DESIGN AGAINST DESERTIFICATION

A landscape scenario design study to explore the future of desertification in southeast Spain and develop potential means to combat desertification

Feline Verbrugge

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ABSTRACT

Desertification is a global threat with consequences on social, technological, economical, environmental and political levels. Also for Spain, numerous studies acknowledge the severity of the issue. Adequate involvement of stakeholders and the development of appropriate governance to combat desertification particularly remain challenging. Landscape scenarios can be used as a tool to generate stakeholder involvement for dealing with the unknown future of desertifying landscapes. This thesis explores different future scenarios for southeast Spain as a way to develop alternatives for landscapes prone to desertification and to explore which pathways may lead to such future scenarios. Four scenarios were developed, using an empirical foundation based on existing and emerging trends assessed according to five main drivers (STEEP). In a subsequent stakeholder survey held amongst people involved with the Pedrera case study area, thoughts and preferences on the scenarios were assessed. A Multiple Criteria Analysis then revealed desirable elements from the scenarios that were selected and implemented in a regional design for the Pedrera case study area. This design showcases a future landscape in which desertification is less likely and that aims to reduce, prevent or reverse desertification and possibly by rehabilitating degraded landscape.

Terms
Desertification, landscape scenarios, southeast Spain, landscape design

PREFACE

It might be hard to imagine now, but around 2019 desertification was not really taken seriously. Coming from a country almost unfamiliar with water shortages and droughts – with more and more exceptions – I was drawn to areas that coped with serious desertification issues. In those days however, most people thought about short-term gains only and it was hard to convince them of the seriousness of what was going on.

In southeast Spain, farmers collectively ripped the land to pack it with citrus as an attempt to survive, whilst project managers pulled their concrete money-makers out of the earth and sprayed the lush green colour of golf courses onto the coastal area. The landscape was changing dramatically and seemingly irreversibly. People just couldn't picture the alternative to overcome the odds.

Fortunately, a hopeful wave started emerging. When I visited southeast Spain as part of my fieldwork, I encountered some ambitious projects. At the time, there were only few of such restoration initiatives. But look where we are now. Degraded lands are slowly rehabilitated and people are finding their way back into balance with nature. Just imagine what would have happened if we didn't start acting when we did.

Whatever we do, whether we are scientists, policy makers, farmers or landscape architects, we have to dare to imagine. Time has come to stop thinking about worst-case scenarios and to start writing our desirable future. We should be visionary and accommodate meaningful change, solve problems, explore possibilities and most importantly, give shape to a bright future. Since, *we can be whatever we have the courage to see.*

I want to thank the following people for contributing to this thesis: Niek Hazendonk, Rudi van Etteger, Paul Roncken, Héctor Moreno Ramon and the Universitat Politècnica de València, Carlos Javier, Manuel Gomez, Yolanda Jimenez, CIDE Research Institute, all people at Sunseed and Ecosystem Restoration Camp La Junquera and above all my friends and family; in particular Adrià, Laura, Milan, Bastiaan and my parents.

INTRODUCTION

1.1 THE CONTEXT

Many regions around the world cope with desertification issues (Imeson, 2012) (Figure 1.1). This complex phenomenon is driven by biophysical and anthropogenic factors and occurs in arid, semi-arid and dry sub-humid areas (UN, 1994). The consequences of desertification entail loss of fertile land and biodiversity, salinization and water deficits (Taye et al., 2006). In this research, desertification is looked at from a holistic perspective, with origins in social, technological, economical, environmental and political (STEEP) drivers (Hunt et al., 2012).

The southeast of Spain is one region that is expected to suffer from the effects of desertification (NAP, 2006) (Figure 1.2). The existing harsh climate and especially the pressure on natural resources from human activities have a degrading effect on the landscape. Tourism, urban sprawl and intensive agriculture have changed environmental conditions and led to shifting land-use patterns (Barbero-Sierra et al., 2013). These landscape-changing factors play an important role in accelerating desertification in southeast Spain.

The question is how these factors change the landscape and lead to desertification. The majority of the people hardly realises the severity of the issue (Martínez and Marín, 2010), as it is such a slow and complex phenomenon with a highly uncertain future. It is therefore difficult to involve stakeholders and develop adequate policy tools to prevent or reverse desertification (Barbero-Sierra et al., 2014). A possible way to connect people might be the development of landscape scenarios. Scenarios are '*coherent, internally consistent and plausible descriptions of a potential future trajectory of a system*' (Merrie et al., 2018). Following this definition, this thesis sees the *landscape* as this *system* when speaking of landscape scenarios.

Scenarios are used to proactively think about and anticipate things to come. They have been applied in multiple fields (Merrie et al., 2018) – planning and landscape architecture amongst others (Dammers et al., 2017; Kok and Van Delden, 2009; Manders and Kool, 2015; Palang et al., 2000; Provincie Zuid-Holland, 2016; Soliva and Hunziker, 2009; Tress and Tress, 2003). They can be relevant for the desertification issue in exploring different possible pathways as they loosen cognitive restrictions (Merrie et al., 2018). Scenarios can moreover be potential tools to address over-complexity and encourage dialogue about possible future landscape changes (Tress and Tress, 2003). This thesis assesses what the contribution of landscape scenario design can be to explore and communicate future options for desertifying landscapes in southeast Spain. I furthermore examined what regional design can be created for the Pedrera case study area from the different landscape scenarios that works against desertification.

The case of southeast Spain

As desertification is such a complex phenomenon of which its context and implications differ globally, it is recommendable to make use of a case study – especially when approaching the problem from a landscape architectural perspective (Van den Brink, 2016). Being a worldwide issue, cases are widely available and are not only restricted to developing countries. Within Europe, southeast Spain is one of the countries most affected by desertification (Barbero-Sierra et al., 2013).

Its vulnerability comes from the combination of climatic, geomorphological and demographic factors. First of all, over two third of Spain is dry sub-humid and semi-arid area in which complex geomorphology reinforces natural erosive processes (Barbero-Sierra et al., 2013). Secondly, Spain has a low demographic number compared to the European average and is concerned with a polarised settlement pattern. Most of the population is concentrated in dense urban areas along the coast and rivers, with an exception of the inland capital Madrid. The remaining part of Spain is characterised by its sparsely populated interior (Del Molino, 2016). Thirdly, the region experiences changing environmental conditions and shifting land-use patterns such as agricultural intensification, land abandonment and urbanisation (Taye et al., 2006). Altogether this has resulted in a significant share

of the country that is currently prone to desertification (about 15%) (NAP, 2006), making it a representative and prototypical case.

An advantage of selecting southeast Spain as case study is the fact that background knowledge is widely available due to the many published studies on desertification – although primarily biophysically oriented (Barbero-Sierra et al., 2014). Moreover, several national plans to combat desertification have been developed over the past decades. One of which is the National Action Programme (NAP, 2006), also known as PAND (Programa de Acción Nacional contra la Desertificación) in Spain. Despite these hopeful programs, the problem of desertification is still predominant and growing, as no substantial actions have been taken yet (Estrela and Vargas, 2012).

Spain is furthermore an interesting country to focus on seen its many possible future directions. It is a developed country that is member of the EU and has a high nominal GDP. In combination with the rich cultural and historical background, it makes a well-founded case to study alternative futures for the landscape. More information about the Spanish context can be found in Appendix A.

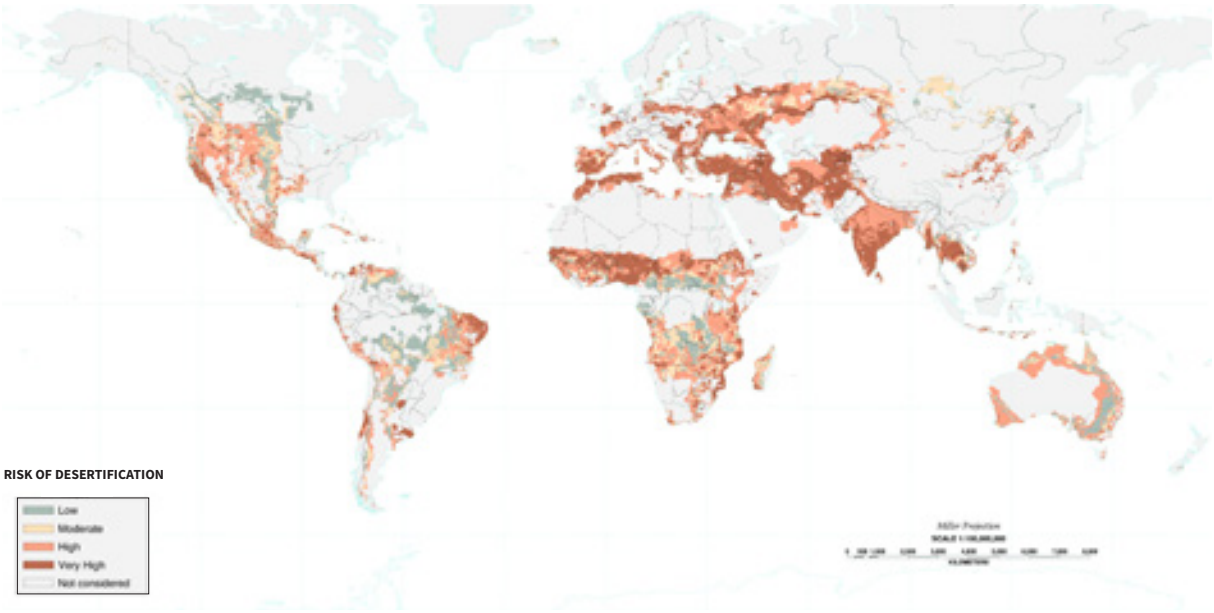

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FIGURE 1.1 / Risk of human induced desertification, based on an overlay of the global desertification map and global population density map (USDA, 1999).

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FIGURE 1.2 /Risk of desertification in Spain (PAND, 2008).

1.2 THE ASSIGNMENT

In this paragraph the research is introduced. The main challenge and knowledge gap are defined, as well as the main aim of this thesis. The section concludes by elaborating on the research questions that are covered in this thesis.

The challenge

The main problem of desertification is its abstract, complex and slow nature, making it difficult for people to understand and grasp the severity of the issue (Martínez and Marín, 2010). Public support however, is indispensible to successfully halt and reverse the process of desertification. Therefore, the major challenge is to increase public awareness on the issue of desertification (Imeson, 2012).

Despite several programmes and policies initiated by the government (NAP, 2006), no substantial actions have been taken yet and issues with desertification remain (Estrela and Vargas, 2012). The majority of landowners are not yet applying sustainable management methods, urban expansion is still at stake and natural resources are structurally overexploited (Barbero-Sierra et al., 2013). A clear overview of the possible consequences of the interplay of such developments is lacking, and is moreover involved with a high level of uncertainty.

The unknown future of landscapes prone to desertification, in combination with the lack of public support, makes it difficult to come up with appropriate strategies. However, without the right approach it is impossible to overcome the challenge to adequately combat desertification and give direction to a desired future.

Until now, the predominant call for action was aimed at policymakers and scientists. However, landscape architects are pre-eminently capable of dealing with complex societal and environmental issues such as desertification, by shaping a desired future through design. As the drivers and consequences of desertification deeply involve the landscape, the challenge to halt and reverse this process very much applies to landscape architects as well.

Knowledge gap

Designing against desertification is a new challenge for landscape architects, both in research and in practice. The majority of current desertification research in Spain is biophysically oriented, which is why there is a call for a more integral approach (Barbero-Sierra et al., 2014). Such an approach can be provided by developing landscape scenarios to explore potential futures of desertifying landscapes in southeast of Spain. These landscape scenarios can be used to give an idea of the possible consequences of certain developments and can help to exchange information and encourage dialogue (Tress and Tress, 2002).

Scenario development has already been applied to multiple environmental issues (Merrie et al., 2018). Specified to the issue of desertification, Kok and Van Delden (2009) were the first to present an integrated scenario study to this problem. They combined quantitative land-use models and qualitative participatory methods to develop scenarios for a Spanish region prone to desertification. This thesis applies a different approach, by using a research through design method to develop the landscape scenarios. Moreover, the outcome of the landscape scenarios will be linked to a regional design for a specified case study area. Such a practical outcome of a scenario study, a design, is new in this context. Hence, unlike Kok and Van Delden (2009), the emphasis will be less on the participatory approach and more on the research through design aspect. The development of new approaches to tackle desertification from a design perspective will not only contribute to desertification research, but to landscape architectural research as well.

Research objective

The purpose of this thesis is twofold. First of all, the aim is to assess what the potential contribution of landscape scenario design can be to explore and communicate future options for desertifying landscapes in southeast Spain. To do this, future trends need to be investigated, which will be used to build the landscape scenarios. To achieve an integral outcome, trends should be explored within the directions of all STEEP drivers (social,

technological, economical, environmental and political) (Hunt et al., 2012).

Secondly, the design purpose of this thesis is to create a spatial design for the Pedrera case study area that fights desertification. This regional design should be based on a consideration of the landscape scenarios and aims to contribute to the imaging and planning of different stakeholders (policy makers, farmers, laymen). The design moreover functions as a proposal for future developments of the landscape and should offer practical tools to combat desertification. Within this objective, four ambition levels can be distinguished for the design: first of all, the aim is to reduce current desertification rates while maintaining current systems (1). Secondly it is the ambition to prevent further desertification (2), then to reverse current erosion processes (3) and finally and most preferably to rehabilitate currently degraded landscapes (4).

Ultimately, the higher aim is to contribute to the global fight against desertification by offering a new approach to the problem. Hopefully it leads to more awareness and more action amongst stakeholders.

Research questions

To meet the research objective of this thesis, several questions have been formulated. As this research is divided into two parts, there are specific questions for both the research and the design part. At first there is a main research question that overarches the entire research and that covers the research element:

What can be the contribution of landscape scenarios to explore and communicate future options for desertifying landscapes in southeast Spain? (MRQ)

Then the aim is to create a design for the Pedrera case study area that will fight desertification. Therefore, the design assignment for this thesis is the following:

What spatial design can be created for the Pedrera case study area from the different landscape scenarios that will contribute to combatting desertification? (DQ)

In order to find the answers to these two questions, four sub research questions have been assembled. The first sub research question helps to investigate different trends in the landscape of southeast Spain. The trends will be researched according to the five STEEP drivers (social, technological, economical, environmental and political). The results of this empirical foundation will be used for the development of the future landscape scenarios. This will help to answer the second sub research question, which aims to examine what different landscape scenarios can be created with the trends from the empirical foundation that was developed for the previous question. When the landscape scenarios are formulated and shaped, principles to translate elements from the landscape scenarios for southeast Spain to a spatial design for the Pedrera case study area should be developed.

Furthermore, to create an adequate design that is able to fight desertification, it is necessary to examine possible landscape interventions and strategies that can be used to combat desertification. This will answer the final sub research question of this thesis.

What are possible future social, technological, economical, environmental and political (STEEP) trends in the landscape of southeast Spain that can determine the future landscape scenarios? (SRQ 1)

Which landscape scenarios can be created from these trends that show the possible futures for the landscape of southeast Spain? (SRQ 2)

What principles can be developed to translate elements from the landscape scenarios for southeast Spain to a spatial design for the Pedrera case study area? (SRQ 3)

What are potential landscape interventions and strategies that can be applied to combat desertification? (SRQ 4)

When these questions are answered, it is possible to apply this knowledge to shape the spatial design for the Pedrera case study area and to answer the main research question. Figure 1.3 shows the relationship between the questions.

MAIN RESEARCH QUESTION

What can be the contribution of landscape scenarios to explore and communicate future options for desertifying landscapes in southeast Spain?

SRQ 1	SRQ 2	SRQ 3	SRQ 4
What are possible future STEEP trends in the landscape of southeast Spain that can determine the future landscape scenarios?	Which landscape scenarios can be created from these trends that show the possible futures for the landscape of southeast Spain?	What principles can be developed to translate elements from the landscape scenarios for southeast Spain to a spatial design for the Pedrera case study area?	What are potential landscape interventions and strategies that can be applied to combat desertification?

DESIGN QUESTION

What spatial design can be created for the Pedrera case study area from the different landscape scenarios that will contribute to combatting desertification?

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FIGURE 1.3 / Overview of the relationship between the research questions.

1.3 THESIS OUTLINE

With the main challenge, objectives and questions stated, it is important to describe the relationship between the most important concepts of this thesis about landscape scenarios for the future of desertification in southeast Spain. Therefore, Chapter 2 – *execution* – first of all presents the conceptual framework as is used in this thesis. Then the two most essential concepts, desertification and landscape scenarios, are profoundly elaborated on. This will help to get a deeper understanding of the context, as well as the approach that should be taken. Lastly, the chapter will describe the methodology as is applied in this thesis. This section discusses the ways I collected the data and how that data was used to answer the research questions.

Chapter 3 describes the first *empirical* phase of this thesis. This is an analytical chapter that consisted of 5 weeks of fieldwork in southeast Spain that covered two different methods. First of all, I undertook a discourse analysis through interviews with different stakeholders. Secondly, I executed a qualitative trend analysis of the landscape by observing during fieldwork. The chapter starts with an elaboration on a first attempt on scenario development: blank scenario prototyping. The chapter concludes with a second set of scenario prototypes that incorporated the findings from the analytical steps.

To back-up the findings from the *empirical* phase, a desk study was conducted to find more background information on possible future trends in southeast Spain. Therefore, Chapter 4 (*exploration*) presents the results from a literature analysis on future trends in southeast Spain. Then a landscape analysis was conducted to get a deeper understanding of the Pedrera case study area – the focal area for the regional design. This chapter also concludes with a new set of scenario prototypes that used the gained data from this explorative phase.

In Chapter 5 – *generation* – the final landscape scenarios for southeast Spain are presented. They help to give a deeper understanding of the possible consequences of different actions and inactions concerning the desertification issue in southeast Spain. The chapter furthermore elaborates on how the landscape scenarios can be used in a regional design for the Pedrera case study area. Therefore, the concept of landscape scenario building blocks is presented, which are applied to the Pedrera area. These building blocks are incorporated into a Multiple Criteria Analysis to select the most preferable ones for the regional design in order to combat desertification. As a concluding part of this chapter, the regional design for the Pedrera case study area will be presented, accompanied by two design details.

The final chapter of this thesis, *evaluation*, concerns the answer to the different research questions and an elaboration on the landscape scenarios as well as on the design. Moreover, different elements of this thesis are discussed, such as the methodology and the use of landscape scenarios in combination with a design. At last, I will finish this chapter with recommendations and possible topics for future research.

2 EXECUTION

2.1 CONCEPTUAL FRAMEWORK

This section describes the relationship between the essential concepts of this thesis. The first and most important theme in this research is desertification. This process is the result of the interplay of biophysical and anthropogenic factors, but foremost as a result of landscape changes caused by human activity (AGE, 2004).

Landscape change is a continuous process of which its degree depends on several mechanisms (Figure 2.1) (Palang et al., 2000). It is under influence of political decisions, the prevailing attitude in society and on culture. As landscape values change, policy shifts, which in turn may lead to socio-economic changes, and with that generates further changes in the landscape. Socio-economic changes may also lead to changes in landscape valuations and attitudes, which could have new policies as a result (Palang et al., 2000).

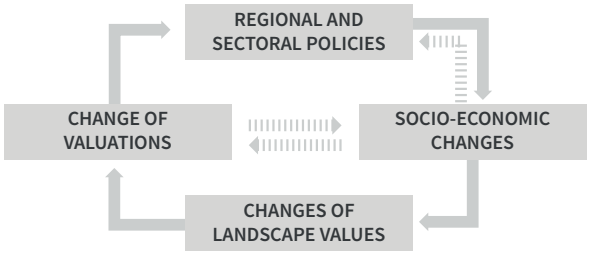

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FIGURE 2.1 / Cycle of landscape change at regional level (adapted from Palang et al., 2000).

This cycle is also applicable to the desertification problem of southeast Spain. Societal developments for example, have caused socio-economic and political changes have occurred, such as the need for urbanisation and intensification of agriculture (AGE, 2004). On their turn these developments induced significant landscape changes and thus accelerated desertification.

It is important to notice that landscape change is rarely a planned process. It is rather a mixture of autonomous and planned actions. This means landscape changes predominantly occur chaotically, despite efforts to steer and plan them (Palang et al., 2000). Also in southeast Spain the landscape changes uncoordinatedly, resulting in a high degree of uncertainty about the possible future of landscapes prone to desertification. One way to explore the possible future of these landscapes is by developing landscape scenarios. This is how the other main concept of this thesis – landscape scenarios – is linked to desertification. Figure 2.2 shows the relationship between the concepts in a conceptual framework. A deeper understanding of the two concepts (desertification and landscape scenarios) will be provided in paragraph 2.2 and 2.3.

STEEP drivers

Throughout the report I approach desertification and landscape scenarios from a holistic perspective, by incorporating factors on all STEEP levels: social, technological, economical, environmental and political (Boschetti et al., 2016). These factors play a key role in the process of desertification, as they lie at the heart of both the drivers and the consequences of desertification. Landscape scenarios on the other hand, are built according to an elaborate consideration of different trends on all STEEP levels (Boschetti et al., 2016). Therefore, they are incorporated into the conceptual framework of this thesis as well (Figure 2.2).

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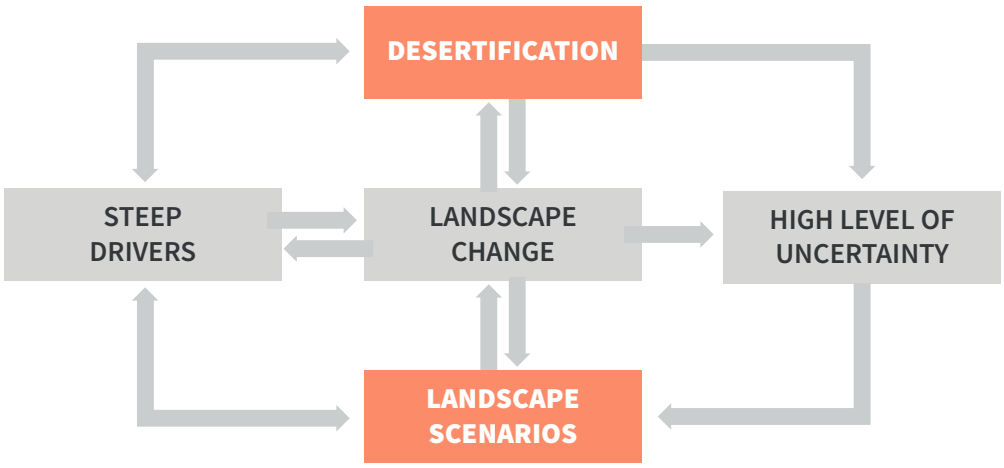
FIGURE 2.2 / Conceptual framework of how desertification is linked to landscape change, and how landscape scenarios can be used to overcome the high level of uncertainty that comes with landscape change. The STEEP drivers influence the desertification process and the landscape scenarios derive from a consideration of the same STEEP drivers.



2.2 DESERTIFICATION

Already since the 1950's, desertification has been recognised as a severe problem globally and on the Spanish level (Barbero-Sierra et al., 2013). As the main theme of this thesis, it is important to provide a profound understanding of the concept. Therefore, this section discusses the concept and gives an overview of the definitions, drivers, consequences, perceptions and possible solutions. Moreover, the potential role of the landscape architect within the desertification realm is examined.

Definitions

Desertification is a worldwide phenomenon to which many definitions have been assigned. The most commonly accepted definition was given by the United Nations Convention to Combat Desertification (UNCCD) that sees desertification as '*land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities*' (1994). Generally, it implies the persistent reduction and degradation of terrestrial ecosystems as a result of overexploitation and inappropriate land use and management in vulnerable areas weakened by drought and aridity (AGE, 2004). In contrary to land degradation (Figure 2.3), desertification is by definition *not* a natural process, as it is always involved with human action.

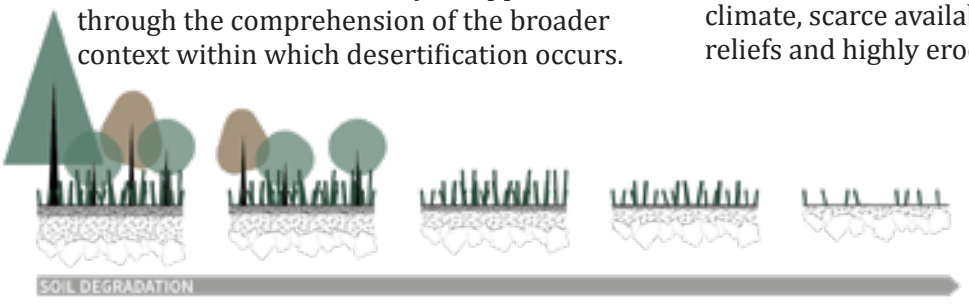
This thesis approaches desertification from a holistic perspective and seeks its origins in social, technological, economical, environmental and political (STEEP) drivers (Hunt et al., 2012). It is a process that results from the interplay of these different factors and manifests itself at different levels – both spatial and temporal (Schwilch et al., 2012). As this study aims to develop adequate landscape scenarios for southeast Spain and a regional design that works against desertification, this can only be approached through the comprehension of the broader context within which desertification occurs.

Drivers

Desertification is a process of which the drivers must be sought in the synergistic set of climatic, geomorphological and anthropogenic processes (Figure 2.4). Ultimately it is the result of the combined action of these three general factors, but foremost as a result of degrading human activities (AGE, 2004). Therefore, desertification is also referred to as persistent *human induced land degradation* (Imeson, 2012). Also in Spain, desertification is approached as a society-driven phenomenon. For this reason, Spain has adopted two words for desertification: *desertización* and *desertificación* (Fernández Naves and García Pérez, 2000). The first as a way to describe the natural process of degradation without any human intervention, and the latter describes the loss of fertile area due to human actions.

The driving forces behind desertification can be divided into five broad clusters – the STEEP drivers – with each their direct and indirect consequences (Figure 2.5). In general the process is determined by the interaction of global drivers (such as climate change and increasing competition over land and resources) with local circumstances (soil type and fertility, land use and management, water availability and socio-economic conditions). This results in complex scale interactions, which makes desertification a complex phenomenon that is very site-specific and appears in many forms all over the world (Schwilch et al., 2012).

On a global scale, the cause of desertification is commonly found in the unsustainable use of scarce resources (Millennium Ecosystem Assessment, 2005). Often this is driven by poverty and political instability, leading to deforestation, overgrazing and land mismanagement (Schwilch et al., 2012). In Spain, desertification is first of all rooted in the natural physical conditions, with its semi-arid climate, scarce availability of water resources, reliefs and highly erodible rocky soils (AGE,



< FIGURE 2.3 / Land or soil degradation is the reduction of fertile soil and vegetation cover, eventually leading to desertification (based on Imeson (2012), adapted by author).

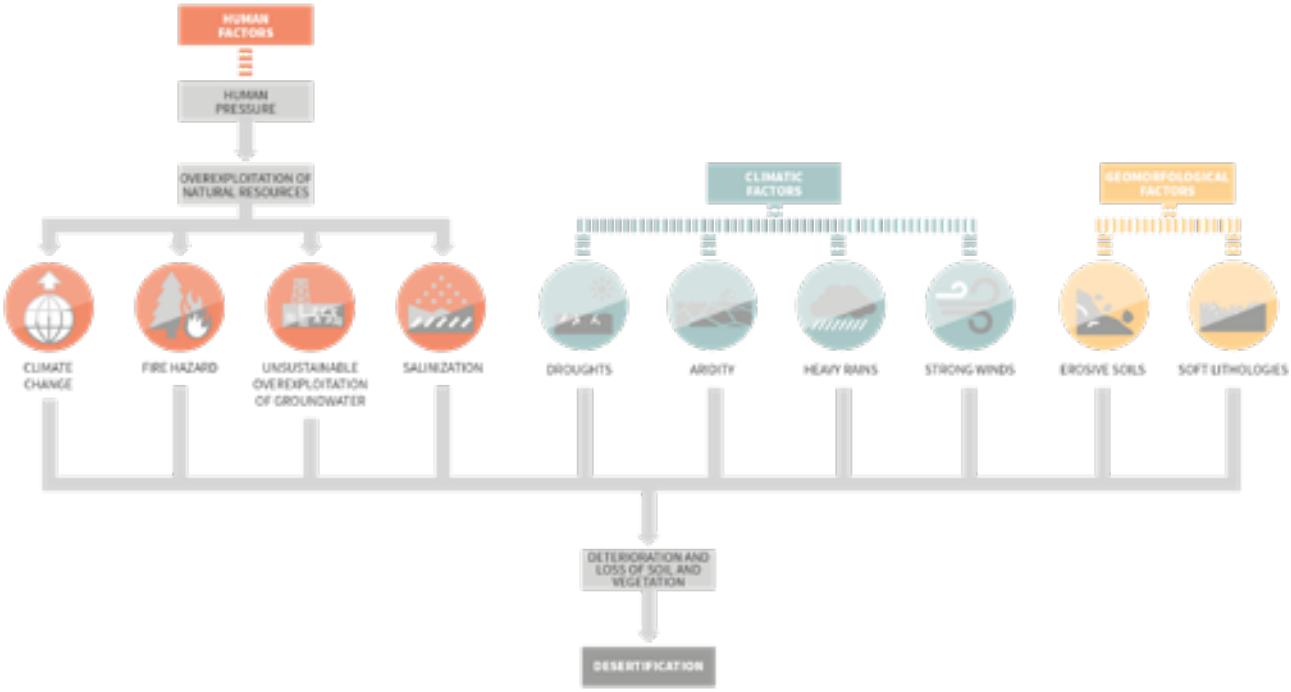


FIGURE 2.4 / Interrelated process of desertification. Desertification is the response to the combined action of three large groups of factors, but above all, to human action manifested in economic, technological and political decisions. Based on AGE (2004), adapted by author.

2004). Next to that, human induced drivers, such as the (over-) exploitation of (water) resources, human migration, climate change, (agricultural) land management, tourism (golf courses), poor planning and agricultural and regional policies all contribute to desertification in southeast Spain (Kok and Van Delden, 2009). In the past decades, these activities have led to disruptive changes in the Spanish landscape, driving the process of desertification (Imeson, 2012).

Landscape change

Change is inherently linked to the landscape. It is a continuous process determined by biophysical and/or socio-economic processes – either planned or not (Metzger et al., 2018). In the past decades, landscapes on the Iberian Peninsula have transformed more significantly than before due to both intensification and extensification (Millennium Ecosystem Assessment, 2005). These include for example urbanisation, industrialisation and intensification of agriculture on the one hand, and depopulation and land abandonment on the other hand (Hill et al., 2008). In (semi-) arid landscapes, such sudden changes can trigger desertification processes. This usually emerges from conflicts between past and present land uses, or when the economic priorities do not match the ecological priorities (Hill et al., 2008; Martínez-Valderrama, 2016). When studying landscape transitions, a focus on change in land use is necessary, of which the degree largely depends on social, political and economical driving forces (Palang et al., 2000). With environmental and technological developments involved as well, landscape change is a process that involves all STEEP drivers.

Change is automatically involved with complexity and uncertainty due to nonlinear changes (Merrie et al., 2018). These are hard to predict due to their abrupt and unexpected nature and due to the fact that they are not based on simple cause and effect. As predictions in desertification research rely on other models – climate change, population growth, urbanisation rates, economic growth, etc. – the output is not completely reliable (Barbero-Sierra et al., 2013). Another complication comes in, as the decisions that are made today determine future outcomes. Related to desertification, this means that there are several possible future pathways that have to be considered.

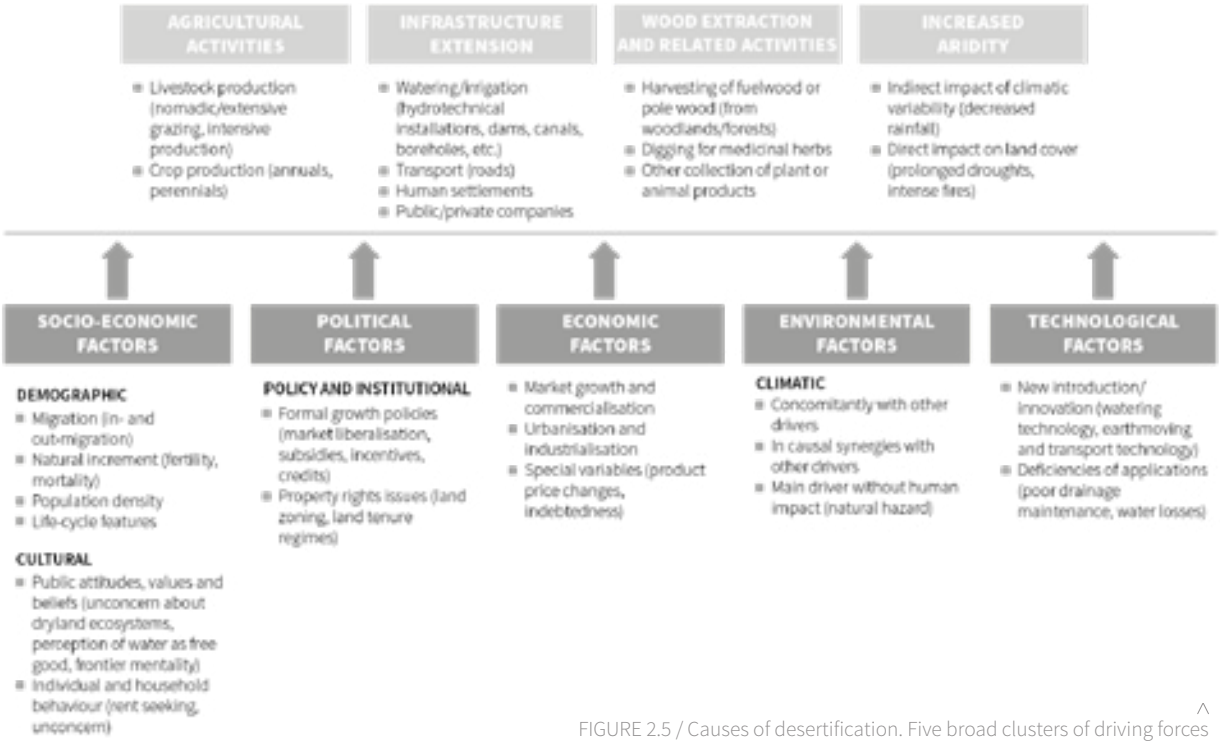


FIGURE 2.5 / Causes of desertification. Five broad clusters of driving forces with direct consequences on the landscape system. Again the STEEP drivers are applied: socio-cultural, political, economical, environmental and technological. The scheme is adapted from Helmut et al. (2004).

Agriculture

Many soil erosion problems in Spain occur in agricultural areas as a result of inappropriate farming practices (Ecologistas en Acción, 2007). This sector actively contributes to desertification due to unsustainable agricultural management (Barbero-Sierra et al., 2013). This happens for example when soils of marginal areas are worked, or when crops are promoted in inadequate areas. Another agricultural driver of desertification is the proliferation of greenhouse areas, which involves big land movements and soil sealing. Passively, agriculture causes problems in areas where highly intensive agriculture has caused irreversible soil degradation (Barbero-Sierra et al., 2013). However, if agricultural land is abandoned there is an opportunity for natural re-vegetation and afforestation, which can reverse former degradation processes (Barbero-Sierra et al., 2013).

Urbanisation

Perhaps an even more important driver of desertification in Spain is urban development (Barbero-Sierra et al., 2013). The conversion from rural to urban land in Spain has been induced by a push-pull dynamics. These dynamics caused a significant share of formerly agricultural land to be transformed into urban area. The effects are soil sealing, a general decrease in soil moisture content, impeded water infiltration, higher runoff, increase of evaporation, disrupted water cycles, rise of temperatures, increase of waste and emission rates and decreased (soil) biodiversity (Barbero-Sierra et al., 2013). Urbanisation not only means a loss of fertile land and ecological functions, but also the irreversible destruction and transformation of land and the permanent occupation of fluvial valleys, increasing flood risk (Ecologistas en Acción, 2007).

The type of urban development determines to a high extend its impact on the desertification process. In Spain, the sprawled city model is often promoted and applied to town planning (Ecologistas en Acción, 2007). This is a model where scattered buildings are linked to extensive sport and leisure areas, which consume a lot of water. This model is unfavourable compared to the other model, that of a compact city. Compact cities are considered more sustainable by minimising land use and energy and water consumption (Barbero-Sierra et al., 2013).

Consequences

Already since the 1950's, desertification has been recognised as a severe problem in Spain and is been said to affect environmental, economic and social activities (AGE, 2004). This implies the reduction and degradation of terrestrial ecosystems by causing a loss of fertile land, biomass and biodiversity, erosion, salinization, water deficits and the alteration of water regimes and availability (Taye et al., 2006). In areas with substantially reduced nutrient soils and water holding capacity, lands are no longer able to properly sustain its economic and/or original ecological functions (Schwilch et al., 2012).

Also in terms of its impact, desertification affects all 'STEEP' levels. Therefore, it is not only applicable to speak of environmental desertification, but of social and economical desertification as well as livelihoods deprive and local economies decline as a result of its effects (Imeson, 2012). Moreover, as it is expected that land degradation and desertification are likely to increase the risk of conflict over resources (Millennium Ecosystem Assessment, 2005), it is also very much an issue with political consequences.

Reversibility

It is important to take into account the degree of reversibility. Some effects of desertification are permanent, while others are temporary and can be reversed (Barbero-Sierra et al., 2013). Irreversible desertification indicates the terminal stage of accelerated erosion with damages that cannot be reversed in a time span of about 100 years or four human generations (Blum, 2009). The degree of reversibility depends on the intensity and duration of active driving forces, the environment where it takes place and the time and costs involved with the restoration (Barbero-Sierra et al., 2013).

Indicators

The most commonly accepted indicator in Spanish desertification research is erosion, measured with the Universal Soil Loss Equation (USLE) (Barbero-Sierra et al., 2013). However, this model differs widely per context, seen the fact that direct measurements often find lower erosion rates than the model provides (Martínez-Fernández and Esteve, 2005). As official national reports often anticipate on the results from the model, these desertification figures should be approached carefully (Barbero-Sierra et al., 2013).

Other desertification indicators are aridity index, fire affected areas and aquifer overexploitation. Social, economical and political indicators related to land use changes (depopulation, urbanisation, changing agricultural practices and land abandonment) are often not incorporated in desertification research, due to the fact that most of this research is biophysically oriented (Barbero-Sierra et al., 2014).

Perceptions

The ambiguous definition for desertification that was given by the UNCCD (1994) often results in misconceptions and misunderstandings amongst stakeholders. When incorporating input from stakeholders, it is important to realise this discrepancy in the way people approach the concept of desertification.

In their study, Oñate and Peco (2005) found five general perceptions on desertification. The first group indicated they approached the issue from a climatic point of view. A second group saw the concept as a problem with primarily anthropogenic origins. The third group indicated they understood desertification as a phenomenon of land abandonment due to population loss. In the fourth category, people emphasised the need for a focus on the unsustainable management of water resources, which they regarded as the main component of desertification. A last group had the perception that desertification should be seen as a global process of environmental degradation, with both natural and human drivers.

Solutions

Combatting desertification is a contextual activity linked to the spatial, temporal, cultural, socio-economic and environmental conditions of each region (Barbero-Sierra et al., 2013). The social, technological, economical, environmental and political (STEEP) capacities moreover differ between countries, which significantly influences

the ability to respond to desertification challenges.

Not just the drivers and consequences, but also the solutions should be sought in the interplay of social, technological, economical, environmental and political (STEEP) factors. A solution can be technically effective, but if there is no social support, political will or economical incentive, the measure will not be implemented. Hence, before it is possible to apply practical measures, major policy interventions and changes in management and culture are needed (Millennium Ecosystem Assessment, 2005).

When combatting desertification, a distinction should be made in terms of the ambition of the solutions. First of all, the aim is to reduce current desertification rates while maintaining current systems (1). Secondly it is the ambition to prevent further desertification (2), then to reverse current erosion processes (3) and finally and most preferably to rehabilitate currently degraded landscapes (4) (Figure 2.6).

Throughout this thesis, the concepts of rehabilitation and restoration are used alternately. The difference between these two terms is that restoration aims to reestablish a previous ecosystem state and all its functions and services, while rehabilitation seeks to repair specific parts of the system, in order to regain ecosystem productivity (Millenium Ecosystem Assessment, 2005).

Sustainable Land Management

The answer to the challenges of desertification can be the overarching concept of Sustainable Land Management (SLM), which combines measures in all STEEP levels as a response to desertification (Schwilch et al., 2012).

This management strategy aims to improve agricultural productivity, livelihoods and ecosystems. The key principle is that land resources – including soils, water, animals and plants – are used for the production of goods to meet changing human needs, while the long-term productive potential of these resources and the maintenance of their environmental functions are ensured (Schwilch et al., 2012).

Many of the proposed SLM measures have been known for a long time, but it has appeared to be difficult to find the right combination and balance of possible solutions for the specific situation and location, especially when considering the complex scale interactions that are behind desertification (Schwilch et al., 2012).

Within SLM, four categories can be distinguished with each their own practical measures: agronomic, vegetative, structural and management measures (Schwilch et al., 2012). A table of these measures can be found in Appendix B. To comply with the first two ambition levels – reducing and preventing the effects of desertification – the Millennium Ecosystem Assessment (2005) has listed a set of possible actions, although this mostly focuses on developing countries. These can be found in Appendix B. When aiming to reverse or rehabilitate degraded landscapes, it is required to combine the right policies and technologies within close involvement of local communities (Millennium Ecosystem Assessment, 2005). A list of restoring measures can be found in Appendix B as well. These measures should also be approached carefully, as they are very context dependent.

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FIGURE 2.6 / Four ambition levels in combatting desertification: reduction of current desertification rates, prevention of further desertification, reversal of current desertification processes and rehabilitation of currently degraded landscapes.

Critical note

Ever since the concept of desertification has been introduced, it is a controversial term. The three issues mostly debated are its ambiguity over the relative importance of natural versus human drivers, the degree of its ecological reversibility and the total area and population it affects (Barbero-Sierra et al., 2013). Behnke and Mortimore (2016) argue that '*ecological change is as varied and locally specific as the heterogeneous social and physical environments in which it takes place*'. Hence, in all cases related to desertification, its drivers and potential solutions should be considered according to the specific context. Often, the answers lie in the interplay between different factors and not just in one specific development (Imeson, 2012). This means the importance of natural versus human drivers differs in each context, as well as the ecological reversibility and the way it affects the populace. For these reasons, desertification will be approached integrally in this thesis, by looking at drivers, consequences and possible solutions on all STEEP levels.

Furthermore, desertification figures should be approached carefully as numbers differ with different measurement techniques (Barbero-Sierra et al., 2013). Assumptions that were once made, for example in the Sahel desertification crisis, might become invalidated when they turn out differently than first anticipated – the Sahel became wetter than before (Behnke and Mortimore, 2016).

Role of the landscape architect

Landscape architects can use their trans-disciplinary knowledge and creative backgrounds to solve significant societal and environmental issues such as desertification. In general, landscape architects often play a role in areas that are characterised by increasing urban pressure through spatial planning or urban design. Landscape architects are moreover capable of finding answers to challenges that come with complex urban-rural relationships by providing adequate design tools. Exactly these two dynamics – urban pressure and urban-rural complexities – play a key role in the desertification process in southeast Spain. A landscape architect can intervene and potentially help to cure the degrading landscape by offering a spatial design that combats desertification.

Designing against desertification is a new challenge for landscape architects, both in research and in practice. However, the restoration of degraded landscapes is highly involved with spatial elements and this influences the quality and functioning of the landscape. With knowledge about several lifescience disciplines, landscape architects can adequately apply numerous physical interventions to restore ecosystems – such as the use of green spatial elements like hedges and tree rows, but also agroforestry, terracing, wadi's, cover cropping, stormwater harvesting and reforestation. Hence, it is a challenge that is pre-eminently suitable for the landscape architectural discipline.

2.3 LANDSCAPE SCENARIOS

To come to different, perhaps even better futures, it can be useful to imagine what those futures could be like and what the impacts and implications of different types of change might be. When the future is concerned with developments that have big consequences, but which are involved with a high level of uncertainty – such as desertification – scenario building can be an effective technique (Merrie et al., 2018).

This section explores the concept of and theory behind landscape scenarios. An overview will be provided of its definitions, building techniques and different types. The paragraph concludes with an elaboration on the role of the landscape architect in designing landscape scenarios.

Definitions

The interpretation of the term 'scenarios' differs widely amongst its users, as can be seen from the many definitions that it has been given (Boschetti et al., 2016). For this thesis I define the concept as '*coherent, internally consistent and plausible descriptions of a potential future trajectory of a system*' (Merrie et al., 2018). When speaking of *landscape* scenarios, the *landscape* is seen as the *system* in this definition.

Scenarios are used to proactively think about and anticipate things to come. By exploring possible futures and the developments that may lead to those futures, scenarios can envision (desirable) future pathways and the developments that are necessary to achieve this (Dammers et al., 2017). Landscape scenarios can explore various (spatial) trajectories from which future options for the landscape of, in this case, southeast Spain can be determined (Mahmoud et al., 2009; Palang et al., 2000). As they can be potential tools to address over-complexity and encourage dialogue about possible future landscape changes (Tress and Tress, 2003), scenarios can be useful tools in the context of desertification.

It is important to note that scenarios are not forecasts, predictions, prognoses or speculations, but dynamic constructions of possible alternative future developments (Mahmoud et al., 2009; Tress and Tress, 2002). In the context of desertification the use of scenario building as a way of future exploration is recommended over for example prognoses or speculation. Scenarios are useful for developing possible or desirable futures rather than making accurate statements about the future (prognoses) or statements that are based on expectations, desires and creative ideas (speculation) (Figure 2.7) (Dammers et al., 2017).

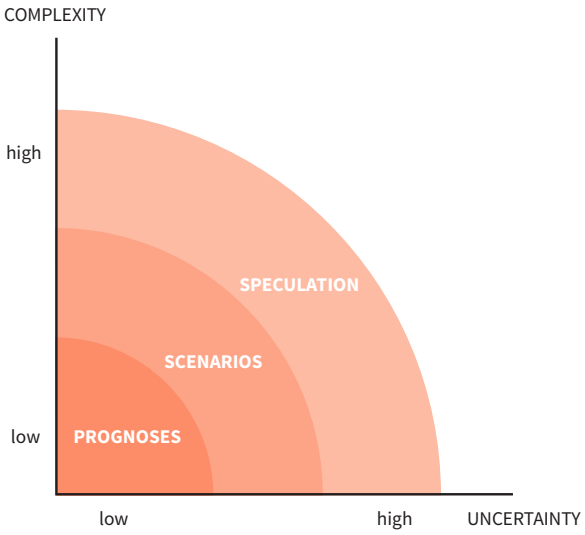

FIGURE 2.7 / Difference between prognoses, scenarios and speculaton (based on Dammers et al., 2017).

Scenario building

Scenarios can be applied in multiple fields (Merrie et al., 2018) – planning and landscape architecture amongst others (Dammers et al., 2017; Kok and Van Delden, 2009; Manders and Kool, 2015; Palang et al., 2000; Provincie Zuid-Holland, 2016; Soliva and Hunziker, 2009; Tress and Tress, 2003). They are especially useful tools for issues with big impact and high degree of uncertainty (Dammers et al., 2017). When scenarios are used, they can help to support and structure the decision-making processes by providing an overview of the uncertainties.

The number of scenarios appropriate for a futures study is between three and six, leading to a choice of four in most cases (Boschetti et al., 2016). Throughout years of scenario studies, this has led to a commonality in scenario archetypes. Scenario archetypes are groups of scenarios that incorporate a great deal of similarities (Hunt et al., 2012). From the different scenario

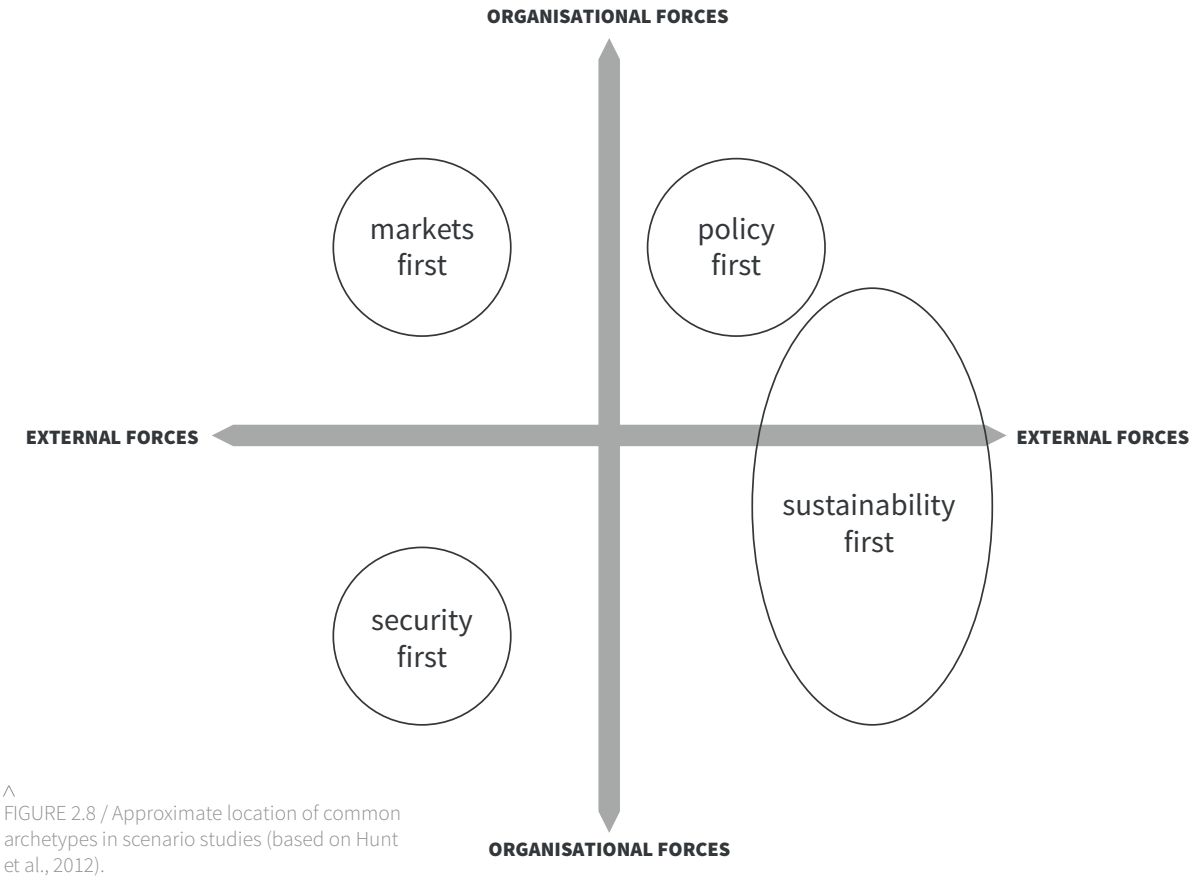

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FIGURE 2.8 / Approximate location of common archetypes in scenario studies (based on Hunt et al., 2012).

studies they analysed, Hunt et al. (2012) have made a generalisation of the most common scenario archetypes (Figure 2.8). It is recommendable to choose a set of these pre-defined archetypes, as they provide a starting point and framework that integrates years of applied experience of futures studies (Boschetti et al., 2016). The chosen archetypes can then be changed according to the specific context.

The appropriate archetypes can be selected by identifying two of the most critical and uncertain drivers of change (Boschetti et al., 2016). A helpful tool to rank the most important drivers is by putting trends into an impact and uncertainty matrix (Maack, 2001). This matrix reveals the relevance of the trends by ranking them according to their level of impact and degree of uncertainty (Figure 2.9). When two critical drivers are identified from this impact and uncertainty matrix, they can be placed along the two axes of the scenario space. Often these drivers are organisational on the one hand (vertical axis) and external (an attitude or concern) on the other (horizontal axis) (Hunt et al., 2012).

To acquire credibility in the scenarios, they should focus on different driving forces and/or scenario objectives, while having a set of common variables so that the scenarios can be compared (Mahmoud et al., 2009). They can be based on climatic, socio-economic, environmental and technological aspects while taking into account historical and current trends in the landscape. In this thesis, I aim to achieve scenarios that are sufficiently diverse, clearly defined, internally consistent and meaningful in terms of the STEEP drivers (social, technological, economical, environmental and political) (Figure 2.10) (Boschetti et al., 2016). This means that relevant trends for the landscape of southeast Spain will be analysed and identified according to these five pillars. Eventually these trends will be arranged and shaped into the framework of the final landscape scenarios (Dammers et al., 2017).

Methods

Techniques for scenario building differ from study to study. Palang et al. (2000) promote a thorough analysis of political and contextual factors to construct scenarios, based on a landscape impact analysis method. In the

DEGREE OF UNCERTAINTY

LEVEL OF IMPACT	low	medium	high
high	**CRITICAL PLANNING ISSUES** Highly relevant and fairly predictable (can often be based on existing projections). Should be taken into account in all scenarios.	IMPORTANT SCENARIO DRIVERS Extremely important and fairly certain. Should be used to differentiate scenarios.	**CRITICAL SCENARIO DRIVERS** Essential factors and forces, but highly unpredictable. Should be used to differentiate scenario plots and trigger exit strategies.
medium	IMPORTANT PLANNING ISSUES Relevant and very predictable. Should be figured into most scenarios.	IMPORTANT PLANNING ISSUES Relevant and somewhat predictable. Should be present in most scenarios.	IMPORTANT SCENARIO DRIVERS Relevant issues that are highly uncertain. Plausible, significant shifts in these forces should be used to differentiate scenario plots.
low	MONITORABLE ISSUES Related to the decision focus but not critical. Should be compared to projections as scenario is implemented.	MONITORABLE ISSUES Related but not crucial to the decision focus. Should be monitored for unexpected changes.	ISSUES TO MONITOR & REASSESS IMPACT Highly unpredictable forces that do not have an immediate impact on the decision focus. Should be closely monitored.

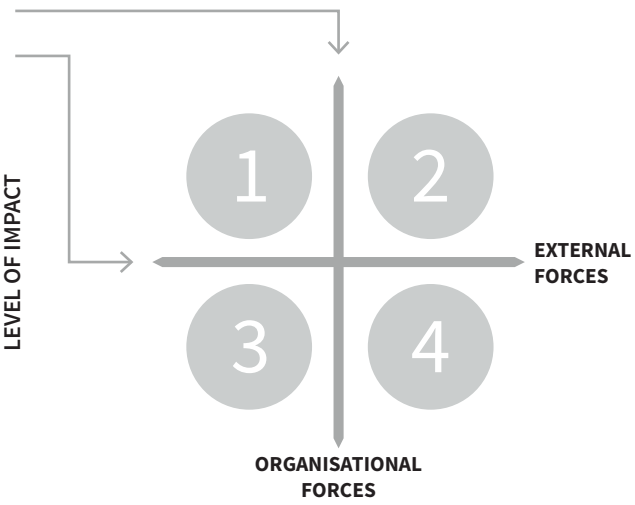

FIGURE 2.9 / Overview of the methodology behind an impact and uncertainty matrix. The shaded areas indicate trends that need key focus. Based on Maack (2001), adapted by author.

context analysis, natural conditions, former land use and current trends were taken into account. Kok and Van Delden (2009) proposed another technique for scenario building, by combining two methods: quantitative land-use models and qualitative participatory scenario development through active stakeholder involvement. Tress and Tress (2002) designed four extreme landscape scenarios as distinct paths, each focusing on the domination of one monofunctional land use (industrial farming, recreation and tourism, nature conservation and residential expansion).

There is a distinction between different types of scenarios. Forecasting/projective scenarios project and extrapolate current trends or expectations to the future. Backcasting/prospective scenarios construct possible futures that are contrasting with the present situation (Palang et al., 2000). Anticipatory scenarios on the other hand, are based on desired or feared perspectives on the future if certain events or actions take place. They are more subjective constructions of past and possible future conditions (Mahmoud et al., 2009).

In general, there are four possible ways to come to landscape scenarios: trend extrapolation by extending present trends of landscape development to the future, the assessment of the effects of concrete policy measures on the landscape, a normative future that presents a landscape with desirable elements and a surprising future, which expresses the role of unexpected landscape change (Palang et al., 2000).

The scenarios that will be produced in this thesis will be based on an extrapolation of current trends. The scenarios will be developed according to two critical drivers that are placed along two axes, with four scenarios as a result. This means there will be four scenarios with elements that are expected seen from the present situation. However, because uncertain trends are extrapolated as well, the scenarios will also incorporate elements that are contrasting with the present and hence present a surprising future.

Role of the landscape architect

Landscape architects can use the technique of scenario building to explore and visualise future landscape changes and anticipate

on possible future directions. With their knowledge about the landscape system and creativity they can convert natural and social sciences into understandable entities. By thoroughly analysing possible future trends on all five STEEP levels (social, technological, economical, environmental and political), they can shape and design possible future landscapes. They can use these landscape scenarios as a foundation to design a desirable outcome. By interpreting information from different disciplines to develop the landscape scenarios, a landscape architect could moreover function as a mediator between different stakeholders (laymen, scientists, policymakers).

Instead of relying on predictions, landscape scenario design enables a creative and flexible approach to preparing for an uncertain future (Merrie et al., 2018). Especially when working with changing conditions, not just one future solution can be given. Through an interactive research through design process and based on different assumptions and influences, a set of possible future landscape scenarios will be created. Next to the designing itself, the insights the scenarios will give into the mechanisms and outcomes of future landscape change in southeast Spain are the main aim.

∨ FIGURE 2.10 / Overview of the categories and examples of the different STEEP drivers. Partly based on Maack (2001), adapted by author.

DRIVER	CATEGORY	EXAMPLES
SOCIO-CULTURAL	Social factors	Education levels, social priorities, societies character, cultural and class tensions, social values and attitudes, living circumstances, occupations and interests, land and water rights, differentiated membership in groups and associations, gender issues, historical landscape features
	Demographic patterns	Age, family, household and ethnic structures; regional and national migration patterns; spatial distribution of population, wealth distribution including regional and national poverty rates
POLITICAL	Geopolitical	Trends in international relations; relationship with other nations in region (regional trading blocs, military alliances); levels of tension, conflict (regional, international), trade and protectionism
	National	Change in governmental development strategy and policy (privatisation); changes in legislation (including regulation, creation of enabling environment); changes in structure and responsibility of ministries; changes in rules governing formation and functioning of parties; stability of government, likelihood of change/overthrow; governmental environmental action
ECONOMICAL	Macroeconomic conditions	GNP, balance of trade, rate of inflation, exchange rate; current and future relations with international financial markets, current debt levels; governmental expenditures, deficits Changes in the economic structure of nation (dependence on single export, percentage of exports in finished goods), formation of new regional trading blocs
	Microeconomic conditions	Change in size, type and ownership of firms; formal and informal labour forces structure by region; employment rate; changes in economies of scale/structure of key industries; style of tourism
	Market forces	Spending patterns of consumers (urban/rural, national/regional), international demand for key exports Distribution and efficiency of rural and urban markets, impact of the informal sector, sources of competition (national, regional, international)
	Impacts of global economy and development	Volume of assistance from multilateral and bilateral agencies, conditions for assistance (policies, requirements)/harmonisation Risk tolerance and conditions for entry and exit by international firms, stake in local economy by international firms
ENVIRONMENTAL	Physical environment	Air/water/land pollution trends and locations, environmental quality issues (climate change), landscape conditions (signs of desertification, erosion levels)
	Natural resources	Energy prices and availability (likelihood/impact of an oil shock), raw materials (rate of depletion, ease of access), sustainability (strategic use of resources) regional distribution of natural resources
TECHNOLOGICAL	Style of land management	Farming methods, water management
	Infrastructure	Level of technology in key industries, emerging technologies, capacity to manufacture technology for export
	Future directions	Basic research and technical education trends in nation; 'digital divide' – computer and telecom infrastructure/trends; potential for the rapid diffusion of new technologies from abroad

2.4 METHODOLOGY

This paragraph describes the methodological structure as employed in this thesis. The research methods that will be presented were used to answer the research questions. Overall, the methodology shows what is necessary to develop the landscape scenarios for the desertifying landscape of southeast Spain and what is needed to create a design from this approach.

Research structure

The landscape scenarios developed for southeast Spain are based on an empirical foundation. For this foundation, credibility was generated by identifying trends according to five 'STEEP' drivers (social, technological, environmental, economical and political) (Boschetti et al., 2016). The knowledge for this empirically informed background was found in expert interviews and a qualitative trend analysis of the landscape from observations during fieldwork. This has resulted in a trend catalogue with photographs indicating different trends from the 'STEEP' drivers. Furthermore, a literature analysis has revealed a set of emerging future trends on multiple spatial levels, which were categorised according to the same five pillars and identified according to an impact and uncertainty matrix (Maack, 2001). In this research structure, the 'STEEP' drivers are used to build the empirically informed background, which is then used to develop the landscape scenarios. An overview of this research structure can be found in Figure 2.11.

Methodological framework

The overarching methodology of this thesis is highly iterative and incorporates an interactive design approach (Figure 2.12). A sequence of four phases has been followed to answer the research questions.

As a very first step in the process, an attempt was made to compose a set of un-informed landscape scenarios (blank scenario prototyping). This was used as a first moment to think of possible narratives for the possible futures of desertification in southeast Spain. After this research kick-off, the possible future social, technological, economical, environmental and political (STEEP) trends in the landscape of southeast Spain needed to be determined to use for the development of the landscape scenarios. This was done by retrieving information from field observations and expert interviews (*empirical* phase) and a literature and landscape analysis of the Pedrera case study area (*exploratory* phase). Each of these two phases concluded with a new set of scenario prototypes; interim storylines for the landscape scenarios. The empirical foundation that resulted from these phases informed the development of the landscape scenarios (*generative* phase) and therewith answered the question what landscape scenarios can be created from different trends that show the possible futures for the desertifying region of southeast Spain.

It has to be noted that the landscape scenarios that resulted from this process are not prognoses, predictions or forecasts and are not meant to present the most likely or probable future state. They are used to visualise several extreme, but believable possible future landscapes in southeast Spain taking into account the uncertainties.

To increase the connection between the scenarios and the landscape, landscape scenario building blocks were developed. These building blocks are the spatial embodiments of the scenario narratives and depict emerging trends in the landscape that appeared from the 'STEEP' analysis.

These landscape scenario building blocks are a way to translate elements from the landscape scenarios for southeast Spain to the spatial design of the Pedrera case study area. They were assessed in a stakeholder survey with people from the Pedrera case study area (*generative* phase). The purpose of the survey was to find out which scenarios would have their preference and which landscape scenario building blocks have most support from them. To develop the regional design for the Pedrera case study area, these building blocks were analysed using a Multiple Criteria Decision Analysis (Greco, 2016) according to the 'STEEP' drivers (their public acceptance, political feasibility, economical gain, environmental impact and technological feasibility). This analysis made it possible to select the building blocks that fight desertification, which were used to compose

the regional design for the Pedrera area. This answered the final sub research question of this thesis.

By examining possible landscape interventions and strategies that can be used to combat desertification, this regional design can comply with the four ambition levels: to reduce current desertification rates while maintaining current systems (1), to prevent further desertification (2), to reverse current erosion processes (3) and most preferably to rehabilitate currently degraded landscapes (4). This answers the design question of this research, by showing what spatial design can be created for the Pedrera case study area from the different landscape scenarios, which contributes to combatting desertification.

At the end of the process, the main research question can be answered, which follows in the last *evaluative* phase. In this concluding section, it is explained what the contribution of landscape scenarios can be to explore and communicate future options for desertifying landscapes in southeast Spain.

Research and design

By applying both a research for design (RFD) and a research through design (RTD) approach to the desertification problem, integral landscape scenarios were developed to explore future alternatives for desertifying landscapes in southeast Spain. RFD and RTD are familiar methods in landscape architectural research. RFD is used to build a scientifically grounded foundation to support the design process, while RTD describes the process of designing as a research method (Lenzholzer et al., 2013).

The research set-up is based on four phases: *empirical*, *explorative*, *generative* and *evaluative*. The first two are about creating an empirical foundation for the design of the landscape scenarios (RFD). Each of these two phases (*empirical* and *explorative*) covers a design aspect by translating the research outcomes in a scenario synopsis and eventually the outcome of the landscape scenarios is used for the regional design (*generative* phase). This is how the RTD process comes about in this thesis.

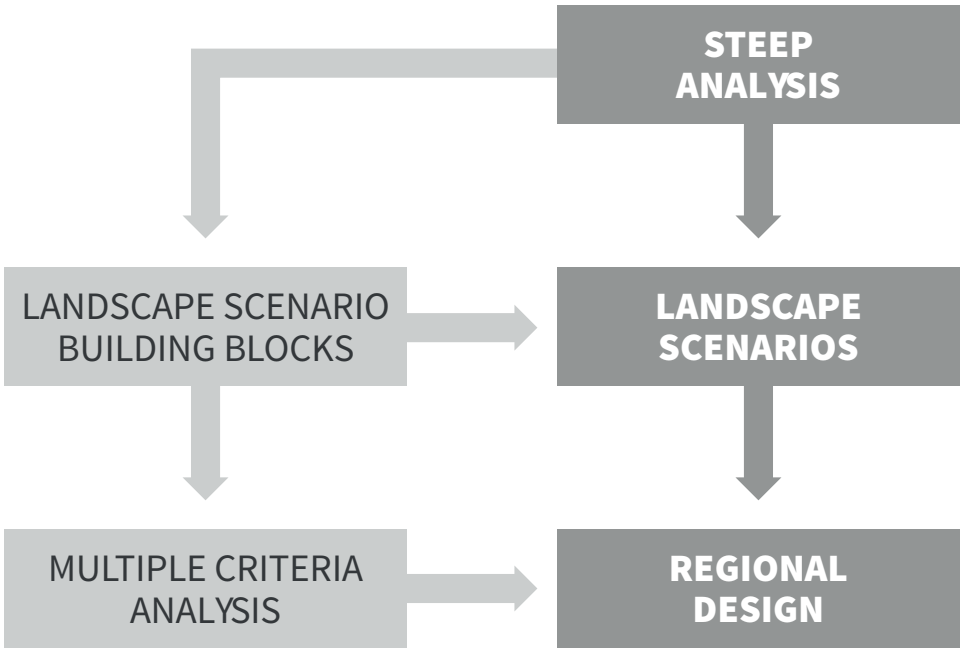

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FIGURE 2.11 / This diagram shows the research structure, with the 'STEEP' drivers that are used to build the empirically informed background, which is used to develop the landscape scenarios for southeast Spain. The landscape scenario building blocks function as a tool to help translate the analysis of the STEEP trends to the landscape scenarios. Eventually this leads to a regional design, which is shaped with the landscape scenario building blocks that appear to be best in combatting desertification according to the Multiple Criteria Analysis.

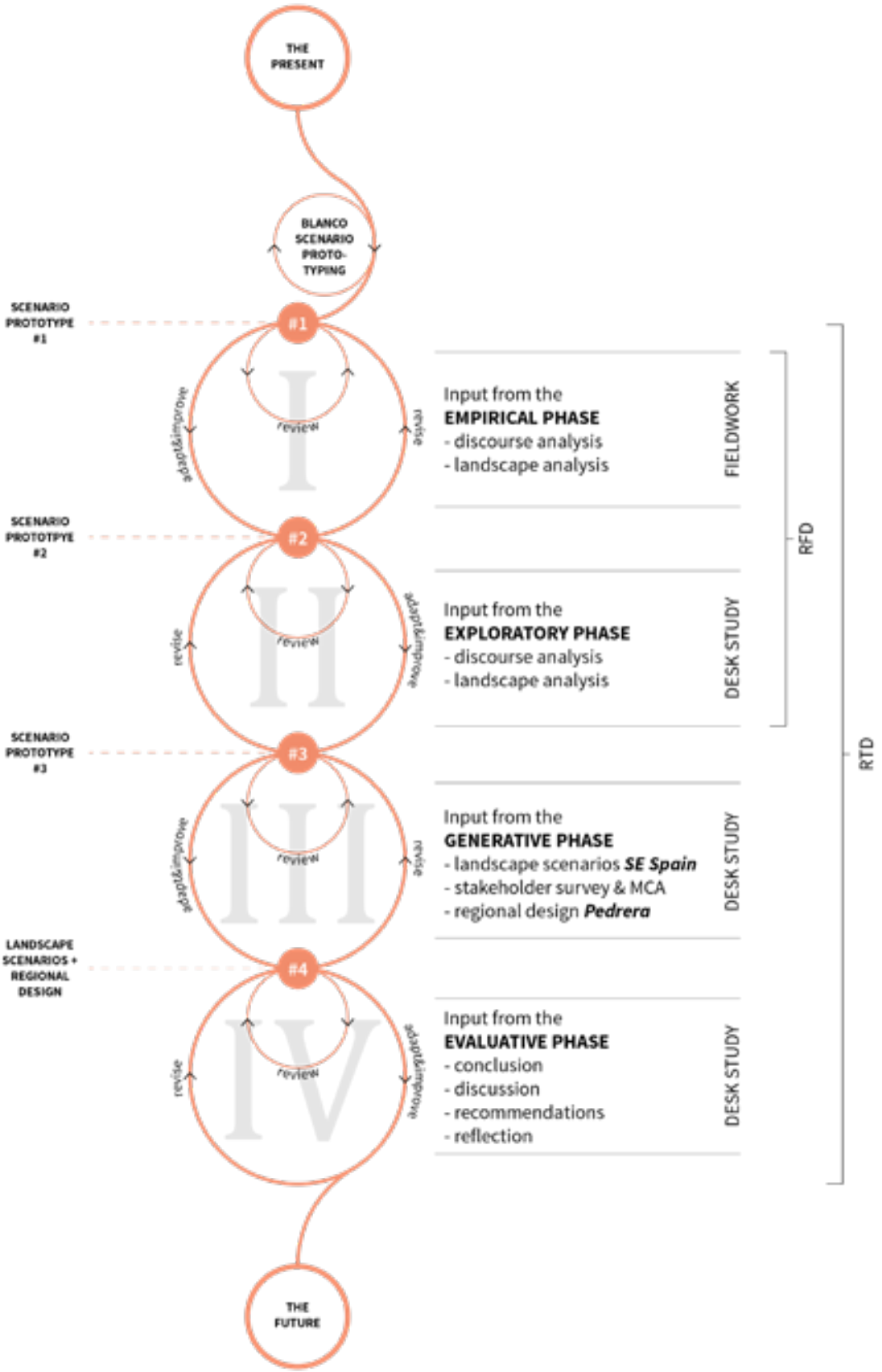

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FIGURE 2.12 / The methodology of this thesis comprises four phases (*empirical*, *exploratory*, *generative* and *evaluative*) of which the first two conclude with a scenario prototype. It is a highly iterative process, as each phase consists of an evaluation moment to revise the gained knowledge and evaluate the scenario prototypes.

3 OBSERVATION

This first analytical chapter describes the results from the *empirical* phase. This phase consisted of 5 weeks of fieldwork in southeast Spain and was twofold. First of all it covered a discourse analysis through interviews with different stakeholders. Furthermore, I executed a qualitative trend analysis of the landscape from observations during fieldwork. Before these analytical steps and fieldwork, an attempt was made to compose a set of un-informed landscape scenarios (blank scenario prototyping).

This chapter reveals the outcomes of these three steps and helps to answer the question what possible future social, technological, economical, environmental and political (STEEP) trends are in the landscape of southeast Spain and shape the empirical background that will determine the final landscape scenarios.

3.1 BLANK SCENARIO PROTOTYPING

As a first step in this research, I introduced a moment of blank scenario prototyping to study potential pathways of landscapes prone to desertification. This step was taken to have an un-informed and un-biased view on the matter to stimulate out-of-the-box thinking. This means that prior knowledge and scientific background was limited in order to create the scenarios with an open mind. It functioned as a research kick-off to start the exploration of possible futures of desertification in southeast Spain. During this process, four contrasting scenario prototypes were created. Each of these scenarios is based on expected trends and parameters as anticipated by the author.

FIGURE 3.1 / Common archetypes and critical drivers. Partly based on Hunt et al. (2012), adapted by author.

Critical drivers

As a common tool in scenario development, the two most critical and uncertain drivers of change were identified first. The result is a double uncertainty grid – also known as a two-dimensional 'scenario space' – that displays two expected important and uncertain issues on two axes (Boschetti et al., 2016). As it is recommendable to make use of a set of predefined archetypes, I analysed the most common archetypes and critical drivers from the study that Hunt et al. (2012) did on scenario archetypes. I also took notice of the drivers that were used in other studies (Dockerty et al., 2006; Merrie et al., 2018). This resulted in a set of possible scenario drivers (Figure 3.1). Clearly, there are many more crucial drivers thinkable, but these were proven to be most common and effective according to Hunt et al. (2012).

Eventually two drivers were selected that would have high impact on desertification in Spain, but which are involved with a high degree of uncertainty. Hence, each of the scenarios from this prototype session is based on the type of governance (the organisational forces): top-down versus bottom-up, and the expected future social values (external forces): re-active individualism versus pro-active solidarity. The external forces also incorporate the amount of action taken to protect the environment and combat desertification as a result of the social values (re-active versus pro-active). These drivers were selected, as desertification in southeast Spain is mostly an issue that results from human action (AGE, 2004). With an individual and reactive attitude, society will not focus on rehabilitating the landscape, whilst a solidary and pro-active society is more likely to do so. On the other hand, a top-down governance will have a different approach on combatting desertification than an organisational structure that comes from bottom-up. Hence, these two drivers will have a significant impact on desertification rates and therewith the future landscape of southeast Spain.

Scenario prototypes #1

The second step in the process was to write expected trends from all STEEP drivers on post-its, which were placed into the spaces of the scenario axis (Figure 3.2). This resulted in a set of four scenarios that significantly differ

from each other regarding possible future pathways and how future major challenges will be handled.

Scenario I, rural maximisation, presents a world in which society is re-active and acts out of self-interest. Governance is top-down, with a focus on the global market. Scenario II, rural emancipation, is a pro-active and community supportive world. The government is top-down, with a focus on global sustainability. Scenario III, rural abandonment, presents a re-active society that is in continuous conflict. Scenario IV, rural refuge, is a pro-active and solidary community that resulted from a massive social transformation.

With the different trends that were identified, four collages were made as a concluding product of the blank scenario prototyping process (Figure 3.3). The main purpose of the collages was to use them as a way to communicate the scenarios with the interview respondents during fieldwork. Another aim of blank

FIGURE 3.2 / Expected trends from all STEEP drivers categorised into the four scenario spaces

FIGURE 3.3 / Scenario space of scenario prototypes #1. Scenario I, rural maximisation, presents a world in which society is re-active and acts out of self-interest. Governance is top-down, with a focus on the global market. Scenario II, rural emancipation, is a pro-active and community supportive world. The government is top-down, with a focus on global sustainability. Scenario III, rural abandonment, presents a re-active society in continuous conflict. Scenario IV, rural refuge, is a pro-active and solidary community as a result of a social transformation.

scenario prototyping was the possibility to make a list of focus elements in the landscape based on the STEEP trends that were identified (Appendix I). This list made clear what elements needed focus during fieldwork.

While creating the scenarios it was assumed that in each scenario, climate change is an expected threat and that technology will advance by any means. Depending on the two given critical drivers of change, the amount of climate change and its effects are determined, as well as the direction in which technology will develop.

3.2 DISCOURSE ANALYSIS

The key method for the discourse analysis were expert interviews. During the course of the fieldtrip and after several interviews, it became apparent once more that the desertification issue is an immensely complex phenomenon for which the solution is not unambiguously. At first sight it seems more an environmental and technical problem. However, knowledge about how to reverse desertification processes and sustainable land management techniques are already available (Appendix B). As literature points out, desertification in Spain is more of a political, cultural and economical issue (AGE, 2004). This vision is shared by most of the interview respondents. The summaries of these interviews can be found in Appendix C and a schematic overview of the conclusions on the desertification issue from the expert interviews can be found in Figure 3.4.

Desertification drivers

One of the interviewees, Héctor Moreno Ramon, an agronomical engineer at the Polytechnical University of València, argues that desertification only has to be a political problem (Interview 1). He mentioned that for example the way groundwater is distributed encourages unsustainable land management. The amount of water designated for agriculture should be decreased in order to prevent farmers from cultivating water intensive crops. Since, irrigation leads to more degradation. This immediately points out another factor in the desertification story, which is the market. Farmers are almost forced to farm unsustainably to achieve high enough yields to survive. Especially after the economic crisis from 2008 to 2012 – which had a big impact on the Spanish economy – initiatives to restore land and apply alternative agricultural methods were set aside (Interview 2).

In contrary to other perspectives in the desertification realm, researchers from CIDE (Desertification Research Centre València) see land abandonment as one of the biggest factors that leads to land degradation and desertification (Interview 2). They argue that, especially the farmers with high yield crops such as cereals and vegetables, take well care of the land and think of the health of their soils on the long term. In the eyes of these researchers, it is preferred to support farmers by means of subsidies to keep them in the countryside. By investing in good infrastructure and by compensating for living in these areas, the rural life should be kept alive. This will avoid land abandonment – a phenomenon that leads to erosion and degradation, and later on leads to increased chance of fire hazards due to emerging vegetation cover. The concern about people leaving the countryside is shared by Yolanda Jimenez, a university professor in regional and physical geography (Interview 4) and Angel Sáez, mayor of the town hall of San Miguel de Salinas and farmer (Interview 6).

Other stakeholders also saw an opportunity for revising subsidies (Interview 3&7), but from a completely different perspective. A representative from the AlVelAl organisation pointed out the fact that current EU funding subsidises unsustainable agricultural methods such as ploughing (Interview 3). They argue for a reconsideration of these subsidies and would like to promote grants that support ecologically beneficial strategies.

Apart from the economical and political complexity of the problem, there is also the issue of culturally and socially grounded factors that increase the risk of desertification. As appeared from several interviews, farming in Spain is a highly social process (Interview 1, 2, 3&4). The people that live in the countryside are mostly farmers and depend on a small social structure – of mostly other farmers. If a farmer decides to take on a different approach, it is likely that he or she is seen as an outsider and falls out of the social group. Farmers are used to do farming the same way as others do, but also the same way

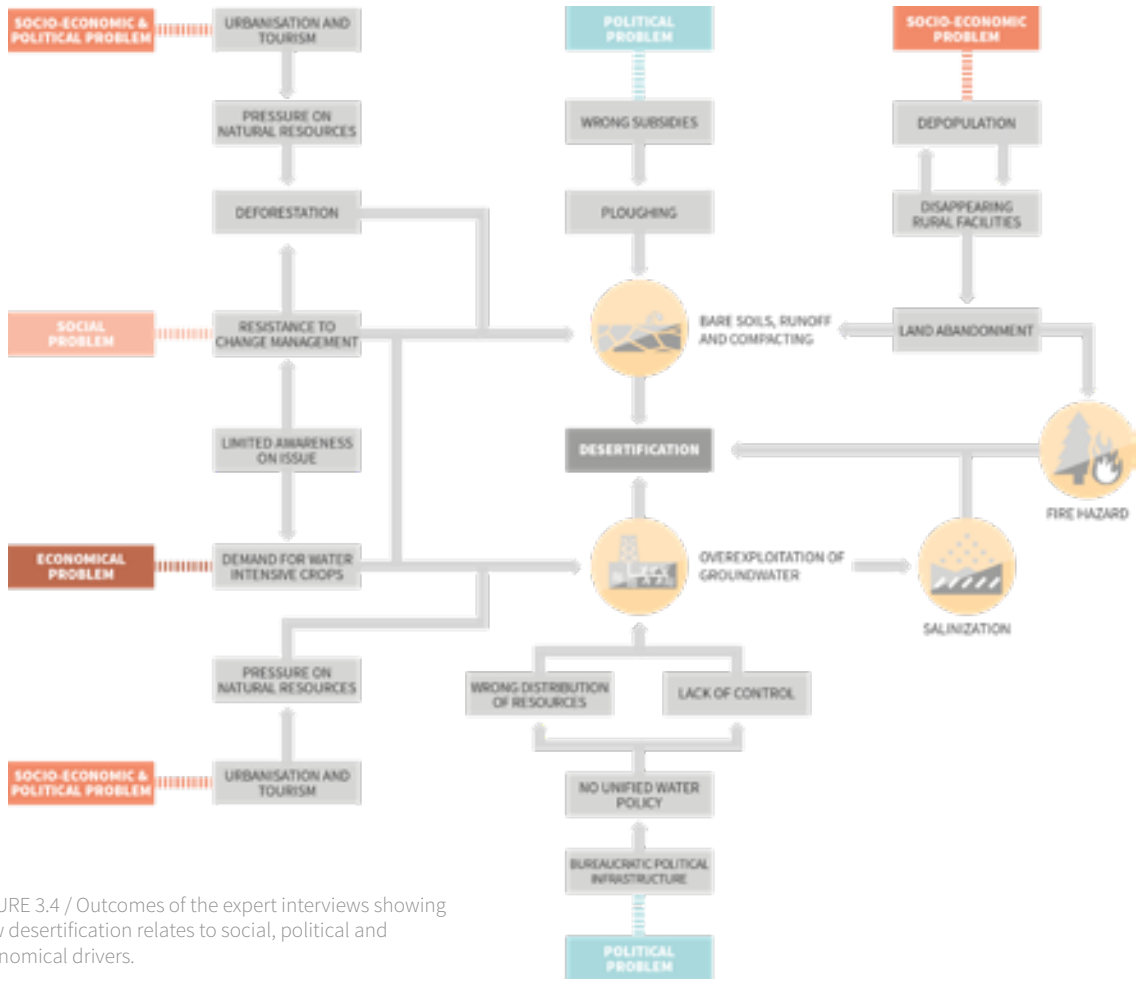


FIGURE 3.4 / Outcomes of the expert interviews showing how desertification relates to social, political and economical drivers.

as they always did. Alternative approaches first have to be proved to work before they decide to apply it on their own land.

Perceptions on desertification

Concerning the perception of desertification, there is a difference in stakeholders that are directly involved with the phenomenon and people that are not directly concerned with the problem. For farmers water quality and quantity is a real concern because it has a direct effect on their business (Interview 1). Already since centuries in Spain, this has resulted in the establishment of irrigation communities. Depending on the province, different water regulation measures are applied. Even though not explicitly admitted or proved, many farmers illegally tap from groundwater resources (Interview 5&7). There is a lack of overview and control over these fragile and fossil resources.

The general awareness of desertification in Spain appears to be limited (Interview 2). It is for example not covered as a topic on schools and it is not regularly considered as a potential danger, unlike forest fires. Water availability on the contrary, is something that regularly gets attention, because it is something that is less conceptual and something that could affect people's personal lives. People are aware that the zone is fragile, but as long as tap water is still running it is not perceived as something with a direct impact. People do talk about the factors that cause desertification or the direct results, but the phenomenon itself is too complex and abstract to generate a discussion (Interview 1 & 2).

Revising scenario prototypes #1

Next to more in-depth information about the situation that exists around desertification in southeast Spain, the first scenario prototypes were reviewed. From multiple interviews (Interview 1, 2, 3, 4 & 6), it could be concluded that most of the trends that were employed in the first scenario prototypes were already happening. (Over-) exploitation of resources was already a common process, as well as rural outmigration and land abandonment. As

the respondents from Interview 2 indicated, southeast Spain was pretty much already in the situation of scenario prototype 1. Therefore, the landscape scenarios should become much bolder and extreme when they are adapted and improved in order to explore possible future landscapes of southeast Spain.

3.3 LANDSCAPE ANALYSIS

The observations that were made to analyse the landscape of southeast Spain were based on the list of key elements that resulted from the blank scenario prototyping process (Appendix I). The results of this visual content analysis were collected in a trend catalogue (Appendix K). This catalogue shows photographs that were taken during fieldwork, categorised per STEEP driver, to show what processes and developments are at stake in the region. Its purpose is to get an understanding of the landscape system and the context it deals with. The specific themes it is divided up in, point out both past and current trends in the landscape. These on their turn bring up evidence for possible future trends. Each of the categories is accompanied by a short remark from field notes and a brief analysis on the depicted content. Eventually, the main aim of the catalogue is to contribute to the empirical foundation that is necessary to develop credible landscape scenarios for southeast Spain.

Observations

Many of the trends that were expected beforehand and which were listed down before the fieldwork, have been observed in the landscape. Some occurred frequently, such as abandoned houses or monocultures, whilst others were not as common and had to be looked for, such as eco villages or eco-tourism. During the fieldwork, I also encountered elements in the landscape I had not foreseen, such as dust devils and overgrazing.

One of the most important observations and realisations has been that desertification is not something obviously visible in the landscape. Its effects are not easy to point, which emphasises the abstract nature of desertification. When looking more closely however, it is possible to find signs that are characteristic for a desertifying landscape, such as erosion, gullies and salinization. Moreover, with the many vacant buildings scattered around the landscape, the social and economical 'desertification' were very apparent in the landscape.

Revising scenario prototypes #1

Just as the interview respondents pointed out, the field observations made it clear that many of the trends that were applied in the first scenario prototypes were not extrapolated enough, as most of it was already happening. This emphasised once more that the final landscape scenarios should be made more extreme.

3.4 IMPACT AND UNCERTAINTY MATRIX

To rank the trends that were encountered during the discourse analysis (expert interviews) and landscape analysis (field observations), trends were put into an impact and uncertainty matrix (Appendix E). This matrix reveals the relevance of the trends by ranking them according to their level of impact on desertification and degree of uncertainty. The trends are categorised based on the STEEP drivers. The coloured blocks indicate that a trend has a spatial impact and is visible in the landscape. The most significant trends in terms of desertification impact are marked with a grey background.

3.5 SCENARIO PROTOTYPES #2

Based on both the discourse analysis (expert interviews) as findings from the landscape analysis (field observations), scenario prototypes #1 appeared not to be extreme enough. A lot of trends that were described in these first prototypes were already happening. Examples are the overexploitation of resources in scenarios I and III, uncontrolled urban sprawl in I and III, signs of alternative land use management in II and IV, bottom-up initiatives and local corporations as in III and IV and governmental enforced policies as in I and II.

To evoke a livelier discussion and to appeal more on the imagination, it was necessary to extremify the scenarios during prototype session #2. The results are four new landscape scenario prototypes, with each a new collage (Figure 3.5). They are an extrapolation of observed trends during the fieldtrip and remarks from the interview respondents. The foundation behind the scenarios remained the same, with type of

FIGURE 3.5 / Scenario space of scenario prototypes #2, showing extremer possible future landscapes in southeast Spain.

governance on the vertical axis (top-down to bottom-up) and social values on the other (re-active individualism to pro-active collectivism).

Outcomes

Scenario I is extremer in terms of the use and impact of technology on the landscape. Water resources decreased due to high demands and passive management, which is backed-up by highly efficient desalinization plants and expanded irrigation systems. In this scenario, problems often emerge from the last solution, sometimes leading to problems that occur faster than the solution itself.

Scenario II shows an eco-modernist state, with a strong government taking control to achieve national sustainability. Institutional reform is used to solve environmental problems, for example by forced environmental care and taxes on pollutants. The result is a techno-optimist state aiming to benefit the ecosystem without undermining quality of life.

In scenario III, authorities have fallen and frictions between social groups have led to social conflict. People's main concern is their safety, not environmental problems. This has resulted in the overexploitation of resources, water deficits and loss of global commons and ecosystem services, causing increasingly and almost irreversibly fragile environments.

Scenario IV is characterised by a social transformation, in which people have created networks of restorative communities with low environmental impact. There is much focus on local environmental management strategies and local organisations. Property is communal and the economy works with common goods, local currencies and gifts. Lifestyles are sober, although technology is embraced.

4 EXPLORATION

This chapter explores the results from the second explorative phase. The information retrieved from the literature analysis and landscape analysis of the Pedrera case study area that came out of this chapter, is used to inform the empirical foundation to develop the landscape scenarios. These desk studies are incorporated in this thesis to back-up observations and findings from fieldwork with a scientific foundation. The aim of this phase is to contribute to the question what possible future social, technological, economical, environmental and political (STEEP) trends exist in the landscape of southeast Spain that can determine the future landscape scenarios.

4.1 DISCOURSE ANALYSIS

The trends that were analysed in this discourse analysis of on-going and possible future developments were retrieved from literature and newspaper articles. Currently existing policies and rehabilitation programs for desertifying regions in Spain were also incorporated in the research. Trends on both short- and long-term were assessed, which were divided into the STEEP drivers. Their impact on different scales was also taken into account if this was applicable (global, European, national, regional, local or individual). Moreover, trends were as much as possible analysed through different timescales: past, current and future.

As desertification is such an overarching and multidimensional phenomenon, each trend relates in some way to it. Therefore, each section attempts to describe what consequences the trend has for desertification, or how it is influenced by it.

The outcome of the literature analysis is a very extensive document with trends on all STEEP levels. The most important findings were filtered and put into an impact and uncertainty matrix (Appendix F). Also in this matrix, the coloured blocks mean that a trend has a spatial impact and is visible in the landscape. The most significant trends in terms of desertification impact are again marked with a grey background. The literature analysis document itself is not incorporated in the appendix, but can be requested from the author. The reference list that comes with the document can be found in Appendix D.

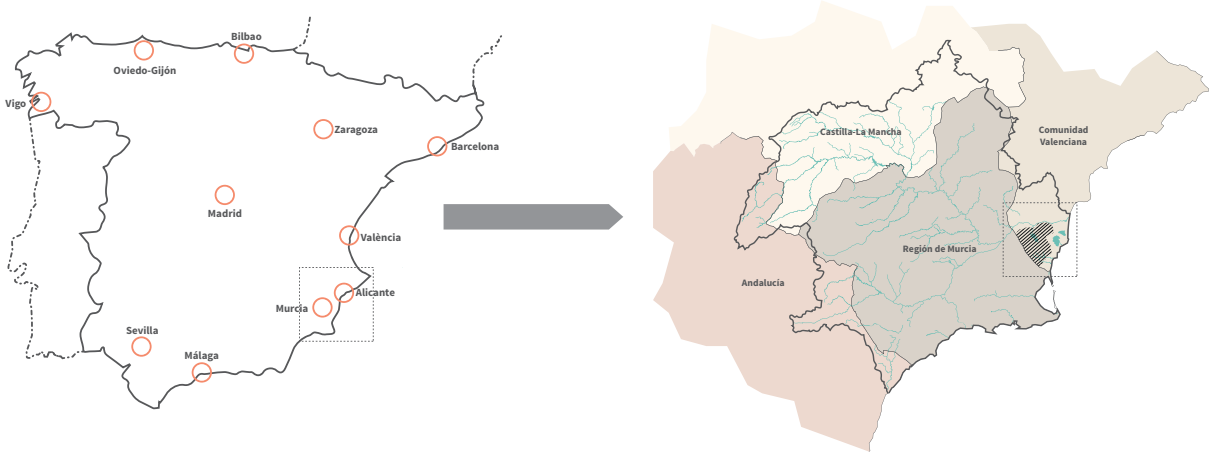
Revising scenario prototypes #2

The literature analysis allowed a new moment to revise the second scenario prototypes in order to adapt and improve them. This analysis made it possible to back-up the trends that were observed and heard during fieldwork with scientific data.

As can be seen from the impact and uncertainty matrixes (Appendix E and F), there is an overlap in trends from the empirical phase and explorative phase. Trends that were confirmed are for example the increasing number of desalination plants, new farming styles (more technological, automated land management), rural shrinkage, urbanisation and illegal water depletion. Few new trends were added as well, such as the increased risk of water pollution as a result of climate change and mismanagement of water resources, initiatives for forest wind energy projects, the possibility of introduction of GMO's in the EU, the proposal of implementing an urban green belt to restore degraded land and prevent further urban expansion and several rural revitalisation projects with local currencies and new social movements. An example of a trend that was invalidated/ not confirmed is the possibility of increased amount of dust devils. This phenomenon is not researched in southeast Spain and it is not confirmed whether they will occur more frequently.

4.2 LANDSCAPE ANALYSIS PEDRERA

The case study area where the stakeholder assessment was conducted and on which the regional design is focused, is the Pedrera area (Figure 4.1 and 4.2). This case was selected, as it has been the research area of soil scientists from the Polytechnical University of Valencia since the '70's. Through Héctor Moreno Ramon I encountered the research and was invited to collaborate and use their data. It is a prototypical case for an area prone to desertification seen the developments that are characteristic drivers of desertification in southeast Spain (urbanisation, intensification of agriculture, deforestation and land mismanagement). This paragraph will proceed with a short introduction of the area pointing out the most important findings. The landscape biography with the essentials from the Pedrera area can be found in Appendix G.



NATIONAL
southeast Spain
southern Valencian Community
coastal Mediterranean zone

SUPRA REGIONAL
Vega Baja del Segura region
part of the Segura river basin
part of touristic coastal area Costa Blanca

FIGURE 4.1 / Location of the Pedrera case study area within Spain and the province of Valencia.

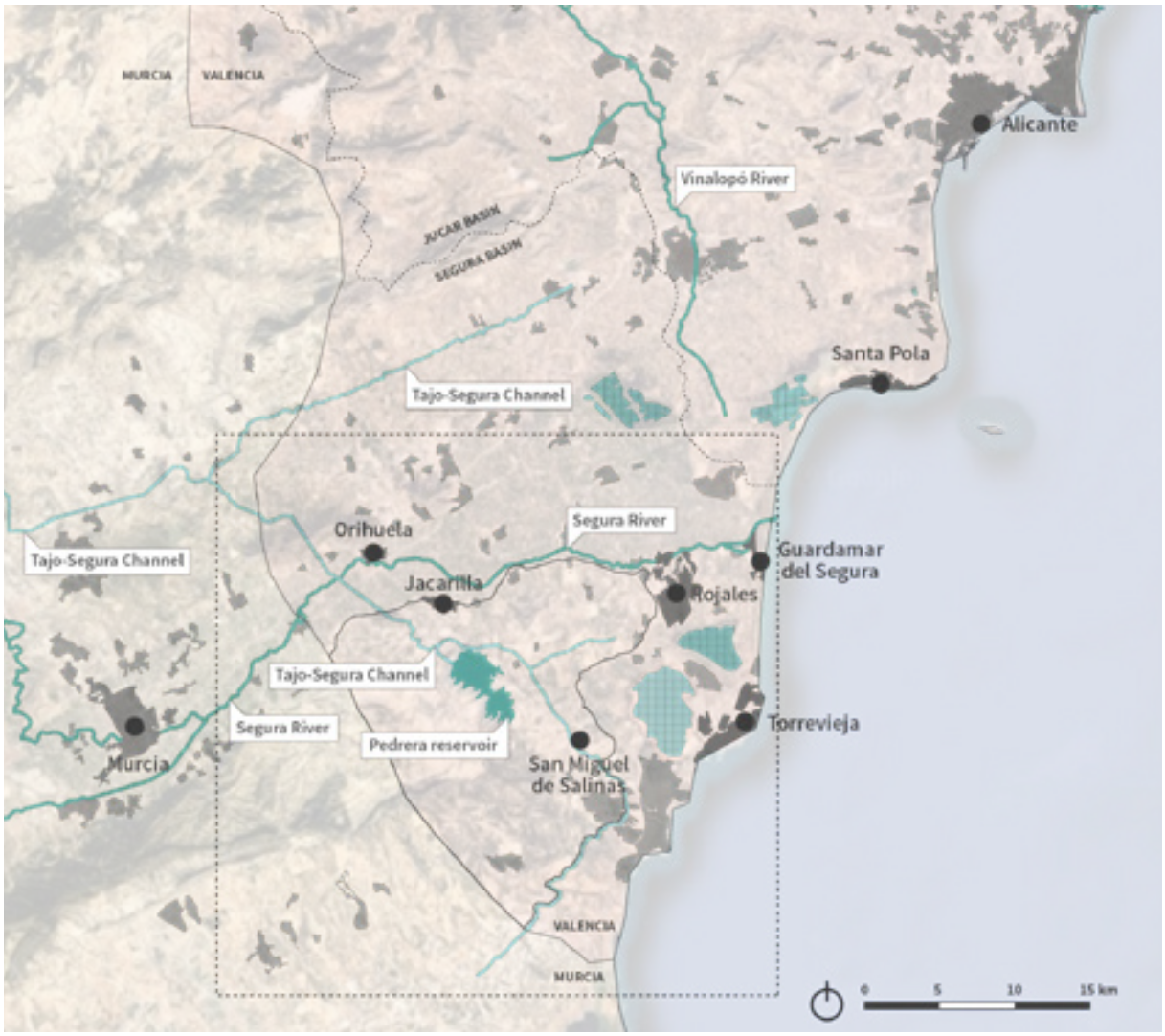


FIGURE 4.2 / Location of the Pedrera case study area within the closer region. It is the area irrigated from the Pedrera reservoir, which depends on the Tajo-Segura channel. The area is located between the cities of Alicante and Murcia.

The Pedrera area is named after the reservoir it is irrigated with. This reservoir is filled by the Tajo-Segura transfer channel, which was established in 1979 (Ibor et al., 2011). The reservoir provides water for agriculture as well as for tourism and urban consumption (Morote et al., 2017). The arrival of the channel had a major impact on the local landscape. Before, most agricultural land was used for dry land cultivation such as almonds. After the channel was constructed, more and more of these traditional lands got converted into irrigated citrus cultivation. Now about a third of the area is cultivated with citrus, and only a marginal acreage is still occupied with traditional almond production. Next to this there are several urban expansion projects at stake, which threaten the protected natural area 'Sierra de Escalona'.

These land-use changes (intensified agriculture and urban sprawl) have resulted in increased soil compaction, leading to erosion, salinization, land degradation and desertification (Barbero-Sierra et al., 2013). These complications are further complicated by an irrigable deficit due to poor water management in the region (Ibor et al., 2011).

Impact and uncertainty matrix

Next to the trends that were revealed during the fieldwork and in the literature analysis, some specific trends for the Pedrera case study area occurred from the landscape analysis. These were ranked in a smaller impact and uncertainty matrix with trends only applicable for the Pedrera area. This matrix can be found in Figure 4.3.

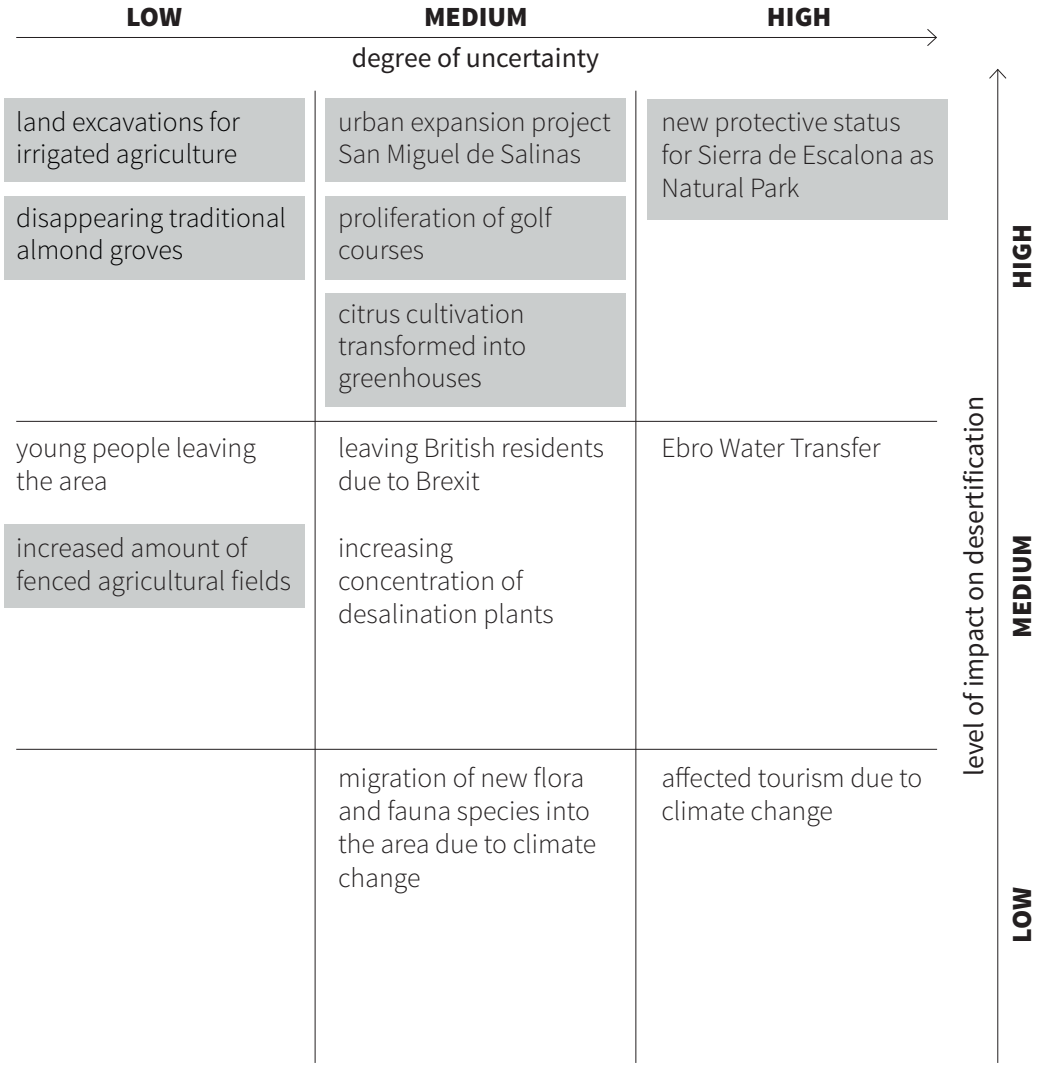


FIGURE 4.3 / Impact and uncertainty matrix for the Pedrera case study area. Trends indicated in grey have a direct spatial impact.

FIGURE 4.4 / Scenario space of scenario prototypes #3, fine-tuned according to the findings of the literature and landscape analysis.

4.3 SCENARIO PROTOTYPES #3

The last stop before coming to the final landscape scenarios was the development of the third scenario prototypes, meaning that the previous prototypes have been fine-tuned according to the outcomes of the literature and landscape analysis. The basic structure and storylines remained the same, with scenario I focusing mainly on the economy, scenario II focusing on policies and sustainability, scenario III concerned with security issues and scenario IV prioritising a sustainable community.

The main changes have been made in the detailing of the stories. For example, in scenario I people have been completely removed from the countryside. Agricultural robots maximally exploit resources in order to provide society with food and other utilities. No attention is paid to the environment, and thus the landscape is completely degraded. This is compensated with technological solutions. In scenario II, the world is still highly technological. With top-down governance, restoration and reforestation projects are carried out. The same environmentally minded society can be found in scenario IV. Only here it is not a result of policies, but of people's individual and communal actions. Projects to restore the landscape are scattered around the country and people have embraced different farming techniques. In scenario III, the dust devils as a results of changing climate and incorrect land management were removed from the storyline. Instead, the main problem in this scenario is water pollution due to mismanagement and overexploitation of resources. As a result the landscape has been abandoned by humans and is slowly being taken over by nature.

The collages for scenario prototypes #3 can be found in Figure 4.4.


5
GENERATION

In this chapter, the final landscape scenarios for southeast Spain are presented. These help to get a better understanding of the consequences of alternative actions and inactions concerning the desertification issue in southeast Spain. They show how combinations of governance and societal action may affect changes in ecosystems services, human well-being and desertification. This chapter furthermore elaborates on landscape scenario building blocks and how these come about when applied to the Pedrera area. These landscape scenario building blocks are then analysed according to a Multiple Criteria Analysis as selection procedure for the regional design. As a concluding part of this chapter, the regional design for the Pedrera case study area will be presented, accompanied by two design details.

5.1 FINAL LANDSCAPE SCENARIOS

To explore the future landscape of southeast Spain, four landscape scenarios were developed. The four scenarios; rural maximisation, rural emancipation, rural abandonment and rural refuge are represented in a two-dimensional scenario space (Figure 5.1). They can be placed along both an organisational (top-down – bottom-up) and social (re-active individualism – pro-active solidarity) axis.

The scenarios do not incorporate a 'business-as-usual' scenario, which would be a continuation of current conditions. It can be misleading to create such a scenario, since it gets too close to a prediction. Moreover, it could be the more attractive scenario, by being closest to the present state (Tress and Tress, 2003). Furthermore, a time indication is not

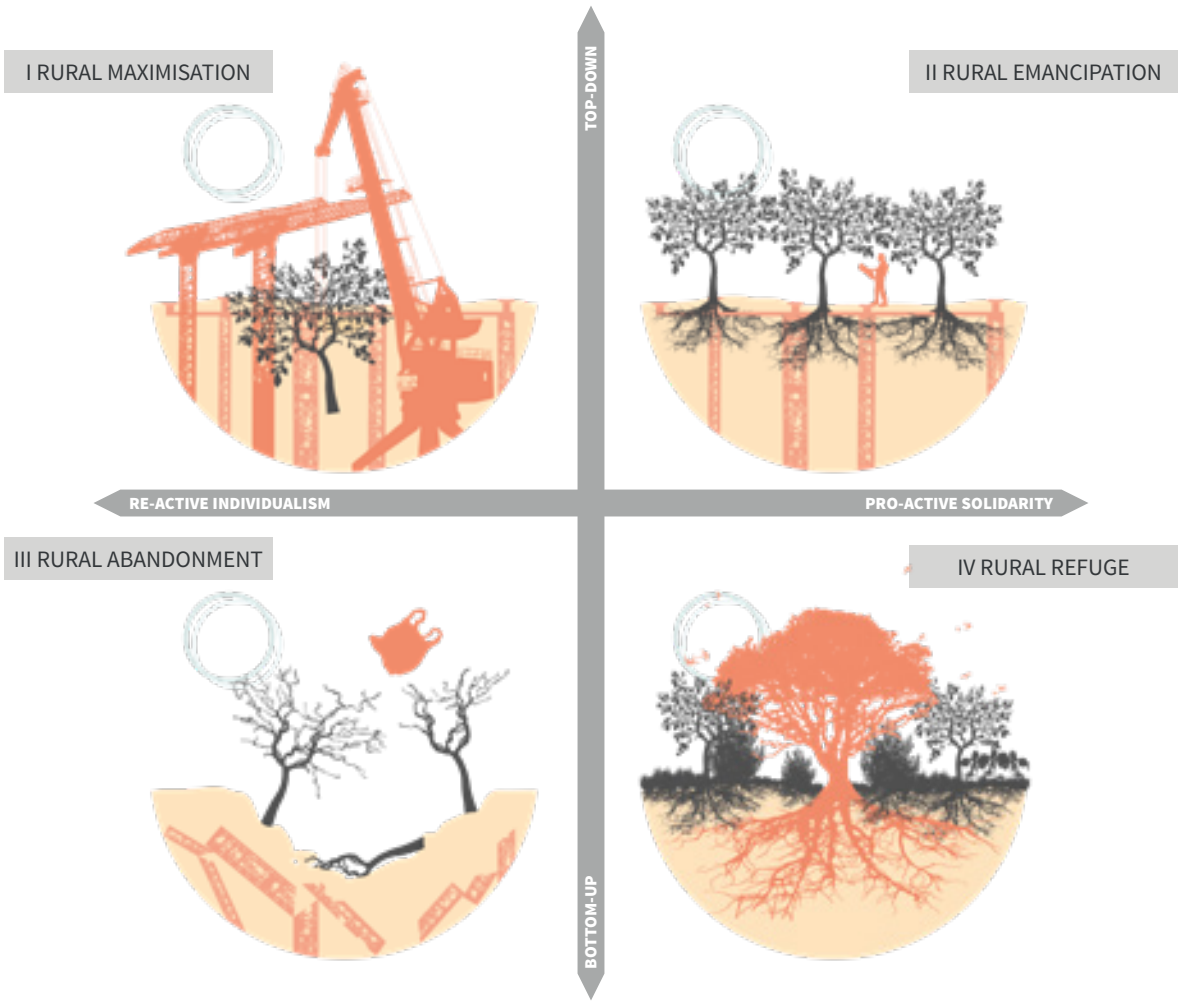


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FIGURE 5.1 / Scenario space that clarifies how the scenarios differ along a social and a political dimension. The social dimension differentiates between solidarity and individualism. The political dimension differentiates the way political institutions work - top-down or bottom-up. These critical scenario drivers are trends with a high impact on the future landscape and the degree of desertification, but which are involved with a great deal of uncertainty.

given for the scenarios. This would touch too closely upon a prediction or forecast as well and could be misinterpreted.

All four scenarios are based on the empirically informed background that appeared from the 'STEEP' driver analysis and are focused on southeast Spain as a whole. Each of the scenarios is accompanied by a narrative, which is used to enrich the scenarios and to make it easier to relate to them. Each of these narratives is built around the same semi-ignorant, but curious character of a journalist. This character pays a visit to the four worlds of each scenario and explores the most important characteristics of those futures. The scenarios are furthermore accompanied by two visualisations each: one that reveals the possible future surroundings (Figures 5.3, 5.5, 5.7 and 5.9) and the other reveals the possible future agricultural landscape of that scenario (Figures 5.4, 5.6, 5.8 and 5.10).

Key findings

First of all, it is important to point out that the final scenarios are four extreme potential futures. Reality will probably be a mixture of all fours. Nevertheless, the result is a description of four different possible worlds, from which it is explored what they could mean for the landscape in southeast Spain.

Due to climate change, desertification is likely to happen in all four scenarios, though at different rates (Figure 5.2). This degree of desertification will most likely depend on the social and/or economical situation. A re-active attitude towards the environment is more likely to cause inaction and unsustainable land use practices, therewith driving desertification in the future. Current pressures such as climate change, rapid urbanisation, intensive agriculture and large-scale irrigation will continue and perhaps even increase, which will lead to further desertification.

With pro-active environmental management and a solidary society, chances are higher that desertification can be coped with and will be reduced or prevented. Possibly, degraded landscapes will even be rehabilitated on a long-term notice. With a pro-active approach, the aim is to be adaptive to changes and to make ecosystems more resilient. On its turn, this will also reduce society's vulnerability to disturbances caused by desertification. It is an approach that will take time to show its benefits, but it is necessary to halt desertification.

The difference between a top-down versus bottom-up governance is less significant. A top-down government will not automatically lead to increased desertification. In case the attitude of society is pro-active towards the environment and when people are willing to sacrifice some of their personal freedom, a top-down type of governance can even stimulate ecosystem management due to institutional reformations and investment in technological development. Unless economies collapse or policies fail, there will be less pressure on the landscape and thus a lower risk of desertification. In a bottom-up society, it very much depends on the social attitude whether there is attention for ecosystem management. In case of limited interest in restoration, a bottom-up and fragmented society is more likely to cause ecological collapse as a result of inaction and absence of policies.

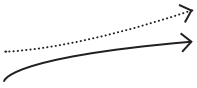
SCENARIO	TOP-DOWN		BOTTOM-UP	
	RE-ACTIVE INDIVIDUALISM	**ACTIVE SOLIDARITY**	**RE-ACTIVE INDIVIDUALISM**	**ACTIVE SOLIDARITY**
DESERTIFICATION RATE				
URBANISATION RATE	very high	high	low	very low
INTENSITY OF AGRICULTURE	very high	high	very low	low

FIGURE 5.2 / Key findings for each scenario. A solid line indicates the most positive desertification rate for that scenario, the dashed line indicates the worst case. It is also clarified how urbanisation and agriculture, two main drivers of desertification in southeast Spain, are shaped in each scenario.

1

Scenario I – RURAL MAXIMISATION

In this scenario, Spain is ruled by a top-down government that is shaped by right-wing parties, with Vox as the leading party. Their initial focus is on liberalisation, global trade and economic growth. However, this government is also known for its nationalistic ideology by seeking Spanish unity (a 'Reconquista') and by putting a halt to climate immigrants.

Despite political attempts to reverse rural depopulation and protect traditional cultural heritage, the Spanish inlands have become empty. This is the result of continuous modernisation and the migration of people to megacities along the coast or in Madrid. These urban environments are completely separated from the countryside. Literally, as large agricultural companies have made the countryside inaccessible for humans by putting fences between farming and human zones. Farming has become a non-human practice with agribots doing all the work. These robots are virtually operated by the big food companies that maximally exploit local resources to gain maximal profits.

Amongst society, there is a strong trust in technology. The fact that people are mainly focused on their individual lives has left rural landscapes to be completely abandoned and degraded. The limited public attention for this environmental disaster is a result of societies' belief that such environmental problems will be solved by technology anyway. When water aquifers ran dry in southeast Spain due to over-exploitation and passive management for example, national rescue plans were set-up to install highly advanced desalination plants and expand national irrigation systems. Another example is the approval to cultivate genetically modified drought tolerant crops (GMO's). This was an inevitable decision, as several years of extreme drought threatened national food reserves.

Desertification

The desertification rate as a result of the prevailing developments of this scenario will be progressing. In the worst case, the desertification rate will rise exponentially (Figure 5.2). Soils are sealed due to urbanisation, leading to high water runoff and increased flood risk. Biodiversity is decreased as a result of deforestation and intensive agriculture. Inappropriate land management has led to high erosion rates as lands are left bare and due to overexploited aquifers. The rapidly changing climate moreover, has increased the amount of droughts and extreme weather conditions. Action to prevent the process of desertification is absent.

One of the hopeful trends in this scenario is the development of precision techniques in agriculture. This could benefit efficient farming systems by balancing in- and output. It can moreover measure precisely how much water is necessary to grow crops, without spilling anything. Technology could also help to monitor salinity and erosion rates, which can be used to improve the quality of the soil.

Challenges

In most cases, economic growth and technological improvements can compensate for losses of ecosystems services, for example by finding substitutes. Sometimes however, this is not the case. Risks can be sudden and can lead to unexpected losses of for example potable water supplies, or they can lead to crop failures, floods, invasive species and outbreaks of pathogens. New problems could emerge from the last solution and sometimes these problems occur faster than the solution. Therefore, the main challenge in this scenario is to cope with the increasing number of abrupt, unpredictable changes in ecosystems that are destructive for society.

LAST TREE STANDING

Federico Martínez was a farmer in Zarzadilla, a small village hidden from the buzzing world. He was forced to sell his land to a big company, but withstood the pressure and never left. Over the years he ended up living in a no-man's land, in the middle of large-scale citrus plantation, all owned by this single company. Six years ago, he suddenly died. Today I am visiting the old farm, Finca Buendía, together with his daughter Marta.

She looked like an original Spanish girl. Clearly she didn't had some alterations done on herself in some kind of clinic. She told me it was the first time she would go back after her father died. She wished she had sold the farm right away, but always had doubts. Now she decided to go there one last time and say goodbye forever.

In the solar car she explained that after the long drought, a lot of farmers left their homes in search for a better life in the city. The countryside got emptier and emptier with the years. It was true, despite the densely packed intensive agriculture, the land still felt empty. It was like visiting a new planet and being the first to set foot on this land. And then the agribots were the aliens inhabiting this planet.

We passed endless seas of shimmering plastic greenhouses that covered the earth like a damp blanket. Further inland, where the plastic jungle turned into wide fields of citrus, there were fences all around us. Marta said that they had put fences all over the country. Crops failed on a large scale due to the long drought and several disease outbreaks, so the EU decided to allow modified crops to provide people of enough food. They made them more drought tolerant so they would grow in these dry lands. She said that the big companies had put the fences to keep out unwanted guests. Some believe however, that it's to keep people out because of the risk of contamination. But no one knows what you would be contaminated with.
I asked her if she believed it. She said it's hard to know what to believe, as the internet is full of false and true news. Nevertheless, she hopes they must want the best for the people.

When we arrived at the gate, Marta scanned her chip at the fence. She has authorisation because she is still the legal landowner. When we stepped out of the car, Marta pointed out the old terraces. Her father was the only one that stuck to traditional almond groves. This saved him when the drought came. All his friends got bankrupt when their trees died.
Around us, I saw that the land was eaten away by erosion. Apart from the citrus trees, there was not a single other tree around. At the farm however, there was still one tree Marta said. It even had governmental protection because trees had become so scarce.

Finally we saw the old Finca. It was still standing upright, but that was all there was to say. It was like a ghost, of which the soul had blown away. After walking around, Marta seemed confused about what to do.
She didn't say farewell to the land when we left. Instead, she said 'see you another time, perhaps', and walked away.

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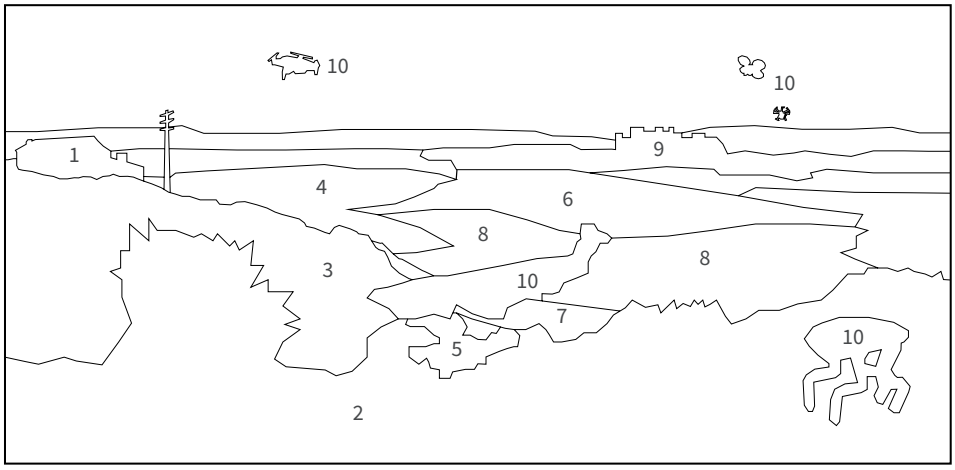
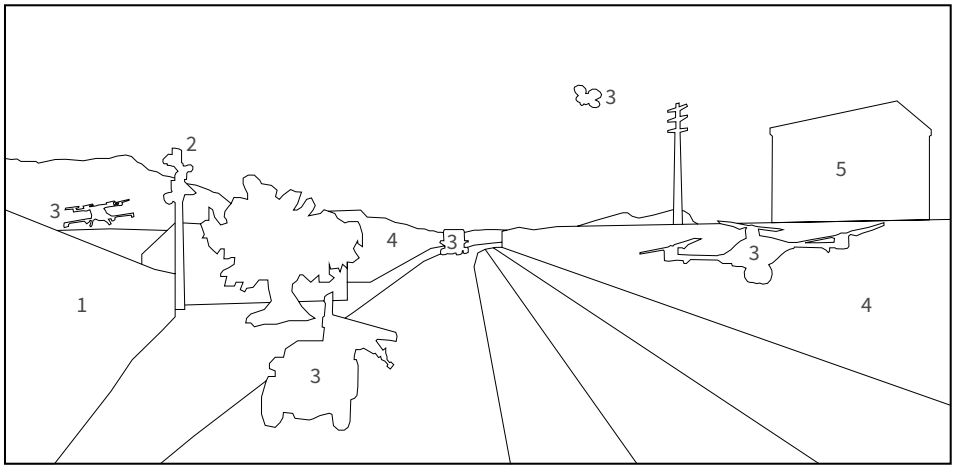
FIGURE 5.3 / This is what the future surroundings may look like in this scenario. The sky is full of drones and there are large cities but vacant buildings in the countryside with intensive agriculture and non-accessible land.

1. RURAL SHRINKAGE
2. ISOLATED NATURE
3. EROSION AND GULLIES
4. LARGE SCALE MONOCULTURES
5. RISK OF WILDFIRES
6. LARGE SCALE ENERGY FARMS
7. CLOSED LANDSCAPE
8. GOLF COURSES
9. URBAN EXPANSION
10. TECHNOLOGISED ENVIRONMENT





1. FENCED OFF FARMLAND
2. PROTECTION AND PRIVATISATION
3. ROBOTISED AGRICULTURE
4. GREENHOUSES
5. DESALINATION PLANTS

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FIGURE 5.4 / In the agricultural landscape you will not find any people. Only robots flying around taking care of all the crops. Large desalination plants mark the land.


Agrii

2

Scenario II – RURAL EMANCIPATION

In the second scenario, a strong socialist government has taken control over Spain. Under the reign of the EU, they aim to achieve international sustainability. As fragile ecosystems collapsed and more droughts occurred as a result of climate change, water supplies ran dry and farmers started to protest. That is why a new political movement stood up with the attempt to lead the country to a sustainable future. National institutions make sure ecosystems services are improved and environmental problems are solved. They do this in the name of the EU, by criminalising pollution, introducing an ecological credit system and applying strict restrictions and regulation in agriculture.

There is a lot of focus on green technology and ecological engineering. Cities are car-free, houses have to be carbon neutral by law and electricity is generated with solar roofs and windows. An agricultural transformation happened as well, as national farming education programs are used to change traditional farming practices. Chemicals, ploughing, inappropriate crops and greenhouses for example are completely banned and mixed cropping is obligated. Farmers are moreover encouraged to provide ecosystem services by rewarding them for preserving key watersheds or important ecological habitats. Benefiting local ecosystems has become the norm, rather than maximisation of food production.

Furthermore, the government has invested in a national reforestation plan. This green buffer zone runs from Cádiz in the southern tip of the country to Gerona in the northeast, to prevent further desertification. Along the coast, project developers are demanded to build according to the compact city model. Such urban developments need to be combined with reforestation projects to compensate for ecological losses.

Desertification

A lot of effort is put into restoring degraded ecosystems, for example by national reforestation plans and the reformation of agriculture. The government moreover stimulates rural revitalisation projects to encourage people to stay in the countryside. This will limit rural abandonment and can help to prevent erosion and fire hazards. However, in this scenario there is still urbanisation, which puts pressure on the land. Also the effects from climate change cannot be neglected. Prolonged drought periods, increasing sun intensity and intensified rainfalls all have a big impact on the desertification rate. Therefore, the chances are likely that desertification will continue to happen, of which its rate can slightly decrease or stabilise (Figure 5.2).

Challenges

In this scenario, solutions are always sought in benefitting both the economy and environment. However, in order to achieve (inter-) national sustainability, individual choices are limited. As the movement of goods, people and information is strongly regulated, there is limited amount of freedom in the market as well. Therefore, the challenge is to organise such socio-ecological system that can maintain ecosystem services, without restraining people's personal freedom too much.

Another difficulty emerges in this scenario, as the costs of managing the environment are continuously rising due to the changing climate. Too much reliance and dependence on technological solutions makes society vulnerable for sudden changes.

BETWEEN A THOUSAND PINES

The scratchy song of the cicadas looped through the pine forest. The canopy of trees protected me while the sun was climbing through the hazy August sky. This wasn't a normal forest. Each tree had the same height and I counted only five species, planted in a strict grid. Further away there were wind turbines planted in the middle of the reforested land. I was in a state-owned eco-park, which is part of the government's reforestation plan.

All of this had been initiated by Juan de Dios Segura, the man I was about to meet. He is leading the country after he gained attention with his successful national green buffer plan to prevent further degradation of the soil and to connect natural areas. He was the one who stood up after years of crop failures, droughts, floods and poor land management. As a farmer's son, he knew how to support farmers and improve their lives. Then, as a university lecturer in economy, he started to fight for a system that would limit the impact on the environment while increasing human well-being.

I opened the door of the park's eco-café. Juan was looking out the window. He had a herbal tea in his hand. Nothing sweet for him he said, his bodywatch said his sugar level was too high.
He started explaining his movement. For a long time people thought it was absurd and unrealistic to liberate the environment from the economy. But then, when farmers couldn't produce any longer, people started to realise action was needed.
"Every year during summer I would return to my parents farm, where I grew up. I always walked up a hill and sat there, imagining how much had changed since I was young. I realised that in that tiny forest that was left, most insects had gone and even the raptors that used to fly around were gone, too. That's when I started dreaming of returning those beauties and bring this land back to life. Right there I decided to start the reforestation campaign."

Reforestation had been done here before, in Spain, but never at such scale. When it turned out to be a success, Juan became politically active and stood up as the leading figure. It was the right timing, as it was a time of economical instability and ecological decay. With his party, they fought the destructive government and then formed a new government. As Juan said in his inaugural speech: 'Now is the time to safeguard our children's futures. Now is the time to not only take from the earth, but to give back too. Now is the time to protect what is all ours; the land!'

The new sustainable policy had changed the entire system. They stimulate people to minimise their footprint by using artificial intelligence systems that measure the environmental impact of each person. This ecological credit system taxes polluters and subsidises people that provide ecosystem services. They've strictly regulated agriculture and initiated farmer's universities mandatory for all landowners. Chemicals are used no longer, ploughing is forbidden and mixed cropping is the new normal.
No limitation of freedom Juan said, just a government that steps up and leads the country to a sustainable future.

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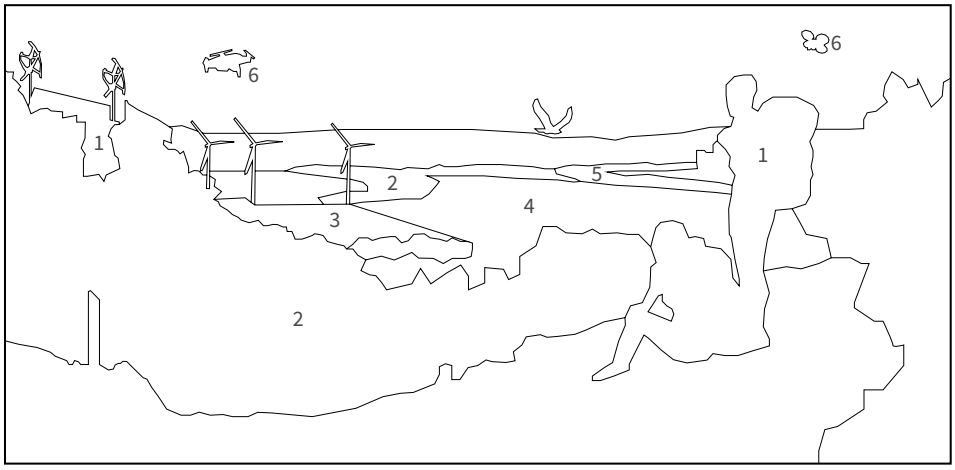
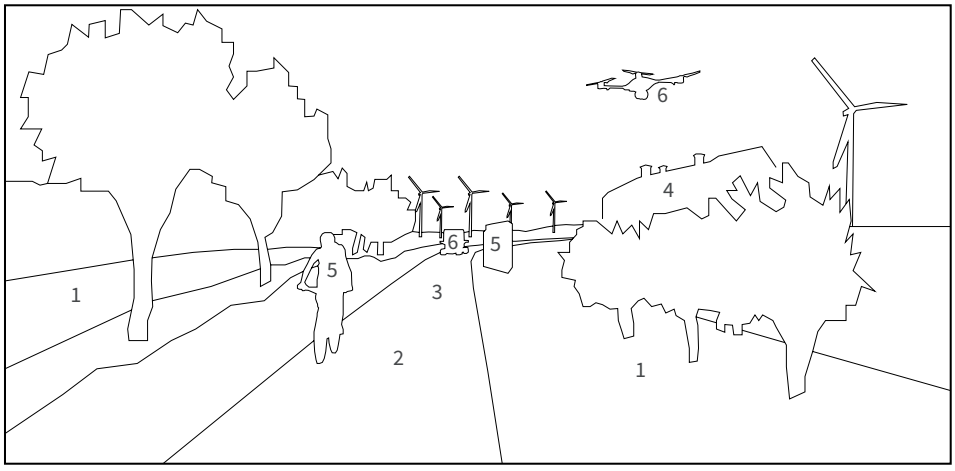
FIGURE 5.5 / This is what the future surroundings may look like in this second scenario. The agricultural landscape is accessible and reforested, ecotourism is stimulated and governments developed renewable power plants.

1. ECO&AGRI TOURISM
2. REFORESTATION
3. STATE OWNED ENERGY PARK
4. REGENERATIVE AGRICULTURE
5. URBAN GREEN BELT

6. TECHNOLOGISED ENVIRONMENT





1. MIXED CROPPING
2. ACCESSIBLE FARMLAND
3. IMPROVED RURAL CONNECTIONS
4. RURAL REVITALISATION
5. ECO&AGRI TOURISM

6. TECHNOLOGISED ENVIRONMENT

>
FIGURE 5.6 / In the agricultural landscape you will find a mix of activities. Terraces of almonds will be mixed with different kinds of crops and people can buy products right at the farmer.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3

Scenario III – RURAL ABANDONMENT

This scenario shows a situation in which the Spanish autonomous communities have fallen after frictions between social groups led to social conflict. When several countries left the EU, political instability stirred up the Catalan independency movement. When they separated, the Spanish national government collapsed, and eventually with them the entire European Union.

As a result of this major crisis, there is limited attention for common goods and ecological improvement. Climate agreements and green innovation projects got aborted and as a result of the lack of proper water management, a water crisis emerged. Most drinking water supplies are polluted and salinised, groundwater aquifers ran dry and farming is impossible, with water and food shortages as a result. Therefore, people's main concern has become their safety, which is why most money is invested in security systems and protected gated communities.

The majority of the people lives in fragmented urban areas with a focus on their own small social groups. There are big differences between neighbourhoods and high inequality between different groups. The limited social control gives room to the emergence of extremism. Some of these groups transformed abandoned farmlands in the countryside into rural enclaves.

There is a lot of activity on the online black market to trade illegal goods. Food is one of these highly demanded goods, as growing conditions are far from optimal. This is often concerned with unfair prices and at the expense of people's health.

Desertification

As a result of structural mismanagement and overexploitation of resources, ecosystems have become increasingly and almost irreversibly fragile. Therefore, it is likely that desertification will continue to be a problem. Such environmental problems are of low concern in this scenario. Only immediate crises are resolved, but the causes of these disasters are not solved or prevented by any (inter-) national organisation.

Water deficits and losses of ecosystem services make it difficult to recover these environments. However, permanent rural abandonment can give room for natural rehabilitation as the landscape is slowly being taken over by nature. In that case, the desertification rate could slowly stabilise (Figure 5.2).

Challenges

Before recovering the environment, the main challenge is to find ways to rebuild society and overcome the resource crisis. A focus on the recovery of institutional structures is inevitable to save this society from further collapse.

A positive side of this scenario could be the urge from people to become self-supportive, both in food production as in energy generation. This could potentially stimulate innovation and could increase awareness on the limitation of resources.

THE EMPTY JUNGLE

Where the land and villages were deserted, where houses had been boarded up and fields were left bare, there were still people to be found. People, living in rural enclaves only accessible by hidden dirt roads. I had been discouraged to go here. Yet here I was, on the land that was once owned by latifundio, but got occupied by the rebels, or terrorists as some say. They were once farmers, but got angry and frustrated when politics failed and water deficits emerged. These people bombed the irrigation water pipe after a water conflict with the macrogranjos. An act of terror according to the then still existing government.

The guard dog was disabled. With his metal leash tightened around his neck, it quietly looked around while sniffing the air.
I was allowed to meet one of the members, Pedro. One day, the guardia civil had surrounded their camp. They said they had to leave the land, or they would get shot. They didn't care and started shooting themselves with the weapons they had bought on the online black market. Machine gun drones, amongst others. They killed most of the cops and never saw them back again. No wonder, as there isn't even a police enforcement anymore. There are only private security companies now, which is why most people protect themselves.

I asked why they moved to the countryside. Pedro said they wouldn't have enough autonomy in the city. Besides, cities had become shitholes, with rebellious groups constantly fighting and no one to trust. It was always the question if you'd have any food or water, and if so, if it were going to be any good. So, no city for him he said.
When the EU collapsed, regions started to fight for their autonomy. Fed by fake news, the national government at the time got accused of killing the leader of one of the independence movements. That's when things escalated, especially because the ungoverned nation suffered from a severe water crisis. With no control over resources, water disputes started to emerge and fear amongst the people grew.
Pedro said people are desperate everywhere. Large groups of migrants would come to see if there was any water left. He showed a video of hundreds of people marching the streets, plundering and squatting empty houses. They were not welcome here, Pedro said, he would kill them with his own hands, he said.

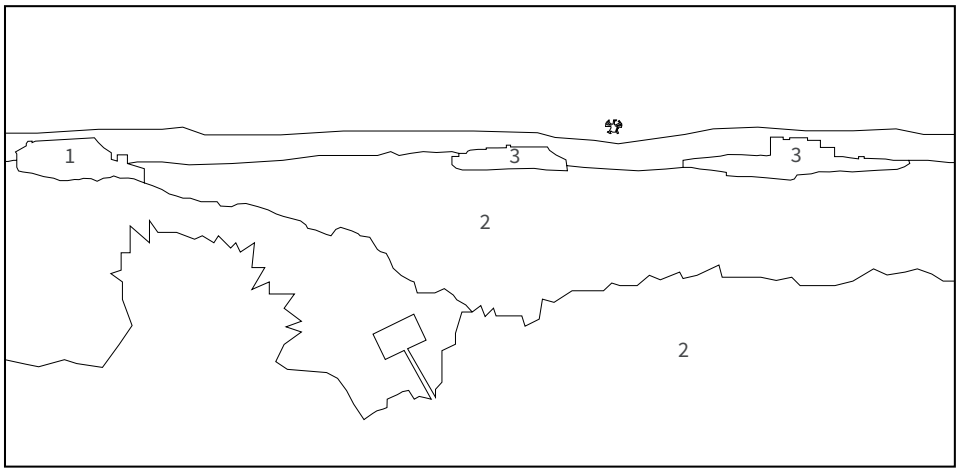
Amidst the empty land, a small bird was picking flies out of the sky. The trees around the encampment were cut down. Pedro said they'd done it to keep it open so they could see who or what was coming.

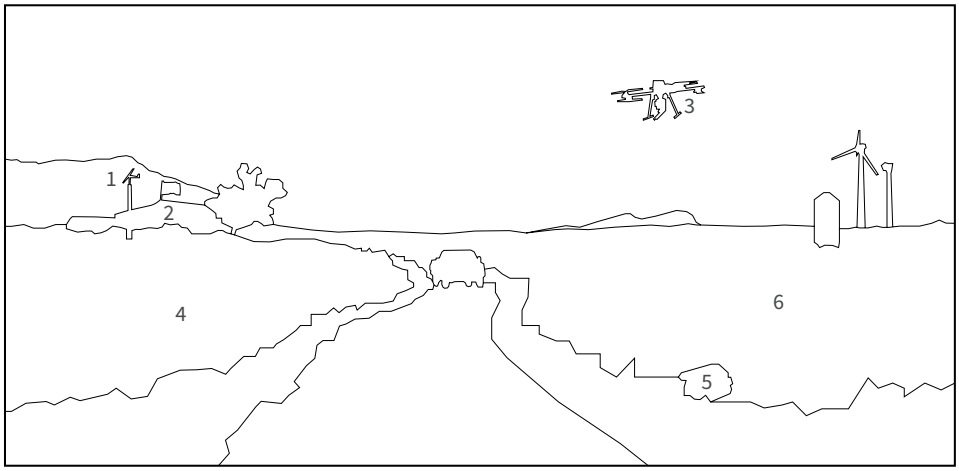
Next to the house he showed me their well. There was not much water in there, and the bit that was left was polluted. Their filtering system had broken. Luckily one of his men had seen one being delivered at a neighbour the other day. It was at the house of a former banker, he said.

When I read the news a few days later it said a terrorist group had blown up the house of a rich man. It was an accident, it said. Only one of them survived.

>
FIGURE 5.7 / In this scenario, most of the surroundings seem empty. There are parts of cities scattered around the landscape and every now and then there is a rural enclave in a reoccupied village.

1. RURAL SHRINKAGE
2. RURAL WILDERNESS
3. FRAGMENTED URBAN AREA





1. SELF SUPPORTIVE ENERGY GENERATION
2. RURAL ENCLAVE
3. SECURITY AND PROTECTIONISM
4. RURAL WILDERNESS
5. POLLUTION
6. ABANDONED FARMLAND

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FIGURE 5.8 / Most of the rural areas are abandoned and large-scale agriculture has disappeared. The few people left in the countryside try to grow their own food and live in rural enclaves.

4

Scenario IV – RURAL REFUGE

This scenario is characterised by a social transformation, in which people have created networks of restorative communities. In Spain, the national government has taken a supporting role, with local organisations as the main drivers of society. There is an active approach in protecting the environment, with limited political interventions necessary. This is because landscape restoration is carried out as a result of people's individual and communal actions. The driver of this social transformation has been the visible collapse of ecosystems. People decided it was enough and turned towards the countryside to collectively reoccupy formerly abandoned villages and farmland. Regenerative projects are scattered around Spain where people live closely to their natural environment. They have embraced different and more traditional farming techniques, such as agroforestry and permaculture.

As people live in extreme solidarity, most property is communal, including land and resources. Everything is shared, which is why the economy works with common goods, local currencies and is based on gifts. In this *ecologised* economy trade mainly happens locally.

In general, lifestyles are sober, although technology is embraced. Information is shared widely via open source platforms and cheap communication technologies. Community networks make sure national and global resources are properly managed. They also coordinate the distribution of knowledge about social and environmental problems on how to improve environmental management. Education is key in enhancing this kind of knowledge about ecosystem functioning and management.

Desertification

Due to massive and active landscape restoration, degraded ecosystems can slowly recover. This means that the desertification rate will probably decrease over time (Figure 5.2). People are aware of their environmental impact and try to minimise their footprint. They do this for example by applying different, restorative farming techniques or by reforesting degraded environments. As arid environments take a lot of time to recover, the effects of desertification disappear steadily, but slowly. Sudden impacts from climate change however, still have a significant influence on the environment. The latter could have the effect that the desertification rate will only stabilise, and not decrease (Figure 5.2).

Challenges

One of the challenges in this scenario is the fact that people live sober lives. This is not always easy, as some of the modern comforts are lacking. Moreover, communal living requires a sacrifice of personal space and freedom.

Furthermore, it will be a challenge to keep an overview in managing resources on multiple levels without an overarching organisation. There is a chance that communities will focus too much on their direct environment and forget about the impact they have on a larger scale.

ALL OUR TREES

Under the eye of the village, some people were working the field. A setting you could find in any other Finca Publica. These restorative communities have spread all over the country as a result of a massive social transformation. Cities slowly depopulated when more and more people changed their lifestyles to reverse the effects of desertification and climate change, and decided to retreat to the land.
In this village, Carmen is one of the oldest of the ten families it houses. She has been here from the beginning, when she and her partner decided to save this village that was on the brink of collapse. They had lived as nomads for a long time, travelling from place to place to spread and gain knowledge about permaculture and restorative farming. After many years of hard work and patience, they managed to reforest the degraded valley and turned it into a lush green land.

On the small square children were running around and played with the dogs. Some stands around the tree in the middle displayed artisan jewellery and knitwear. A bit further, some men were loading a horse carriage with crates full of fruit and vegetables for the farmers market tomorrow.
The entire ecommunity was based around the idea of sharing and common goods, Carmen said. When they started rebuilding the village, they had help from the online grassroots platform for example. All property in the village is communal and they use a local coin when they would sell at the market. Carmen explained that they used a smart system that keeps track of the surpluses and shortages in the network of communities around. It projects on the long term, so they always knew what would be necessary. She said she would show it at their Community Resource Centre.
I asked her if any problems ever occurred. She said some social problems had happened. Situations in which people turned out to be unreliable and kept food for themselves for example. Those people got banned from the community and had been put on a black list in the network's database.

We had to walk a bit lower down the valley. Most houses in the village were renovated and fully equipped with solar panels and boilers. Carmen said there were often nomads passing by and installing them for free, in return for a roof and some food. Some houses we passed were left bare as ecoruins, to offer a place for bats and other wildlife to shelter. We walked along a wild flower meadow and hedges full of fruits and berries.
Carmen pointed at the woodland a bit further down. She said they had their tea garden there, where they grow herbs for tea, medicine and cosmetics. Her favourite place to sit and listen to the trees or talk to the bees, she said.
When we got to the Centre, there was a great variety of people hanging around. It was the educative area, where people learned about earth technology and bio mimicry, or bee keeping and econstruction. The children were given nature education already from a young age, but got taught their languages and maths as well.
This village was not at all the sober lifestyle or the step back that would be expected. It's more a reinvention of the past, but not the opposite of modernity.

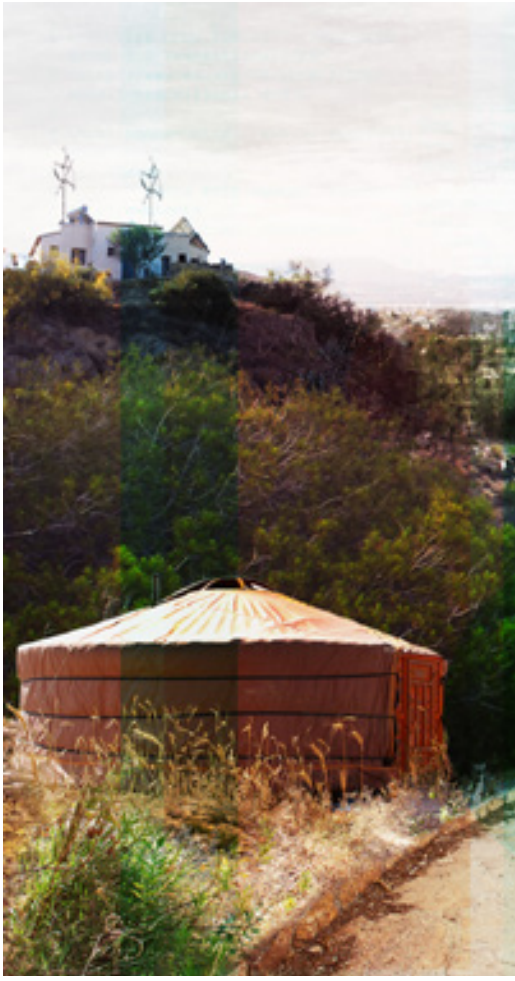

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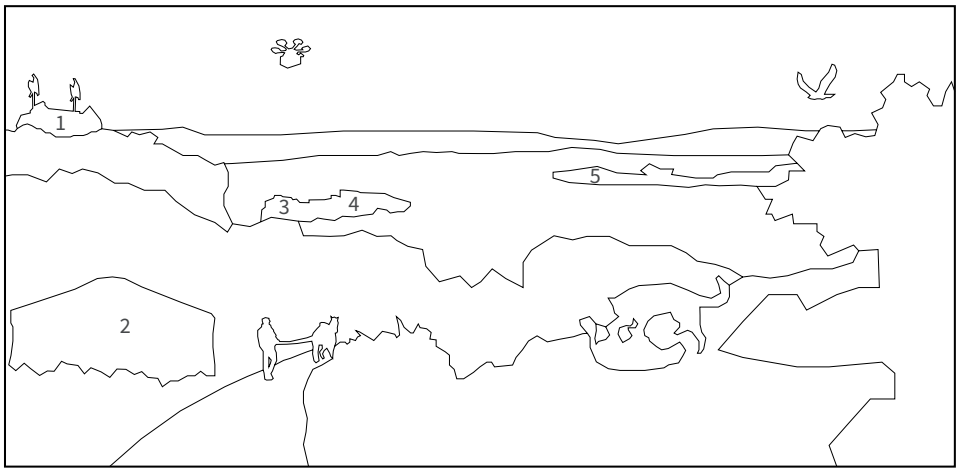
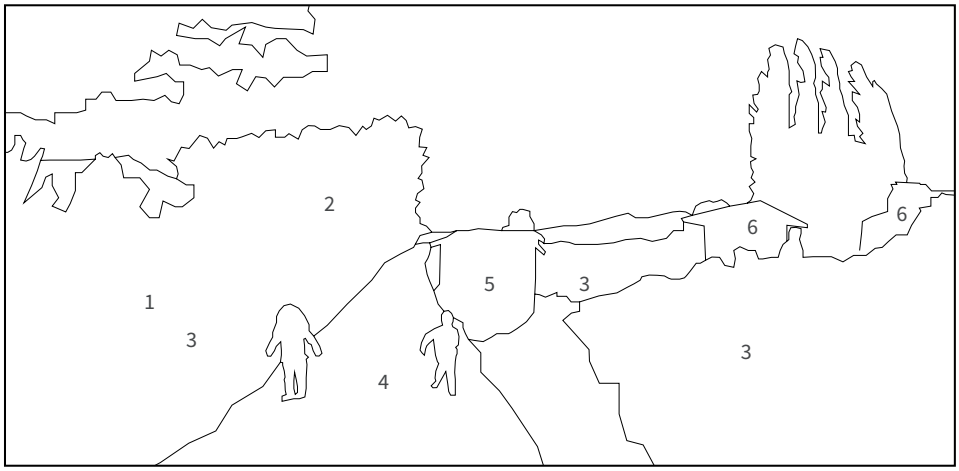
FIGURE 5.9 / In this fourth scenario, the environment is re-greened. People retreated to the rural landscapes and are often self-sustaining.

1. SELF SUSTAINING COMMUNITIES
2. ECO&AGRI TOURISM
3. RURAL REVITALISATION
4. COMMUNITIES AS GREEN HEARTS
5. RE-GREENED URBAN AREA





1. AGROFORESTRY
2. NATURE MERGED WITH AGRICULTURE
3. REGENERATIVE AGRICULTURE
4. ACCESSIBLE FARMLAND
5. ECO&AGRI TOURISM
6. SELF SUSTAINING COMMUNITIES

>
FIGURE 5.10 / People do sustenance farming by using permaculture and agroforestry. Moreover, they applied regenerative techniques such as keyline swales, terraces and by capturing water in ponds.

5.2 LANDSCAPE SCENARIO BUILDING BLOCKS

To create a stronger connection between the scenario narratives and the landscape, landscape scenario building blocks were produced (Figure 5.11). They are the spatial trends that appeared from the trend analysis from the previous chapters. These spatial trends are marked in the impact and uncertainty matrixes in Appendix E and F. The landscape scenario building blocks depict these possible trends in the landscape and can be seen as the spatial embodiments of the landscape scenarios. They are an essential link to go from the landscape scenarios to the final landscape design. From a few of them I will explain how they derived from the STEEP drivers and what the entail.

One of these landscape scenario building blocks is the proliferation of greenhouses, also referred to as *plasticulture*. This type of cultivation is rapidly expanding across southeast Spain. This specific example is a result of economical and technological drivers. As farming techniques advance and economical pressure to produce efficiently and cheaply rises, the step towards greenhouse cultivation is understandable.

Another example of a building block is the mixed cropping farming method. This is encouraged by different organisations in Spain, as a way to secure farmers of stable incomes while enhancing soil quality. This is a result of social, environmental and technological drivers. Social, as the transition towards new farming practices is highly involved with social and cultural structures. Technological, as it is the result of new innovations and perceptions on farming. Environmental, as it is a development that better complies with local environmental conditions.

The emergence of large solar farms is another spatial trend in southeast Spain. Especially in thinly populated areas, large fields with solar panels are installed. This is a result of both economical and technological drivers. It is an economically resourceful business, especially as techniques improve.

Rural revitalisation is another landscape scenario building block. This means that facilitites in the countryside are improved, that tourism in these areas is promoted and that attractive assets are utilised and accentuated. This is a development that will emerge from social and political decisions. Within Spain, there are several programs to revitalise the countryside, mostly in order to prevent further depopulation.

Furthermore, illegal welling is increasingly frequently happening in southeast Spain. This is a development that mainly emerges from environmental conditions, as there is not enough water accessible for farmers. However, it is also very much politically, economically and socially driven. The distribution of water is not governed sufficiently, farmers need to earn a living so take the step towards illegal welling.

Each landscape scenario building block can be categorised into one or more scenarios (Figure 5.12). It has to be noted that they can behave differently within each different scenario, such as for example a nature inclusive golf course or solar farm. By placing them into the different scenarios, it is possible to test these blocks and apply them into four spatial overviews of hypothetical future landscapes of the Pedrera area according to the four scenarios (Figure 5.13).

These figures illustrate how each scenario would come about in the landscape of Pedrera. The figure matching the rural maximisation scenario (scenario I) shows how the coastal area is highly urbanised, how agriculture happens on a large scale and how the natural area is left to a minimum. In the rural emancipation scenario (scenario II), the natural area is reforested, as well as the edges of urban areas. Farming happens on smaller plots, alternated with large-scale solar parks. The rural abandonment scenario (scenario III) shows how the urban area is fragmented, agricultural fields are abandoned and water is polluted. The last scenario, rural refuge, is characterised by the scattered pattern of reforested area, both in the city as outside.

Multiple Criteria Analysis

A Multiple Criteria Analysis (MCA) was used to select the most desirable landscape scenario building blocks to fight desertification. As this will only succeed through an integral approach, they were analysed according to the five STEEP indicators. Therefore, information

STEEP DRIVERS

LANDSCAPE SCENARIO BUILDING BLOCKS

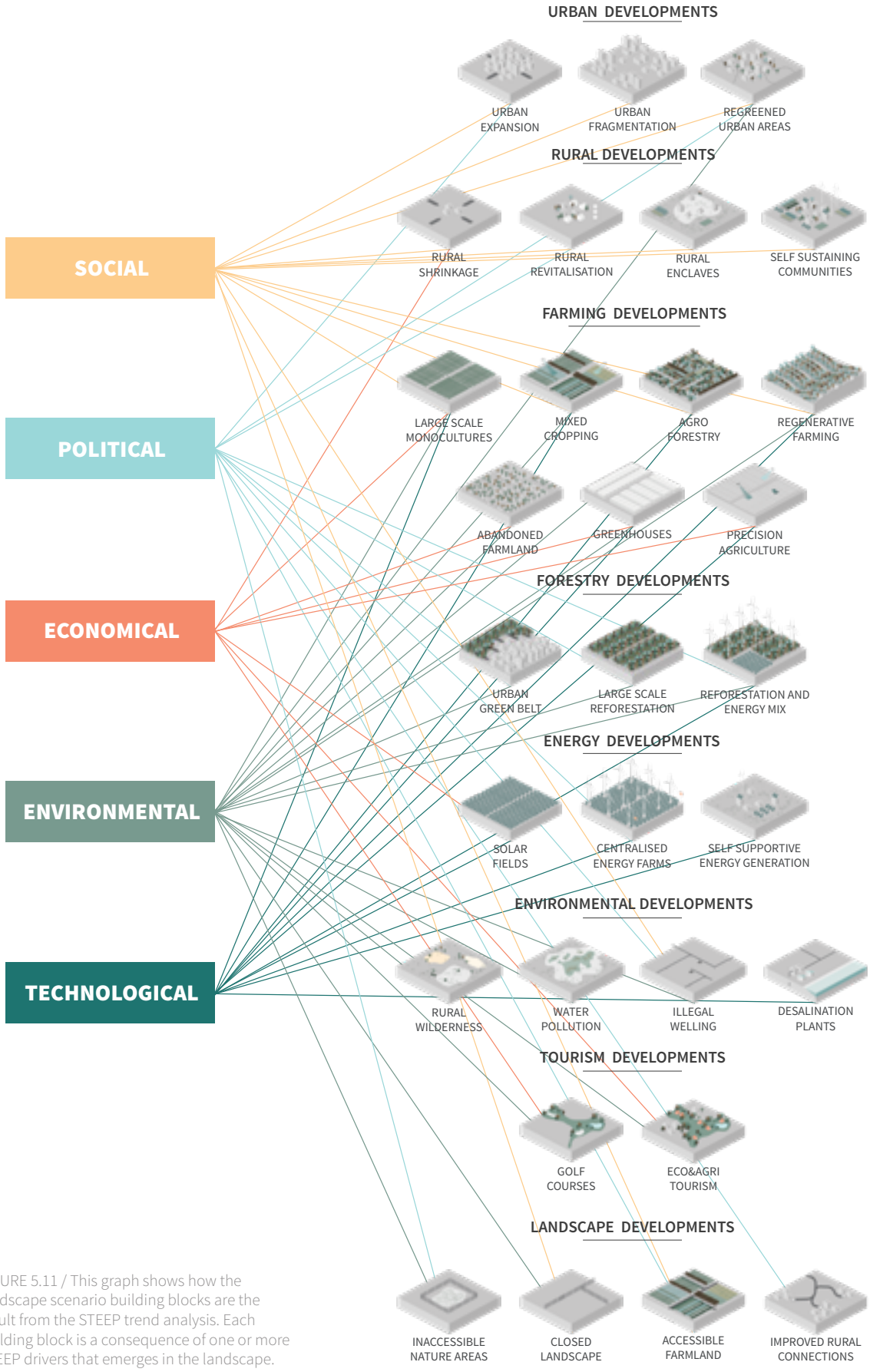


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FIGURE 5.11 / This graph shows how the landscape scenario building blocks are the result from the STEEP trend analysis. Each building block is a consequence of one or more STEEP drivers that emerges in the landscape.

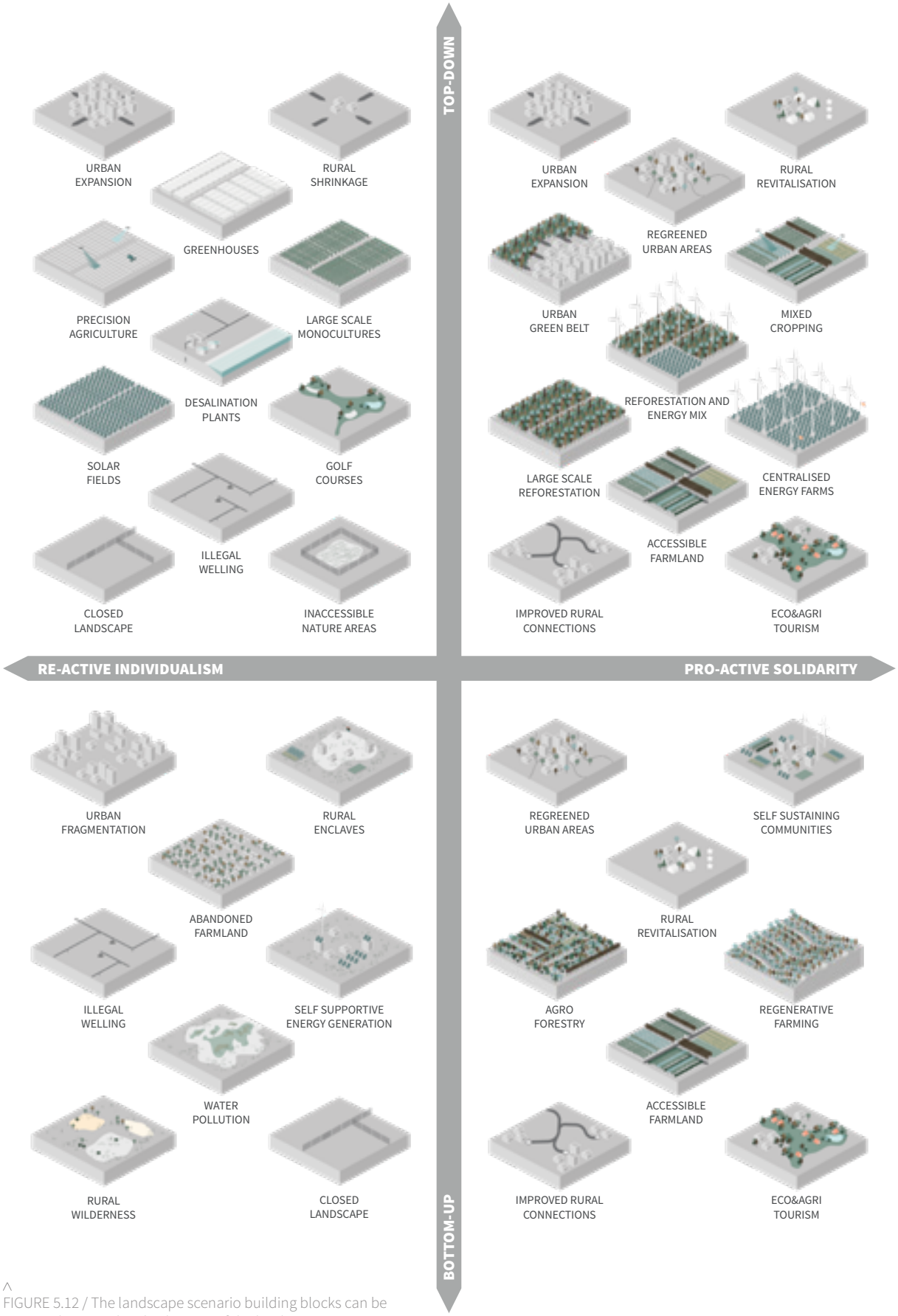

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FIGURE 5.12 / The landscape scenario building blocks can be seen as the spatial embodiments of the landscape scenarios. They fit within the storyline of one or more scenarios, as can be seen from the figure above.

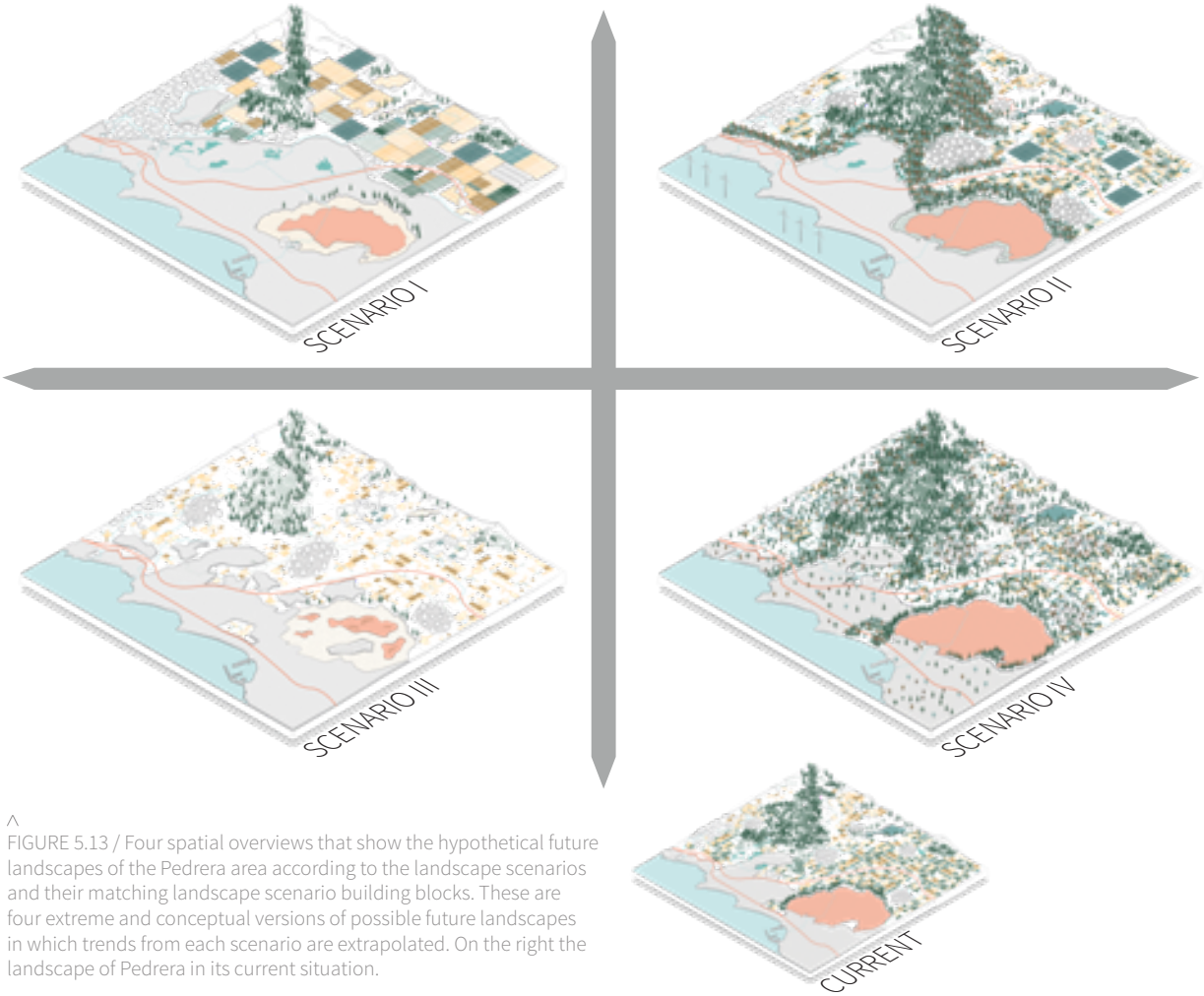

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FIGURE 5.13 / Four spatial overviews that show the hypothetical future landscapes of the Pedrera area according to the landscape scenarios and their matching landscape scenario building blocks. These are four extreme and conceptual versions of possible future landscapes in which trends from each scenario are extrapolated. On the right the landscape of Pedrera in its current situation.

on public support, combined with the political management, economic gain, environmental gain and technological feasibility of each landscape scenario building block was used in the MCA.

To assess public support, meaning the degree of acceptance of the different landscape scenario building blocks amongst survey respondents, a stakeholder survey was conducted. The findings from this survey can be found in the next paragraph. The other indicators for the MCA are defined as following: political management indicates the manageability of the different landscape scenario building blocks by local governments. Economical gain refers to profits, stability and job created, weighed against investment and management costs. Environmental gain means the increase of biodiversity, improvement of soil quality and increase of water retention. Furthermore, technological feasibility is defined as the complexity of technology that is necessary for the landscape scenario building block. If the required technology is very advanced, the building block will be less favourable.

As five different indicators are covered in this analysis, the degree of success does not only depend on one of these criteria. Each indicator has a different weight, which means the total scores for each landscape scenario building block are a sum from the different indicators. Apart from public support and environmental gain, most of the scoring is based on educated guesses, and occasionally backed-up by literature or interviews.

The results from the MCA can be seen in Figure 5.14, the entire MCA can be found in Appendix H. The building blocks with a score above 1,0 are more preferable in combatting desertification according to all five indicators, which are the selected elements to work with in the regional design. Many of the landscape scenario building blocks from scenarios II and IV are selected, such as for example the re-greening of urban areas, mixed cropping

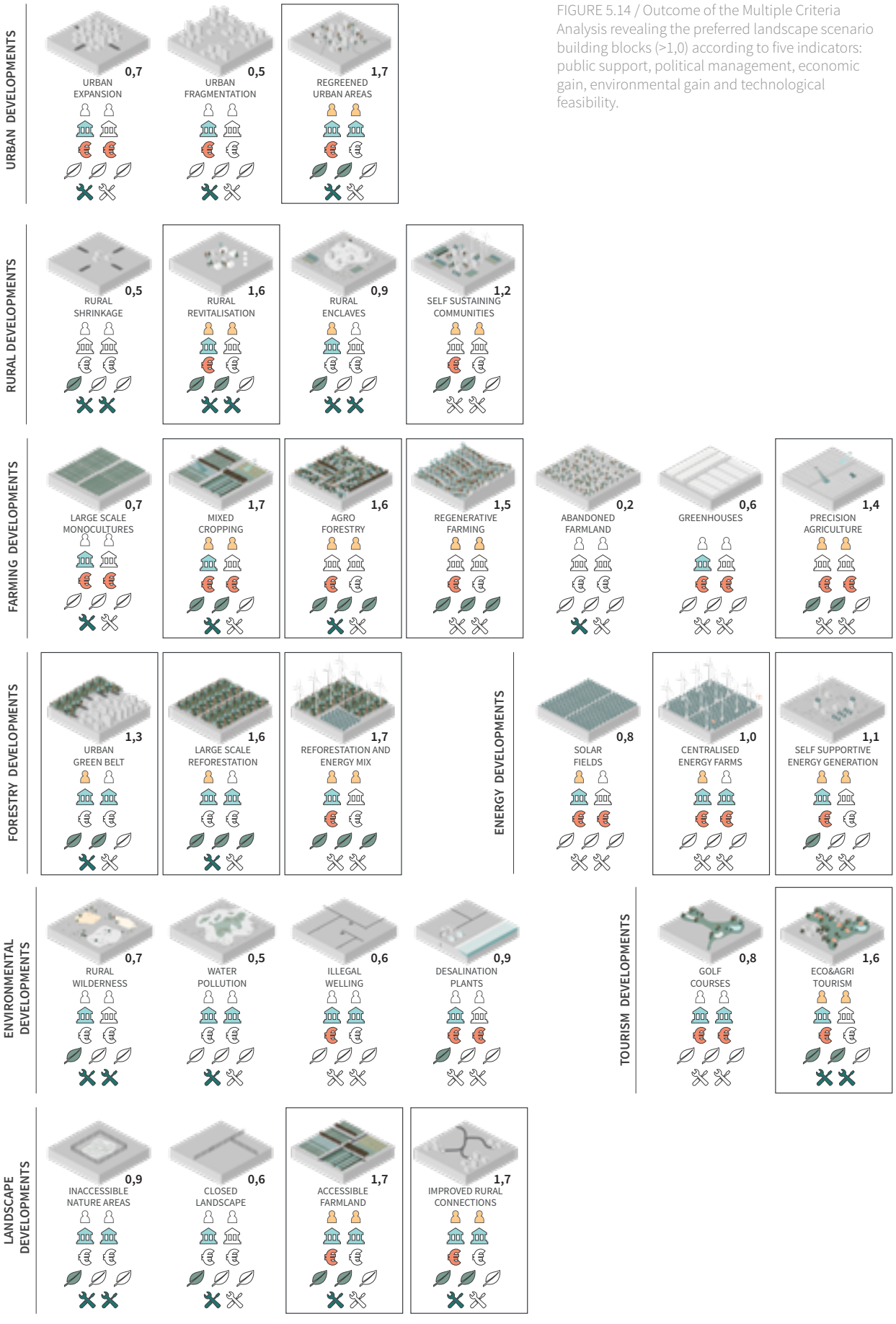

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FIGURE 5.14 / Outcome of the Multiple Criteria Analysis revealing the preferred landscape scenario building blocks (>1,0) according to five indicators: public support, political management, economic gain, environmental gain and technological feasibility.

or agroforestry, reforestation and eco&agri tourism. From scenario I, precision agriculture came out as a preferable development.

Stakeholder survey

The landscape scenarios, stories, visualisations, landscape scenario building blocks and spatial overviews for the Pedrera area were used as input for this survey. There were five respondents in total, all involved with the Pedrera case study area. They had backgrounds in science (1), local government (2), a local environmental group (1) and agriculture (1). This survey revealed which scenarios were most often preferred and which landscape scenario building blocks had most public support.

The key findings from the stakeholder survey are that respondents' perception on the desertification problem varies, as one sees it as a holistic problem, whilst others see it more as a slow process of land degradation. Every respondent indicates desertification is a visible process that happens around him or her. The most preferred scenarios are 2 or 4, or a mix of the two. The first and third scenarios are seen as the least favourable scenarios. In terms of the most likely scenario, this will probably be close to scenario 1. One respondent points out however, that there are developments happening in different directions. Some social movements are actively working on a future as in scenario 2 and 4, while there are other developments happening, such as the growth of agricultural companies and appearance of real estate and mining companies, which indicate a future more like scenario 1.

The opinion on the landscape scenario building blocks is rather uniform, with a few exceptions. One of the local government representatives regarded urban expansion as a positive development; rural shrinkage was perceived as negative by most, except for the scientist. Precision agriculture is not seen as positive by the farmer, on which others disagree. The scientist sees an urban green belt as an undesirable development, as it will increase the distance between agriculture and urban life. Solar fields are by some seen as positive, while others think it is harmful for the natural environment.

According to one of the representatives of the local government, prevention of desertification is a task that should come from higher instances, such as the EU. Awareness building and stimulating socio-political movements are advised by the respondents as well.

5.3 REGIONAL DESIGN

The regional design for the Pedrera area as proposed here, includes a mix of different ambitions, which was possible by implementing the most preferred landscape scenario building blocks that formed the landscape scenarios. These are the following: re-greened urban areas, rural revitalisation, self sustaining communities, mixed cropping, agroforestry, regenerative farming, precision agriculture, urban green belt, large scale reforestation, reforestation and energy mix, centralised energy farms, self supportive energy generation, eco&agri tourism, accessible farmland and improved rural connections. With this collection I was able to compose a regional design for the Pedrera case study area (Figure 5.16).

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FIGURE 5.15 / The overarching regional design can be seen as a serving tray with several possible no-regret interventions for the Pedrera case study area.

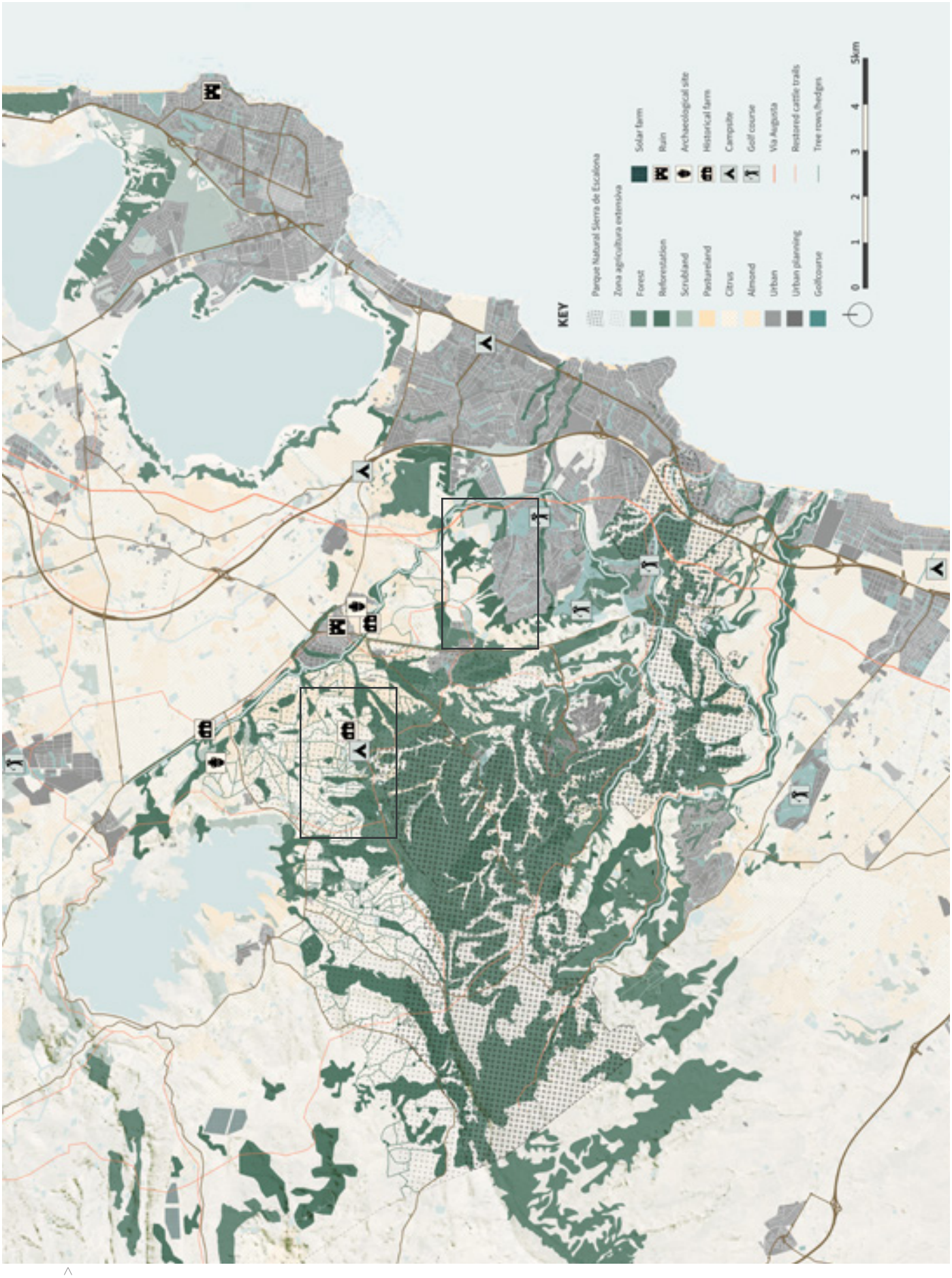

FIGURE 5.16 / The regional design for the Pedrera case study area.

The result is a proposal for a flexible design with a focus on a robust vegetative structure to combat desertification. This is achieved by complying with four ambition levels. First of all, the aim is to reduce current desertification rates while maintaining current systems (1). Secondly, it is the ambition to prevent further desertification (2), then to reverse current erosion processes (3), and finally and most preferably to rehabilitate currently degraded landscapes (4).

The design offers many possible attractive interventions (Figure 5.15). These 'no-regret' measures are the development of a national park from the Natura 2000 area, re-greening of the Tajo-Segura irrigation channel, creating an urban green belt, a green network of hedges, tree rows and grass strips, large scale reforestation, regenerative agriculture and the restoration of riparian zones.

Two of these interventions were selected to design further. They were selected as they are each concerned with a main driver of desertification in Spain: urbanisation and agriculture. With these designs I show that it is possible to intervene on both these drivers as a designer to contribute to the fight against desertification. To connect the designs with the landscape scenarios as well, I selected one that could be seen as a more top-down oriented design for a green urban edge and another one that can be considered as a more bottom-up intervention, which is a proposal for a green network in the agricultural areas.

In the regional design, most golf courses are maintained and urban expansion is still possible. This seems contradictory to the aim of the design, which is to combat desertification. However, this area currently depends on a certain type of tourism and economy. Instead of completely abolishing this, another tactic can be applied. For example by transforming these golf courses into eco-friendly leisure areas and by incorporating green infrastructure into urban expansion projects. A slow transformation will have more effect than no transformation at all. Due to this compromise however, these specific parts of the regional design can therefore only comply with ambition level one, meaning current desertification rates can be reduced but current systems are still maintained.

However, by developing an elaborated green network, re-greening the Tajo-Segura irrigation channel and creating an urban green belt, desertification could possibly be prevented and perhaps erosion processes can be reversed. This means ambition levels 2 and 3 can be achieved within the design as well. Other interventions in the regional design can possibly even rehabilitate degraded landscapes in the area by reforestation, restoration of riparian zones and by promoting regenerative agriculture. The latter means the stimulation of mixed cropping, using cover crops, limiting ploughing, constructing ponds, creating terraces or swales and using appropriate crops (see Appendix B).

The regional design worked with a set of preferred landscape scenario building blocks that resulted from the MCA: re-greened urban areas, rural revitalisation, self sustaining communities, mixed cropping, agro forestry, regenerative farming, precision agriculture, urban green belt, large scale reforestation, reforestation and energy mix, centralised energy farms, self supportive energy generation, eco&agri tourism, accessible farmland and improved rural connections. Rural revitalisation for example, means that facilitites in the countryside are improved, that tourism in these areas is promoted and that attractive assets are utilised and accentuated. A reforestation and energy mix means that wind turbines are combined with reforestation projects. As the Pedrera area is not suitable for wind energy, this specific building block is not considered in the regional design.

Some of these building blocks are clear spatial interventions that can be designed with, such as reforestation and an urban green belt. These are visible in the landscape design. Other elements are less obvious, but are still used for the regional design. For example, regenerative farming is promoted in an extensive agricultural zone. The borders of this area are based on the bird protection zone that forms part of the Pedrera area. Furthermore, agri&eco tourism and rural revitalisation are used as building blocks in the design by assigning new campsites and by improving the routing network. Historical cattle trails and a former Roman road (Via

FIGURE 5.17 / The design proposal for a green network in the Pedrera area, with tree rows along bigger roads, hedges along dirt roads and within farming fields and grass strips along contour lines as much as possible, alternated with reforested patches within the agricultural landscape.

FIGURE 5.18 / 3D visual that shows what the hedges, tree rows and grass strips could look like in between farming fields.

Augusta) are restored, which can be used as hiking or mountainbike tracks, and the irrigation channel is re-greened and now accessible for cyclists.

Detail #1 - GREEN NETWORK

One of the proposed interventions is the design of a green network of hedges, tree rows and grass strips. The current agricultural developments are characterised by dense monocultures of citrus on fenced-off plots. These fences are a new development in the area since the coming of citrus cultivation. The proposal is to remove the fences, plant rows of trees along roads, implement a network of grass strips within and around agricultural fields and to introduce (edible) hedges along or between different plots (Figure 5.19). The hedges will be a new asset in the area, which can replace the fences and can most imporantly provide several ecosystem services.

The result is an agricultural landscape with a dense vegetative network that increases biodiversity, reduces water runoff, enhances soil structure and captures carbon (Figure 5.17 and 5.18). With this design, desertification processes can be reduced and possibly prevented. The areas that are reforested, on mountain ridges or as nodes within the agricultural area, have the opportunity to be rehabilitated.

The trees that will be used for the tree rows will comprise a mixture of different species, to increase biodiversity and to enhance resilience. The tree rows can be planted with a combination of the following possible species: *Pinus pinea* (stone pine), *Pinus halepensis* (Aleppo pine), *Quercus ilex* (holm oak), *Quercus coccifera* (Kermes oak), *Quercus faginea* (Valencian oak), *Phoenix dactylifera* (date palm), *Jacaranda mimosifolia* (blue jacaranda).

For the hedges, a mix of edible and non-edible species can be used, for example *Pistacia lentiscus* (mastic), *Arbutus unedo* (strawberry tree), *Ficus carica* (fig), *Prunus dulcis* (almond), *Ceratonia siliqua* (carob), *Juniperus communis* (common juniper), *Olea europea* (olive), *Diospyros lotus* (date-plum) and *Punica granatum* (pomegranate).

The grass strips can either occur naturally or they can be planted with herbal species, such as thyme (*Thymus hyemalis*),

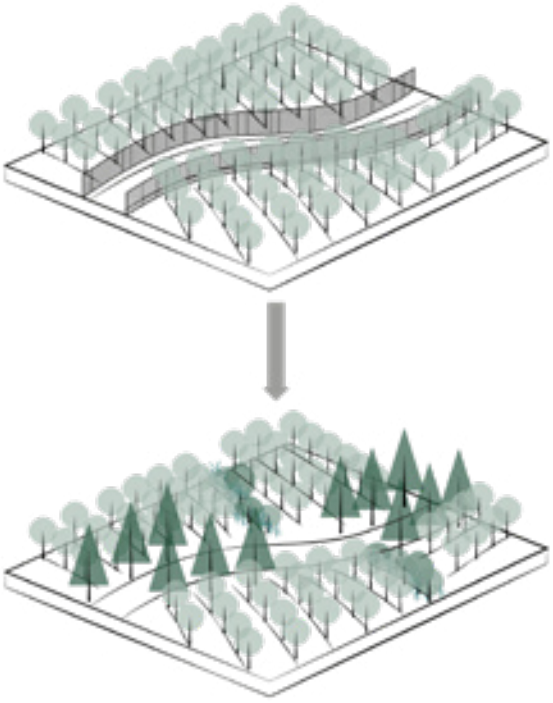

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FIGURE 5.19 / The concept for the design of a green network, with tree rows, hedges and grass strips within the agricultural area.

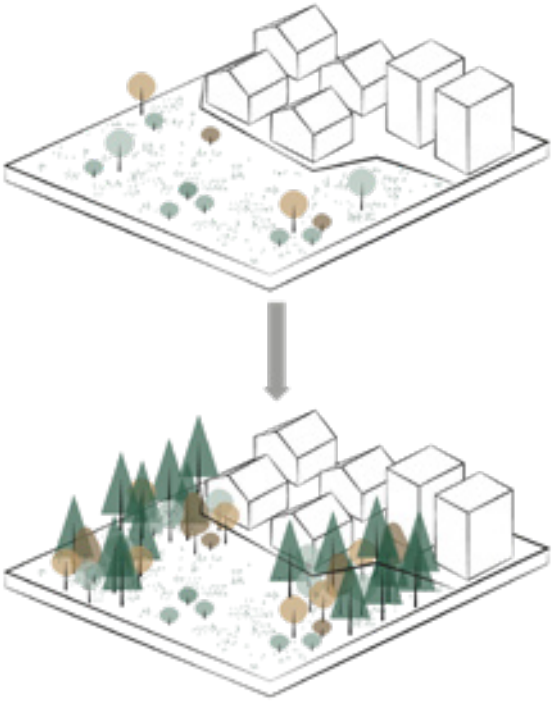

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FIGURE 5.20 / The concept for the design of a green urban edge, with reforested urban edges to increase biodiversity, limit runoff, enhance soil structure and limit urban sprawl.

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FIGURE 5.21 / The design of a green urban edge for the southern urbanisation area of San Miguel de Salinas. It shows how the edge is alternated with reforested area and farming fields.

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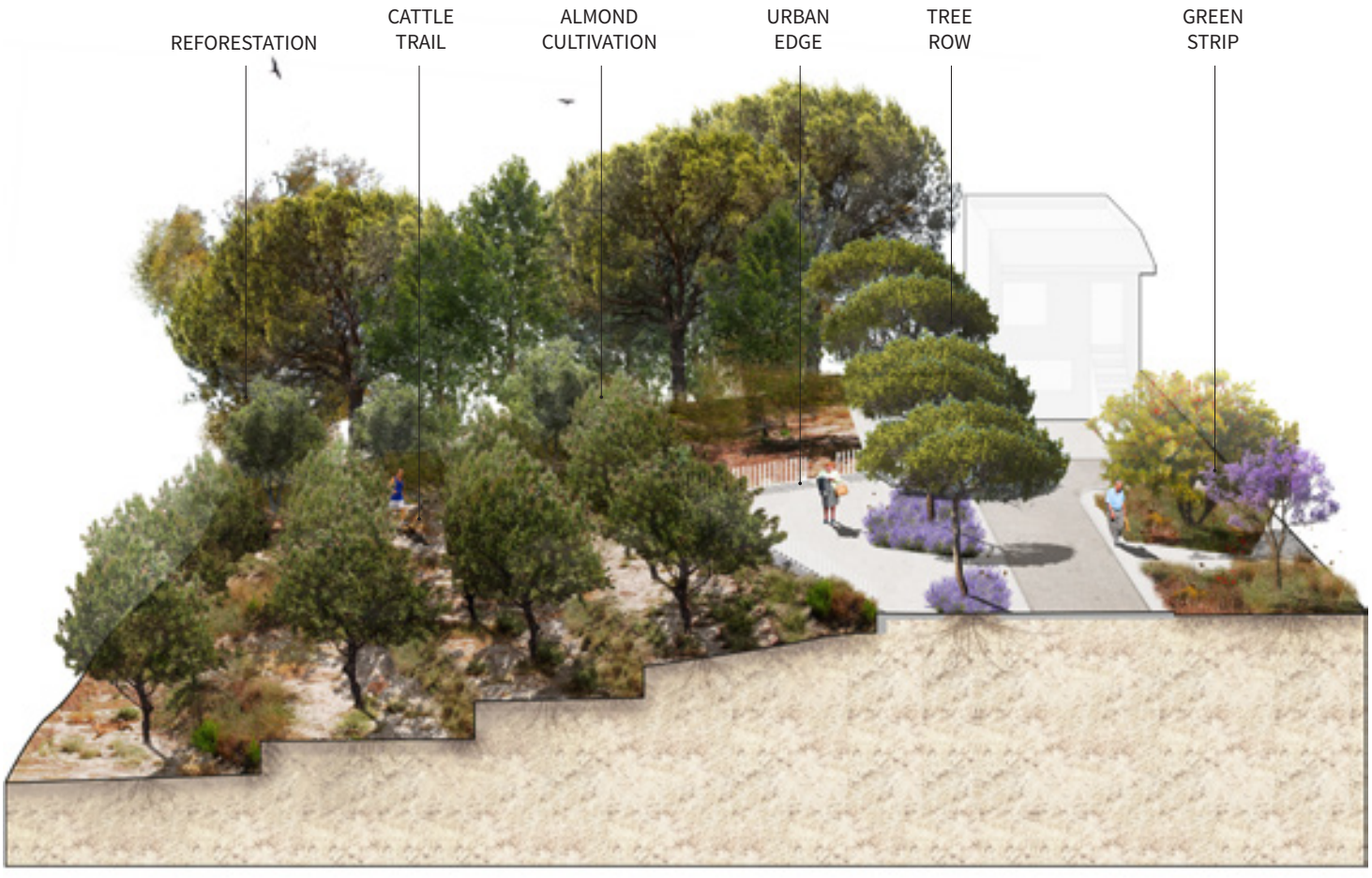
FIGURE 5.22 / 3D visual of the proposed urban edge, in which the connection between agriculture and urbanisation is enhanced by creating a viewpoint and increasing biodiversity.



rosemary (*Rosmarinus officinalis*) or lavender (*Lavandula*). By offering the opportunity to farmers to select species for hedges and grass strips on their land, they can possibly gain extra income from the fruits and herbs that will grow. These can be sold locally at farmshops, which will also stimulate agritourism. Subsidies can be used as a tool to stimulate the planting or to partially cover management costs.

The recreational network is also improved in this design. There are more paths and tracks created between agricultural plots, a historical cattle trail is restored and transformed into hiking and mountain bike track, and the historical farm 'Lo Balaguer', is proposed as a recreational hub with an eco campsite.

This design could contribute to combatting desertification, by providing several ecosystem services. The design incorporates the interventions of a network of hedges, tree rows and grass strips, stepping-stones, pop-up rewilding, regenerative agriculture, improving the recreational network and providing opportunities for eco/agri tourism.

Detail #2 - GREEN URBAN EDGE

The second design intervention is a suggestion for a green urban edge (Figure 5.20). This design attempts to tackle the problem of urbanisation by aiming to limit urban sprawl by (re-)foresting the current urban edge (Figure 5.21).

One of the survey respondents' reaction on the proposal for an urban green belt was that it would be an unfavourable intervention as it would increase the distance between people and agriculture. To show that this is not necessarily the case, I incorporated it in my design to show it can actually enhance this connection. By creating a diverse edge, with alternating forest areas and farmlands, the link between the urban life and the countryside can even be increased.

In this thesis I did not study urban development to the fullest, but this design is primarily to showcase what is possible within the current setting. It can especially show how biodiversity can possibly be increased, as well as how water runoff can be limited and soil structure can be enhanced within an urban context (Figure 5.22).

The urban edge will be marked with a tree row, which besides aesthetic purposes, provides a clear limit for future urban sprawl. The farmland that will touch the urban areas can be used for regenerative or traditional agricultural practices, for example traditional almond cultivation on terraces. Possibly it can even be combined with a cover crop such as lavender, rosemary or thyme.

To further increase the connection between farmland and urban life, former cattle trails will be restored. These can be used for hiking, running or cycling. Furthermore, green strips from within the urban areas will be connected to the areas outside of the urbanisations. These green strips can function as biodiversity hotspots in the city, can increase water storage capacity and limit runoff, which could eventually reduce desertification caused by urbanisation.

The reforestation that is part of developing the urban edge can possibly contribute to regenerating degraded land. Species for the reforesting can be similar as proposed in the design proposal for a green network. As long as it is not a monotonous assembly of species (especially pine), biodiversity can be increased and fire hazard can be prevented.

In the end this design could contribute to combat desertification, by halting urban sprawl and providing a variety of ecosystem services. The design incorporates the interventions of an urban green belt, reforestation, tree rows, restorative agriculture, stepping-stones and an improved recreational network.

Landscape scenarios

In any case, a pro-active and solidary attitude seems inevitable to accomplish the proposed regional design. When looking at the desirable and selected landscape scenario building blocks, which were applied in the design, almost all of them appear in either scenario II (rural emancipation) or scenario IV (rural refuge). This indicates that without the motivation to change towards active environmental management, it is unlikely that the design will become reality.

The final outcome will depend on the type of governmental approach. For

example, the proposal for a green network can be achieved with a top-down structure, by subsidising the planting of the hedges and grass strips, the tree rows can be planted by local municipalities or provinces themselves. When looking at scenario II, it is thinkable that the planting is an obligatory intervention that farmers need to do by law. However, this is hard to demand from land owners and will likely cause protest, especially in Spain. In scenario IV, where activities will be organised from bottom-up, it is imaginable that farmers and landowners decide to do the planting themselves, which could be encouraged by social platforms or farmers' communities.

Another proposed intervention is the reforestation of mountain ridges and riparian zones. This is a measure that requires coordination and planning, which makes it more likely to occur in scenario II. Especially as the riparian zones are owned by the state. However, this could also happen as a result of local action groups, which makes it a measure that fits scenario IV as well. This will be similar for agroforestry or regenerative farming. This is a measure that would be expected to occur from bottom-up, organised by farmers' groups and stimulated by NGO's. Nevertheless, it is also a development that would fit well in scenario II if the national government or European law demands farmers to manage their land that way (regenerative).

In scenario III, there would be no coordination at all to accomplish the regional design proposal; neither will there be the motivation to do so. In scenario I, the focus is on (fast) economical gain, which makes it unlikely that interventions from the design will be carried out. Moreover, in scenario I the landscape is approached very differently than what the regional design intents to. The design aims for a diverse and multifunctional landscape that fights desertification. In scenario I, the landscape is merely seen as a source of income and supplier of resources.

Toolbox for landscape architects

To go from the current situation to the desired future of the regional design, several adequate spatial measures can be applied. These measures derived from the regional design I developed in this thesis. This has resulted in a toolbox with a specific set of landscape interventions for southeast Spain that can prevent or reverse desertification, or regenerate the landscape (Figure 5.23).

The interventions from the toolbox are based on the solutions that are part of Sustainable Land Management (Appendix B) and on findings from the interviews and literature analysis. They can be split up into three categories: vegetative, agronomic and infrastructural measures.

The vegetative measures are: the use of wind breaks and hedges, tree rows, grass strips, reforestation, fire prevention strips, reforested ridges and steep slopes, urban green belt, restoration of riparian zones and dry river beds, greening of irrigation channels, stepping stones between natural areas, pop-up re-wilding and green recreational hotspots.

Agronomic interventions are: restorative agriculture, agroforestry and storm water harvesting.

On the infrastructural level, recreational networks can be improved, the inland can be connected with coastal zones, farmlands can be made more accessible, eco&agri tourism can be stimulated and national parks can be created.

The interventions from this toolbox can be implemented in the landscape, and can be used by planners and landscape architects that aim to combat desertification.

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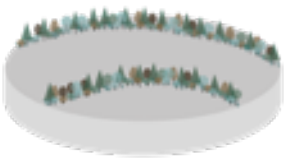
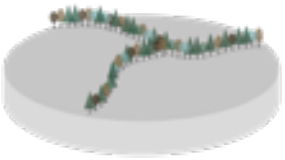
FIGURE 5.23 / Toolbox with possible landscape interventions to prevent or reverse desertification, or potentially rehabilitating degraded landscapes. It can be used by designers and planners to design against desertification.

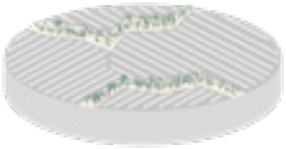
VEGETATIVE



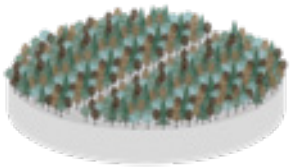
WIND BREAKS/HEDGES



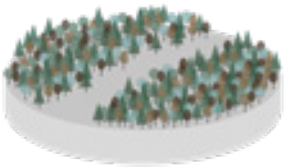
WEB OF TREE ROWS



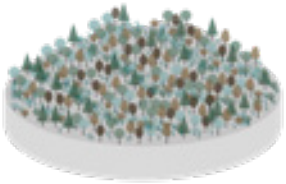
NETWORK OF GRASS STRIPS



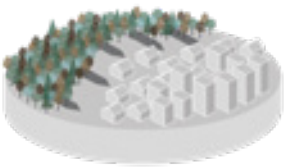
REFORESTATION



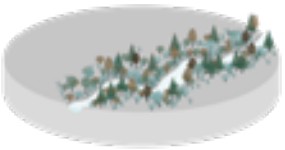
FIRE PREVENTION STRIPS



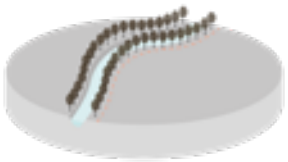
REFORESTED RIDGES & STEEP SLOPES



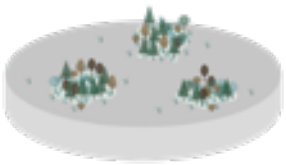
URBAN GREEN BELT



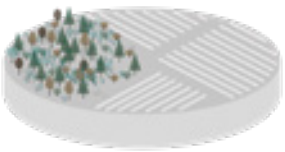
RESTORATION OF RIPARIAN ZONES AND DRY RIVER BEDS



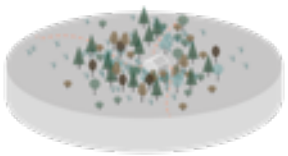
IRRIGATION CHANNEL AS VIA VERDE



STEPPING STONES BETWEEN NATURAL AREAS

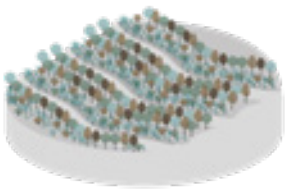


POP-UP REWILDING

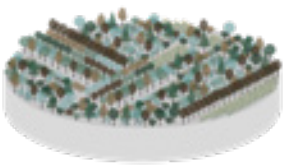


FARMS/FINCA'S AS GREEN AND RECREATIONAL HOTSPOTS

AGRONOMIC



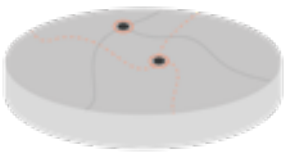
RESTORATIVE AGRICULTURE



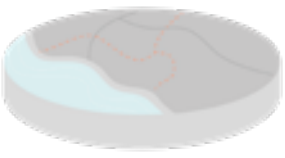
AGROFORESTRY/POLYCULTURE

STORMWATER HARVESTING

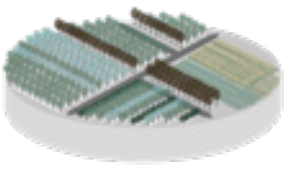
INFRASTRUCTURAL



RECREATIVE NETWORK

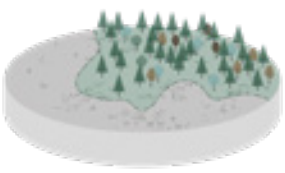


CONNECT INLAND WITH COASTAL ZONE



ACCESSIBLE FARMLAND

ECO CAMPINGS



CREATE NATURAL PARK FROM NATURA 2000 AREA

6 EVALUATION

In this final evaluative chapter, the main conclusions from this thesis are discussed and the research questions that were formulated at the beginning will be answered. Moreover, different elements from this thesis will be covered in a discussion, being the methodology, the use of landscape scenarios and the regional design. The chapter closes by elaborating on future recommendations.

6.1 CONCLUSIONS

The starting point of this thesis was that without an integral approach to landscape management, it is impossible to overcome the challenge to adequately combat desertification and give direction to a desired future. Due to the lack of adequate involvement of stakeholders and development of appropriate governance to combat desertification, it is key to find new approaches. According to literature, a possible way to connect people is by developing future landscape scenarios (Tress and Tress, 2003). Therefore, this thesis aimed to assess what the potential contribution of landscape scenarios would be to explore and communicate future options for desertifying landscapes in southeast Spain. By doing this, it was examined if this technique could indeed help to explore possible future developments in the landscape and could increase engagement, as Palang et al. (2000) argue.

The other objective of this thesis was to create a spatial design for the Pedrera case study area that fights desertification. The purpose of this design was that it would be based on a consideration of the landscape scenarios, which would contribute to the imaging and planning of different stakeholders.

Use of landscape scenarios

The main question for this thesis was to find out what the contribution of landscape scenarios would be to explore and communicate future options for desertifying landscapes in southeast Spain. Five important conclusions can be drawn as an anwer to this question, which will follow consecutively.

(1) First of all, it can be concluded that the use of landscape scenarios for the desertification issue has allowed the possibility to synthesise information from diverse disciplines and knowledge sources. This has resulted in four landscape scenarios that show different options for the future landscape of southeast Spain. The scenarios are based on an extrapolation of current trends and developments within different drivers: social, technological, economical, environmental and political (STEEP). The contribution of landscape scenarios has been that those different trends and developments could be assembled into a coherent and plausible story that show the possible effects of certain actions.

(2) Secondly, the use of landscape scenarios has been useful to explore possible futures of desertification in southeast Spain. The main conclusion that can be drawn is that the future of southeast Spain is most likely one of further desertification. This has been backed-up by a literature analysis, several expert interviews and field observations. This indicates that it is recommendable to invest in adaptation measures.

(3) A third conclusion from this scenario study is that the desertification rate will most likely depend on the social situation. A re-active attitude towards the environment is more likely to cause inaction and unsustainable land use practices, therewith driving desertification in the future. In that case, current pressures such as climate change, rapid urbanisation, intensive agriculture and large-scale irrigation will continue and perhaps even increase, which will lead to further desertification. With a pro-active and solidary attitude, chances are higher that desertification can be coped with and will be reduced or prevented. Possibly, degraded landscapes can even be regenerated on the long-term. This is the result of a pro-active approach to increase ecosystems' resilience and to reduce society's vulnerability to disturbances caused by desertification.

According to the landscape scenarios that were produced, the difference between a top-down versus bottom-up governance is less significant than the social attitude. A top-down government will not automatically lead to increased desertification and neither will desertification necessarily be a result of bottom-up governance.

(4) Hence, to successfully fight desertification in southeast Spain it is most important to adopt collective thinking as a society and to take on a pro-active approach

towards the environment. This could indicate that some personal, organisational and economical freedom needs to be given up.

(5) The question remains whether landscape scenarios contribute to communicating future options of desertification. Even though the number of participants in the stakeholder survey was low, the landscape scenarios did make the process of engaging people from different backgrounds easier. They were moreover useful to evoke discussion. However, hard conclusions cannot be drawn from this research. Nevertheless, I believe that it is crucial to come back to stakeholders with the scenarios in a form of member checking. It might not actually stimulate a system's change, but at least it can help to give an overview of people's opinions and desires. In the best case it could even make people think more about their actions.

Future trends

To come to a plausible set of scenarios, it is important to base the future landscape scenarios on a robust fundamental background. Therefore, possible future social, technological, economical, environmental and political (STEEP) trends in the landscape of southeast Spain were based on information that was retrieved from interviews, field observations and literature analysis. The trends that were revealed during this process were categorised according to their impact and degree of uncertainty in different matrixes. This allowed me to extrapolate these trends into four different landscape scenarios.

The set of possible future trends that was produced is extensive. The use of the impact and uncertainty matrixes has been useful to coordinate the analytical process and give an overview in the findings. Some of the results are obvious trends and developments, such as the outmigration in the Spanish countryside, the urban sprawl in the coastal areas and the intensification of agriculture. Others were more unexpected and incorporate more uncertainty for the future, being the emergence of self-supportive communities, the reoccupation of abandoned villages and the possible construction of the Ebro Water Transfer for example.

Landscape scenarios

The four landscape scenarios that were created from the trend analysis are based on the distinction between a re-active individual versus pro-active solidary society and a bottom-up versus top-down governance. The results show four possible futures for the landscape of southeast Spain, with four different outcomes on the desertification rate. As discussed earlier, it is more likely that desertification will decrease in a pro-active and solidary society.

Scenario II – rural emancipation – for example, shows an option for a Spain that is controlled by a strong government that aims to achieve national sustainability. This scenario is only plausible when the populace collectively hands over power to the national government and only when the feeling towards the environment is shared amongst the majority of the people. Otherwise protests against such strict law enforcement will emerge. In the context of Spanish history with a recent dictatorship, it is not likely that Spain will obey to that kind of centralisation, not even incorporating the unlikeliness of a collectively shared pro-active attitude towards protecting the environment.

Concerning scenario IV (rural refuge), it is hard to imagine that such large-scale social transformation will happen. There are developments going on in Spain that could point towards more communalism, such as the fact that it is the country with the highest number of eco-villages and seen the presence of a handful communist communities (Marinaleda for example). However, seen the most dominant and large-scale future trends (outmigration, urbanisation), these developments are minorities and therefore rather unlikely future trajectories.

The scenarios in which the desertification rate is most likely to increase are both characterised by a re-active and individualistic society. Scenario III, rural abandonment, sketches a world in which authorities have fallen and Spain has become fragmented. This is the result of political and economical instability and water deficits. Even though it seems to be the most ominous scenario, it is perhaps not the most unlikely. Current developments that point towards this scenario, such as the independency movement in Catalonia, the prevailing impact of the

economic recession and increasing water deficits play an important role in today's Spain, and most likely in the future Spain as well.

Most plausible would be the first scenario, rural maximisation. This almost seems a continuation of current practices, with intensifying agriculture, high urbanisation rates, growing nationalism and growing environmental problems. It is only the question how far into the upper left corner the future will be. There are still important elements in this scenario however, that are involved with a high degree of uncertainty, such as the approval of the use of GMO's (genetically modified drought tolerant crops for example). So far, it is not likely that the EU will allow this in Europe. Nevertheless, it is not unimaginable that after prolonged droughts, measures will be taken, and this could be one of them.

It is important to notice that each scenario incorporates both desirable and undesirable elements. None of the scenarios is exactly going to happen as such, since they are four rather speculative and subjective extremes. The future will probably be a mixture of all four scenarios. However, they have helped to explore possible future trajectories and can be used to think of where we want to steer towards to: the most desirable future. Leaving the question of what *is* most desirable.

Scenario principles

To go from the landscape scenarios to a spatial design for the Pedrera case study area, several principles were developed. First of all, the spatial trends from the STEEP analysis have been translated into landscape scenario building blocks. These depict possible future trends in the landscape and can be seen as the spatial embodiments of the landscape scenarios. They were useful as a link between the landscape scenarios and the final landscape design, because they revealed possible elements to work with in the design.

To make a selection of the most desirable landscape scenario building blocks in order to apply them to a design, a Multiple Criteria Analysis was conducted. By analysing elements according to public support, political manageability, economic gain, environmental gain and technological feasibility, it was possible to unravel the most desirable landscape scenario building blocks. These are: re-greening of urban areas, rural revitalisation, self sustaining communities, mixed cropping, agroforestry, regenerative farming, urban green belt, large scale reforestation, reforestation and energy mix, centralised energy farms, self supportive energy generation, eco&agri tourism, accessible farmland and improved rural connections.

To assess public support, a stakeholder survey was conducted. Different stakeholders were questioned about their preference for the scenarios and landscape scenario building blocks. This survey made it possible to get an understanding of the different feelings and perceptions on the scenarios and landscape scenario building blocks.

Regional design

The design question for this thesis was concerned with what spatial design could be created for the Pedrera case study area from the different landscape scenarios that would contribute to combatting desertification. With the four different landscape scenarios I explored what these worlds could mean for the landscape of southeast Spain. By looking far into the future it has been possible to determine what is desirable. Combined with the MCA, this allowed me to sketch a vision of a desirable future world that was gathered into a regional design. In that way, the design can be seen as a way to steer towards a desirable scenario by proposing a set of future developments.

The regional design for the Pedrera area that came out of this process includes a mix of different ambitions, which was possible by implementing the most preferred landscape scenario building blocks that formed the landscape scenarios. The result is a flexible design with a focus on a robust vegetative structure to prevent and reverse desertification. Certain design elements can potentially even contribute to the rehabilitation of degraded landscapes. By improving accessibility and a recreational network, an attempt is made to attract people to experience the landscape. There is no guarantee however, that this will actually revitalise inland areas and it is not ensured

that this encourages people to take care of the environment. Nevertheless, it does improve the likelihood of that.

The design offers many possible attractive interventions. It comes with a set of practical tools that help to combat desertification. To do this, the design comprises of four different ambitions. First of all, the aim is to reduce current desertification rates while maintaining current systems (1), secondly it is the ambition to prevent further desertification (2), then to reverse current erosion processes (3) and finally and most preferably to rehabilitate currently degraded landscapes (4). In each situation, an attempt has been made to achieve the best possible ambition.

It has to be noted that the design is an exploration of what the Pedrera area could look like in the future and is not a definitive end result that is set in stone. It should be seen as a way to show the possibilities and what those could look like.

The proposed regional design is likely to thrive best in a world that is in between scenario II and IV, and that is slowly moving away from scenario I. Currently, society is used to practices that are common for a world like scenario I. It is not recommendable to propose a radical design that is miles away from current practices. Therefore, the design that is offered in this thesis is slightly modest and tries to achieve the highest ambition level where possible. This means that the highest ambition level, meaning the rehabilitation of degraded landscapes, is not fully achieved in this design. Urbanisation is not abolished, citrus cultivation is still possible and golf courses still exist. This concession is part of the belief that a slow transformation will have more effect than no transformation at all.

Overall, the addition of a landscape design next to the landscape scenarios is relevant and important. It can be used to show what can actually come out of the landscape scenarios and can contribute to the imaging and planning process of stakeholders (such as policy makers, farmers, citizens). Often (landscape) scenarios stay quite vague and conceptual, which makes it hard to see the useful side of it. A practical and spatial implementation in the shape of a design that contains desirable aspects from each landscape scenario can give a clear overview of which practical tools can be applied in the landscape that prevent or reverse desertification. It can moreover be a useful tool to stimulate local dialogue when people share the output of the landscape scenarios and regional design.

Toolbox

There is a relevant role for landscape architects and designers to combat desertification. They can provide a framework in which they can apply a wide range of measures. These interventions are covered in the toolbox that was produced in this thesis, which can be divided in vegetative, agronomical and infrastructural categories. This toolbox offers a set of different potential landscape interventions and strategies that can be used to prevent and reverse desertification, specifically for southeast Spain. Combined in a landscape design policy makers can be provided with important and practical tools to combat desertification that fit within the current socio-political framework.

6.2 DISCUSSION

This landscape scenario study to explore the future of desertification in southeast Spain has revealed contributions for both landscape architectural research and practice, as well as for the desertification issue in southeast Spain in general. Landscape scenarios can be useful to explore possible future developments of desertification and can help to point out a desired future trajectory. Moreover, this thesis aimed to develop possible means to combat desertification. This has resulted in a toolbox that can be used by planners and designers within the specific context of southeast Spain. Elements from this toolbox, combined with the desirable aspects from the landscape scenarios have been applied in a regional design proposal for the Pedrera case study area.

Besides these contributions, it is important to consider the limitations of this research as well. Therefore, this section will reflect on the methodology, the use of landscape scenarios in landscape architectural research and the final outcome of the regional design.

Methodology

The approach in this thesis is worth to consider for replication or broader dissemination in future landscape architectural research, but could use improvements. First of all, there was not much literature available on combining landscape scenario development and landscape architectural design. This means that for my research, I was limited in sources and therefore had to rely on literature from other fields to assemble my research methodology. Secondly, it can be questioned if landscape scenarios should be combined with landscape design at all. Especially since the development of the landscape scenarios is not a necessary step to come to a reliable design.

As the approach contained different elements, they will be discussed separately in the coming sections.

Trend analysis

To acquire credibility in the landscape scenarios, it was ensured that they had a set of common variables so that the scenarios could be compared as recommended by Mahmoud et al. (2009). Moreover, trends that were used to develop the scenarios were analysed within the range of five drivers: social, technological, economical, environmental and political (STEEP). In each analytical step, being the field observations, expert interviews, literature and landscape analysis, these five pillars were considered. This gives no guarantee however, that all relevant data is incorporated. By focusing completely on these five drivers, there is a possibility that certain developments that do not fit into these criteria are neglected.

Throughout the analysis, I attempted to use the most recent and reliable data I could find, but there is a possibility that the data I used was out-dated. Especially when analysing possible future trends, it is likely that assumptions and biases are involved with the selection process of the data. The likelihood of bias in the interview outcomes is a limitation that should also be taken into account. Moreover, my personal interpretation of the data is subjective, as it is involved with my experiences, social environment and background. Nevertheless, I attempted to produce a reliable trend analysis and plausible set of scenarios by constantly documenting the sources, different steps taken, decisions that were made and outcomes.

The analytical steps are also concerned with a time constraint. As there were many steps and due to the time limitation, I was not able to dig deeper into each element, being the interviews, landscape analysis and literature analysis. The result could be that the analysis is somewhat shallow.

Multiple Criteria Analysis

As it is hard to point out what is most desirable, the MCA was incorporated to unravel the most preferred, and thus desirable, landscape scenario building blocks in terms of the criteria of public support, political manageability, economic gain, environmental gain and technological feasibility.

This process was not completely reliable, as the weighing factors for each of these criteria were based on a subjective consideration. The scoring of the political, economical, environmental and technological indicators have moreover been educated guesses, although they were based on a scientifically grounded foundation as much as possible. At the very least it opens up the process of weighing the different factors and allows for discussion on that.

Survey

To assess public support as part of the MCA, a stakeholder survey was conducted. The number of respondents in the survey was rather low (5) and is therefore not the most desirable sample group. A more extensive and quantitative assessment is necessary to examine how much public support on the scenarios and building blocks actually exists within southeast Spain.

The participants of the survey had various backgrounds, but it can still be questioned if it was a correct reflection of the nature of public support and what people think is desirable. To overcome this pitfall and limit the focus on public opinion, the feedback from the respondents has been weighed next to other criteria in the MCA, and was not a decisive factor on itself.

By presenting the scenarios in a random order, credibility was increased. This way, the order was not the determining factor in people's opinion on the scenarios.

More research is necessary to find ways to examine whether landscape scenarios could enhance communication with desertification issues. This could happen in an experimental set-up for example, or by long-term monitoring. Such research would be interesting for behavioural sciences and not so much for landscape architectural research.

Landscape scenario building blocks

In this thesis, landscape scenario building blocks were produced as a step to go from the landscape scenarios to a design. They were analysed and assessed according to the MCA, with the most desirable ones as a result.

However, these landscape scenario building blocks are not waterproof. They were based on the interpretation of the trend analysis. This means there could have been more or different ones, depending on the gathered data and selection procedure.

In the trend analysis, some developments are incorporated that could have been spatial trends as well, but which were not incorporated in the set of landscape scenario building blocks. This is for example the possibility to transform Natura 2000 area into a National Park with higher protection status. The reason this possible development was not incorporated, is because I considered it as too local and specific for the Pedrera area. However, other areas in Spain could be involved with this development as well. Hence, the main limitation in developing the landscape scenario building blocks has been the subjective nature of the selection procedure.

Use of landscape scenarios

As stated before, it can be debated if landscape scenarios should be combined with landscape design at all. The development of the landscape scenarios is not a necessary step to come to a reliable design. Without the scenarios, it would have been clear as well what spatial measures would help against desertification. However, I believe the addition of a landscape design next to the landscape scenarios is relevant and important to show what can actually come out of the landscape scenarios. Especially as scenarios can be used to explore unstructured problems and the act of designing to restructure the case (De Jonge, 2009). It is worth to further research the possibilities of combining landscape scenarios and landscape architecture. Nevertheless, it has to be said that scenario development can already be seen as a specific type of *research by design*, according to De Jonge (2009).

The main question in this thesis was to examine if scenario technique could indeed help to explore possible future developments in the landscape. Through the development of four different scenarios, it was possible to explore four possible futures. However, it was also questioned whether these scenarios would increase engagement. The latter is not answered in this thesis, as this is a long-term process that needs more research.

A critical remark on the final output of the landscape scenarios itself is that they can be considered as not specific enough for southeast Spain. I attempted to incorporate as much national and regional trends as possible, such as demographic patterns, the political situation and traditional farming practices. However, as many future trends are projected on the global context, it was difficult to stay away from commonalities. Time could have been one of the constraints in this case. If I had more time, I would have fully submerged myself into the Spanish situation and taken more time to unravel trends specifically for southeast Spain.

Scenarios should be used with carefulness, as they are simplified versions of possible future worlds and show a landscape from the perspective of the creator (Tress and Tress, 2003). In this case that means the landscape scnerios are a result of my perspective. The effect is that they cannot entail all elements and complexities of the real world. The selection process that is part of scenario development is inherently subjective, but is the determining factor to shape the final outcome.

According to Sheppard (2005), another consideration should be taken into account when using visual content to stimulate or motivate. Landscape scenarios, and especially the accompanying visualisations, are powerful tools that can arouse both positive and negative emotions. They can especially be misleading when they cause false expectations, wrong interpretations and misunderstandings. Therefore, Tress and Tress (2003) advocate for a combination of different visualisation techniques.

In this thesis, it can be questioned on what ground the survey respondents disliked scenario I and III. Was it because they genuinely disapproved these scenarios, or because they were steered by the visualisations? Another limition of using scenarios is the possibility that stakeholders prefer the scenario that maintains the status quo, as was the case in the studies by Tress and Tress (2003) and Palang et al., (2000). For this scenario study, this was avoided as much as possible by not assigning one of the scenarios as the 'business as usual' scenario.

Sheppard (2005) also points out such possible risks of using scenarios, being the chance of biased responses, disbelief, confusion, overkill, upsetting people or perpetuation of the problem. For these reasons and others, a focus on public opinion should be approached carefully.

Regional design

Despite the fact that the design was created according to an empirical foundation and a thoughtful selection of building blocks, designing itself is never a completely rational process. Possible limitations and biases could have occurred, affecting the way I selected data. The biases I had could also have steered the way I approached the problem of desertification and possible ways to solve this.

Moreover, as the main aim of this thesis was not solely to make a regional design, but to create four plausible scenarios as well, there was only limited time for the design process. This means that the design could use more consideration and further detailing. Nevertheless, the purpose of the design has never been to come to a definitive end result that is set in stone. It is merely an exploration of what the Pedrera area could look like in the future and should be seen as a way to show a selection of possibilities.

6.3 RECOMMENDATIONS

From the landscape scenarios and information provided by literature and experts, different design principles and strategies can be recommended to prevent or reverse desertification. Much of these potential strategies are political interventions, such as initiating a general plan for southeast Spain on the national level, the limitation of water use and water demanding crops, the reconsideration of European (agricultural) funding (CAP) and covering desertification as an educational topic in Spain.

There are also spatial interventions thinkable, being several vegetative measures, agronomic interventions and infrastructural measures. Together, these interventions compose the toolbox as proposed in this thesis, which can be used by planners and landscape architects that want to combat desertification.

It is recommended to study further on the different interventions from this toolbox. It can be interesting to examine how they can be used in other locations, and if they are still adequate in contexts outside Spain.

I certainly believe that the addition of a landscape design next to the development of landscape scenarios can be relevant and important to show what can actually come out of the landscape scenarios. Therefore it is recommendable to do further research on the possibilities of combining landscape scenarios and landscape architecture.

Furthermore, the landscape scenarios are worth to use more often in the future, for example at schools or in local governments. This could help to unravel more opinions and feelings and could be used to find common grounds and shared visions.

Desertification in southeast Spain is an issue that finds its origins mostly in politics and socio-economic dynamics, which does not mean that it is not a field of interest for landscape architects. The landscape scenarios that were provided in this thesis and the practical tools that were given in the toolbox can be used by designers who can hopefully stimulate and inspire decision makers towards more action and sustainable land management.

The landscape is always transitioning and human decisions play a big part in determining the direction of the future. The desire is to encourage those that encounter the scenarios from this thesis to work collaboratively towards a resilient and feasible future without desertification.

Conclusively, my main recommendation would be instead of researching what steps need to be taken, we'd better start acting.

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