herders are vulnerable to fire and erosion. These results are consistent with the findings of Coelho et al. (2004). Historically, transhumance herders have demonstrated a relatively high adaptive capacity, particularly to changes such as expanding urban areas, decreasing subsidies, and land abandonment (Campos-Palacin, 2004). Under the A1 scenario, the Land Management Associations, including herders (Campos-Palacin, 2004), are vulnerable to fire, erosion, invasive species, urbanization, and land abandonment. Under scenario B2 this stakeholder group is vulnerable to fire and erosion. The results are consistent with the general trend of land degradation (erosion), decreasing quantity and increasing irregularity of precipitation, and high fire potential that are characteristic for the Iberian Peninsula. This is related to the greater emphasis on the environment under the B2 scenario.

Health
Public health in Andalusia is potentially vulnerable to future changes in climate, which could result in more frequent and more intense climatic events like storms, flooding, and heat waves (Díaz et al., 2005). Climate changes could also result in reduced water for meeting drinking water and sanitary needs and for supplying adequate food for public nutrition. Under the A1 scenario, the more intense climate effects coupled with reduced adaptive capacity result in high vulnerability, while the lower climate impacts and enhanced adaptive capacity (as represented by social services) under the B2 scenario make the region not vulnerable to these changes. Increased pollution under the A1 scenario results in high public health vulnerability, while the efficiency policies followed under B2 coupled with protective social services renders society resilient to these changes. The expansion of invasive species under a globalized world in A1, including range expansion in disease vectors, results in high vulnerability to new diseases (Moreno, 2005) while this pressure is reduced under the B2 scenario. Finally, increased population densities and greater urbanization in the A1 scenario provides a high potential for the spread of disease, while stable, well-planned cities in the B2 scenario are not more vulnerable than today.

The assumption of relatively high adaptive capacity in the B2 scenario is derived from an increase in social services, including the availability of and access to public health resources, improved communication regarding these services, and general increases in equity and increased state involvement in protecting and ensuring the welfare of its citizens. If this assumption is not true, then overall vulnerability in the B2 scenario would be greatly increased, from zero to -4 on our overall vulnerability scale. Similarly, if adaptive capacity were increased under the A1 scenario, the overall vulnerability would be reduced from the current level of -9.

Nature Conservation

The two stakeholder groups (PAMs and NGOs, and nature tourism employees) are included in this analysis to combine the aesthetic values of ecosystem services with direct economic benefits from nature conservation. While the interests in conserving nature are rooted in very different motivations, the vulnerability assessment for both scenarios only differ in scenario A1 (-11 for PAMs and NGO's and –9 for ecotourism employees) but are identical in scenario B2 (-4 for both stakeholder groups). Under the A1 scenario, the stakeholder group of PAMs and NGOs holds the second rank in overall vulnerability assessment results. This high vulnerability is consistent with changes in biodiversity that have been calculated for the Mediterranean region applying different scenarios (Sala et al., 2000). In this scenario, PAMs and NGOs are very vulnerable to increasing temperature, decreasing precipitation, fire, and invasives. PAMs and NGOs are also vulnerable to decreasing water availability and to increasing pollution and erosion. Under scenario B2, this stakeholder group is only vulnerable to temperature, precipitation, fire, and erosion due to the higher emphasis on environmental aspects. The stakeholder group of nature tourism employees is also more vulnerable under the A1 scenario with vulnerability rank of –9 relative to –4 under the B2 scenario. Under scenario A1 ecotourism employees are most vulnerable to fire and less vulnerable to temperature, precipitation, water availability, pollution, erosion, invasives, and social services. Under scenario B2 this stakeholder group is only vulnerable to precipitation, fire, erosion, and tourism.

Tourism

The three main pressures on the tourism sector are likely to be water availability, pollution (e.g. in cities) and increases in fires. This holds for both scenarios although vulnerability is likely to be stronger under A1. For this scenario, the tourism sector will also be vulnerable to temperature and precipitation changes, land abandonment and decreases in social services. We distinguished two stakeholders groups: tourists themselves and tour operators. We decided to first assess vulnerability for tourists as their future behavior will directly impact on the vulnerability of tour operators.

We assumed that tourists would not have any adaptive capacity. A possible adaptation to change would simply be not to come to Andalusia anymore as climate would improve in their home (Northern) countries (Moreno, 2005). However, for this analysis we envisaged them as already present in Andalusia and therefore we see them as victims of climate change. We assumed that the typical A1 tourist goes to a four-star hotel in Torremolinos while the B2 tourist enjoys nature in the Sierra Nevada, but neither likes crowded places. This explains the value of the potential impact regarding tourism pressure in the two scenarios. In both scenarios, we assumed that tourists would enjoy a decrease in rainfall (who likes rain on holidays?). Finally, B2 ecotourists will be more vulnerable to fires than A1 beach tourists as fires will mainly occur in dry inland areas.

Contrary to tourists, we viewed tour operators as able to somewhat adapt to changes. This explains while their overall vulnerability is slightly lower. However, water issues are likely to strongly affect them and a decrease in precipitation is seen as a potential cause of concern. Finally, an increase in tourists (i.e. "tourism pressure") means more profit.

Conclusions

As one of the warmest, driest regions in Europe, already subject to droughts, desertification, and water shortages, Andalusia is already vulnerable to biophysical impacts. These pressures will increase under projected global changes, with pressures more severe under the A1 scenario. Andalusia's relatively low economic resources further increase its vulnerability via reductions in adaptive capacity.

We found significant differences in future vulnerability between the two scenarios, with much greater impacts from pressures and overall vulnerabilities under the A1 scenario. Under both scenarios, agriculture, nature conservation, and tourism are the most vulnerable sectors. Within agriculture, there are discrepancies between stakeholder vulnerabilities, largely based on adaptive capacity. Under the A1 scenario, the greatest pressures were changes in water availability, followed by increases in temperature, land abandonment, and fire frequency. Under the B2 scenario, the greatest pressure was fire, followed by changes in temperature, precipitation and erosion.

This type of rapid, qualitative assessment is useful in highlighting major areas of vulnerability, but could be improved by actually involving stakeholders in the process and including detailed quantitative analysis at the local level. Key areas for further research include the measurement of adaptive capacity because overall vulnerability is quite sensitive to potential adaptive capacity, which relies on complex socio-economic factors.

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Appendix 1. Tables & Figures

Figure 1. Land use categories in Andalusia.

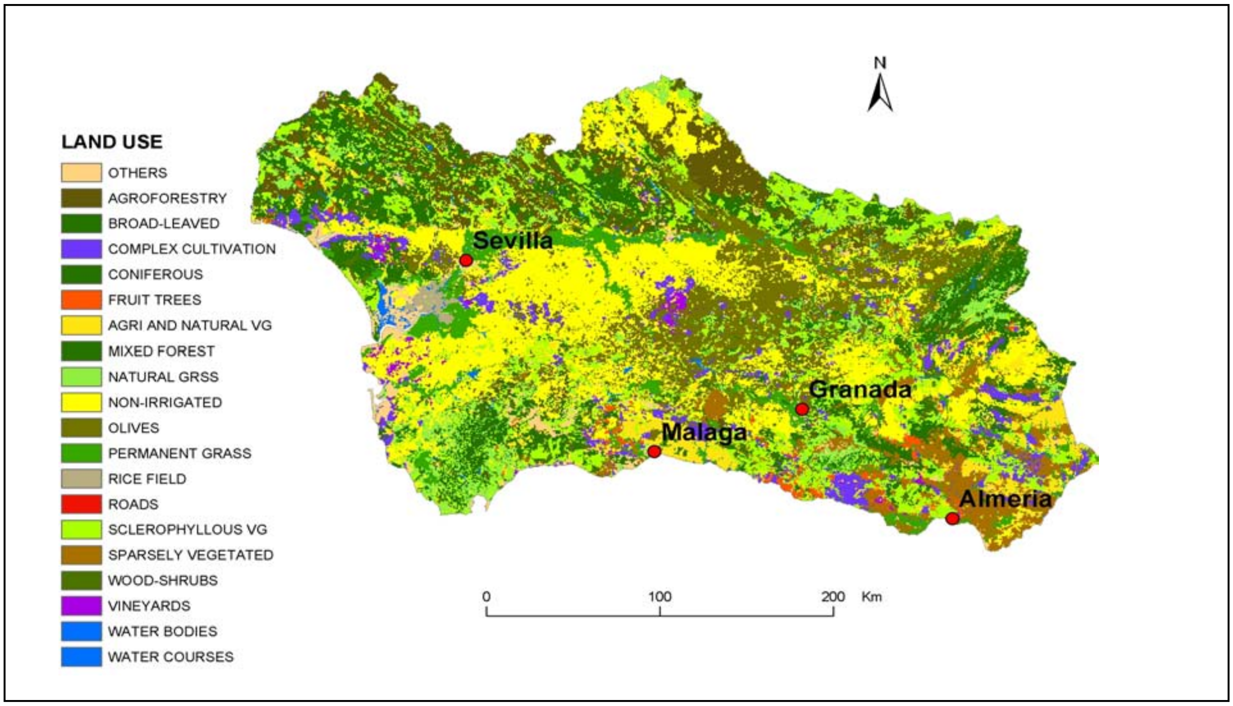


Figure 2. A “decision tree” diagram illustrating our method of vulnerability assessment.

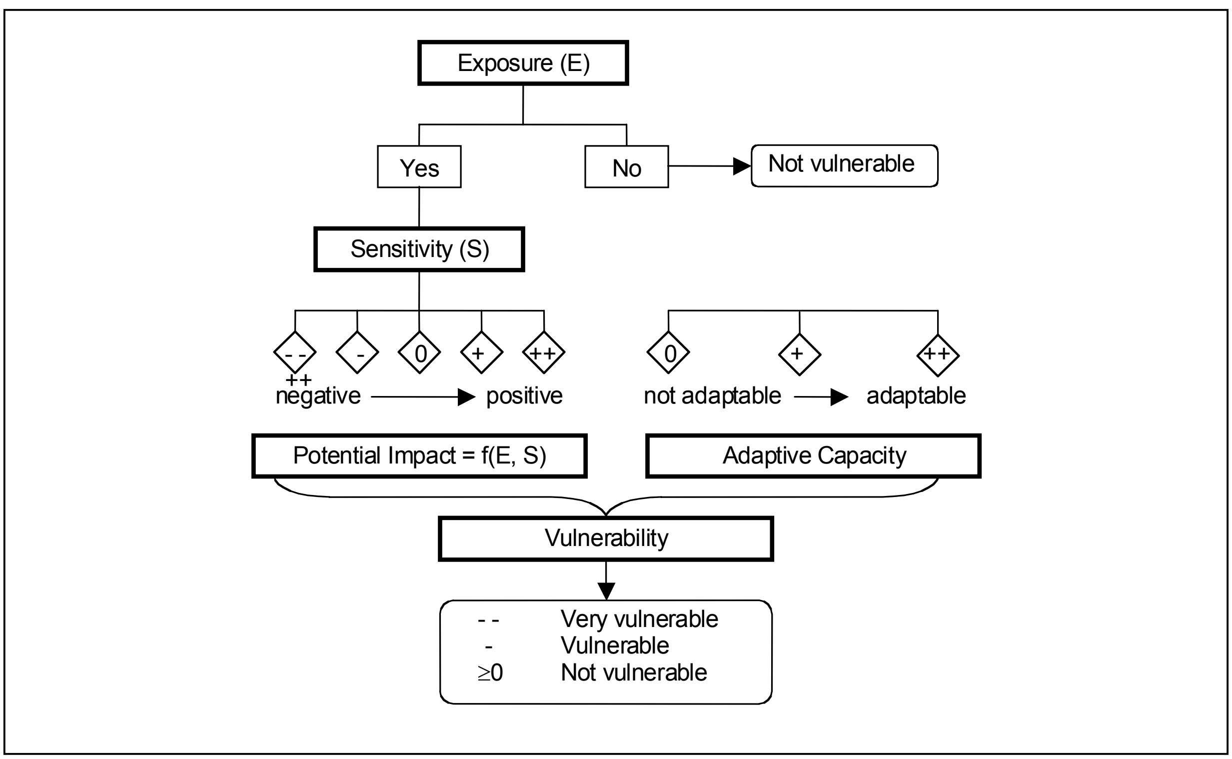


Figure 3. Overall vulnerability of each stakeholder under A1 and B2 scenarios.

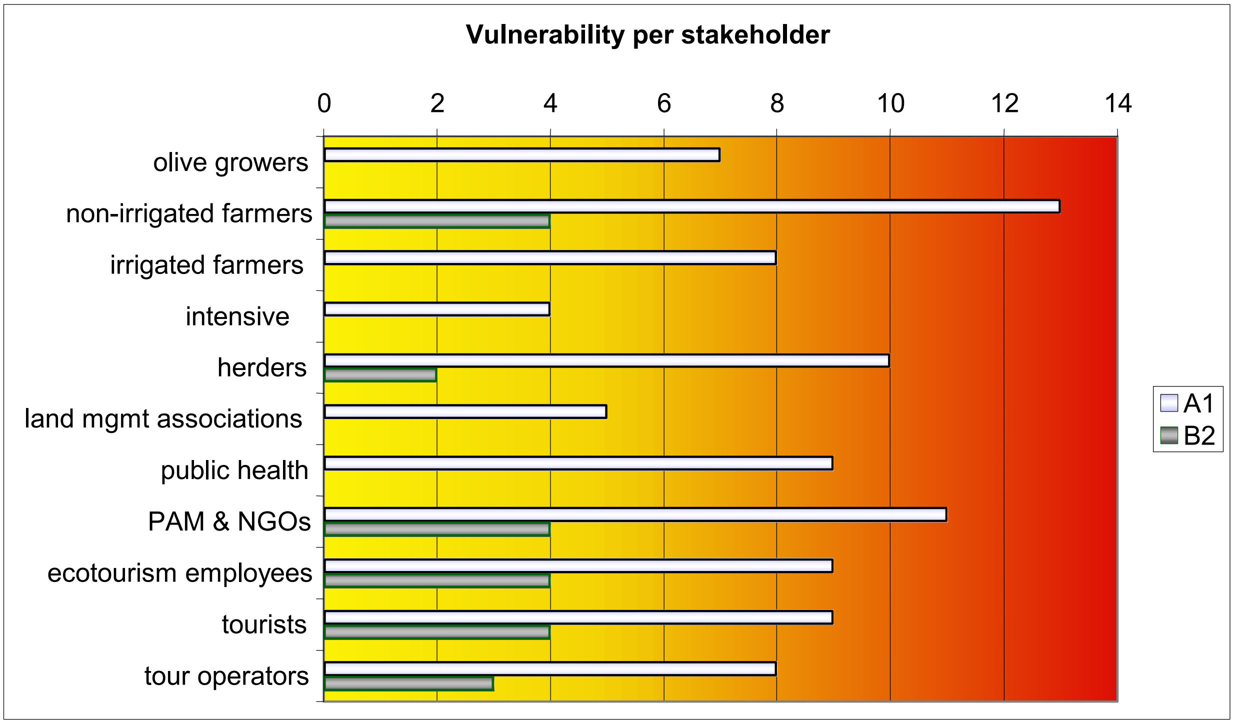


Figure 4. Overall vulnerability caused by each pressure under A1 and B2 scenarios.

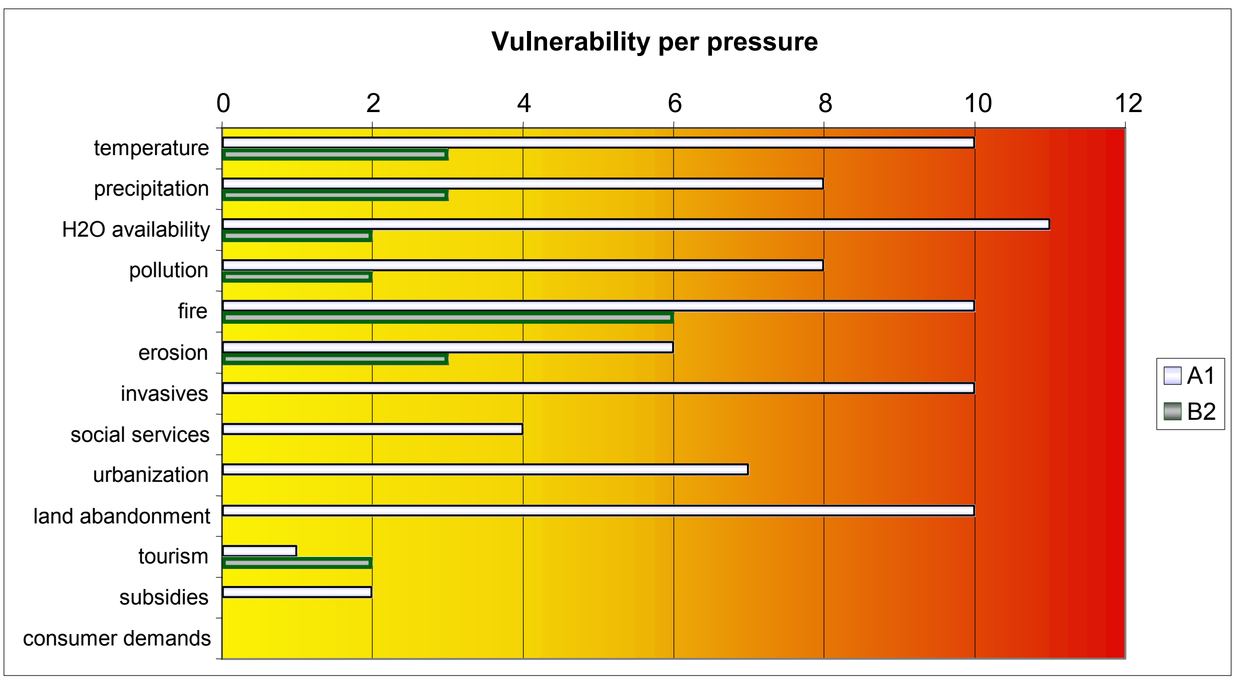


Table 1: Qualitative ranking of pressures expected under the A1 and B2 scenarios for the year 2050 in Andalusia. Positive and negative signs represent an increase or decrease compared to a current baseline state; the number of signs represents the magnitude of expected change. Zero represents no change expected from current (baseline) conditions.

	A1		**B2**	
Pressures	summer	winter	summer	winter
Temperature	++	++	+	+
Precipitation	-	--	-	-
Water availability	--		-	
Pollution	++		+	
Fire	++	+	+	0
Erosion	+		+	
Invasive species	++		-	
Social services	-		+	
Urbanization	++		0	
Land abandonmt	++		0	
Tourism pressure	+		-	
Subsidies	--		++	

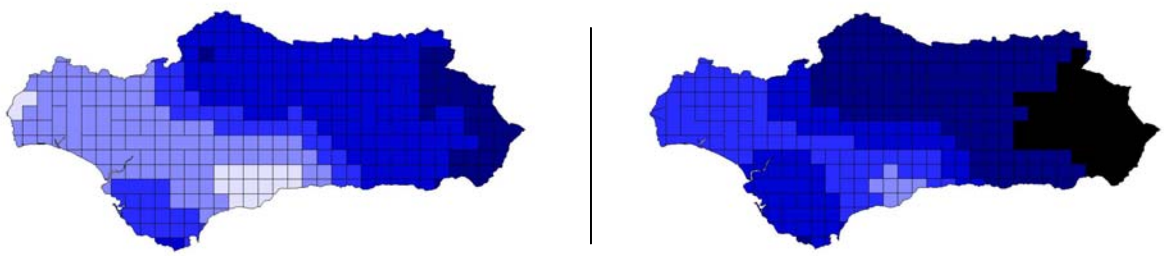
Appendix 2. Landscape functions of ecosystems

A. Productive (economic) functions **1. Availability of renewable resources** a. Production of biomass (suitability for cultivation) • Plant biomass: arable fields (husbandry), permanent grassland, special crops (fruit culture), and wood (forestry) b. Water accumulation • Surface waters • Groundwater
B. Ecological functions **1. Regulation of matter and energy circles** b. Pedological (soil) • Resistance against erosion • Resistance against drying up • Decomposition of harmful matters (filtering, buffering, and transforming functions) c. Hydrological (water) • Ground water recharge • Water storage and run-off balance d. Regulation and regeneration of populations and communities (plants and animals) • Biotic reproduction and regeneration (self-renewal and maintenance) • Regulation of organism populations (e.g. pests) • Conservation of gene pools
C. Social functions **1. Psychological functions** • Aesthetical (scenery) • Ethical (gene pools, cultural heritage) **2. Information functions** • Science and education • (Bio-)indication of environmental conditions **3. Human-ecological functions** • Recreation (psychological and human-ecological effects)

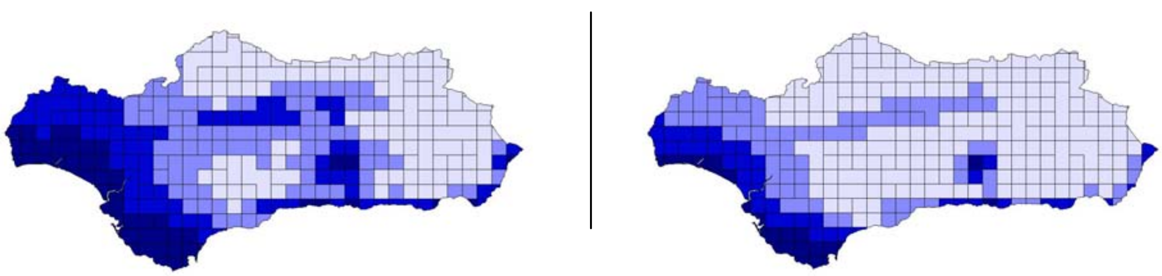
Appendix 3. Maps

Scenario A1 **Scenario B2**

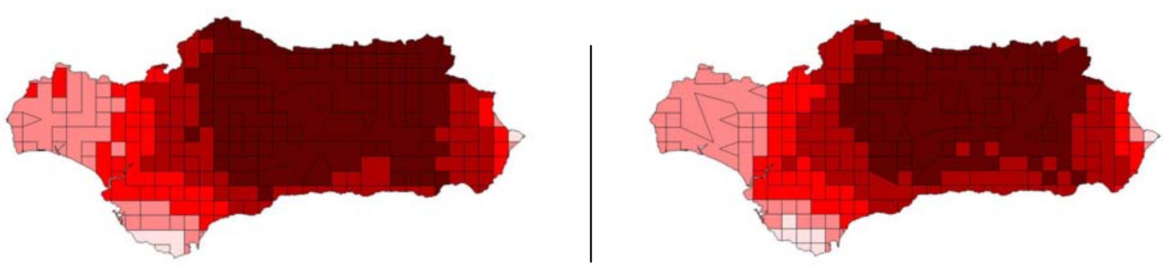
Winter (D-J-F) precipitation changes (2050 - 1990)

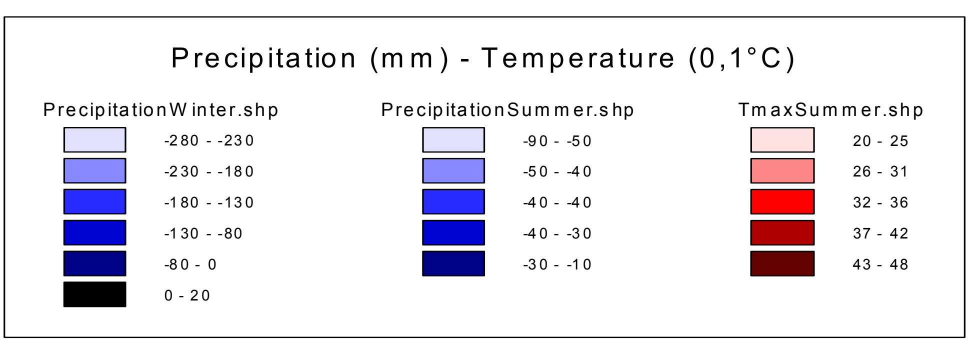


Summer (J-J-A) precipitation changes (2050 – 1990)



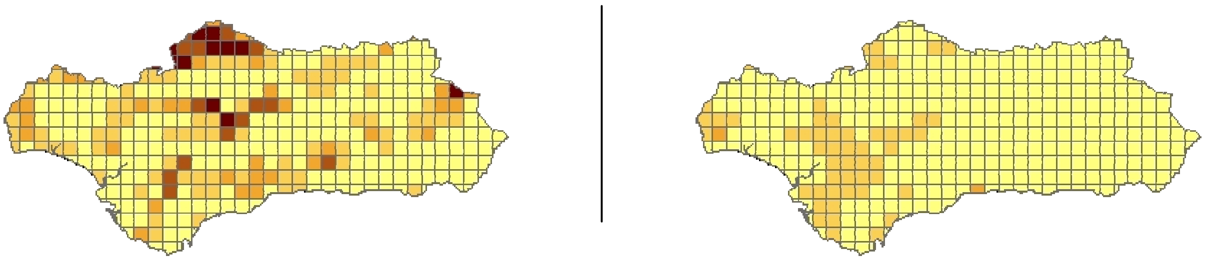
Summer (J-J-A) maximum temperature changes (2050 – 1990)



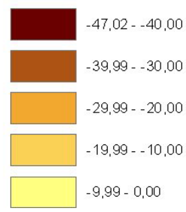


Scenario A1 **Scenario B2**

Loss of agricultural area (2050 - 1990)



Change in agricultural area (%)



Appendix 4. Vulnerability Assessment for Sectors and Stakeholders

List of Acronyms: E=Exposure, PI=Potential Impact, AC=Adaptive Capacity

Table 4A. Agriculture - Olive Growers

Pressures	A1	B2	E	PI	AC	Vulnerability	E	PI	AC	Vulnerability
Temperature	++	+	X	-	+	0	X	0	+	0
Precipitation	- -	-	X	-	+	0	X	0	+	0
Water Availability	- -	-	X	-	+	0	X	0	+	0
Pollution	++	+	X	0		0	X	0		0
Fire	++	+	X	- -	+	-	X	-	++	0
Erosion	+	+	X	- -	+	-	X	-	+	0
Invasive species	++	0	X	-	++	0	X	0	++	0
Social Services	-	+	-			0	-			0
Urbanization	++	0	X	-	0	-	X	0		0
Land Abandonmt	++	0	X	- -	0	--	X	0		0
Tourism Pressure	+	-	-			0	-			0
Subsidies	- -	++	X	- -	0	- -	X	++		0
Consumer Demands	++	0	X	+		0	X	0		0

Table 4B. Agricuture – Non-Irrigated Cropland Farmers

Pressures	A1	B2	E	PI	AC	Vulnerability	E	PI	AC	Vulnerability
Temperature	++	+	X	- -	- -	- -	X	-	- -	- -
Precipitation	- -	-	X	- -	0	- -	X	-	0	-
Water Availability	- -	-	X	- -	0	- -	X	-	0	-
Pollution	++	+	-			0	-			0
Fire	++	+	X	-	+	0	X	-	+	0
Erosion	+	+	X	- -	+	-	X	-	+	0
Invasive species	++	0	X	- -	++	0	X	-	+	0
Social Services	-	+	-			0	-			0
Urbanization	++	0	X	-	0	-	X	0		0
Land Abandonmt	++	0	X	- -	0	- -	X	0		0
Tourism Pressure	+	-	-			0	-			0
Subsidies	- -	++	X	- -	0	- -	X	+		0
Consumer Demands	++	0	X	-	++	0	X	0		0

Table 4C. Agriculture – Irrigated Cropland Farmers

Pressures	A1	B2	E	PI	AC	Vulnerability	E	PI	AC	Vulnerability
Temperature	++	+	X	+		0	X	+		0
Precipitation	- -	-	X	- -	+	-	X	-	+	0
Water Availability	- -	-	X	- -	+	-	X	-	+	0
Pollution	++	+	-			0	X			0
Fire	++	+	X	-	+	0	X	-	+	0
Erosion	+	+	X	-	+	0	X	-	+	0
Invasive species	++	0	X	- -	+	-	X	-	+	0
Social Services	-	+	-			0	-			0
Urbanization	++	0	X	-	0	-	X	0		0
Land Abandonmt	++	0	X	- -	0	- -	X	0		0
Tourism Pressure	+	-	-			0	-			0
Subsidies	- -	++	X	- -	0	- -	X	+		0
Consumer Demands	++	0	X	-	++	0	X	0		0

Table 4D. Agriculture – Intensive Vegetable Farmers

Pressures	A1	B2	E	PI	AC	Vulnerability	E	PI	AC	Vulnerability
Temperature	++	+	X	+		0	X	+		0
Precipitation	- -	-	X	- -	+	-	X	-	+	0
Water Availability	- -	-	X	- -	+	-	X	-	+	0
Pollution	++	+	-			0	-			0
Fire	++	+	-			0	-			0
Erosion	+	+	-			0	-			0
Invasive species	++	0	X	- -	++	0	X	-	- -	0
Social Services	-	+	-			0	-			0
Urbanization	++	0	X	-	0	- -	X	0		0
Land Abandonmt	++	0	-			0	-			0
Tourism Pressure	+	-	-			0	-			0
Subsidies	- -	++	X	-	0	-	X	+		0
Consumer Demands	++	0	X	+		0	X	0		0

Table 4E. Agrosilvopastoral – Transhumance Herders

Pressures	A1	B2	E	PI	AC	Vulnerability	E	PI	AC	Vulnerability
Temperature	++	+	X	- -	+	-	X	0	+	+
Precipitation	--	-	X	- -	+	-	X	0	+	+
Water Availability	--	-	X	- -	+	-	X	0	+	+
Pollution	++	+								
Fire	++	+	X	- -	0	- -	X	-	0	-
Erosion	+	+	X	-	0	-	X	-	0	-
Invasive species	++	0	X	- -	0	- -				
Social Services	-	+								
Urbanization	++	0	X	-	+	0				
Land Abandonmt	++	0	X	- -	+	-				
Tourism Pressure	+	-								
Subsidies	- -	++	X	- -	+	-	X	+ +	+	+++
Consumer Demands	++	0								

Table 4F. Agrosilvopastoral – Land Management Associations
(including herders, Campos-Palacin, 2004)

Pressures	A1	B2	E	PI	AC	Vulnerability	E	PI	AC	Vulnerability
Temperature	++	+	X	-	+	0	X	-	+	0
Precipitation	- -	-	X	-	+	0	X	-	+	0
Water Availability	- -	-	X	-	+	0	X	-	+	0
Pollution	++	+	X	-	+	0	X	-	+	0
Fire	++	+	X	- -	+	-	X	-	+	-
Erosion	+	+	X	- -	+	-	X	-	+	-
Invasive species	++	0	X	- -	+	-				
Social Services	-	+								
Urbanization	++	0	X	- -	+	-				
Land Abandonmt	++	0	X	- -	+	-				
Tourism Pressure	+	-								
Subsidies	- -	++								
Consumer Demands	++	0	X	-	+	0				

Table 4G. Public Health

Pressures	A1	B2	E	PI	AC	Vulnerability	E	PI	AC	Vulnerability
Temperature	++	+	X	- -	0	- -	X	-	+	0
Precipitation	- -	-				0				0
Water Availability	- -	-	X	-	0	-	X	-	+	0
Pollution	++	+	X	- -	0	- -	X	-	+	0
Fire	++	+				0				0
Erosion	+	+				0				0
Invasive species	++	0	X	- -	0	- -	X	0	+	0
Social Services	-	+	X	-	0	-	X	+	++	0
Urbanization	++	0	X	-	0	-	X	0		0
Land Abandonmt	++	0				0				0
Tourism Pressure	+	-				0				0
Subsidies	- -	++				0				0
Consumer Demands	++	0				0				0

Table 4H. Nature Conservation – PAMs and NGOs

Pressures	A1	B2	E	PI	AC	Vulnerability	E	PI	AC	Vulnerability
Temperature	++	+	X	- -	0	- -	X	-	0	-
Precipitation	- -	-	X	- -	0	- -	X	-	0	-
Water Availability	- -	-	X	-	0	-	X	0	0	0
Pollution	++	+	X	- -	+	-	X	-	+	0
Fire	++	+	X	- -	0	- -	X	-	0	-
Erosion	+	+	X	- -	+	-	X	--	+	-
Invasive species	++	0	X	- -	0	- -	X	0	0	0
Social Services	-	+								
Urbanization	++	0								
Land Abandonmt	++	0								
Tourism Pressure	+	-	X	-	+	0	X	0	0	0
Subsidies	- -	++								
Consumer Demands	++	0								

Table 4I. Nature Conservation – Ecotourism Employees

Pressures	A1	B2	E	PI	AC	Vulnerability	E	PI	AC	Vulnerability
Temperature	++	+	X	- -	+	-	X	-	+	0
Precipitation	- -	-	X	-	0	-	X	-	0	-
Water Availability	- -	-	X	-	0	-	X	0	0	0
Pollution	++	+	X	-	0	-	X	0	0	0
Fire	++	+	X	- -	0	- -	X	-	0	-
Erosion	+	+	X	-	0	-	X	-	0	-
Invasive species	++	-	X	-	0	-	X	0	0	0
Social Services	-	+	X	-	0	-	X	+	0	0
Urbanization	++	0								
Land Abandonmt	++	0								
Tourism Pressure	+	-	X	++	++	0	X	-	0	-
Subsidies	- -	++								
Consumer Demands	++	0	X	+	+	0	X	0	0	0

Table 4J. Tourism – Tourists

Pressures	A1	B2	E	PI	AC	Vulnerability	E	PI	AC	Vulnerability
Temperature	++	+	X	-	0	-	X	+		0
Precipitation	- -	-	X	+		0	X	+		0
Water Availability	- -	-	X	- -	0	- -	X	-	0	-
Pollution	++	+	X	- -	0	- -	X	-	0	-
Fire	++	+	X	-	0	-	X	- -	0	- -
Erosion	+	+								
Invasive species	++	0								
Social Services	-	+	X	-	0	-	X	+		0
Urbanization	++	0								
Land Abandonmt	++	0	X	-	0	-				
Tourism Pressure	+	-	X	-	0	-	X	+		0
Subsidies	- -	++								
Consumer Demands	++	0	X	+		0				

Table 4K. Tourism – Tourist Operators

Pressures	A1	B2	E	PI	AC	Vulnerability	E	PI	AC	Vulnerability
Temperature	++	+	X	- -	+	-	X	+		0
Precipitation	- -	-	X	-	0	-	X	0		0
Water Availability	- -	-	X	- -	+	-	X	-	+	0
Pollution	++	+	X	- -	0	- -	X	-	0	-
Fire	++	+	X	- -	+	-	X	- -	+	-
Erosion	+	+								
Invasive species	++	0								
Social Services	-	+	X	-	0	-	X	0		0
Urbanization	++	0								
Land Abandonmt	++	0	X	-	0	-				
Tourism Pressure	+	-	X	+		0	X	-	0	-
Subsidies	- -	++								
Consumer Demands	++	0	X	+		0				

Appendix 5. Comparison Between Nature Conservation Stakeholders

(PAMs and NGOs, and Nature Tourism Employees)

	PAMs and NGOs	Nature Tourism Employees
Interest	Conservation Management	Economic benefit from protected areas being in good condition and thus attracting tourists.
Potential for action	Implementation of measures to achieve conservation goals (e.g. eradication of invasive plant, insect, and animal species).	No authority to improve conditions of protected area.
Exposures	Not exposed to water availability decrease unless it directly affects personal water consumption needs.	Exposed to water availability decrease as sufficient water is needed to meet tourists' needs.
	Pollution is a sensitive issue that can be mitigated within certain thresholds (e.g. pollution by tourists' waste) but hard to mitigate at the environmental level (e.g. pollution of rivers upstream from protected areas).	Pollution only has negative effect when it exceeds a certain level so that is disturbing to visitors (e.g. affects the visual aesthetics of the landscape in protected areas).
	Land abandonment, urbanization, and subsidies are not of great importance unless they are near cities (e.g. if urbanization encroaches into protected areas the consequences affect consumer demands and behavior).	Land abandonment, urbanization, and subsidies do not have a negative effect on tourists interested in natural areas (e.g. protected areas near cities tend to attract more tourists because they are more accessible in terms of distance and travel time).
Summer vs. Winter Tourism	Seasonality of tourism does not impact the role and functions of PAMs and NGOs.	Summer tourists' visits are generally higher than winter tourists' visits.
Mountainous vs. Inland vs. Coastal Region	The mountainous region currently exhibits climatic changes that are different from those in the inland and coastal regions (e.g. less urbanization in the mountainous region).	The coastal region attracts generally more tourists than the inland and mountainous region.

Appendix 6. Results of Vulnerability Assessment

Table 6A. Vulnerability Assessment under Scenario A1

Systems (Sectors)	Components (Stakeholders)	Temperature	Precipitation	Water Availability	Pollution	Fire	Erosion	Invasives	Social Services	Urbanization	Land Abandonment	Tourism Pressure	Subsidies	Vulnerability
Agriculture	Olive growers	0	0	0	0	-	-	0	0	-	- -	0	- -	- 7
	Intensive vegetable farmers	0	0	-	0	0	0	0	0	-	- -	0	- -	- 6
	Irrigated cropland farmers	0	-	-	0	0	0	-	0	-	- -	0	- -	- 8
	Non-irrigated cropland farmers	- -	- -	- -	0	0	-	-	0	- -	0	0	-	- 11
Tourism	Tourists	-	0	- -	- -	-	0	0	-	0	-	-	0	- 9
	Tour operators	-	-	-	--	-	0	0	-	0	-	0	0	- 8
Conservation	Protected area managers (PAMs) and NGOs	- -	- -	-	-	- -	-	- -	0	0	0	0	0	- 11
	Ecotourism employees	-	-	-	-	- -	-	-	-	0	0	0	0	- 9
Agrosilvo-pastoral systems	Transhumance herders	-	-	-	0	- -	-	- -	0	0	-	0	-	- 10
	Land management associations (incl. Herders)	0	0	0	0	-	-	-	0	-	-	0	0	- 5
Health	General public	- -	0	-	- -	0	0	- -	-	-	0	0	0	- 9
Total Impact From Pressure		**-10**	**-8**	**-11**	**-7**	**-10**	**-6**	**-10**	**-4**	**-7**		**-1**	**-8**	**-92**

Table 6B. Vulnerability Assessment under Scenario B2

Systems (Sectors)	Components (Stakeholders)	Temperature	Precipitation	Water Availability	Pollution	Fire	Erosion	Invasives	Social Services	Urbanization	Land Abandonment	Tourism Pressure	Subsidies	Vulnerability
Agriculture	Olive growers	0	0	0	0	0	0	0	0	0	0	0	0	0
	Intensive vegetable farmers	0	0	0	0	0	0	0	0	0	0	0	0	-4
	Irrigated cropland farmers	0	0	0	0	0	0	0	0	0	0	0	0	0
	Non-irrigated cropland farmers	--	-	-	0	0	0	0	0	0	0	0	0	0
Tourism	Tourists	0	0	-	-	--	0	0	0	0	0	0	0	-4
	Tour operators	0	0	0	-	-	0	0	0	0	0	-	0	-3
Conservation	Protected area managers (PAMs) and NGOs	-	-	0	0	-	-	0	0	0	0	0	0	-4
	Ecotourism employees	0	-	0	0	-	-	0	0	0	0	-	0	-4
Agrosilvo-pastoral systems	Transhumance herders	0	0	0	0	-	-	0	0	0	0	0	0	-2
	Land management associations (incl. Herders)	0	0	0	0	0	0	0	0	0	0	0	0	0
Health	General public	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Impact From Pressure		**-3**	**-3**	**-2**	**-2**	**-6**	**-3**	**0**	**0**	**0**	**0**	**-2**	**0**	**-21**