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Combining two approaches of integrated scenario development to combat desertification in the Guadalentín watershed, Spain

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Abstract. Desertification in Spain is a largely society-driven process, which can be managed effectively only through an understanding of environmental, sociocultural, and economic driving forces. This calls for a more active role of decision makers and other stakeholders. We present two promising approaches—participatory stakeholder workshops and a spatial policy support system (PoSS)—to develop future scenarios of land-use change for a watershed in Spain. We furthermore discuss the efforts involved and the added values of combining both methods. Based on two local workshops, three scenarios were constructed, which were subsequently formalised, parameterised, and quantified. We conclude that there are large advantages of linking narrative storylines and a spatial PoSS. Storylines ensure an active participation of a large range of stakeholders, additionally offering the possibility to develop highly integrated scenarios. The PoSS provides a spatially detailed and quantitative output, that can also be used to check the internal consistency of the qualitative scenarios. Linking stories and models can thus open the way for more successful management strategies to combat land degradation.

1 Scenarios to combat desertification

Over the past decades the causes and consequences of land degradation and desertification in the Mediterranean region have been identified, monitored, and modelled in a large number of different studies (see eg Brandt and Thornes, 1997; Geeson et al, 2002; and Van der Leeuw, 2000, for an overview of recent efforts). In recent years the emphasis has shifted from analysing direct and proximate causes and consequences of land degradation to adaptive management approaches. This calls for a much more active role of decision makers and other (local) stakeholders during all phases of the process, also because it is increasingly realised that desertification can be reversed only through profound changes in local and (inter)national behaviour. Awareness raising, education, and training are important additional goals of the involvement of stakeholders. Such a participatory approach creates a sweep of new challenges and a need for development of new methods and the novel application of existing ones.

1.1 Definition, concepts, and key scenario development methods

In the context of this paper we will discuss the potential of scenarios as a tool for combating desertification. A scenario is defined as a story—that can be told in both words and numbers—offering an internally consistent and plausible explanation of how events unfold over time (Gallopín et al, 1997; Raskin et al, 2002). Scenarios are about envisioning future pathways and accounting for critical uncertainties. The process of building scenarios is about asking questions, as well as providing answers and guidance for action, and as such is a promising tool to combat desertification. The intention of scenario development is to consider a variety of possible futures that include important uncertainties, rather than to focus on the accurate prediction

of a single possible future (Peterson et al, 2003). Kahn (Kahn and Weiner, 1967) and others were pioneers in developing scenarios for strategic planning applications. Scenarios were refined at Royal Dutch/Shell by Wack in the 1970s and 1980s, and Shell became a leader in the scenario approach to business planning (Wack, 1985). Today scenario development is used in a variety of different contexts ranging from political decision making, to business planning (Schwartz, 1996; Wack, 1985), to local community management (Peterson et al, 2003; Wollenberg et al, 2000) and understanding global-scale environmental patterns and processes (Gallopín et al, 1997). This variety of applications has spawned a broad variety of methods that have been employed. In the context of land use, spatial models have traditionally been used frequently. Increasingly, decision makers and other stakeholders are being involved in the process in different ways (see Van Asselt and Rijkens-Klomp, 2002). The combination of quantitative models and more qualitative participatory methods to develop scenarios is currently being advocated as a promising way forward (Alcamo, 2001; Kok et al, 2007).

Therefore, the focus in this paper is on two distinct scenario development methods: the development and use of decision, planning, or policy support systems (here abbreviated as DSS) and the organisation of stakeholder scenario workshops; thus we include a qualitative and a quantitative method.

1.2 Decision, planning, and policy support systems

In the broadest sense, land-use-related DSSs are usually developed to communicate the results of land use and land degradation to politicians and decision makers as well as members of the public at large, to visualise the consequences of implementing different policies, and to aid complex decision making (see eg De la Rosa et al, 2004; Shim et al, 2002). DSSs are often developed in an iterative process in which end users, scientists, and IT-specialists are involved. The emphasis of stakeholder involvement is normally during the first and the final stages of the process—that is, during the problem formulation and first design phases, and when using the final product. The actual development of the DSS is largely in the hands of scientists and programmers, although stakeholders are usually consulted to discuss the formal system description. The primary goal is to develop an interactive tool that can be used for policy support. Once the tool has been developed, it can be used by consultants or technicians supporting policy makers in individual or workshop sessions. The product is a quantitative, for land-use-related questions often spatially explicit, tool that can generate detailed maps and time graphs of the consequences of external impacts, autonomous developments, and certain (policy) actions.

1.3 Participatory storyline development

Participatory approaches range from in-depth interviews and questionnaires to workshop settings in which a group of stakeholders meet regularly (see Van Asselt and Rijkens-Klomp, 2002). Besides communication of the consequences of management on land use, the engaging of stakeholders in a process of long-term participation, mutual learning, and conflict resolving is often an important additional key issue. Qualitative approaches are often employed, especially when stakeholders include lay people. Within the earth sciences, participatory scenario development has recently been gaining support. Excellent overviews of the state of the art of scenarios in land-use planning have been given by Xiang and Clarke (2003) and Shearer (2005) in this journal. The participatory approach described here is aimed at the development of qualitative scenarios, based on methods similar to those described in these papers.

1.4 Combined strength

Scenario development using (spatial) DSSs and during stakeholder workshops both have their own focus and their own potential specific strengths. The main advantage of using a DSS is that relationships are quantified and documented. The modelling framework within the DSS, and thus the resulting scenarios, is internally consistent, transparent, and can always be reproduced. Additionally, the system is usually an integration of modules that cover a number of different disciplines. It is thus well suited to tackle complex interactions between, for example, climate, price change, soil erosion, and the impacts on desertification. Finally, the type of DSS presented here produces highly detailed spatial results. On the other hand, during stakeholder workshops, a wider range of stakeholders, from laymen to students to computer experts, can be involved in the actual scenario development. The scenarios are qualitative and therefore very flexible, because they do not depend on data availability or computing limitations. The complementarity between both methods is potentially high, particularly in the setting of the rural Mediterranean, where stakeholders and decision makers are not very familiar with spatial models.

There are more examples of linking qualitative and quantitative scenarios, at a variety of scales. Worth mentioning are the Millennium Ecosystem Assessment (Carpenter et al, 2005; Lebel et al, 2006); and EURURALIS (Westhoek et al, 2006). What distinguishes *MedAction* from these examples is that both the spatial model and the qualitative scenarios were developed in parallel during the course of the project and therefore had the same aim of combating desertification. A second distinguishing factor is the strong influence of laymen during the qualitative scenario development and the large flexibility that they were given while developing storylines. The added value of this paper is a critical presentation and evaluation of the methods that were used when linking qualitative and quantitative scenarios. Special attention is given to the (differences in) underlying perceptions, worldviews, and key assumptions.

2 Background

2.1 The Guadalentín watershed

The Guadelentín is a small watershed in southeastern Spain (see figure 1). The climate is semiarid with an annual precipitation of 200 – 300 mm/year. The area is relatively sparsely populated, although urbanisation and industrialisation rates are high. Immigration from Morocco and Ecuador has had a severe social impact. Tourism has recently become more important with the construction of residential areas and large-scale development plans for a number of golf courses. Because of its long land-use history, large parts of the region are already severely degraded. The top map in figure 4 shows the land-use map with current land uses—the most important being *irrigated agriculture* along the valley bottom, extensive areas of *dryland agriculture*

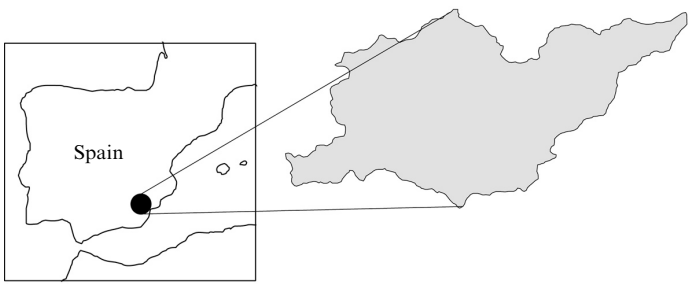

Figure 1. Location of the Guadalentín watershed.

on the less steep slopes to the northwest, and *natural vegetation* on the steeper slopes. The main roads, as well as the major population centres, are located in the valley bottom.

2.2 Institutional setting and methods employed

The work described in this paper was part of a larger EC-funded project, MedAction (De Groot and Rotmans, 2004). The methodology to construct scenarios in this project built on its predecessor, the VISIONS project (Rotmans et al, 2000; Van Asselt et al, 2005), and was executed by the same institutes, the International Centre of Integrative Studies (ICIS) and the Research Institute for Knowledge Systems (RIKS). There are a few small but significant differences between the methodology employed in VISIONS and in MedAction. Most importantly, rather than having scientists in the project combining a number of storylines into scenarios and 'visions', local stakeholders within MedAction constructed the scenarios completely themselves. This created a greater sense of ownership and maximised the incorporation of stakeholders' perception in the scenarios. Secondly, MedAction scenario development aimed at a discussion of short-term, concrete actions, besides the construction of long-term visions. And finally, the policy support system (PoSS) developed in MedAction is far more comprehensive; the land-use model used in VISIONS is only one out of fifteen modules in the integrated MedAction PoSS.

The overall aim of MedAction was to develop an information and decision-support base on land degradation to assist decision makers from the local to the European level in the formal and informal decision-making and policy-making process to combat desertification in the northern Mediterranean region. The specific problems of desertification and mitigation measures were addressed at the European, Mediterranean, and local scales, with the ultimate goal to aid sustainable land management at the local level. Work was carried out in four local case studies. Only the result of the work in the Spanish case study (Guadelentín) is reported here. A simplified flowchart of the main activities within MedAction is given in figure 2, highlighting the components important in this paper.

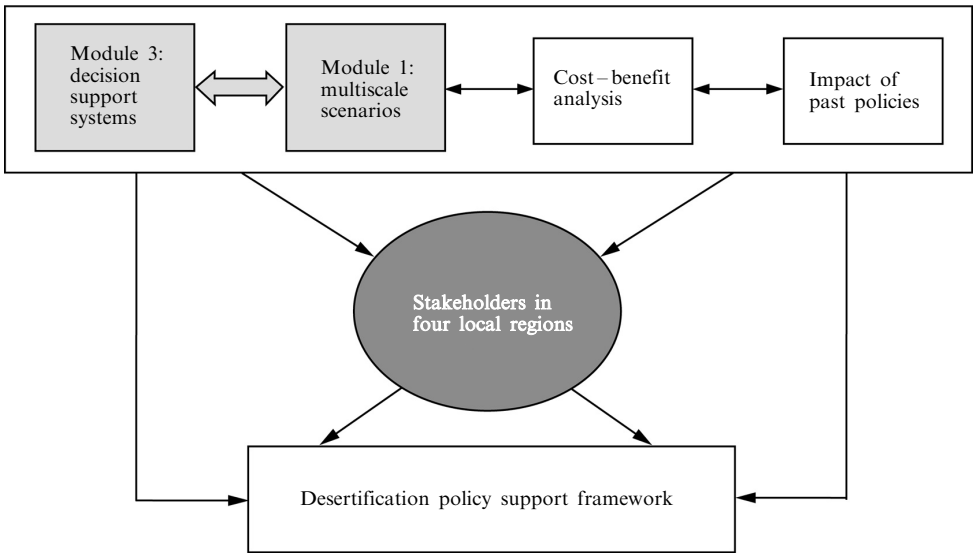

Figure 2. Simplified flowchart of main activities within MedAction. The grey shading indicates components important to this paper.

The final goal of module 1, coordinated by ICIS, was to develop multiscale (land-use change) scenarios, focusing on land degradation and desertification, using participatory methods. Within module 3, policy and decision support systems were constructed that were used to develop guidelines on, and to contribute towards, policy formulation for land use in the four case studies. At RIKS, a PoSS for the Guadalentín watershed in Spain was developed.

2.3 Participatory scenarios

Narrative storylines were developed at European (Kok et al, 2003), Mediterranean (Kok and Rothman, 2003), and local (Kok and Patel, 2003) levels, following a primarily top-down approach. First, the three European scenarios developed within VISIONS were enriched with information on a variety of factors and sectors relevant to the rural Mediterranean. These were subsequently downscaled to the Mediterranean level and served as a main input during local scenario development. The three scenarios were named *convulsive change* (focus on climate change); *knowledge is king* (focus on technology); and *big is beautiful* (focus on an expanded EU and multinationals and the consequences thereof).

2.3.1 *Local scenario development—purpose and methods*

The process of local scenario development set out to actively engage key local stakeholders in a dialogue process in which they could discuss and create a series of different futures, as well as to propose a series of short-term actions and policy options in accordance with each of the respective scenarios. As such, the primary goals were both to provide conditions for an active learning environment and to encourage participants to reach common ground as to the causes and realities of desertification in their region, resulting in stories of the future of their region. A vital step in the process was the selection of stakeholders (see Wollenberg et al, 2000). We aimed at a very broad selection, involving, among others, policy makers and farmers, but also laymen, such as poets and other free thinkers. A first selection of about forty-five stakeholders was made, out of which around thirty five were invited to the first workshop and around twenty five participated. As the stakeholders themselves also noted, the main group that did not show up at the first workshop were the farmers. The location of the first workshop was too far away from the study area, and not enough attention was paid to the cropping calendar and to other farmers' activities. These factors were successfully taken into account and increased farmers' participation during the second workshop. From questionnaires that were handed out immediately after each workshop it was concluded that the participants valued the discussion time that they had (Patel et al, 2007) and that they were eager to continue the discussion (Kok et al, 2006b), although they criticised the limited time that was available. Patel et al (2007) provide a detailed analysis of the participatory process that was undertaken.

2.3.2 *Local scenario development—products*

In the Guadalentín three workshops were organised in 2002–03, which resulted in a small number of largely qualitative scenarios, in the form of storylines, collages, and cognitive maps. The workshops yielded four main products, which are summarised in table 1. During 'the story of the present' stakeholders individually noted down a number of main factors, the connection between which was discussed afterwards. The end product was a flowchart that characterises the perception of the local stakeholders on the situation in their region and the current drivers of (land-use) change. A set of 'stories of the future' was obtained during a forecasting (see Kasemir et al, 2000) session, during which the stakeholders discussed possible future pathways of change based on a number of Mediterranean scenarios. The main product was a number

Table 1. Main results and methods employed during stakeholder scenario workshops within module 1 of MedAction.

	Present (2003)	Short term (2008)	Long term (2008 – 30)	Long term (2030)
Workshop number	1	2	2	1
Date	October/ November 2002	June/July 2003	June/July 2003	October/ November 2002
Grouping	individual and all	groups and all	groups	groups
Main method	Post-its® and discussion	discussion	backcasting	collage and forecasting
Results	current situation	major current trends	desirable futures	'visions'

of collages portraying the situation in 2030. During 'the extension of the present', stakeholders were asked to extrapolate current trends in agriculture, tourism, water availability, and environmental resources five years into the future. The discussions resulted in detailed descriptions of the main trends in agriculture and tourism. The desirable futures were obtained by means of a backcasting exercise (Dreborg, 1996; Robinson, 2003), reasoning back from a desirable end point in 2030 to short-term measurements that are necessary to realise this future. The stakeholders focused on desirable futures that can be typified as sustainable, multifunctional agriculture integrated with ecotourism. The diversity of methods provides a good overview of the perception of stakeholders on the present situation, short-term fears, long-term hopes, and long-term expectations.

Details of the methods employed and results obtained can be found in Kok et al (2006a; 2006b) and on the MedAction website—http://www.icis.unimaas.nl/medaction/download.html.

2.4 Policy support system

Spatial DSSs are all explicitly designed to support a decision process for complex spatial problems. Decision support systems are generally designed to support short-term policy making by isolated individuals and business organisations (Clarke, 1990). Planning support systems and PoSSs on the other hand, focus more on strategic issues and group discussions. The system developed within MedAction is termed a PoSS, and is similar to planning support systems as defined by Geertman and Stillwell (2003). They describe them as being designed to provide support to ill-structured problems, playing particular attention to long-range problems and strategic issues and being explicitly aimed to facilitate group interaction and discussion (for examples of good recent discussions see Klosterman and Pettit, 2005; Pettit, 2005). The PoSS differs, however, in its practical application. The PoSS is not a task specific system; rather, it is intended to provide support in the integrated design and implementation of a wide range of policies targeted to water resources, sustainable farming, land degradation, and desertification. In addition, the PoSS aims to be applicable in a diversity of situations: detailed analyses by scientists or technicians; support during participatory sessions with stakeholders; and communication with the larger public.

The PoSS is implemented with the GEONAMICA® application framework,[(1)] which is specifically designed to build PoSSs featuring complexly linked multiscale spatially dynamic models of the kind discussed here (for software specifications see

[(1)] GEONAMICA® is a product developed and commercialised by RIKS bv.

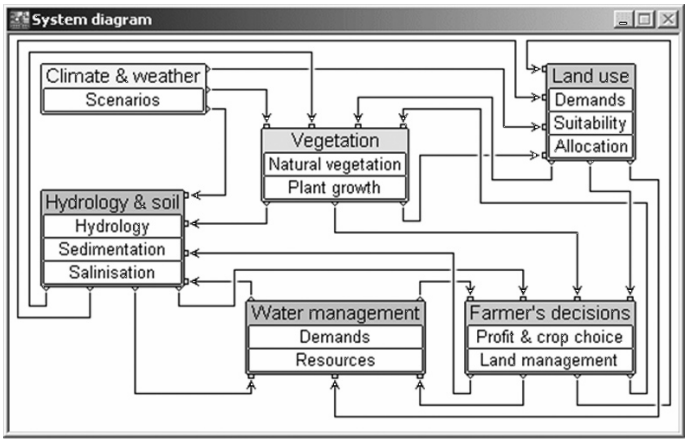

Figure 3. Simplified structure of the policy support system as developed in module 3 of MedAction.

appendix A). Its user interface features a system diagram (figure 3) graphically representing the interacting processes and enabling interactive access to the individual models representing the processes. Thus, the user may enter and change parameter values to specify his inputs, can invoke tools for the analysis and visualisation of the model outputs, and can access the online help system which clarifies the underlying assumptions and formal definitions of the models and the data used.

The core of the system consists of a number of submodels, integrated into a single model that simulates the developments in the region up to thirty years into the future. Driving forces in the MedAction PoSS are demographic and economic growth as well as climate change. The socioeconomic growth is translated into demands for the different land-use functions in the region. The demands are allocated dynamically in the *land-use* submodels, based on the spatial dynamics caused by the detailed interactions among land-use functions, their dependencies on access to infrastructure, the zoning regulations restricting or facilitating particular land uses, and the physical suitability of the land to sustain the functions. For two of the land-use functions—agriculture and natural vegetation—a dynamic suitability map is used, which changes as a result of the combined physical processes represented in the system: soil moisture, soil salinity, fertile soil depth, slope, and temperature. These aspects are in turn calculated in the *climate and weather* and *hydrology and soil* modules, and are influenced by social processes such as water use and land management practices. Dynamic suitability maps are also used in the *vegetation* module and one of the *farmers' decisions* submodels in which crop choices are calculated based on physical characteristics, crop price, water price and use, and social aspects influencing farmers' decision making. The availability of water is calculated in the *water management* module and is one of the main variables in the policy options of the system. All impacts can be measured by means of a number of policy-relevant indicators, which change dynamically during the run of a simulation. More information on the MedAction PoSS can be found in Van Delden et al (2007).

3 Selecting the qualitative scenarios

3.1 European and Mediterranean developments

The selection of local scenarios was limited to those linked to the Mediterranean and European developments, as described within convulsive change:

Climate change accelerates and many regions in northern Europe are overwhelmed by floods, while the south experiences severe droughts, leading to permanent deserts. In the Mediterranean an extensive network of new water pipelines eventually increases water availability, while rainfed agriculture increasingly suffers from lack of water. Eventually, there is a slow but fundamental change in general attitude towards a much more sustainable way of living.

Details on the developments within the convulsive change scenario can be found in Kok and Rothman (2003) and Kok et al, (2006a).

3.2 Local scenarios

The resulting scenario after the forecasting exercise was a pessimistic view of the Guadalentín in 2030, in which the tourist industry and rich farmers profit most from the new water transport network, and agricultural smallholders progressively suffer from drought and gradually disappear. The first scenario (*scenario 1: multiple threats*) is based on this long-term vision. The desirable futures developed in the backcasting scenarios can be characterised as 'sustainable agriculture and sustainable tourism'. Participants envisioned a strong tourist sector, but with ecotourists rather than golf courses and apartment buildings. This would stimulate demand for local, artisan products and boost a local, high-quality, small-scale agriculture. The second scenario (*scenario 2: local sustainability*) is based on the backcasting exercise. A third scenario (*scenario 3: running dry*) was added, omitting one of the key assumptions in the first two scenarios—the construction of a canal from the Ebro River—thus strongly limiting water availability and the effects thereof. The third scenario was not directly formulated by the stakeholders, although the possibility was discussed during the workshops. This selection of qualitative scenarios maximises the variety present in the narrative stories.

4 From qualitative stories to quantitative model input

4.1 Key assumptions in the qualitative scenarios

The final products of the scenario workshops contained a wealth of information on projected factual developments, but were rather poor on the underlying assumptions on which some of the key developments were based. Essential to the successful quantification was therefore making these assumptions more concrete. Much of the information below was based on the observations of the facilitators of the various scenario development groups.

4.1.1 *Quantifiable assumptions*

Local stakeholders were very specific on changes in a number of categories. The main developments and assumptions, grouped by main factors, actors, and sectors (see Kok et al, 2006a) are summarised in table 2. Although the PoSS required more detailed information on many aspects, the translation of the key assumptions regarding *water* (*availability and distribution*), *tourism*, *agriculture*, and *migration* was feasible. Interestingly, the issues that were discussed in most detail overlapped only partly with the expertise of the stakeholders that were present. For example, developments in the tourist sector will only for a very small part depend on local stakeholders. Local changes were thus partly based on assumed (inter)national developments as projected in the higher level scenarios. A wealth of detailed and often quantified information was extracted from the stakeholder workshops on the majority of the important drivers that influence the Guadalentín watershed.

4.1.2 *Nonquantifiable assumptions*

In the workshop process we opted to give considerable freedom to the participants, which led them to discuss the sociocultural factors in great length, perceiving them as

Table 2. Main developments and key assumptions in the three selected narrative storylines, grouped by main factors, actors, and sectors.

	Scenario 1: multiple threats	Scenario 2: local sustainability	Scenario 3: running dry
Factors			
Water availability	Increasingly limited due to drought	Limited, distribution favours agriculture	Strongly limited, no 'Ebro water'
Migration	Rural–urban migration European sunbelt	Fewer permanent tourists	Strong rural–urban migration, fewer immigrants from Morocco
Sectors			
Agriculture	Increasingly difficult position	Multifunctional, favoured for water	Lack of water, although still favoured
Tourism	Booming	Ecotourism, less in numbers	Lack of water stops expansion
Actors			
Businesses	Large-scale, mass tourism, smallholders disappear. Industry important	Small scale favoured, industry under pressure	Lack of water limits developments

essential for the understanding of land-use change and land degradation. This is also because social processes change more rapidly and have a stronger short-term impact than long-term processes, such as soil erosion. For many of those processes it was difficult to translate a quantitative input for the PoSS:

- The projected strong immigration is assumed to cause *a loss of cultural identity*, which enhances out-migration of the local population, which in turn negatively influences cultural identity. In all scenarios this is projected to be an important process.
- Local farmers strongly argued that 'farming' has lost its attractiveness and standing as a profession. Changes in the agricultural sector were strongly linked to this *low social status*.
- Many of the actions of the local population were linked to (un)*happiness*, of which status and cultural identity are two aspects. The starting point of many of the discussions was a decreasing feeling of happiness.

Through discussions with local partners on how these sociocultural changes were to be interpreted, all the factors above were eventually linked to quantifiable parameters in the PoSS.

4.2 Quantification of assumptions

The three qualitative scenarios were then quantified to the extent possible. For all parameters common to the scenarios and the PoSS, it was indicated what the expected change was in each of the three scenarios. Change was semiquantitative, ranging from $+++$ (very strong increase) to $---$ (very strong decrease). This methodology was earlier applied in the VISIONS project (White et al, 2004).

We used a baseline scenario for all parameters that had no relation with the narrative storylines. For example, there are detailed modules for hydrology, soil erosion, salinisation, and plant growth, for which not much information could be extracted from the qualitative scenarios. The output of these modules is, however, influenced by the impacts of the different scenarios. The possible futures in turn are also influenced by the output of the modules, since the core of the PoSS is an integrated

dynamic model with strong feedback loops between the processes represented. In the parameterisation process, we were as consistent as possible. Yet, many small additional assumptions were necessary, given the amount of parameters in the PoSS that were not explicitly referred to in the narrative stories. All scenarios make use of the same climate scenario (ECHAM, see Roeckner et al, 1996), with a manually imposed extra rainfall shortage in order to approximate the assumptions of the European convulsive change scenario (see also appendix B).

5 Output of the PoSS

In figure 4 some of the resulting maps of the PoSS are presented. Figure 4(a) shows the land-use patterns in 2000, as discussed in section 2.1. The two other maps give the situation in 2030 as projected by scenario 1 [figure 4(b)] and scenario 3 [figure 4(c)]. The resulting map of scenario 2 is not presented, as it highly resembles land-use patterns in 2000.

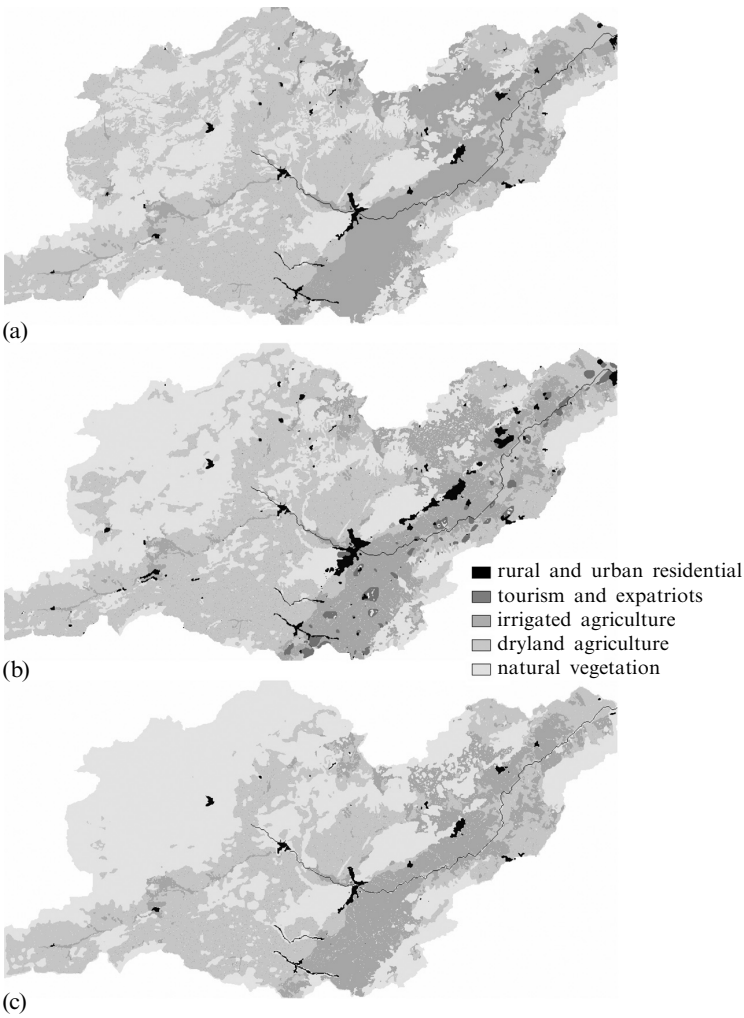

Figure 4. Input and output maps from the policy support system for the Guadalentín watershed. (a) land-use patterns in 2000; (b) land-use patterns in 2030 under scenario 1; (c) land-use patterns in 2030 under scenario 3. Only five classes out of more than thirty are shown.

Under scenarios 1 and 3 large areas of dryland agriculture in the northwest are abandoned, and various types of natural vegetation expand. Irrigated areas remain limited to the valley bottom; the areas of dryland agriculture in the centre of the Guadalentín are also largely maintained. These similarities between land-use change under both scenarios mostly result from similar assumptions, based on the Mediterranean convulsive change scenario. The effects of a strongly decreasing precipitation have a disproportionally large influence on land-use patterns. Under scenario 1 a large number of golf courses and additional residential areas for tourists are developed, replacing irrigated agriculture. The overall irrigated area shrinks only marginally. In scenario 3 the Guadalentín becomes a region without many prospects. Low precipitation and discontinuation of the water transport plans induce a strong rural outmigration. The entire northern part of the Guadalentín watershed is abandoned, while the irrigated area shrinks. Scenario 2—the desired scenario of the local and regional stakeholders—envisions changes that are mostly related to market structures, and social and cultural change, resulting in small-scale spatial changes.

The output of scenario 2 indicates a potential limitation of translating qualitative to quantitative assumptions. Inherently, a spatial representation will emphasise spatial changes, and as those are small the output as presented here could give the inaccurate impression that nothing will change in the Guadalentín. Focusing on the spatially explicit output might obscure part of the processes that are viewed as important by the stakeholders. On the other hand, the fact that spatial changes are small is an important conclusion in view of the overall aim to combat desertification. In line with the hopes and desires of the stakeholders that formed the foundation of this scenario, the output of the PoSS demonstrates that the desired sustainable balance between economy (tourists), environment (no large changes), and society might be possible.

5.1 Comparing model results and narrative scenarios

5.1.1 *Overall comparison*

The maps generated by the PoSS depict a future for the Guadalentín as the stakeholders sketched in their scenarios, especially for factors that are strongly linked to the narratives. The output maps, however, also serve to highlight key differences between the assumptions of the stakeholders of the PoSS. Most importantly, stakeholders were more negative about the prospects of water supply for the agricultural sector than the results of the PoSS indicate. In particular, local farmers claimed that 'the Guadalentín would be doomed' without extra water supply from the new water transport canals. Yet the results of the PoSS for scenario 3 indicated that more than 75% of irrigated agriculture could remain profitable. Similarly, although the assumption of the input narrative for scenario 3 was that little of the extra water supply would become available for agriculture, the PoSS calculated that water can and will be used for agriculture, even though tourist activities are highly favoured (see appendix B, division of water). Another example is the assumed total domination of tourists in scenario 1. As can be seen in figure 4, golf courses are projected to occupy a small percentage of the irrigated area only. In the model urban areas do grow substantially, but this is likely to be insufficient to trigger the assumed loss of cultural identity described in the storylines.

5.1.2 *Spatial comparison*

During the first stakeholder meeting, a map of the Guadalentín was created while drafting scenario 1. Stakeholders depicted general areas where land-use changes would take place by 2030. This provided the opportunity to compare directly the output of the PoSS and the results of the workshops. In figure 5 a schematised version of the map

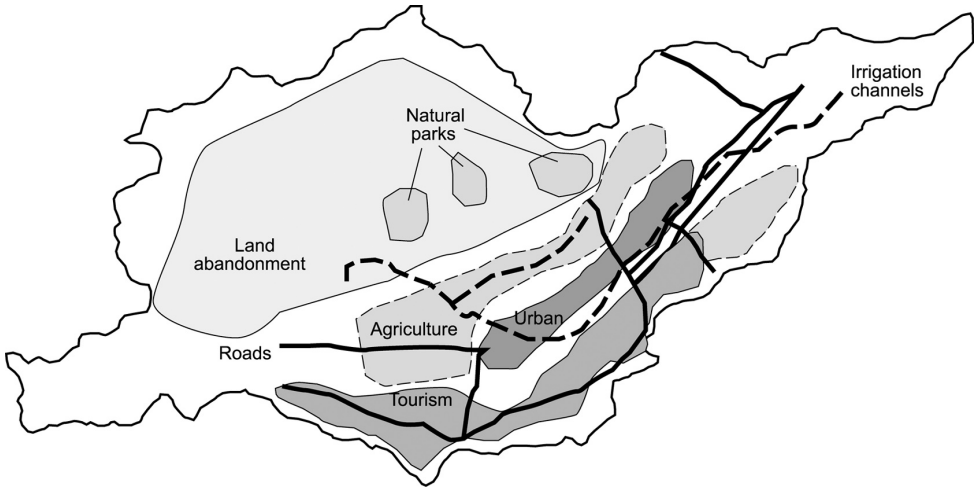

Figure 5. Schematised version of a map of the Guadelentín watershed in 2030 under scenario 1, as drawn during a stakeholder workshop in Murcia (Spain) in 2002.

that the stakeholders produced is given. From a visual comparison between figure 5 and the central map in figure 4 it can be concluded that there is a widespread agreement on the locations of change. Generally, the areas where urbanisation, land abandonment, and increase of tourism are projected to take place coincide almost completely. The areas of disagreement can be explained by differences in basic assumptions on driving forces. Stakeholders could more easily change laws, which, for example, result in new national parks and the abolishment of a law that prevents tourism from spreading to the southwest of the watershed. The assumptions were not incorporated in the PoSS. Furthermore, stakeholders were strongly convinced that urban areas would expand only in one concentrated zone along the valley bottom. The PoSS projects a more dispersed pattern of urban sprawl, based on the assumption that the influx of tourists prefer to take residence outside of the main urban zone. Finally, stakeholders assumed a widespread domino effect of rural outmigration because of social factors, which was not assumed in the PoSS.

6 Added values of linking narratives and quantitative models

6.1 Consistency

The product of a stakeholder workshop is not necessarily internally consistent, especially when stakeholders voice different opinions, and a quantitative model can help to reveal these inconsistencies. In particular, the spatial comparison in figure 4 indicated that there were no major inconsistencies in the forecasting scenario as produced by the stakeholders (scenario 1). The other two scenarios likewise resulted in maps that fit the descriptions in the narrative scenarios. The fact that stakeholders were consulted several times, thus providing the opportunity to reflect in their product, and that a large number of experts were present during the workshops in Spain might have contributed towards the high level of consistency of the resulting scenarios.

6.2 Visualisation tool

An evident added value of a spatial PoSS is its ability to visualise changes in the form of detailed maps. As discussed in section 5.1, however, stakeholders can produce maps of the future that roughly show the same changes as a PoSS. Thus, if the main aim of the use of a spatial model is to visualise general changes, this goal is possibly

reached more cheaply and more effectively by also inviting stakeholders with the capacity to think spatially to the workshops.

6.3 Integrated scenarios

Within a PoSS it is not uncommon to use 'scenario generators' to deal with the sheer endless number of possible combinations of parameter values to detect communalities between scenarios (see eg Pomerol, 2001), while the product of stakeholder workshops is a small number of highly integrated scenarios. We hope to have demonstrated that, by using such a scenario as the input of the PoSS, clusters of (related) parameters can be changed simultaneously. Given the large number of dynamic parameters, grouping can be an important guidance for end users of the PoSS, provided that the model integrates socioeconomic as well as biophysical processes.

6.4 Involving stakeholders

Narrative scenarios open the possibility to involve, for example, laymen, children, or local farmers besides experts and policy makers. Patel et al (2007) provide a detailed analysis of the process-related merits of involving stakeholders in MedAction concerning stakeholder dialogue, social learning, and understanding of different perspectives. This wider involvement of nonscientists by combining the two tools can open the way for more successful management strategies and the combating of land degradation.

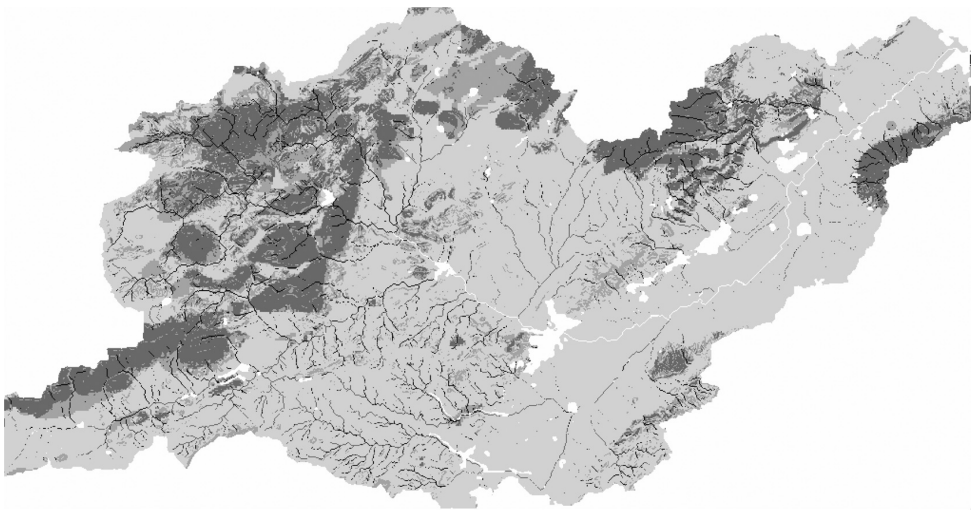

Figure 6. Environmentally sensitive areas under scenario 1. Light shades indicate fragile areas; dark shades indicate critical areas.

6.5 To combat desertification

The largest added value of linking narratives and the PoSS is the ability of spatial models to project the consequences of land-use changes for land degradation and desertification. As an example, figure 6 shows a map of the environmentally sensitive areas as produced by the PoSS. The risk of becoming degraded illustrates how a spatial model can provide information on the impact of spatially explicit land-use changes. With narrative storylines it would be close to impossible to project with this level of spatial detail.

6.6 Practical considerations

There are practical considerations that could hamper the successful linkage between a PoSS and narrative storylines. First of all, it cannot be stressed enough that the

development of participatory narrative storylines and the construction of a PoSS are very resource demanding. Both are expensive and, in the case of MedAction, took years to complete. As more readily accessible models become available and methods for carrying out a participatory process become more standardised, resource demands might decrease but will remain high. Second, in the participatory process as it was carried out here, success is not guaranteed (see Steelman and Ascher, 1997). The aim of stimulating an open discussion to enhance mutual understanding and initiating a longer term participation has the drawback that the second aim of developing actual future scenarios might be jeopardised. In fact, the series of stakeholder workshops was completed in only two out of four local case studies (Spain and Italy). And finally, we hope to have made it clear that the process of linking narratives to a PoSS is not straightforward and mostly only a partial link can be established. We wish to stress that in MedAction the narrative storylines and the PoSS were developed simultaneously for the same goal. This facilitated linking both projects, at least regarding the main drivers, processes, and indicators. Despite this precaution, underlying assumptions nevertheless differ; the PoSS demands detailed quantitative information on a range of parameters that can be distilled only partly from the narratives, while not all elements from the qualitative storylines can be quantified. However, this should by no means be considered a drawback, but, rather, should be considered as an essential first step. Only by attempting a link as described here, and applying a more iterative procedure, can the problems as identified above be made explicit. This will open the way to future improvements of the PoSS, as well as providing guidance to future stakeholder workshops.

7 Conclusions and recommendations

We hope to have made it clear that there are specific advantages of using either narrative scenarios or a spatial PoSS, and that linking the two methods has had important added values in the context of the issue of combating desertification in the Mediterranean region. Based on the experiences in MedAction, we conclude that there are large advantages of linking narrative storylines and a spatial PoSS. Storylines ensure an active participation of a large range of stakeholders, additionally offering the possibility to develop highly integrated scenarios. The PoSS provides a spatially detailed and quantitative output that can also be used to check the internal consistency of the qualitative scenarios. Linking stories and models can thus open the way for more successful management strategies to combat land degradation. However, combining these two methods is very resource demanding and success is not guaranteed. There are several possibilities of improving the link between narrative storylines and spatial PoSSs, some of which are currently being explored. The most promising in the field of land use and land degradation are:

- Group model building (see Vennix, 1999). This approach has recently been taken up in the context of land use by those developing agent-based models (Parker et al, 2002), that can be directly parameterised by stakeholders. At present, successful applications are mostly found in local systems involving a relatively small number of stakeholders.
- Constructing models that are less complicated and more flexible. There are several concepts that seem promising, including transition management (Rotmans, 2003); the syndrome's approach (Schellnhuber et al, 2003); and the work of the resilience alliance (eg Gunderson and Holling, 2002).
- Structuring stakeholder workshops such that a more quantitative output is obtained that can directly be used as an input in a PoSS (see Carmichael et al, 2004). Although this might limit the stakeholders that can participate, as expert knowledge is needed, it would increase the usefulness for a PoSS.

- Using a highly iterative procedure. Alcamo (2001) proposes a so-called storyline-and-simulation approach, in which storylines and models are improved in an iterative manner during a number of stakeholder meetings.

In short, there are a number of promising novel methods available that merit further exploration in the field of land use (change), and which have opened possibilities to move from involving stakeholders to fully integrating them in the process. The efforts described in this paper are but a step in that direction.

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Appendix A
Software availability

Program title: MedAction PoSS.
Developers: RIKS.
Contact address: Hedwig van Delden, Research Institute for Knowledge Systems, PO Box 463, 6200 AL Maastricht, The Netherlands.
Version: demonstration only.
Software required: Windows 98/2000/NT/XP.
Hardware requirements: 512 MB RAM.
Programming language: C++

Appendix B
Parameter setting and key assumptions

Climate

All scenarios made use of the same climate scenario (ECHAM; see Roeckner et al, 1996) with a manually imposed extra rainfall shortage of 40 mm per year to mimic assumptions in convulsive change.

Cellular automata rules: attraction between land uses

Tourism – tourism: stronger attraction in scenario 1 (as compared to standard parameter setting) to mimic the clustering of golf courses and residential areas. Stronger tendency to spread out in scenario 2, assuming that ecotourists will not cluster together.
Tourism – expatriots: some attraction because of communal facilities in scenarios 1 and 3.
Tourism – natural vegetation: stronger attraction from natural vegetation in scenario 2, assuming that ecotourists prefer scenic landscapes.
Urban – urban: stronger attraction in all scenarios. The key assumption is that, because of land abandonment and out-migration, urban dwellers will concentrate in larger centres.

Table B1. Total area changes.

	Agriculture[a]	Industry	Tourism	Expatriots	Urban
2000	0	0	0	0	0
Standard	0	+	+	+	+
Scenario 1	−−	++	+++	+++	++
Scenario 2	0	+/++	+	++	+
Scenario 3	−−−	−	0	0	−

[a] The changes given for agriculture are a maximum. The land-use model determines where these cells are allocated and afterwards the farmer's decision model determines if cells are occupied with dryland or agriculture or if they will be abandoned.

Suitability

Tourism: under the standard scenario: flat areas, current tourism locations, agriculture, and residential areas are very suitable. Scenarios 1 and 3 make use of the suitability map of the standard scenario; a zoning map is added, stating that new tourist areas are restricted to the valley bottom. Under scenario 2, the vicinity of nature is important, therefore the suitability map indicates that natural areas have a high suitability; no policy restrictions are imposed on the areas for tourism in this scenario.

Table B2. Water distribution.

	Division of water in times of shortage Agriculture: tourism	Capacity of desalinisation[a] (m^3/month)	Capacity Tajo water (m^3/month)	Water use by tourists (m^3/month/person)	Water use by expatriots (m^3/month/person)
Standard	1000:1	0	0	0	0
Scenario 1	50:1000	0	0	++	++
Scenario 2	1000:1	0	0	0	0
Scenario 3	1000:1	− − −	0	0	0

[a] Water from the water transport network from the Ebro River is included here.