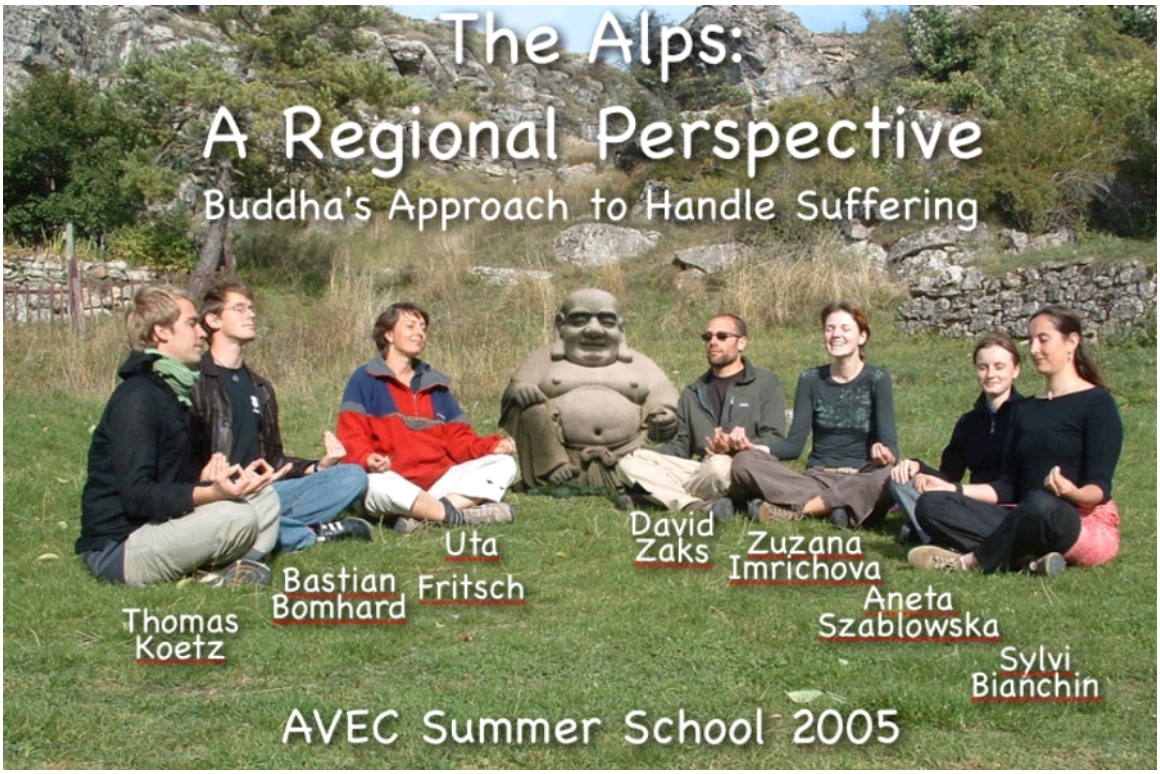
AVEC Summer School

Integrated Assessment of Vulnerable Ecosystems under Global Change

Peyresq, France, 30 September 2005



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I. Introduction

The 21st century ushered in a new epoch in geologic time. The Anthropocene is a period of history where humans have become a driving force behind global environmental change. One area where global change is expected to alter the dynamics of the social and environmental systems is in the Alps. The Alps cover an area of 190,000 km^2. The range is 1100 km long, 170 km wide, with 14.2 million people living in the territory of eight countries, Austria, France, Germany, Italy, Liechtenstein, Monaco, Slovenia, and Switzerland (http://www.cipra.org/). The mountain ridges, which average 2500m above sea level, act as a barrier for atmospheric circulation and separate the maritime temperate and Mediterranean climate from its own regional mountain climate. Climatic gradients caused by the varied topography lead to a wide range of environmental conditions. The lower parts and valleys of the Alps tend to be densely populated with high pressure on the very limited land due to competing needs for settlements, infrastructure, agriculture and recreation (Bätzing 2003). In contrast, the higher parts of the Alps are hardly affected directly by such human activities. Most recreational activities such as climbing, hiking or skiing are concentrated in moderate heights, again leading to only limited impacts in the high mountains. However, the high regions have shown to be strongly affected indirectly by human activities through air pollution, anthropogenic climate change and elevated UV-B radiation for example.

The Alps provides important services for the surrounding lowlands as well. They supply ecosystem goods and services such as wood products and hydropower and serve as sources of inspiration and recreation. Furthermore, the Alps are an important reservoir of biological diversity. About 15% of the 2,500 high alpine species living above the tree line are endemic (UBA 2004). A large variety of traditional land-uses increase the diversity of ecosystem types. High altitude pastures have been managed for 2000 years, depressing the tree line by about 300m. These activities helped to form the current landscapes, which make the region an attractive year-round tourist destination.

For this case study, the Alps are divided into five regions of similar climatic and altitudinal regimes (see Material and Methods). The distribution of land use in the five subregions differs greatly (see figure 1). The dominating land use for the lowland areas is agriculture where the Southern Low Alps have a share of 44%, the Northern Low Alps of 35% and the Western Low Alps of 33%. Forests are mostly located in the highland areas, with 59% in the Northern High Alps and 73% in the Southern High Alps. Interesting is that the Northern High Alps have a percentage of grassland which is much bigger (28%) than in the Southern High Alps (3%). Most of the larger settlement areas are located in the low areas where they have a share of 5%.

The main economic sectors in the Alps are agriculture, forestry, energy production, and tourism, all which are vulnerable to global environmental change. Vulnerability is described as the risk of harm and consequently suffering (Schröter et al. 2004, 2005), and can be calculated based on exposure to risks, sensitivity to change and adaptive capacity.

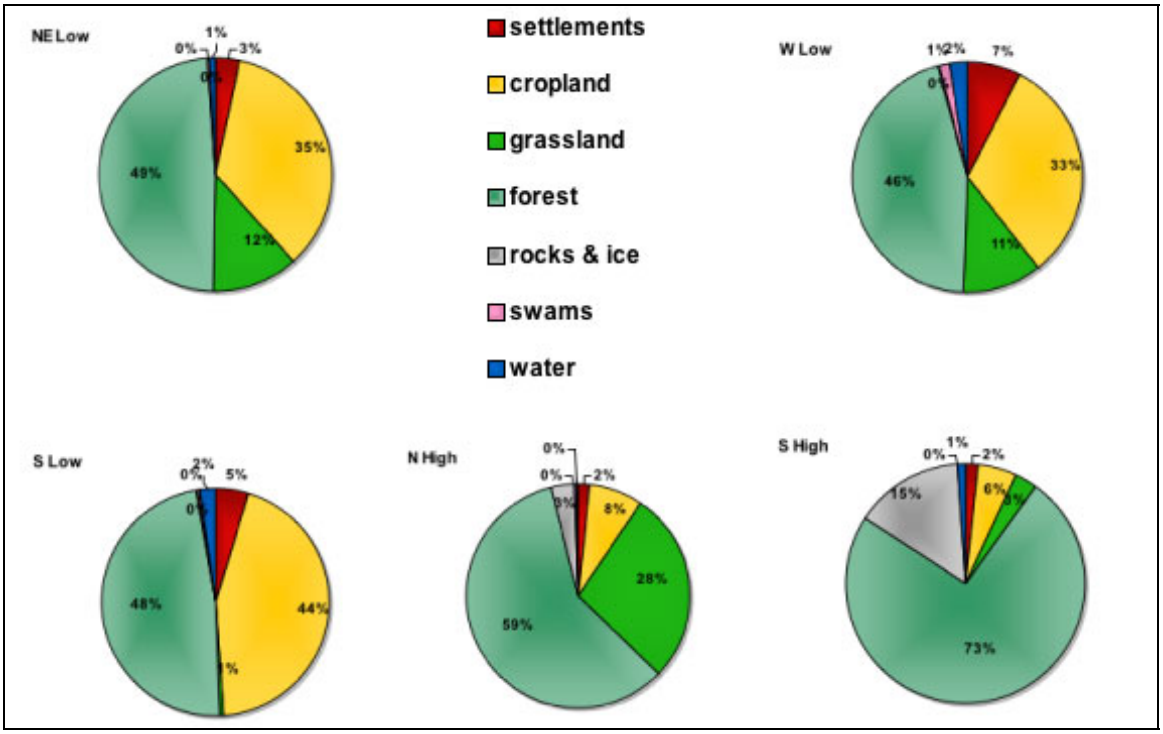

Figure 1. Proportion of different land use types in the five different subregions.

II. Concepts

IIa. Conceptual Framework

Relating vulnerability to notions of harm and suffering emphasizes the important role of the human dimension in vulnerability assessments of ecosystems under global change. The inherent interconnectedness of the social and the environmental dimensions is at the core of any vulnerability assessment. This is also reflected in the concept of the ATEAM approach which defines vulnerability as a function of exposure, sensitivity and adaptive capacity: all of these elements are themselves a function of the human/ environment relationship. It is not only changes in ecosystem services that explain exposure but also the degree to which society depends on them. Both ecological and social systems have varying degrees of sensitivities in respect to outside changes they are exposed to Adaptive capacity is an inherent property of social systems but also related to the dynamic nature of the environment. Vulnerability, then, is influenced by both the nature of the social system as well as the environment in which it is embedded.

Both of these systems are shaped by humans through time. But it is the social system on which we (should) have a lot more influence on in order to make changes to our environment. In this sense, our approach focuses primarily on the adaptive capacity of the human dimension to address the increasing threats from climate change. Emphasizing the potential societies have to change the trajectory of their negative influence on the biosphere and climate system, we have adopted an approach based on anticipative (normative) scenarios. Our approach was to depart

from a given future environmental exposure, add socio-economic scenarios, and to then evaluate them with expert knowledge for the different subregions of the Alps (see Materials and Methods).

As a timeframe we choose 2050. This is to some extent due to the data available. On the other hand this timeframe seemed suitable for our purposes as it covers a time horizon that (a) is short enough to allow us to derive some assumptions on the future climate within a reasonable range of precision, and (b) is long enough to give time for development within our life expectancies.

The underlying storylines or normative concepts for the scenarios that drive our vulnerability assessment (or better mitigation strategy) are based on Buddhist philosophy. In Buddhism suffering is described as the discrepancy between a given set of expectations and a given perception of reality. According to the teachings of Buddha there exist three paths to reduce this suffering:

1. Influence the reality to get closer to what you expect
2. Change your expectations / goals
3. Change your perception / revalidate your narrative

We adapted the essence of Buddha's message to address suffering to the present context (ecosystems under climate change) and developed three scenarios according to the three paths offered by Buddha. They will be described in more detail below.

IIb. Scenario Development

Based on data from the A1 scenario of the ATEAM project for climate change we developed pattern of exposure to environmental change for each region and user group. Once the exposure to environmental change of each user group has been calculated, the vulnerability and adaptive capacity of each group is qualitatively determined through the use of scenarios, each of which is based on a possible set of future events. Three scenarios were developed to illustrate different potential futures for user groups and their adaptive capacity to environmental and social change.

As mentioned above, we agreed on an approach based on anticipative scenarios. That is, instead of exploring various ways from the present in an 'open' future, an anticipative approach begins with an anticipated future and focuses from there towards the present, looking at different ways by which means the anticipated future can be reached or, as in our case, can be mitigated. In this sense, our scenarios present different storylines and develop different strategies to mitigate the exposure to environmental change that would be experienced in 2050.

In the first scenario, named *Rat Race*, the users influence reality to get closer to what they expect. In this sense it is a conservative approach. The social paradigm in this scenario attempts to make nature fit the dominant economic model. Even with impending environmental changes, citizens strive to preserve the lifestyles that they held before environmental pressures caused shifts in behaviors. This scenario is highly reliant on technology, such as the use of snow cannons in the winter to keep ski runs open, the use of genetically modified crops that are

drought and disease resistant, and the construction of dams, dikes, and desalination plants to ensure an uninterrupted supply of water to both agricultural and urban users. These technologies require a vast amount of energy, which is supplied mostly from coal and nuclear sources, as research and development funds are funneled away from alternative energy sources. The reliance on technology increases the risks of failure, especially in the agricultural sector. Intensive management is required in natural areas to maintain the species diversity in 2050 that was observed in 2000. Overall, technology is used to maximize profits and greed while maintaining levels of societal output while facing the challenges of global change.

The second scenario follows the path of reducing vulnerability in terms of changing the expectations and consequently the goals. Accordingly, in this scenario the economy is shifted in order to adapt to changing environmental conditions. For this reason this scenarios has been named *Chameleon*. As users adapt their behaviors and business decisions to the changing environment, norms shift to take the changing climate regime into account. As water availability decreases, especially in the lowlands, conventional farming no longer becomes profitable, and many farms change the crop under cultivation to one more adapted to drought prone climate, or in some cases, it will become more profitable to switch the land use, for example, to a forest plantation. With the decrease in water availability farmers in the uplands may also switch their cropping system, and mange the land to store water for gradual release to lowland areas. The provision of ecosystem services by these land managers would be maintained under a market-based system based on the delivery of water. Upland land managers will reduce their inputs on the landscape as an increased awareness that their runoff will eventually be used in the lowlands. With a decrease in the snow pack in the higher elevations, tourism is expected to shift from a ski-based market, to one dominated by hiking, orienteering, and adventure / ecological / agro-tourism. In urban areas, that already experience heat stress from the urban heat island effect, the amount of green, “living” roofs, green spaces, and open areas is expected to increase. Additionally, housing that is energy efficient and easy to maintain will become the status quo. Changes in the Alps will highlight the new climate regime, and work to adapt with the least amount of resistance.

The third scenario proposes a radical shift in both policy and action that highlights the future resilience and sustainability of the Alps system. This scenario, entitled *Bright Green Future* changes the driving force behind the current society of greed and financial maximization to one of sufficiency and the fulfillment of needs. The complete implementation of this scenario is beyond the timeframe of this assessment, but the framework and background are presented here with changes that can be implemented before 2050. This scenario is based on three underlying concepts, each working toward bettering the social, economic and ecological well being of the society. The gross domestic product (GDP) is the most commonly used indicator on economic activity. GDP values economic transactions that occur in society, but does not factor in negative social or environmental transactions, such as pollution, loss of biodiversity, and divorce. It also neglects positive social transactions such as volunteerism, and childcare. An alternative measure that has been developed is the Genuine Progress Indicator (GPI) that reflects the aforementioned transaction costs. Promoting the GPI, or a similar indicator will provide a positive feedback for socially and environmentally conscious activities within the society.

Another societal indicator, developed by the small mountain country of Bhutan is the Gross National Happiness (GNH) indicator. According to Lyonpo Jigmi Thinley, Bhutan's

foreign minister "individual's quest for happiness and inner and outer freedom is the most precious endeavor, society's ideal of governance and polity should promote this endeavor." The basis for GNH is economic development, environmental preservation, cultural preservation, and good governance. The attainment of these four aspects of society would theoretically lead not only to a stable and well-off society, but also one that has a high degree of happiness.

The third underlying concept is the attainment of Maslow's hierarchy of needs. While this indicator is primary on a personal level, the aggregation of personal well-being leads to a societal well-being. The hierarchy of needs focuses on physiological needs, safety needs, social needs, ego, self-actualization and finally meeting ones spiritual needs. While the framework for meeting the needs is not explicitly stated, the needs can be met by implementing the concepts laid out in the scenario.

Another concept that lies at the heart of the scenario is decentralization. Local economies and ways of knowing will flourish, and dependence on resources from outside of the community will greatly decrease. Knowledge, on the other hand, will flow freely between communities and will act strengthen the non-material ties between cultures. The Internet should be used as a conduit to transfer different ways of knowing between groups of people. The Internet is a decentralized method of knowledge transfer (education) and for places with "inadequate" access to educational or informational materials, the Internet can be used as a tool to "leapfrog" to the technical ability to current levels of technology.

While most of the implementation for the scenario will likely be implemented after 2050, there are certain changes that can set communities on the right path toward a *Bright Green Future.* Intensive farming will give way to extensive farming using a minimal amount of inputs, and the crops grown will be adapted to the changing climate. Animal husbandry will decrease, as communities aim to reduce their ecological footprint. Waste products from urban areas are biologically reduced and used as fertilizer for crops. In urban areas, high-density living is encouraged to reduce living and energy costs, while increasing the structural integrity of the community. Cities will become havens for biodiversity, as the amount of green space increases dramatically, alongside urban food production. These gradual changes should start the gradual shift toward a *Bright Green Future*.

III. Materials and Methods

The study region was divided into the following five subregions based on topographic, topological and climatological characteristics: Western Low Alps, Northern Low Alps, Northern High Alps, Southern High Alps and Southern Low Alps (see figure 2). For each subregion, changes in temperature, summer and winter precipitation as projected for 2050 by the ATEAM scenario A1 were classified into five classes ranging from strong increase to strong decrease (see table 1 and figure 2). These were later transferred into numbers from +2 (strong increase) to –2 (strong decrease) to enable simple calculations such as summing up impacts across regions and user groups.

Table 1. Changes in temperature, summer and winter precipitation for each subregion for 2050 from the ATEAM A1 scenario for 2050 (++ strong increase, + increase, 0 no change, - decrease, -- strong decrease).

	Δ Temperature	Δ Summer Precipitation	Δ Winter Precipitation
Western Low Alps	+	-	+
Northern Low Alps	+	0	+
Northern High Alps	+	-	++
Southern High Alps	++	-	+
Southern Low Alps	++	--	0

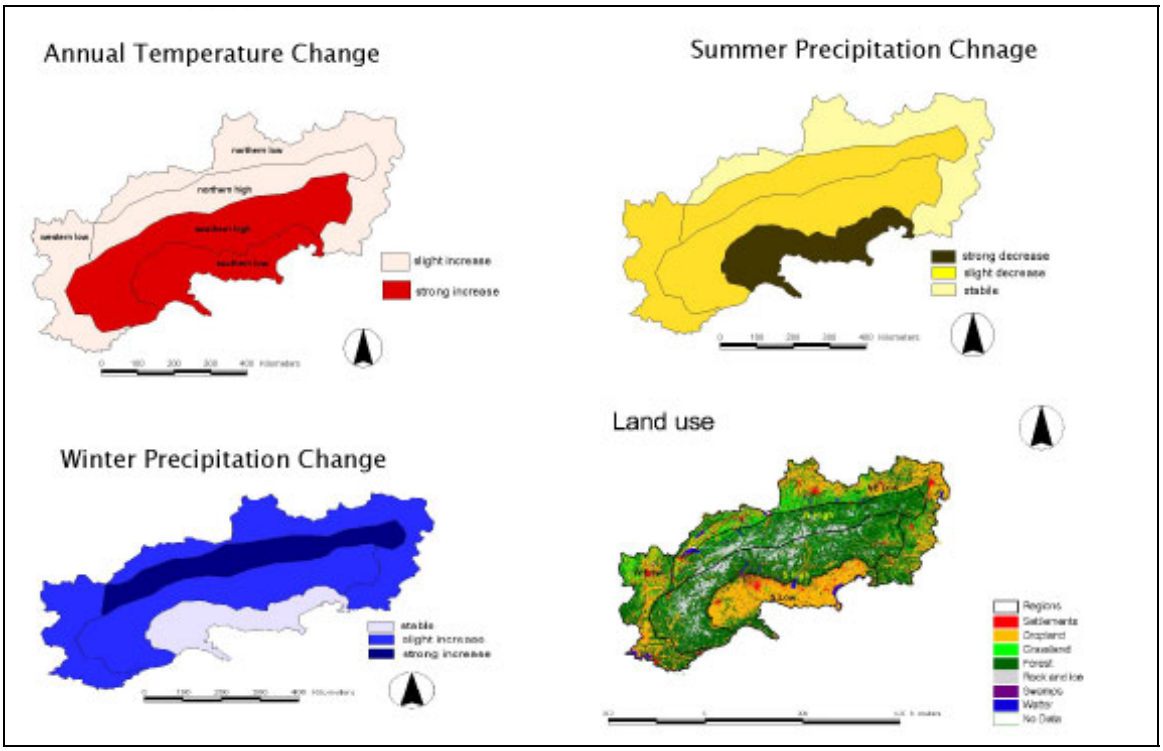

Figure 2. Projected changes (derived from ATEAM A1 scenario) in annual temperature, summer and winter precipitation, and current land use in the five different subregions.

Ecosystem goods and services are the benefits that society derives from ecosystems. Following the Millennium Ecosystem Assessment (Alcamo 2003), the different ecosystem goods and services most relevant in the Alps were identified (see table 2). Then the most relevant "user groups" in the Alps were specified (see table 3). The residential population was classified into rural population, urban population and retirees because of the differences in their reliance on ecosystem goods and services.

Table 2. Relevant ecosystem goods and services in the Alps.

Food	Pollination
Freshwater	Religious/inspirational/spiritual/aesthetic
Forest products	Heritage
Energy production	Education
Genetic resources and biodiversity	Recreation and ecotourism
Water regulation and purification (mgt)	

Table 3. Relevant user groups in the Alps.

Farmers	Retirees
Foresters	Tourism
Energy industry	Conservationist
Rural population	Future Generations
Urban population	

Vulnerability is a function of exposure, sensitivity and adaptive capacity. Thus, the subregion-specific exposure and sensitivity of ecosystem goods and services to the projected changes in temperature, summer and winter precipitation was determined based on expert knowledge. For each user group the ecosystem goods and services they rely on were identified (see table A-1 in Appendix) and the subregion-specific sensitivity of each user group to the projected changes in these ecosystem goods and services specified based on expert knowledge (see tables A-2 and A-3 in Appendix).

Then the expected impacts by 2050 were aggregated by user groups and subregions to allow for comparing the overall sensitivity of the different user groups and subregions (see Results). For two subregions, the Northern High Alps and Southern Low Alps, the information on the sensitivity of the different user groups was summarised in spider diagrams (see Results), providing a baseline scenario for 2050 not taking into account adaptive capacity.

The adaptive capacity of different user groups depends strongly on the political and socio-economic environment they are operating in. This is not constant and can be changed actively through future decision-making. To account for different "futures" and assess their potential effects on the adaptive capacity and, in turn, vulnerability of the different user groups, we developed three different scenarios of future political and socio-economic environments (see Concepts): proactive (Rat Race), adaptive (Chameleon) and alternative world vision (Bright Green Future). For each of these policy scenarios, the vulnerability of the different user groups was re-determined considering the changed political and socio-economic boundary conditions as outlined in the scenario storylines (see Concepts). Given the time constraints for this study, this was only done for the three user groups farmers, urban population and tourism, and for the two subregions Northern High Alps and Southern Low Alps (see tables 5-6 in Results and table A-4 in Appendix). The differences in the vulnerability of the different user groups between the three policy scenarios and the baseline scenario for 2050 were summarised in scatter diagrams (see

figures A-1 to A-6 in Appendix) and are to be used to inform future decision-making about mitigation and adaptation options and the tradeoffs involved (see Conclusions).

IV. Results

Amongst the five subregions in the study area, the Southern Low Alps appear to be by far the most sensitive to future climate change, followed by the Western Low Alps and the Northern High Alps, while the Northern Low Alps appear to be impacted on very little by 2050 under the baseline scenario (see table 4). This scenario takes into account only the changes in temperature, summer and winter precipitation as projected for 2050 by the ATEAM scenario A1. The impacts have been summarized based on how the provision of ecosystem goods and services to the different user groups is expected to change in the five subregions and summed up for comparison purposes. It is important to note that the values were derived from categorical data and thus provide only a relative indication of overall sensitivity. Amongst the nine user groups studied, future generations and the tourist sector are most sensitive to the projected environmental changes, but sensitivity of all the user groups differs strongly from subregion to subregion, reflecting the regional differences in the environmental changes.

Table 4. Expected impacts by 2050 aggregated by user groups and subregions (negative values indicate negative impacts, positive values indicate positive impacts). Note that the values provide only a relative indication of overall sensitivity.

User group	Southern low	Southern high	Northern high	Northern low	Western low	Total
Farmer	-9	-3	-2	0	-4	**-18**
Foresters	-7	-1	-2	-1	-2	**-13**
Conservationist	-8	-1	-2	0	-4	**-15**
Energy industry	-4	-2	-2	1	-2	**-11**
Rural pop.	-6	1	-4	-1	-4	**-14**
Urban pop.	-6	-2	-4	-1	-4	**-17**
Retirees	-7	0	-3	-1	-4	**-15**
Tourism	-8	-3	-6	-1	-5	**-23**
Future gen.	-13	-3	-5	0	-6	**-27**
Total	**-68**	**-14**	**-30**	**-4**	**-35**	

These general trends are confirmed by a closer look at the sensitivity of the different user groups with regard to the different ecosystem goods and services in two subregions. In the Southern Low Alps, where for example freshwater supply and regulating services are likely to become a big problem, future generations, farmers, foresters and the tourism sector appear to be the more sensitive user groups (see figure 3). In the Northern High Alps, the projected environmental changes are comparably small, potentially negatively impacting on regulating ecosystem services. At the same time increased temperatures and changes in seasonal precipitation patterns may, however, positively impact on the recreational and (eco)tourism value of the region. Given the comparably small differences in the sensitivity between different user groups in this region (see figure 4) there seem to be no major climate change winners or losers under the baseline scenario.

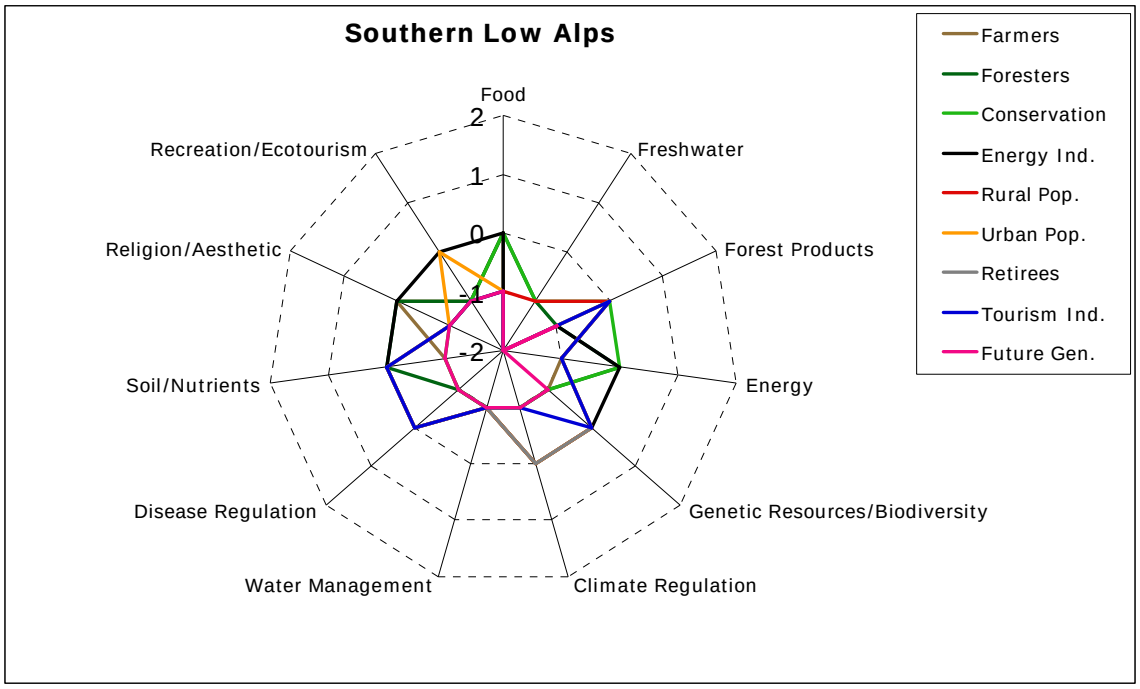

Figure 3. Sensitivity of user groups to projected changes in relevant ecosystem goods and services in the Southern Low Alps by 2050.

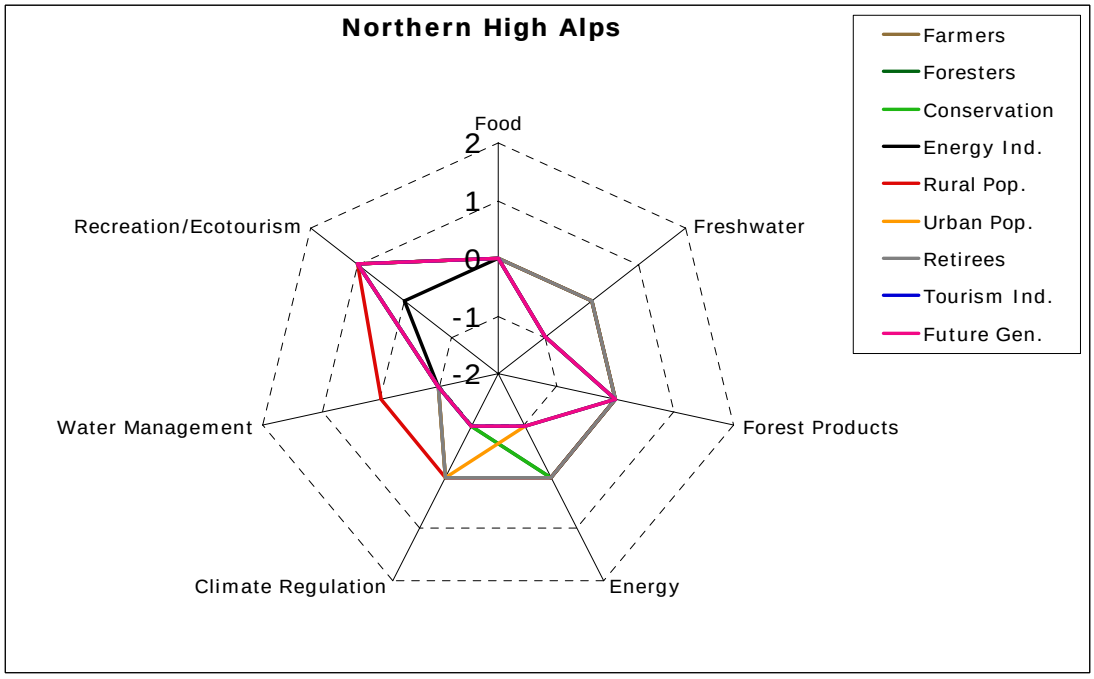

Figure 4. Sensitivity of user groups to projected changes in relevant ecosystem goods and services in the Northern High Alps by 2050.

The adaptive capacity and, in turn, vulnerability of the different user groups in the Alps depends strongly on the political and socio-economic environment they are operating in. This becomes evident when the sensitivity of the different user groups under the baseline scenario is compared to their vulnerability under the three future policy scenarios. Both in the Southern Low Alps and Northern High Alps, the vulnerability of selected user groups by 2050 is highest under the proactive scenario and lowest under the alternative scenario, however with marked differences amongst different ecosystem goods and services under different scenarios (see table 5 and figures A-1 to A-6 in Appendix). This reflects the differing political and socio-economic approaches and agendas under the different scenarios. Interestingly, making the right decisions appears to not only allow for reducing vulnerability but also "reversing" vulnerability to environmental changes in the future – by turning the challenges into opportunities under the adaptive and alternative scenarios.

Table 5. Relative sensitivity/vulnerability under the baseline and three future policy scenarios by 2050 aggregated for selected user groups and subregions (negative values indicate increased vulnerability, positive values indicate decreased vulnerability).

User groups	**Baseline scenario**	**Proactive scenario**	**Adaptive scenario**	**Alternative world vision**
Southern Low Alps				
Farmers	-9	-14	-6	5
Urban population	-7	-10	-1	5
Tourism industry	-9	-13	-2	7
Total	-25	-33	-9	17
Northern High Alps				
Farmers	-4	-9	1	8
Urban population	-2	-6	2	10
Tourism industry	-3	-8	2	9
Total	-9	-23	5	27

V. Conclusions and Policy Recommendations

The picture of our results reflects heterogeneous and distinct views of possible futures. The degree of vulnerability is changing in respect to region, user and underlying scenario. At a first glance it is the alternative world vision (Bright Green Future) that appears to develop most promisingly into the future. But note, it is a creative and positive (not positivistic!) vision that aims for and assumes radical shifts of value sets across societies (a shift of a paradigm of growth into a paradigm of sufficiency) and is therefore certainly the most difficult to implement. The way we have approached this scenario is to think in different phases and across a long time horizon in order to manage the (great) transition. During the first phase, which we call the 'take off phase' societies are to be guided by policies that try to slowly prepare them the transition. Revalidation of central development indicators such as the GDP towards more holistically balanced indicators such as the GPI could be understood as first measures to be taken. Further, public and open deliberation is needed to distinguish needs from greed without paralyzing and equalizing society. To enhance and stimulate this deliberation policy should provide for the

structural, financial, and democratic means that support 'ideal speech' conditions. This leads first and foremost to a set of process oriented policies, such as education in discourse analysis, the implementation of stakeholder panels on various societal levels, and the development of codes of conduct for interaction and responsibilities of the varying social actors (business, NGOs, scientists). These sets of policies (and many more) will easily fill the time until 2050. Later on in the course of this scenario, after a stable phase of transition, a third phase with a 'safe landing' focus aims at completing the shift.

The first two scenarios in contrast are a lot more straightforward and easier to implement as the one just presented, as they don't imply a shift in fundamental value pattern. Especially the first scenario describes in a sense a future of 'much more of what we had already' and is hence the most conservative approach as it maintains the existing interest groups and development strategies. By means of a lot of technological development society tries to counteract the detrimental effects of global environmental change. This path, however easy to follow, is the most vulnerable as it is highly cost intensive and prone to high risks of failure of the artificial protective systems and especially to extreme events.

The second scenario adapting economy to nature performs medium ranges. It is able to reduce future vulnerability for most of the stakeholder, bit only under the cost of the interest of some users. Following this approach, policies need to be put in place that enable a shift in interest and production, hence a strong regulation scheme guiding present user practices towards future practices which adapt to the unfolding environmental situation.

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Appendix

Table A-1. User groups and their reliance on ecosystem services.

User groups	Food	Freshwater	Forest Products	Energy	Genetic Resources	Climate Regulation	Water Management.	Disease Regulation	Pollination	Soil/ Nutrients	Religion/ Aesthetic	Heritage	Education	Recreation/ Ecotourism
Farmers		X		X	X	X	X	X	X	X		X		X
Foresters		X	X		X	X	X	X		X		X		X
Conservation		X			X	X	X	X	X	X	X	X	X	X
Energy Industry		X	X				X							
Rural Population	X	X	X	X			X				X	X	X	X
Urban Population	X	X		X			X				X	X	X	X
Retirees	X	X		X			X				X			X
Tourist Industry	X	X		X	X	X	X				X	X		X
Future Generations	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table A-2. Impacts of projected changes (derived from ATEAM A1 scenario) in annual temperature, summer and winter precipitation on the ecosystem services in the five different subregions.

Southern Low Alps

Ecosystem services	Temperature ++	Precipitation summer --	Precipitation winter 0
Food	-	-	0
Freshwater	-	--	0
Forest Products	-	-	0
Energy	-	--	0
Genetic Resources/Biodiversity	-	-	0
Climate Regulation	-	-	0
Water Mgt.	-	-	0
Disease Regulation	-	0	0
Pollination	0	0	0
Soil/Nutrients	0	-	0
Religion/Aesthetic	0	-	0
Heritage	0	0	0
Education	0	0	0
Recreation/Ecotourism	0	-	0

Southern High Alps

Ecosystem services	Temperature ++	Precipitation summer -	Precipitation winter +
Food	+	-	0
Freshwater	-	-	+
Forest Products	+	-	0
Energy	-	-	+
Genetic Resources/Biodiversity	+	0	0
Climate Regulation	-	0	-
Water Mgt.	-	-	-

Disease Regulation	0	0	0
Pollination	+	0	0
Soil/Nutrients	0	0	0
Religion/Aesthetic	-	0	0
Heritage	-	0	0
Education	0	0	0
Recreation/Ecotourism	-	+	+

Northern High Alps

Ecosystem services	**Temperature +**	**Precipitation summer -**	**Precipitation winter ++**
Food	0	-	0
Freshwater	-	-	++
Forest Products	0	-	0
Energy	-	-	++
Genetic Resources/Biodiversity	0	0	0
Climate Regulation	0	0	-
Water Mgt.	0	-	-
Disease Regulation	0	0	0
Pollination	0	0	0
Soil/Nutrients	0	0	0
Religion/Aesthetic	0	0	0
Heritage	0	0	0
Education	0	0	0
Recreation/Ecotourism	-	+	++

Northern Low Alps

Ecosystem services	**Temperature +**	**Precipitation summer 0**	**Precipitation winter +**
Food	+	0	0
Freshwater	0	0	+
Forest Products	0	0	0

Energy	0	0	+
Genetic Resources/Biodiversity	0	0	0
Climate Regulation	0	0	0
Water Mgt.	0	0	0
Disease Regulation	0	0	0
Pollination	+	0	0
Soil/Nutrients	0	0	0
Religion/Aesthetic	0	0	0
Heritage	0	0	0
Education	0	0	0
Recreation/Ecotourism	-	0	-

Western Low Alps

Ecosystem services	**Temperature +**	**Precipitation summer -**	**Precipitation winter +**
Food	0	-	0
Freshwater	-	-	+
Forest Products	0	0	0
Energy	-	-	+
Genetic Resources/Biodiversity	0	-	0
Climate Regulation	0	0	0
Water Mgt.	0	-	0
Disease Regulation	-	0	0
Pollination	0	0	0
Soil/Nutrients	0	0	0
Religion/Aesthetic	0	0	0
Heritage	0	0	0
Education	0	0	0
Recreation/Ecotourism	0	-	-

Table A-3. Impacts of projected changes in ecosystem services on user groups in the five different subregions for baseline scenario.

Southern Low Alps

Users	Food	Freshwater	Forest Products	Energy	Genetic Resources	Climate Regulation	Water Mgt.	Disease Regulation	Soil/Nutrients	Religion/ Aesthetic	Recreation/ Ecotourism
Farmers		-2		-1	-1	-1	-1	-1	-1		-1
Foresters		-1	-1		-1	-1	-1	-1	0		-1
Conservation		-1			-1	-1	-1	-1	-1	-1	-1
Energy Industry		-2	-1				-1				
Rural Population	-1	-1	-1	-1			-1			-1	-1
Urban Population	-1	-2		-1			-1			-1	-1
Retirees	-1	-2		-1			-1			-1	-1
Tourist Industry	-1	-2		-1	-1	-1	-1			-1	-1
Future Generations	-1	-2	-1	-2	-1	-1	-1	-1	-1	-1	-1

Southern High Alps

Users	Food	Freshwater	Forest Products	Energy	Genetic Resources	Climate Regulation	Water Mgt.	Pollination	Religion/ Aesthetic	Heritage	Recreation/ Ecotourism
Farmers		-1		-1	1	-1	-1	1		-1	1
Foresters		-1	0		1	-1	-1			-1	1
Conservation		-1			1	-1	-1	1	-1	-1	1
Energy Industry		-1	0				-1				
Rural Population	0	-1	0	-1			-1		-1	-1	1
Urban Population	0	-1		-1			-1		-1	-1	1
Retirees	0	-1		-1			-1		-1		1
Tourist Industry	0	-1		-1	1	-1	-1		-1	-1	-1
Future Generations	0	-1	0	-1	1	-1	-1	1	-1	-1	-1

Northern High Alps

Users	Food	Freshwater	Forest Products	Energy	Climate Regulation	Water Mgt.	Recreation/ Ecotourism
Farmers		-1		-1	-1	-1	1
Foresters		0	0		-1	-1	1
Conservation		0			-1	-1	1
Energy Industry		-1	0			-1	
Rural Population	0	0	0	0		0	1
Urban Population	0	-1		-1		-1	1
Retirees	0	0		0		-1	1
Tourist Industry	0	-1		-1	-1	-1	1
Future Generations	0	-1	0	-1	-1	-1	1

Northern Low Alps

Users	Food	Freshwater	Energy	Pollination	Recreation/ Ecotourism
Farmers		0	0	1	-1
Foresters		0			-1
Conservation		0		1	-1
Energy Industry		1			
Rural Population	0	0	0		-1
Urban Population	0	0	0		-1
Retirees	0	0	0		-1
Tourist Industry	0	0	0		-1
Future Generations	0	0	0	1	-1

Western Low Alps

Users	Food	Freshwater	Energy	Genetic Resources	Water Mgt.	Disease Regulation	Recreation/ Ecotourism
Farmers		-1	-1	0	-1	0	-1
Foresters		0		0	0	-1	-1
Conservation		0		-1	-1	-1	-1
Energy Industry		-1			-1		
Rural Population	0	-1	-1		-1		-1
Urban Population	0	-1	-1		-1		-1
Retirees	0	-1	-1		-1		-1
Tourist Industry	0	-1	-1	-1	-1		-1
Future Generations	0	-1	-1	-1	-1	-1	-1

Table A-4. Impacts of projected changes in ecosystem services on three selected user groups in the Southern Low Alps and Northern High Alps for baseline scenario and three policy scenarios for 2050.

Southern Low		Food	Freshwater	Forest Products	Energy	Genetic Resources	Climate Regulation	Water Mgt.	Disease Regulation	Soil/ Nutrients	Religion/ Aesthetic	Heritage	Education	Recreation/ Ecotourism
Farmer	baseline scenario	0	-2	0	-1	-1	-1	-1	-1	-1	0	0	0	-1
	proactive scenario	0	-1	0	0	-2	-1	-1	-2	-2	-1	-1	-1	-2
	adaptive scenario	-1	-1	0	-1	-1	-1	-1	-1	-1	0	1	1	0
	alternative scenario	0	-1	1	0	0	-1	0	0	0	1	2	2	1
Urban	baseline scenario	-1	-2	0	-1	0	0	-1	0	0	-1	0	0	-1
	proactive scenario	0	0	0	-1	-1	-1	-1	-1	0	-1	-1	-1	-2
	adaptive scenario	-1	-2	1	0	0	0	-1	-1	0	1	1	1	0
	alternative scenario	0	-1	1	0	1	0	0	0	0	1	1	1	1
Tourism	baseline scenario	-1	-2	0	-1	-1	-1	-1	0	0	-1	0	0	-1
	proactive scenario	-1	-1	0	-1	-2	-1	-1	0	0	-2	-1	-1	-2
	adaptive scenario	-1	-1	1	-1	-1	-1	-1	0	0	0	1	1	1
	alternative scenario	0	-1	1	0	1	0	0	0	0	1	2	2	1
Northern High		Food	Freshwater	Forest Products	Energy	Genetic Resources	Climate Regulation	Water Mgt.	Disease Regulation	Soil/ Nutrients	Religion/ Aesthetic	Heritage	Education	Recreation/ Ecotourism
Farmer	baseline scenario	0	-1	0	-1	0	-1	-1	0	0	0	0	0	0
	proactive scenario	0	0	0	1	-2	-1	-1	-1	-1	-1	-1	-1	-1
	adaptive scenario	0	-1	1	0	0	-1	-1	0	0	0	1	1	1
	alternative scenario	0	0	1	0	1	-1	0	1	1	1	1	1	2
Urban	baseline scenario	0	-1	0	-1	0	0	-1	0	0	0	0	0	1
	proactive scenario	0	-1	0	0	-1	-1	0	0	0	-1	-1	-1	0
	adaptive scenario	-1	-1	1	0	0	0	-1	0	0	1	1	1	1
	alternative scenario	0	0	1	0	1	0	0	0	0	2	2	2	2
Tourism	baseline scenario	0	-1	0	-1	0	-1	-1	0	0	0	0	0	1
	proactive scenario	0	0	0	0	-2	-1	0	0	0	-2	-1	-1	-1
	adaptive scenario	-1	-1	1	0	0	-1	-1	0	0	1	1	1	2
	alternative scenario	0	0	1	0	1	-1	0	0	0	2	2	2	2

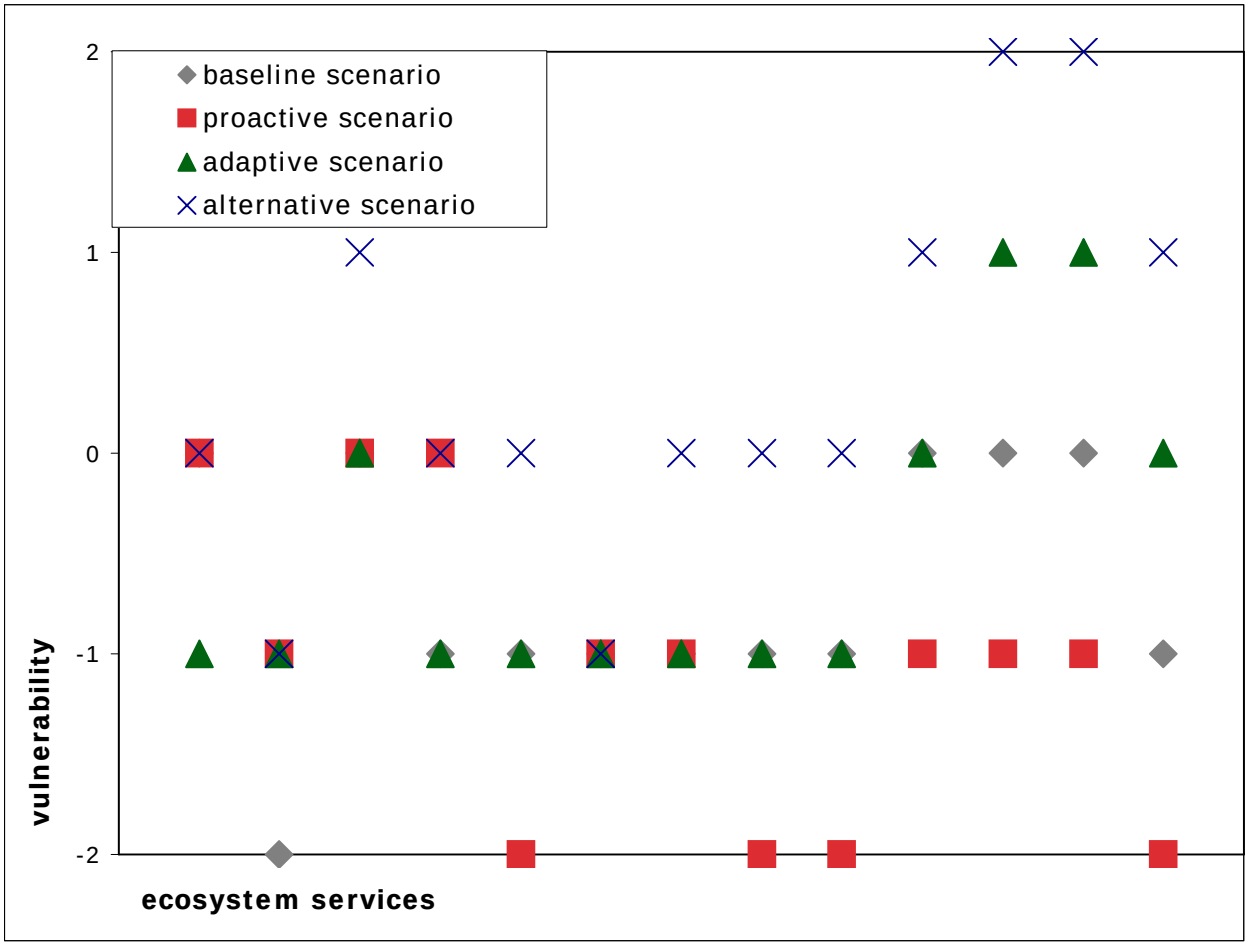

Figure A-1. Vulnerability of farmers in the Southern Low Alps for baseline scenario and three policy scenarios for 2050.

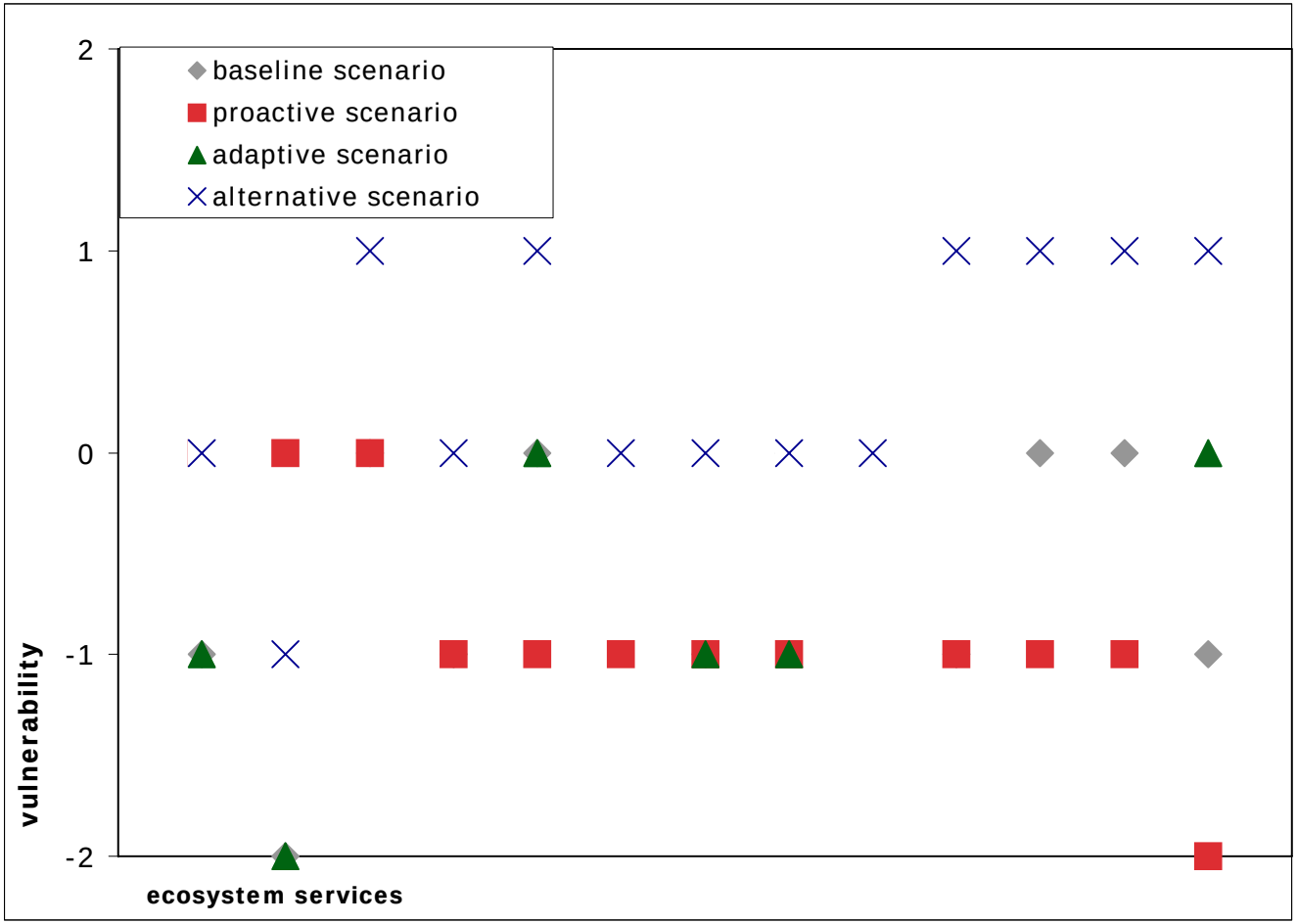

Figure A-2. Vulnerability of urban population in the Southern Low Alps for baseline scenario and three policy scenarios for 2050.

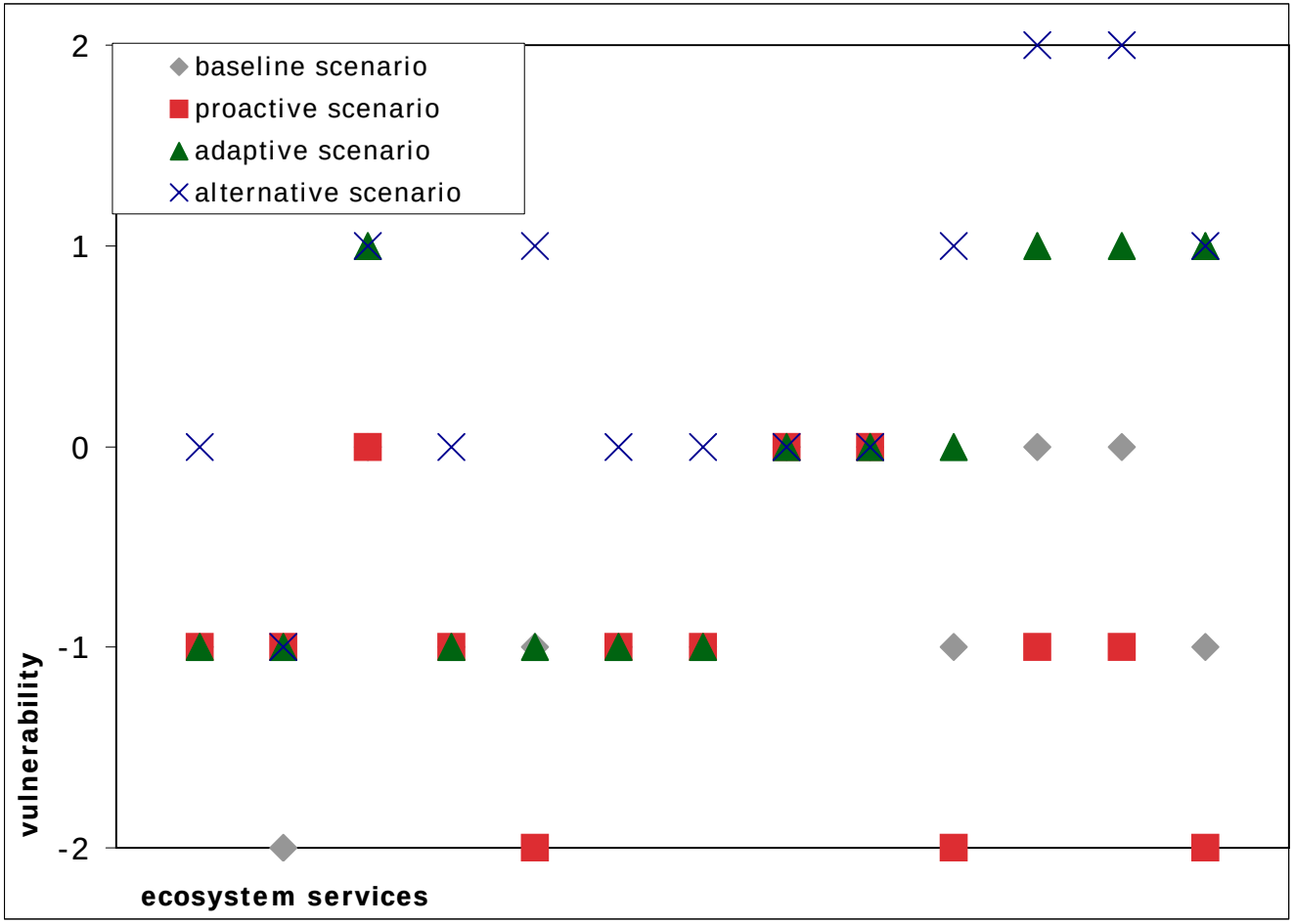

Figure A-3. Vulnerability of tourism industry in the Southern Low Alps for baseline scenario and three policy scenarios for 2050.

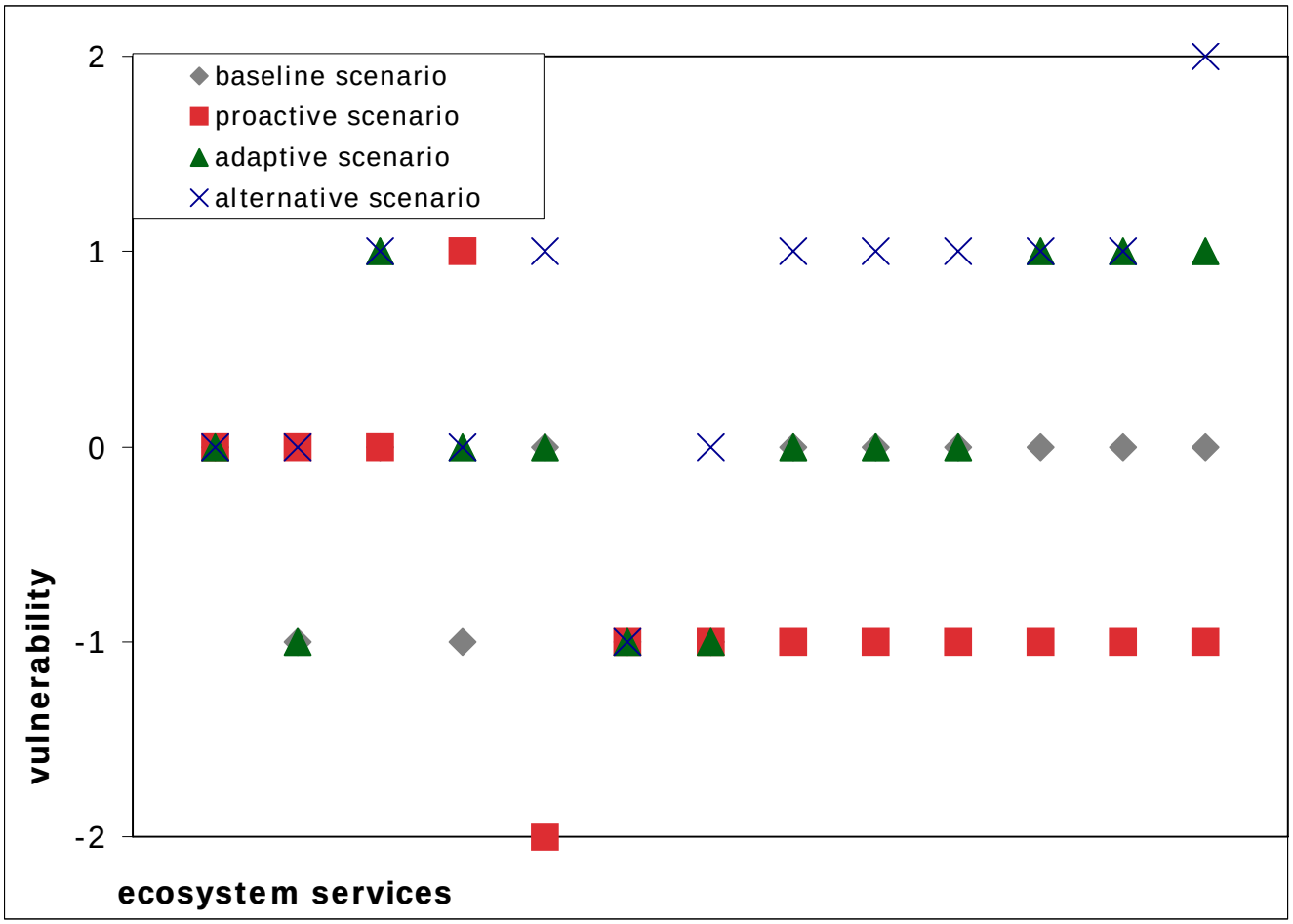

Figure A-4. Vulnerability of farmers in the Northern High Alps for baseline scenario and three policy scenarios for 2050.

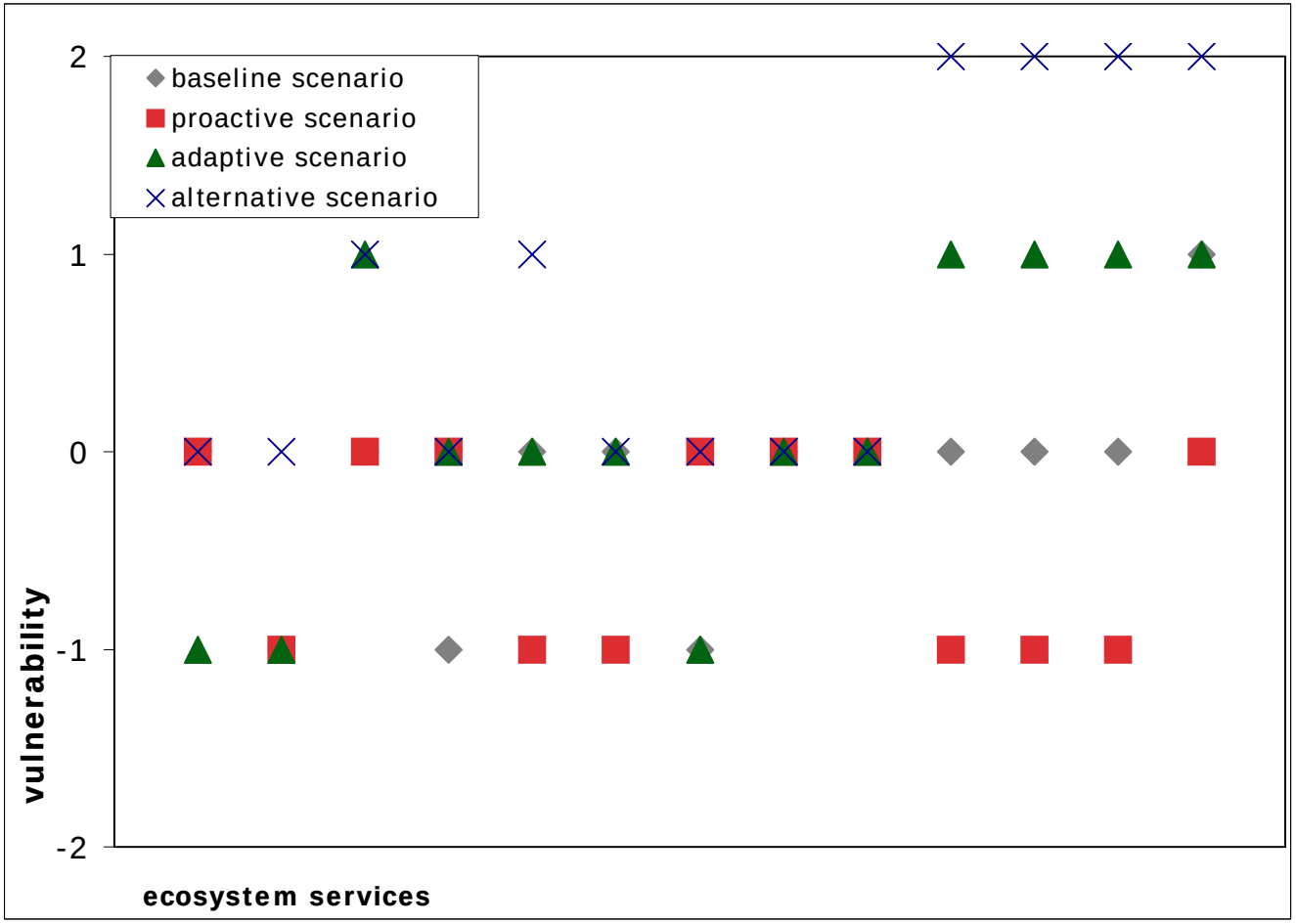

Figure A-5. Vulnerability of urban population in the Northern High Alps for baseline scenario and three policy scenarios for 2050.

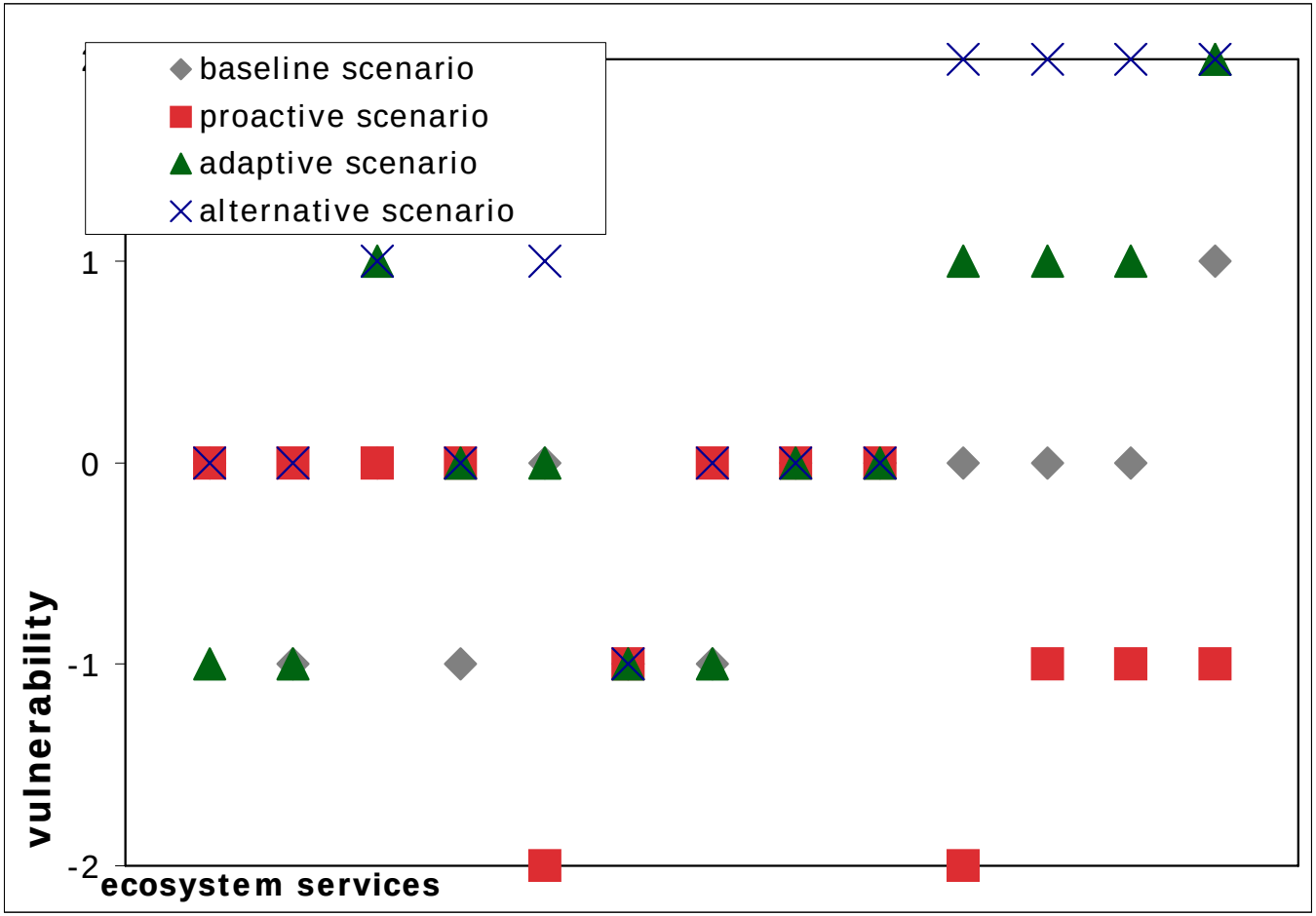

Figure A-6. Vulnerability of tourism industry in the Northern High Alps for baseline scenario and three policy scenarios for 2050.