Managing the human environment system to provide and sustain ecosystem services for all users safeguarding human wellbeing and biodiversity (MEDUSA) - developing strategies to adapt to future changes

Agriculture sector

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Introduction

Biodiversity reflects the number, variety and variability of living organisms in an ecosystem (CBD 1992). In recent decades, the instrumental values of biodiversity were recognized with components of biodiversity acknowledged to contribute directly, and indirectly, to many aspects of human well-being (MA 2005). Anthropogenic perturbations have however had a discernible impact on the natural world during this time and there is growing concern for global change and its effects on biodiversity and on a range of ecosystem services (Sala et al. 2000).

Located in the centre of Europe, the alpine region is a hot spot for biodiversity (OECD 2007). The Mediterranean region is one of the most vulnerable areas in the world (MARs 2005) and is particularly sensitive to the effects of global warming. Despite this, human activities continue to increase the susceptibility of these environments to environmental change (Taillefumier & Piégay 2003).

Agricultural practices offer supporting, provisioning, regulating and cultural services that contribute to biodiversity and human well-being (MA 2003). In the Alps, agriculture was once synonymous with stewardship of the land and management of the countryside. In recent decades, traditional practices have declined following commercialisation and rural depopulation (MacDonald et al. 2000). There is now an increasing awareness that pressures arising from socio-economic conditions, land use practices, climate change, developments in technology, and their subsequent interactions, may have deleterious consequences on agriculture in the alpine regions and for biodiversity and human populations therein. As a consequence there is a pressing need for further research to consider adaptive strategies to safeguard agriculture in rural areas and protect ecosystem services.

Objectives
This chapter assesses the main drivers and pressures that will influence the agricultural sector between the present and 2050. The principal aim is to develop adaptation strategies to sustain ecosystem services in an area of the Southern French Alps (Var catchment), using four future scenarios derived from the Millennium Ecosystem Assessment (MA) (MA 2003). The following questions are addressed: (1) How will agriculture develop in remote areas under future scenarios? (2) What will be the challenges the agriculture sector has to cope with? and (3) How could agriculture adapt to sustain local livelihoods and biodiversity in a changing environment?

Methods

Study area
The Var catchment is situated in the Southern Alps of France and is embedded in the départements of Alpes-de-Haute-Provence and Alpes-Maritimes (Fig 1a). Agriculture is an important land use in the area covering 24% of the total landscape (14% intensive and 10% extensive agriculture) (Corine Land Cover 2000). Due to the altitudinal gradient, the catchment can be broadly divided into two major agricultural zones. The boundary of the

upper region is in the Alps. Here, land cover is a mosaic of alpine pastures and coniferous and broadleaved forests. In these marginal areas, farming primarily consists of extensive animal husbandry. The lower region fans out near Nice into the Mediterranean Sea. More intensive agriculture is practiced in these areas with vegetable, fruit, flower and tree cultivation (Fig 1b). Farms situated in the lower catchment typically (c.60%) operate on less than 1ha of land while larger scale farms (>200ha) are located in the upper catchment (Conseil general des Alpes-Maritimes 2006).

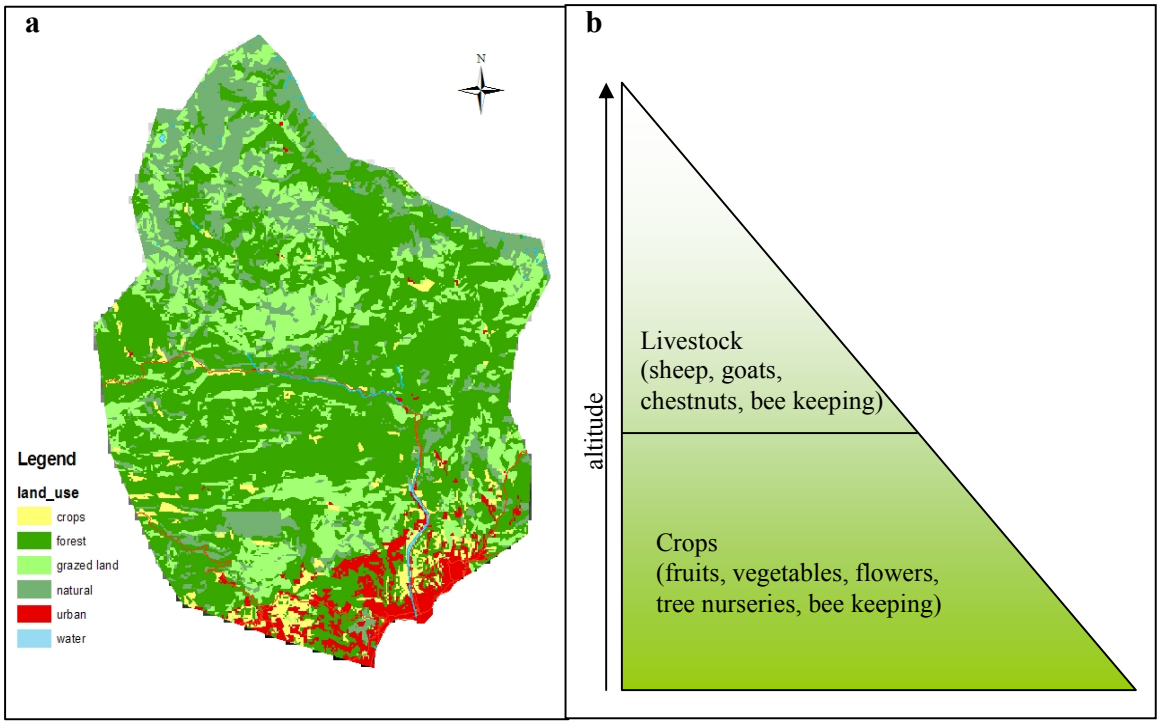

Figure 1. a) Land use map of the Var catchment and b) a schematic overview of agriculture in the Var catchment where practices are divided according to altitude.

Data collection

Data were collected by interviewing: five stakeholders (an olive farmer who is the leader of a farmers association, a civil engineer from the water department, a planning developer, an EU representative and a nature conservationist), three local residents and by reviewing the available literature (Fig 2). Particular emphasis was placed on information related to the current situation, future situation and where conflicts may occur between sectors (Appendix A). Additionally, stakeholders were asked to provide their views on the future of the Var catchment and their concerns for the area (Appendix A). The majority of literature provided information on agriculture from the Alpes de Haute-Provence and the Alpes-Maritimes. As the Var catchment occupies 80% of the Alpes-Maritimes, data from this département were considered relevant and accepted as applicable to the Var catchment.

The most important drivers and pressures were identified and the connections among them considered. Current processes influencing the agricultural sector of the Var catchment were then listed. The four scenario scheme (Global Orchestration, Order from Strength, Techno

Garden and Adapting Mosaic) of the Millennium Ecosystem Assessment (MA 2003, 2005) was used to explore plausible futures for agriculture and the contribution agriculture makes to ecosystem services and human well-being. Temporal scale is important when constructing MA scenarios and in this report scenarios were developed to the year 2050. For each scenario the drivers were weighted based on regionalised data that was provided by the synthesis group (the working group that combined information from all sectors operating within the catchment). The weightings of the drivers, coupled with generalised scenario storylines, allowed future and more specific storylines and adaptation strategies to be developed for the agriculture sector. At all times, the relationship between agriculture and the other sectors was considered, analysed and built into the final assessment.

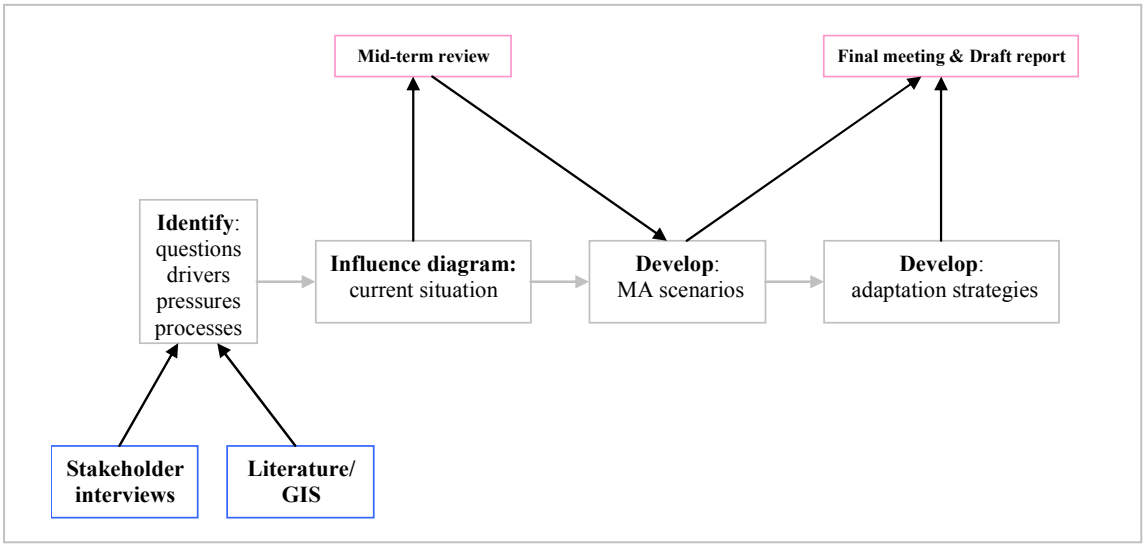

Figure 2. Process of scenario development for the agricultural group.

Results

Stakeholder perspective on agriculture

All stakeholders emphasised the importance of agriculture in the Var catchment. The olive farmer, the EU representative and the nature conservationists were concerned about agriculture and propose adaptation strategies for the future. In contrast, the civil engineer and planning developer emphasised the possibilities for conflicts with agriculture.

Current situation of agriculture: drivers and pressures

Current agricultural practices in the region, and the subsequent provisioning of ecosystem services, are influenced by drivers and pressures (Fig 3). The primary drivers are the 'economy' and 'policy'. Under current economic conditions, income and tourism have a positive trend on ecosystem services. However, the economic viability of agriculture in the Var catchment has declined in recent years. This has encouraged farmers to consider ecotourism and farm tourism as an additional source of income. Policies also drive agricultural practices and these operate at different scales (e.g. EU Directives, French National Policies and local policies from the Council General). Agriculture in the Var catchment is dependent on subsidies, which are central for farmers maintaining market competitiveness and financial security.

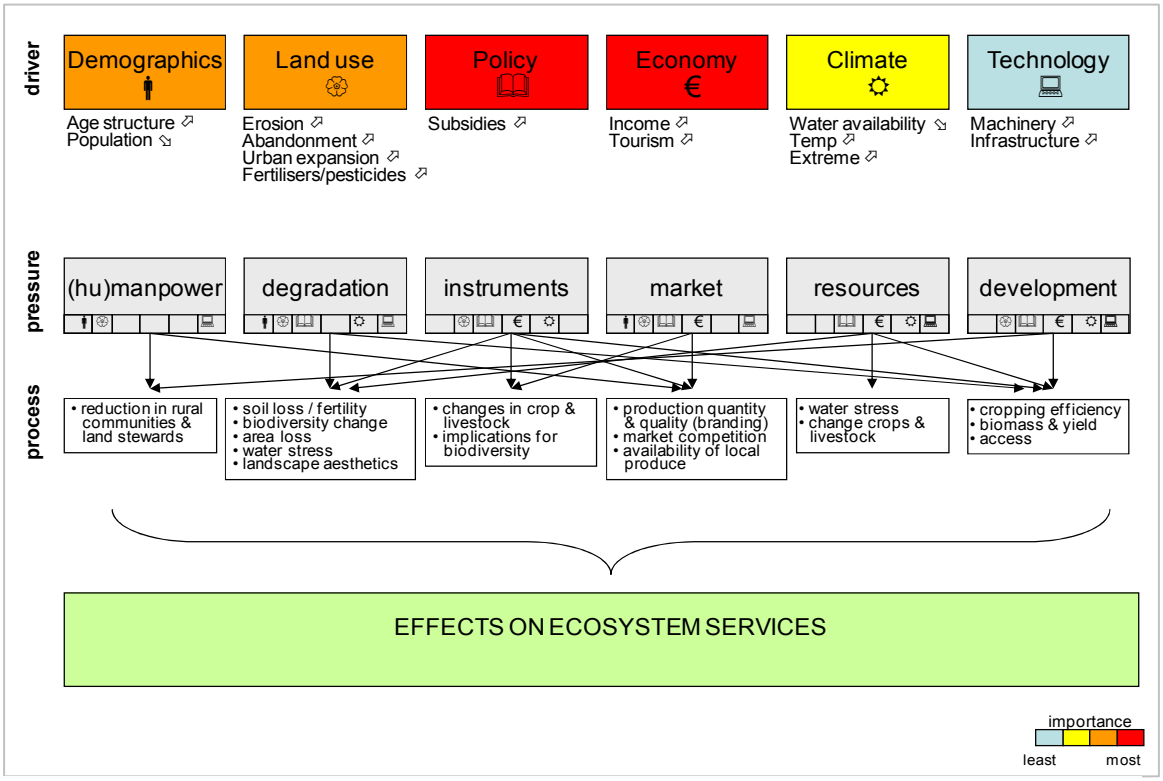

Figure 3. Current situation of the agriculture sector. The importance of each driver is indicated by colour (red most important, blue the last important). Arrows next to the indicators show trends (⇗ increase, ⇘ decrease). Symbols represent drivers and are used to indicate the influence of drivers on pressures.

Other influential drivers are 'demographics' and 'land use'. Changes in the rural population have occurred as many young farmers leave the catchment. This is resulting in an older age structure and lack of successors to manage the land. As a consequence there is a reduction in the transfer of traditional ecological knowledge and land abandonment. Land use changes are occurring, as there is an increased investment in housing and infrastructure. This is diminishing the cultural and historic identity of the landscape. Increasing demand on production is also resulting in land use intensification in the lower catchment. Non-traditional crops are being grown and the use of the machines, fertilizers and pesticides are on the rise. This has led to land degradation (e.g. soil erosion, loss of soil quality) and depletion of other fundamental ecosystem services (e.g. water).

Of growing concern is the impact of 'climate change' on the alpine region. This area currently experiences a higher increase in temperature than the European average, and is therefore more susceptible to the impacts of climate change. Extreme weather conditions are becoming more common, increasing the likelihood of droughts, fire floods and landslides. Fresh water is a major concern for farmers in the region and the area is already experiencing water stress. Grazing is the primary agricultural practice in the upper catchment. This region is also a popular tourist location and conservation area. As a result there is growing conflict between conservation and grazing, one such example is the

conservation of the local wolf population and the threat posed to livestock. Another potential conflict is grazing and conservation of biodiversity. Grazing is important for maintaining the diversity of flora, fauna and the 'openness' of the landscape; however, overgrazing may lead to land degradation and this may become more likely with the additional stress of climate change.

Impacts on ecosystem services

The ecosystem services that are provided by agriculture in the Var catchment include several provisioning, cultural, regulating and supporting services (Appendix B). These services are differentially affected under each of the four scenarios (Table 2). For example, the provision of ecosystem services is positively affected in the scenario Adapting Mosaic but is largely negatively affected in the scenario Global Orchestration.

Table 2. Ecosystem services (ES) provided by agriculture in the Var catchment. Impacts on the provision of ES are indicated according to future Millennium Ecosystem Assessment scenarios (decrease ↓, stable →, or increase ↑). Note, not all ecosystem services are included.

ES	ES sub-category	Scenarios			
		Global Orchestration	**Techno Garden**	**Order from Strength**	**Adapting Mosaic**
Provisioning	Agricultural products	↓	↑	↑	↑
	Water provision	→	↓	↓	↑
Cultural	Landscape aesthetics	↓	↑	↓	↑
	Cultural heritage	↓	↓	→	↑
Regulating	Climate regulation	→	↑	→	↑
	Habitat mosaic/diversity	↓	↑	↓	↑
	Fire prevention	→	→	→	→
Supporting	Biodiversity/wildlife	↓	↑	↓	↑

Storylines

Narratives storylines, specific to agriculture in 2050, were constructed for each scenario. These are plausible, provocative and relevant accounts of how the future might unfold. They are not forecasts, projections or predictions. While potential conflicts and adaptation strategies are considered in these storylines, further details are provided in Table 3 and Appendix C and D.

<u>Global Orchestration</u>

Declines in agricultural subsidies coupled with a liberalised global market have negative impacts on rural agriculture. Rural-urban migration results in a decreased labour force as young people move to the city. As a consequence, land is abandoned and traditional landscapes are lost. The Var catchment is affected by extreme droughts and an increased risk of wild fires in the summer, due to climate change and natural reforestation of abandoned pastures. Environmental problems are considered with a reactive approach which increases the vulnerability of farmers and threatens the fundamental goal of improving the well-being of all people. Farmers should increase the quality of their

products and initiate a form of branding to compete more effectively on the global market. Diversifying income via ecotourism or farm tourism could further increase the resilience of farmers. Conflicts with other sectors are expected to reduce although growing settlements could lead to conflict with resident farmers.

Techno Garden

Agriculture relies strongly on technology and highly managed systems. A reduction in agricultural subsidies with a concomitant increase in ecosystem-orientated subsidies promotes agricultural diversification as farms attempt to supply ecosystem services rather than solely maximise food production. Investment in education and green technology increases. Agricultural techniques are refined to increase both the productivity and sustainability of farming activities but, because of this, many traditional methods and cultural practices are lost. In the lower regions, genetically modified crops reduce the vulnerability of farmers to climate change. The agricultural sector is pressured to focus on the local market but continues to contribute to thriving rural communities. Development of well-located infrastructure (e.g. public transport) helps maintain the rural population and offers increased opportunities for tourism. New technologies increase the efficiency of water use and water distribution. Land conflicts arise between agricultural land owners and housing developments for urbanisation.

Order from strength

A regionalised and fragmented world has a negative impact on the environmental, social, and economic dimensions of the agricultural sector. The population takes a reactive approach to environmental problems; land use intensification, an increase in water demand, a reduction of biodiversity and an increase in soil loss occur without considering the possible impacts on the natural world. Conditions for crops are suboptimal and ecosystem services become less resilient. Conflicts occur due to the high demand on water from the agriculture sector. Improved irrigation techniques, sustainable farming, implementation of conservation measures and environmental education are required.

Adapting Mosaic

Regionalisation and environmental awareness strengthen the agricultural sector in the Var catchment. A market for agricultural products and the support of environmentally friendly landscape management lead to an improved livelihood for farmers. However, the decline of tourism translates to a decline of a second income source in the region resulting in a high dependency on agricultural production. The awareness of climate change impacts and the use of green technology lead to the efficient use of water thus avoiding conflicts in the area. Ecosystem services provided by agriculture are in good condition. To become more independent from the local market farmers could provide high quality produce for the international sector. Furthermore, the diversification of crops and the use of cultivars adapted to warmer climates could enhance the resilience of farms. Some conflicts are expected between shepherds and groups supporting wolf conservation; to increase the acceptance on both sides education is needed.

Discussion

How will agriculture develop in the Var Catchment in the future?
Agriculture will develop differently under each scenario due the changing influence of drivers and pressures. Under the Global Orchestration (GO) scenario, agriculture will be detrimentally affected; total area will diminish and production will be less sustainable. In contrast, the Adapting Mosaic (AM) scenario will enable agriculture to prosper and become more sustainable. The difference between these two scenarios is likely due to the economy. As the main driver in the GO scenario the economy pushes the demand for unsustainable production with limited consideration for ecosystem services. In comparison, 'policy' is the main driver under the AM scenario. Policies will focus more on small-scale practices that maintain ecosystem services (e.g. permaculture) and will create a shift to more sustainable agricultural practices.

Under all scenarios, there will be a transition to increasingly mechanised agriculture resulting in greater efficiency and land use intensification. This transition will be spurred by changes in 'policy' drivers. New technologies will be developed for Techno Garden (TG) and AM. Land use intensification will result in an overall degradation of ecosystem services and will be most prominent under the Order from Strength (OFS) scenario. Green technologies developed under the AM scenario are likely to produce the most sustainable outcome due to the consideration of environmental capital rather than economic growth as observed in TG.

What will be the challenges the agriculture sector has to cope with?
The stability of the agriculture sector within the catchment will be influenced by socio-economic changes. 'Demographics' will be a primary driver behind rural development in the catchment, and will contribute to changes in the population structure. Under GO, OFS and TG there will be an increase in the age of the population resulting in an overall reduction in the "renewal" of farmers (i.e. young generation of farmers). In all scenarios population will increase, with a general upward trend in residency rate, except for GO. This increase in population will have subsequent effects on the economy in the catchment.

The 'economy' will be an important driver for employment and income generation in the area. There will be a strengthened economy under all scenarios except for AM; however, there will be an overall increase in rural employment. The economy will also influence the available market for agricultural products. In the OFS and AM scenario the economy will foster local markets within the region. In contrast, GO and TG will see an overall reduction in local markets forcing the agricultural sector to consider broader international markets. There will be a general trend towards land abandonment and a reduction in land conversion in GO due to limited investment in rural communities. In all other scenarios, land abandonment and conversion is limited.

In all scenarios the catchment will become increasingly vulnerable due to the driver of 'climate change'. Most climatic stress will be experienced in the upper catchment which has delicate alpine pastures. Climate variability will increase the pressure on water resources especially during periods of drought. The frequency of fires may also increase in

Table 3. Impacts, adaptations and conflicts for agriculture under the four Millenium Ecosystem Assessment scenarios

	Global Orchestration	**Techno Garden**	**Order from Strength**	**Adapting Mosaic**
Impacts	- higher economic risk for farmers - decreased agricultural area and production - higher drought risk - loss of biodiversity/cultural landscape	- more viable rural communities - optimised agricultural techniques - increased water demand - weakened local market - increased subsidies for ES	- land use intensification - increased water demand - increasing local market - soil and biodiversity loss	- more sustainable agriculture, biodiversity and soil quality - increased use of green technology - increased water demand - increasing local market
Adaptations	- education of farmers - diversification of crops - increase quality of products - regionalized policy for conservation and fire control	- new technologies for increased water demand - promote local products - diversification of crops - increase infrastructure	- improve irrigation techniques - support sustainable farming - implement conservation measures - focus on local market	- drought-resistant crops - promote local tourism - green technology - focus on local market
Conflicts	- decline of agriculture - decline of potential conflicts	- land conflicts with growing cities - technology minimizes water conflicts	- land conflicts with cities - water conflicts - nature conservation (wolf, intensive agriculture)	- nature conservation (wolf)

the area due to drier conditions and changes in grazing regimes. In the lower catchment other extreme weather events may lead to flooding and landslides resulting in a loss of arable landscape and infrastructure.

How can agriculture safeguard local livelihoods and biodiversity in a changing environment?
Adaptation strategies will be necessary to maintain ecosystem services under all scenarios. Agricultural practices will have to diversify to capture available markets and adapt to climate change. Such diversification will be influenced by 'policy' drivers that maintain or shift production according to the political situation.

Population growth and the associated demand for agricultural products will also be a major driver for protection of livelihoods and biodiversity. New markets will develop and this will create new opportunities for 'rebranding' and creation of 'niche' markets. The number of tourists visiting the region will increase, providing opportunities to develop ecotourism and farm tourism that would integrate conservation and sustainable agricultural practices. A greater emphasis on education will be necessary to facilitate change and adaptation for all stakeholders.

Future research
The development of the MA scenarios for the catchment provides a platform for identifying areas of weakness and direction for future research. While each scenario has different implications for the agricultural sector, there are still many areas of uncertainty. Some of the key areas for future research are considered:

- Long-term trends (i.e. after 2050) in climate change for the region for forecasting impacts and the development of adaptation strategies;
- Improve our understanding of ecosystem resilience and capacity to adapt to different conditions;
- More broadly consider functional diversity and its links with ecosystem services;
- Improve understanding of the productive capacity of areas within the catchment;
- Specifically consider ecosystem services according to sub-category (supporting, provisioning, regulating, cultural) and agriculture by sector (e.g. livestock, crops)
- Greater understanding of the externalities of development in the region; and
- Methods for capacity building and educating farmers within the region.

Literature

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Appendix A. Stakeholders views of agriculture in the Var catchment.

Stakeholder	Current situation	Future issues	Possible conflicts
Farmer	Old age of farmers Decreasing number of farmers Decreasing ground water level Traditional practices Land abandonment Soil erosion Farmers open to tourism Fire and drought more frequent Irrigation in most fields Few machines Difficult to apply for subsidies	More help from government Involve politicians in region Increase tourism	Wolf attack High water demand
Civil Engineer (Water)	Highest water consumers	Reduce water use in agriculture Consider sustainability Technical solutions Financial assistance to install water recycling	High water demand Water quality
EU Representative	Monoculture	Diversify agriculture Support agricultural activities Focus on local market	
Nature Conservationist	Increased fire risk (undergrazing) Ecotourism Extensive agriculture preferred Problems with overgrazing Good relationship with farmers	Organic agriculture Keep landscape open	Leaching Wolf attack Overgrazing Increased fire risk (undergrazing) Intensive agriculture
Planning Developer		Support local markets Recycle water Improving infrastructure	Urban-rural transition

Appendix B. Ecosystem services (ES) provided by agriculture in the Var catchment.

ES category	ES sub-category
Provisioning	Livestock
	Crops, beekeeping
	Gathering goods
	Ornamental plants
	Therapeutic/cosmetic plants
Cultural	Recreation/relax
	Ecotourism
	Landscape beauty
	Cultural heritage
	Education / information
	Scientific research
	Traditional ecological knowledge
Regulating	Pollination
	Climate regulation
	Habitat maintenance
	Food web maintenance
	Fire prevention
Supporting	Genetic resources
	Soil formation
	Biodiversity
	Nutrient cycling

Appendix C. Influence diagrams under four different scenarios i) Global Orchestration ii) Techno Garden iii) Order from Strength and iv) Adapting Mosaic. In all figures, the importance of each driver is indicated by colour (red the most important, blue the last important). Arrows next to the indicators show trends (⇗ increase, ⇘ decrease). Symbols represent drivers and are used to indicate the influence of drivers on pressures.

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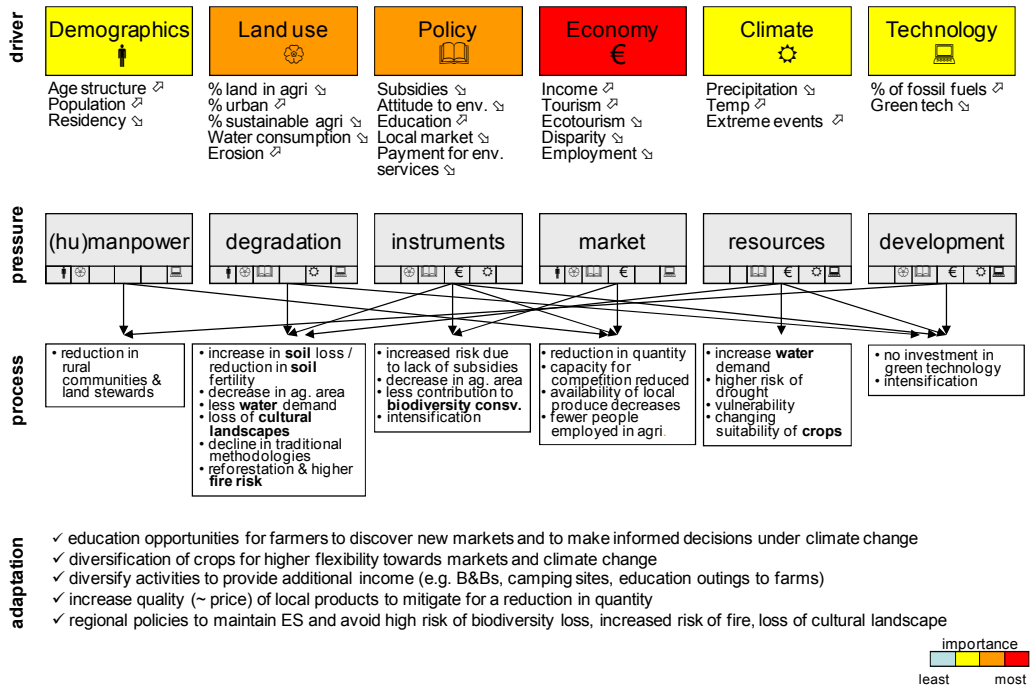

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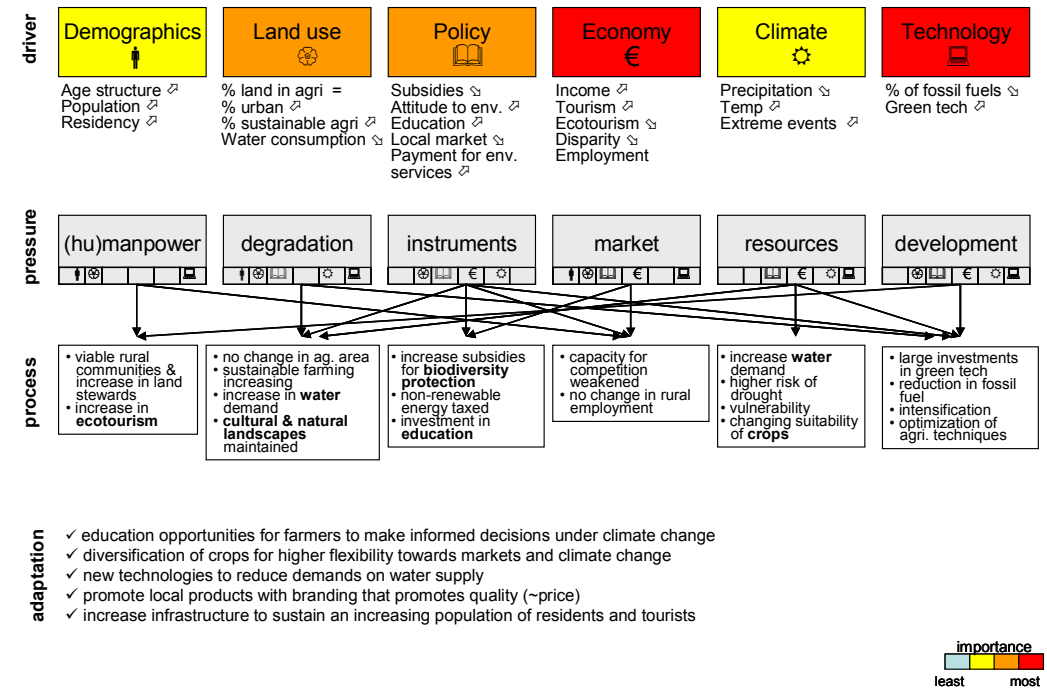

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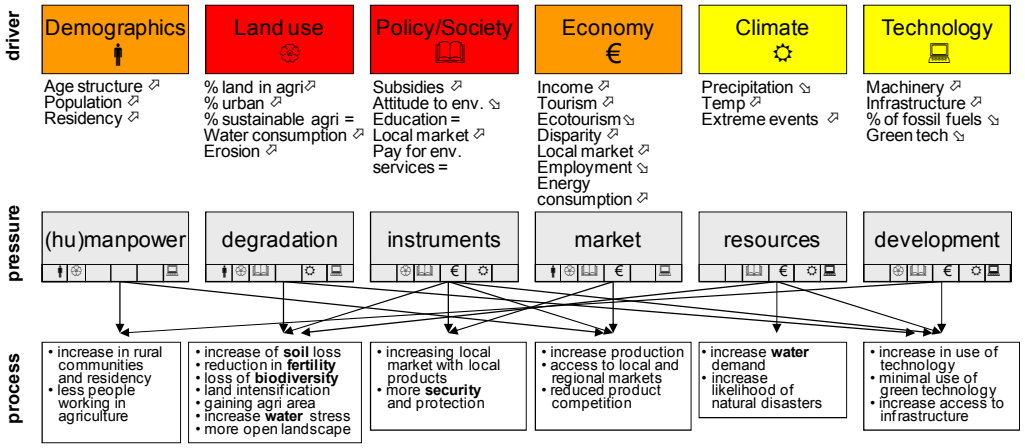
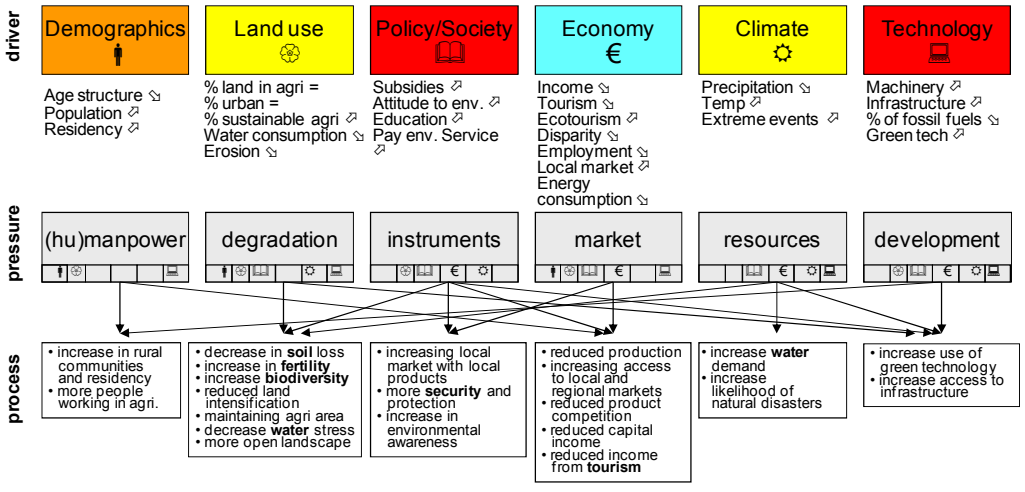


adaptation

- ✓Provide incentives for people to stay in agriculture
- ✓Educate farmers to develop sustainable farming practices and promote organic agriculture
- ✓Introduce water saving technology and waste water recycling
- ✓Introduce crops resistant to water and temperature stress
- ✓Reduce energy consumption by increasing labour or develop technology
- ✓Develop local product security by developing high quality ´niche´ products to appeal to ecotourists
- ✓Promote attitudes towards the environment at all levels – public, farmers, consumers, managers
- ✓Provide compensation to farmers who are affected by climatic extremes – drought, fire, water shortage

iv



adaptation

- ✓Introduce crops resistant to water and temperature stress
- ✓Incentives to support tourism in the area
- ✓Provide social security/service for the community
- ✓Develop local product security by developing high quality ´niche´ products
- ✓Increase income by providing access to regional and international markets
- ✓Provide compensation to farmers who are affected by climatic extremes – drought, fire, water shortage

Appendix D. Schematic overview of the i) impacts, ii) adaptation strategies and iii) conflicts experienced by the agricultural sector under the four MA scenarios.

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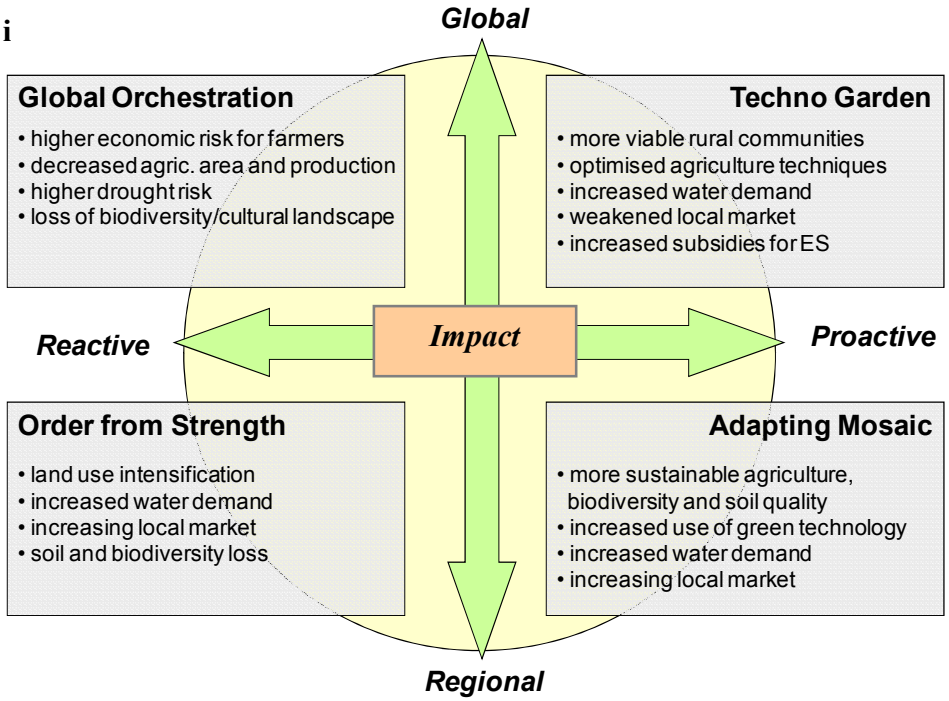

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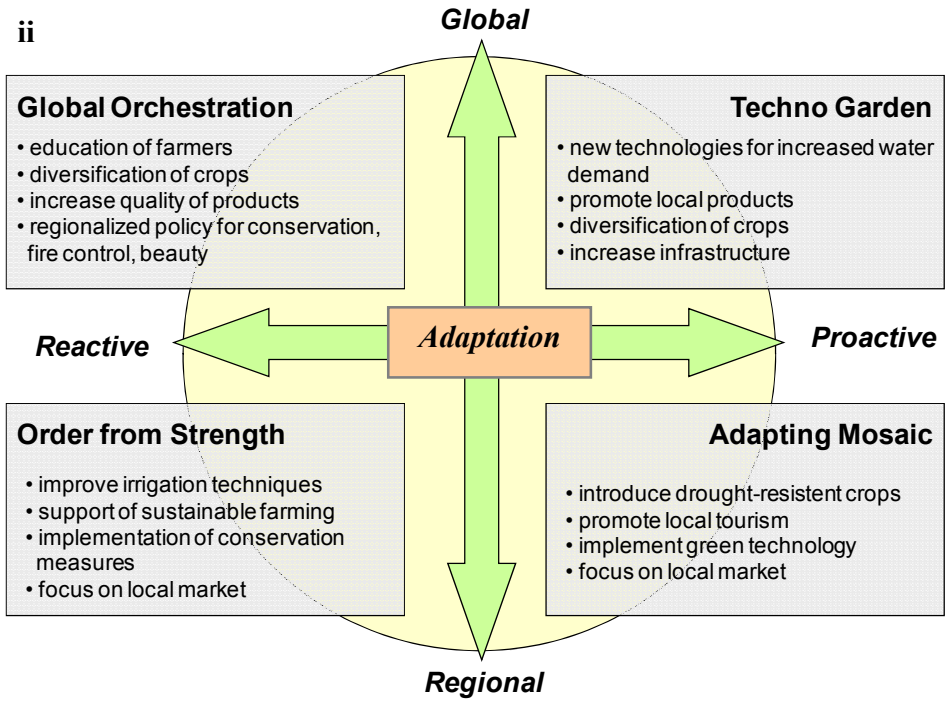

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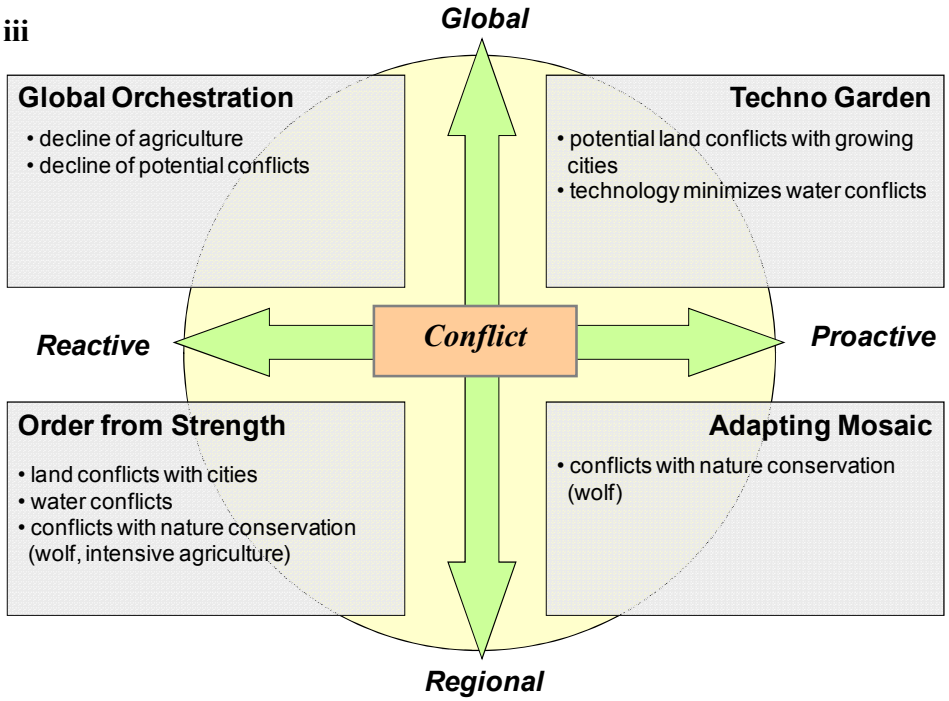
Global
Global Orchestration
• decline of agriculture
• decline of potential conflicts
Techno Garden
• potential land conflicts with growing cities
• technology minimizes water conflicts
Reactive
Conflict
Proactive
Order from Strength
• land conflicts with cities
• water conflicts
• conflicts with nature conservation (wolf, intensive agriculture)
Adapting Mosaic
• conflicts with nature conservation (wolf)
Regional