A process for effective desertification mitigation

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A process for effective desertification mitigation

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Desertification mitigation has fascinated me for quite some time, as it represents a specific and urgent challenge to Sustainable Land Management (SLM) – which has remained an important topic to me ever since I began studying it for my Master's thesis in the Simen Mountains of Ethiopia. After having worked for many years as a research scientist at the Centre for Development and Environment (CDE) of the University of Bern, Switzerland, I was given the opportunity for a (late) PhD study on this topic within a new EU project entitled DESIRE (Desertification Mitigation and Remediation of Land – a Global Approach for Local Solutions). This integrated research project started in February 2007. As one of six working block leaders, I was heavily involved in writing the proposal and in shaping the project during the project's five years of implementation (2007–2012). Project coordinator Coen Ritsema suggested that I expand this involvement into a PhD at Wageningen University.

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Table of Contents

Chapter 1

Introduction

Introduction

1.1 Desertification mitigation

Desertification is defined as “land degradation in arid, semi-arid, and dry subhumid areas resulting from various factors, including climatic fluctuations and human activities” (UNCCD, 1994). Land degradation entails soil erosion by water and wind, physical soil deterioration (e.g. compaction, crusting, sealing), chemical soil deterioration (e.g. fertility decline, salinisation), biological degradation (e.g. biomass and vegetation cover decline, forest fires) and water degradation (e.g. aridification).

Fragile dryland ecosystems are characterised by water scarcity and harsh climatic conditions. Disturbances in these ecosystems can easily result in widespread and severe land degradation and thus desertification. Combined with global issues such as climate change, economic disparities, migration, and competing claims on land, this often leads to a vicious cycle of aridity, land degradation, and productivity loss, affecting the well-being of people living in drylands and causing their development indicators to lag far behind the rest of the world (MA, 2005). Maintaining and improving the productivity of agricultural land in order to enhance food security and ecosystem sustainability is therefore a key concern for drylands (Wegner and Zwart, 2011; Hurni et al., 2008; Thomas, 2008).

The issue of desertification has been on the global agenda for many years, even before the inception of the UN Convention to Combat Desertification in 1994. Now perceived as a global challenge, desertification – together with climate change and biodiversity – is addressed by a strong global coalition of partners (MA, 2005; UNCCD 10-year-strategy; UNCCD, 2008; Cowie et al., 2011). However, despite this heightened attention and long-standing efforts and investments in prevention, mitigation, and rehabilitation, the problems of desertification persist. The recent SOLAW report (FAO, 2011) estimates that 32% of all land is affected by moderate to severe degradation, requiring intervention in terms of rehabilitation or mitigation measures. According to the Millennium Ecosystem Assessment (2005), 10–20 % of drylands are already degraded, and over 250 million people are directly affected by desertification.

Major efforts have been made to assess the extent and nature of land degradation and the rate at which it is increasing or decreasing (Dregne, 2002; Vogt et al., 2011). Identification of physical processes with a view to understanding the system’s functioning and its response to external pressures has received considerable attention at the regional, national, and international levels (Verstraete et al., 2011; Nachtergaele and Licona-Manzur, 2008). Many research projects, however, focused on a single aspect or a limited number of aspects of desertification, and many of them were carried out by mono-disciplinary teams. This approach was reinforced by a simplistic view of desertification as a disaster affecting mainly developing countries.

Various studies contributed to broadening this understanding of desertification, by viewing it as a complex phenomenon involving interactions between multiple causal factors and as a multi-directional process of high contextual and spatial variability (Grainger, 2009). Today, UNCCD itself stresses the involvement of local communities in combating desertification and underlines the importance of redirecting technology transfer so that it is demand-driven (FAO, 2011). Still, desertification research conventionally focuses on the problem, that is, degradation, while neglecting the appraisal of successful conservation practices; and it is usually carried out separately by either natural or social scientists. Although this has resulted in essential insights into the causes and impacts of desertification, findings have remained inappropriate for practical decision support, policymaking, and implementation at the local level. Moreover, scientific results are insufficiently channelled into implementation and policy discourses (Grainger, 2009; Thomas et al., 2012; Winslow et al., 2011).

Figure 1.1. Gullies and poor crop growth due to desertification in Morocco (Photo: G. Schwilch).

1.2 Sustainable land management

Combating desertification is complex and usually requires changing the very land management that led to its occurrence (WWAP, 2012). The concept of Sustainable Land Management (SLM) is the most promising response to desertification that has emerged in the past two decades. It addresses technical and ecological aspects as well as economic and socio-cultural dimensions and is by now acknowledged and widely promoted (Hurni et al, 2006; IAASTAD, 2008; FAO, 2011). Key threats in drylands – and thus challenges for SLM in drylands – include low productivity, water stress, climate variability and change, high risks of natural disasters and hazards, marginality and remoteness, migration, and population pressure. Long-term studies have shown that sustainable agricultural production is possible even in dryland conditions if soil and water conservation is integrated with nutrient management (Sahrawat et al., 2010). ***Strategies*** to mitigate desertification comprise ***technologies*** for sustainable land management coupled with a suitable ***approach*** that supports adoption and implementation of these technologies.

A variety of SLM technologies exist that are suitable for dryland ecosystems. They can be categorised into agronomic, vegetative, structural, and management measures (WOCAT, 2008a). Agronomic and vegetative measures usually require relatively small investments and are fairly easily established, whereas structural measures, such as terraces, are more demanding. The latter can be combined with vegetative or agronomic measures for protection and to improve soil fertility and water management. Management measures are especially important on grazing land and in forest or woodlands. An important group of SLM technologies in drylands consists of rainwater harvesting and sustainable irrigation systems. Conservation Agriculture is a SLM technology which is heavily promoted worldwide and consists in minimal soil disturbance (e.g. no tillage), permanent soil cover, and crop rotation. In dry agro-ecosystems, its most promising feature is the non-inversion tillage component, which primarily constitutes a water harvesting strategy (Rockström et al., 2009), whereas maintaining ground cover remains a challenge (Ward et al., 2012), especially in integrated crop-livestock systems as they are often found in dryland areas.

Despite this full toolkit of suitable technologies, in practice, producing from land without degrading soil, water, animal, and plant resources remains an enormous challenge for land users as well as other stakeholders. Implementing SLM on the ground by selecting appropriate combinations of technologies and approaches is a crucial, but difficult task. Priorities should be determined according to stakeholders' objectives in order to achieve a maximum benefit (de Graaff et al., 2008; Nkonya et al., 2011) – which is not the same as maximum profit. As part of this process, identifying, assessing, and testing SLM technologies together with the stakeholders involved will enhance ownership, feasibility, and applicability.

1.3 Multi-stakeholder collaboration

SLM is a classic multi-stakeholder issue, concerning individual and community land users, agricultural advisors, enterprises, natural resource managers, government authorities, civil society, and researchers alike. This is rooted in the understanding that sustainability is a normative concept which requires concretisation in a reflexive, participatory, and deliberative dialogue between all actors involved (Rist et al., 2007). In practice, however, it often occurs that experts suggest technologically and ecologically sound measures which are financially not feasible or lack social acceptance. Conversely, there are initiatives that base SLM promotion purely on local innovation (Scoones et al., 2008; Wettasinha et al., 2006).

Acknowledging that there is much merit and power in local innovation, Critchley and Mutunga (2002) name two reasons why innovations alone cannot solve the problem. First of all, local innovation does not automatically leap ahead under its own momentum; it requires careful nurturing, support, and guidance. Secondly, such innovation is only one segment in rural research and extension, which equally requires external inputs and experience. Access to knowledge from outside the local context, however, is not always available to all stakeholders and often depends on the support that land users receive from their government – for example, in the form of advisory services, professional training, or technical and financial assistance. It is these enabling conditions which may trigger local innovations (Kessler and Stroosnijder, 2010; WOCAT, 2007).

Figure 1.2. Local land users' families are directly affected by desertification (Photo: G. Schwilch).

The main way in which participatory processes can support the management of social–ecological systems is by enabling learning and meaningful interaction between the two knowledge spheres of specialists and local communities (Stringer et al., 2007). True, effective collaboration and partnership between stakeholders is the only way to bring land users' many generations of local experience and innovation together with scientists' up-to-date ecological and technical expertise. It is thus generally acknowledged to date that mitigating desertification requires multi-stakeholder dialogues and collaboration (Thomas et al., 2012).

1.4 Decision support

Developing and implementing an SLM strategy requires careful selection of alternatives and decision-making based on an evaluation of various SLM options according to multiple objectives and criteria. Multi-criteria Decision Analysis and Decision Support Systems are tools which reveal trade-offs between multiple objectives, reflect multiple criteria, and involve both quantitative and qualitative data to evaluate options.

In sustainable natural resource management, a balance must be found between the three dimensions of sustainability – the ecological, the economic, and the socio-cultural – and their objectives and criteria. This makes decision-making highly complex. Working with many stakeholders simultaneously – a crucial requirement when addressing an issue as complex as land management – adds further complexity to the decision-making process.

Despite the variety of decision support systems available for SLM-related fields such as forest management or water resource planning, few systems exist for local land management. Those that do exist are usually highly sophisticated, depend on data and IT specialists, and are not applicable in all decision-making situations or in variable socio-economic contexts. Practical methods are rare in multi-criteria decision-making, including methods for identifying the underlying problems (Janssen and van Herwijnen, 2006); and existing methods often lack effective mechanisms to support the selection and definition of options to be compared.

SLM options must be carefully chosen based on assessed impacts and stakeholders' preferences, and have to be adapted to local circumstances. Assessing options in an interactive, participatory, and process-focused way is indispensable in order for decisions to be effective. Experience has shown that structured processes support people's intuitive decision-making procedures and foster discussions and negotiations between the stakeholders involved (Ananda and Herath, 2009; Balana et al, 2010).

1.5 The DESIRE project

The present research was embedded in an integrated research project entitled DESIRE (Desertification Mitigation and Remediation of Land – a Global Approach for Local Solutions). During five years (2007–2012) and funded under the EU's Sixth Framework Programme, DESIRE brought together the expertise of 26 international research institutes and non-governmental organisations with the aim of establishing promising alternative land use and management strategies in seventeen areas affected by land degradation and desertification around the world. Project work was based on close collaboration of scientists with local stakeholder groups. The study sites served as a global laboratory for developing and applying new methods of science–stakeholder collaboration and trialling traditional and innovative approaches to combating desertification.

The DESIRE project consisted of six working blocks: 1. Establishing land degradation and SLM context and sustainability goals; 2. Defining and evaluating sets of desertification indicators; 3. Identifying, evaluating, and selecting SLM strategies; 4. Trialling and monitoring SLM strategies; 5. Regional evaluation of SLM strategies; and 6. Disseminating the knowledge to a variety of stakeholders. The seventeen study sites were mainly located in Mediterranean countries (Portugal, Spain, Italy, Greece, Turkey, Tunisia, Morocco) but also beyond (Russia, China, Botswana, Cape Verde, Mexico, Chile).

The present research was embedded mainly in the third and fourth working blocks. It contributed specifically to developing a methodological framework to support the study site teams in selecting an appropriate SLM option after having assessed the context, stakeholders, and desertification indicators in previous steps. Decisions in favour of a particular SLM technology were followed up with test implementation in the field, thorough monitoring, and upscaling; the latter was done by modelling regional effects and disseminating the results.

1.6 Problem definition and research objectives

The present research tackles a multitude of problems. In order to clarify the research objectives, these problems were grouped as follows.

(a) Lack of practical, yet comprehensive methodologies for SLM identification and appraisal

Although many useful approaches exist for upscaling SLM, there is an apparent lack of practical, structured and at the same time flexible methodologies for fostering SLM in diverse contexts. Previous attempts at developing such methodologies have come up short for a variety of reasons: unclear targets, unclear procedures, methods tailored to a single context, use of simplified cause–effect decision chains to address complex problems, time requirements on participants, financial constraints, wishful thinking regarding stakeholder collaboration, the unavailability of well-trained and neutral moderators, and unrealistic expectations regarding broader impacts based on individual project results.

Stakeholders in land management are often understood as comprising farmers only; at best, other land users such as pastoralists and foresters are included as well. Agricultural advisors, private enterprises, traders, technicians, specialists, governmental and non-governmental organisations, and in particular researchers are usually not considered. But only an open, critical, and sometimes controversial debate among all of these stakeholders about the utilisation and usefulness of SLM strategies can finally lead to an optimised management of land and water resources (Herweg, 2007).

The ideas and innovative practices of land users are frequently neither sufficiently recognised nor adequately stimulated. At the other extreme, some implementation approaches focus too narrowly on local knowledge alone, neglecting technical and biophysical issues as well as the viability of projects (time, personnel, funds).

Our hypothesis is that a widely applicable and practical methodology which integrates a broad range of stakeholders from the start will allow a comprehensive appraisal of local as well as external SLM strategies.

(b) Insufficient decision support at the local level

Although decision support systems exist for different purposes, there is none suitable for identifying, assessing, and negotiating SLM options in a simple manner together with stakeholders. There is a general lack of guidance for decision-makers on how to structure effective participatory processes to select the most appropriate intervention option (Kellon and Arvai, 2011).

In SLM, there are no universal best practices, but there are site-specific solutions which can be transferred as SLM options to other locations for own adaptation and further development. The challenge is to identify, globally share, and finally select the most appropriate SLM practices for local implementation.

What is lacking so far is methodologies that provide guidance to agricultural advisors on how and where to obtain new ideas – for example, on how to reduce water losses or how to enhance productivity of the land – and could thus help advisors to better support land users in their local area.

Our hypothesis is that innovative methodologies for guiding decision-makers in selecting appropriate SLM options for local implementation will lead to increased acceptance of, and commitment to, implementation of SLM on the ground. At the same time, such an approach will facilitate multi-stakeholder learning.

(c) Insufficient understanding and monitoring of SLM technologies

SLM technologies identified in a participatory process have a high social acceptance. But although many biophysical processes are studied in detail, the overall biophysical effectiveness of a given conservation measure and of its financial viability are often inadequately understood and monitored. Once an SLM technology is selected for test implementation, it remains to be proven whether it is, indeed, the best option in ecological, economic, and socio-cultural terms. This requires field research and monitoring over a sufficient period of time, ideally on the relevant land user's land and in collaboration with the land user and other stakeholders. In order to effectively mitigate land degradation and desertification, SLM in drylands first and foremost has to tackle water scarcity (Stroosnijder, 2009).

Our hypothesis is that on-farm trials and monitoring will lead to a better understanding of the functioning of SLM, and that in drylands, in particular, better soil cover and minimised soil disturbance will enhance production and improve the water balance.

Based on these hypotheses, the **objectives** of this research were the following.

1. To develop a methodological framework for integrating stakeholders in a standardised and comprehensive appraisal of local innovations and SLM strategies to mitigate desertification.
2. To develop a decision support tool for making decisions on the test implementation of potential strategies with a group of stakeholders.
3. To integrate field research and participatory monitoring tools in the environmental impact assessment of a selected conservation measure, especially concerning soil water conservation.

1.7 Research methods

Due to its being embedded in the large and integrated DESIRE project, this study has a broad geographical and multidisciplinary focus. The study is typical of geographic research in that it is situated at the interface between human and natural sciences. Conducting interdisciplinary research requires a certain level of pragmatism and flexibility (Nuijten, 2011). This study attempted to take account of this need while at the same time striving to achieve scientific rigor. The special features and strengths of this research lie in its integration of ecological, economic, and socio-cultural aspects. A systems approach was taken, which includes interdisciplinary problem-solving approaches as described by Jansen, combining "hard system" and "soft-system" approaches from the natural and social sciences (Jansen, 2009).

1.7.1 Transdisciplinarity

SLM is characterised by a high degree of complexity, uncertainty, and controversy. Searching for solutions to such "real-world" challenges is predestined for being tackled using transdisciplinary methods (Schneider et al., 2009). In development research, transdisciplinary approaches are gaining in importance, although they do not necessarily guarantee better SLM practices (Scott, 2011).

It is important to note that promoting SLM is a social process and must be based on societally negotiated options. Transdisciplinarity means that purely academic research is replaced by a process of shared knowledge co-production by scientific and non-academic partners. The present research is based on these principles. Development experience has shown that when external experts alone acquire, analyse, and process information and then present this information in reports, social change does not usually take place. By contrast, the kind of "social learning" that stakeholders generate and internalise during a participatory process does enable change.

Unlike most research in this field, the present study does not look exclusively at farmer participation, but considers broader stakeholder participation, bringing together land users as well as other stakeholders, such as agricultural advisors, researchers, government entities, and non-governmental organisations. The innovativeness of the proposed methodological framework lies in the focused way in which people are brought together in a learning group to explore problems and solutions related to SLM in their region. This is a fast and economic way of involving various stakeholders in a common process.

Challenges within this research included the usual constraints of transdisciplinary research projects: time restrictions, minimal financial resources, and the limited availability of facilitators and experts. A pragmatic approach was adopted, given that (i) such an approach will likely be required in future SLM selection processes that face similar challenges, and (ii) no ready-made method was available that suited the diverse natural and human environments included in the DESIRE project.

1.7.2 Methodology development and testing

In order to integrate stakeholder workshops with the assessment of strategies to mitigate desertification, two existing methods were combined and further developed. Methodology development took account of recent developments and experiences in the field of integrated and participatory research frameworks (Dougill et al., 2006; Reed, 2008; Stringer et al., 2008; Gonsalves et al., 2005) and experiences from stakeholder workshops based on the concept of "learning for sustainability" (CDE, 1998; Bachmann, 2003).

The present research made use of such innovative, process-oriented approaches to foster social learning processes at the interface between local and external actors. Approaches were integrated in the screening and assessment of SLM options to mitigate desertification, in which the WOCAT methodology (Liniger and Schwilch, 2002; Liniger et al., 2002; WOCAT, 2007; WOCAT, 2008a,b) played an important role. Based on the WOCAT database of conservation strategies, this study aimed to develop a process-embedded tool to comparatively assess technologies and implementation approaches and to support the process of deliberation over the best SLM option(s) in a given human and natural environment.

The development of this comparative selection and decision support tool required studying available methods such as decision support tools, simulation sessions, role play games, and others. The aim was to integrate existing techniques as much as possible, and to develop a concise tool – whether computer-assisted or not, or a combination of both. The tool needed to be integrated into a participatory process which enabled stakeholders to make informed commitments towards SLM and the planned subsequent test implementation.

The study aimed to integrate the whole process from initial co-learning about desertification problems and screening of existing and potential solutions to the selection and negotiation of viable technologies and approaches for test implementation and in-depth ecological and socio-economic assessment of these solutions into one concise but still flexible methodological framework. Once this 3-part methodology (see also Figure 1.3) had been tested in a pilot study site (Morocco), training was offered for researchers in all DESIRE study sites. The training was supported by guidelines including tools such as workshop exercises, questionnaires, databases, and decision support systems.

After the training, study site researchers applied the methodology in their respective areas. In this sense, the DESIRE study sites served as a kind of global laboratory which allowed testing the developed 3-part methodology simultaneously in 17 areas around the world. The great variety of biophysical and socio-economic contexts in these areas posed a challenge in developing a generic methodology, but at the same time it provided an opportunity to test applicability under diverse situations.

1.7.3 Methods of analysis

In-depth qualitative techniques were found to be most appropriate for evaluating outcomes of the application of the methodology developed in line with objectives 1 and 2 of this research. Evaluation data were collected using (a) workshop reports from study sites (based on a template developed for this research), (b) study site feedback obtained by means of informal interviews at project meetings and short questionnaires, and (c) in-depth semi-structured interviews with stakeholders from two study sites located in Morocco and Portugal. Sources (a) and (b) mainly supplied researchers' opinions, while source (c) was specifically designed to provide views of other stakeholders, such as land users, agricultural advisors, and government technicians.

Content analysis according to Flick (2005) was used to analyse the data in a qualitative manner. Data from sources (a) and (b) reflected inputs from all study sites that had applied the overall 3-part methodology, which constitutes a representativeness of 100% – that is, maximum representativeness.

Quantitative analyses were conducted to evaluate the documented SLM technologies and approaches (under objective 1) and to assess the effectiveness of the trialled practice in Morocco (objective 3). In-depth impact monitoring depended on the specific conservation measure chosen by the researchers and stakeholders of the Moroccan study site and was carried out in close collaboration with the local researchers. The first 2–3 years of performance were monitored in detail, observing the development of soil water content, water stress, vegetation development, ground cover, biomass production, productivity, and other parameters. Moreover, monitoring activities included consultation with, and observation of, land users and local researchers. Most parameters were monitored mainly by the local research team, while this study focused on soil moisture measurements.

1.7.4 Study site(s)

Objectives 1 and 2 involved the 17 study sites of DESIRE, where the appraisal methodology and the decision tools were tested. These sites were located in Guadalentin (Spain), Mação and Góis (Portugal), Rendina (Italy), Crete and Nestos (Greece), Eskişehir and Karapinar (Turkey), Sehoul (Morocco), Zeuss-Koutine (Tunisia), Djanybek and Novy-Saratov (Russia), Yan River Basin (China), Boteti (Botswana), Cointzio (Mexico), Secano Interior (Chile), and Ribeira Seca (Cape Verde).

The DESIRE study sites in Sehoul (Morocco) and Mação/Góis (Portugal) were selected for more in-depth studies. Despite similar climatic conditions, they face very different desertification problems: in Morocco, the main problems are increasing aridity and inadequate land management, whereas Portugal suffers from forest fires. The two sites are representative of the various DESIRE study sites in terms of both their environmental conditions and the range of desertification problems they are confronted with. In both sites, semi-structured interviews were conducted in order to evaluate the methodological framework developed within this study and to obtain insights from all stakeholder groups. From the other sites, only the researchers' perspectives were included. In Morocco, the implementation of SLM trials was accompanied by ecological impact monitoring as described above.

Study site in Sehoul, Morocco: The site is located near the city of Rabat-Salé. It is characterised by subhumid to semi-arid conditions and is affected by various desertification processes. Pasture areas, mostly located on steep slopes, are affected by overgrazing, which causes degradation of the vegetation cover, a reduction in palatable species, and development of gullies and rills. In cultivated areas, problems are more related to inappropriate land management in view of the given climatic conditions, soil characteristics, and slope gradients. A decrease in soil moisture (due to delayed and reduced precipitation in autumn or early dryness in spring) leads to reduced grain and biomass yields, putting agriculture and livestock economies at risk. The proximity of the city of Rabal-Salé causes increasing pressure on natural resources due to intensified agriculture and use of land for buildings and transport.

Study site in Mação/Góis, Portugal: Located in the transition zone between the semi-arid and subhumid climatic zones, it has suffered severe periods of drought that have completely changed the region's appearance over the past decade. The impacts of drought were catalysed by catastrophic forest fires that burned down most of the forest. Some areas were burnt twice in 5 years over the last decade, leading to severe degradation of soils and vegetation. In addition, the area's socio-economic outlook is grim, with Mação having the highest percentage of old people of all municipalities in Portugal. Ongoing global change processes are degrading the soils, reducing water conservation, and leading to extended poverty, resulting in outward migration of young people and, consequently, an aging population. Several national and European development projects to reverse these environmental and socio-economic degradation processes are currently being implemented or have recently been completed. Mação is one of four UNCCD Pilot Areas in Portugal.

1.8 Thesis outline

Following this general introduction (Chapter 1), Chapter 2 reviews and discusses cutting-edge methodologies for monitoring and assessing SLM. It consists of an article written in collaboration with a variety of leading scientists at the request of the Dryland Science for Development (DSD) consortium, which had been set up to organise the first UNCCD scientific conference in 2009. The consortium recognised that numerous monitoring and assessment methodologies had been developed and applied over many years without sufficiently being reviewed and acknowledged by the scientific community. WOCAT and DESIRE methodologies are a central focus of the article. Chapter 2 thus helps readers to get a good basic understanding of these methodologies, their underlying conceptual frameworks, and how they are embedded in other initiatives.

Chapter 3 focuses on the presentation, rationale, and discussion of the 3-part methodology developed for and applied within the DESIRE project. A preliminary analysis is presented mainly for part I, which entails a first stakeholder learning workshop for identifying applied and potential SLM solutions. The results of part II are analysed and discussed in Chapter 4, drawing conclusions on 30 SLM technologies and 8 SLM approaches applied in the various DESIRE study sites. These three chapters (2-4) all contribute mainly to objective 1 of this study, whereas the subsequent two chapters relate to objective 2.

Part I – Identification	**Part II – Assessment**	**Part III – Selection and decision**
• First stakeholder workshop • Identification of current and potential solutions to desertification • Mutual learning	• Evaluation, documentation, and sharing of local solutions • Using standardised WOCAT questionnaires	• Second stakeholder workshop • Selection of most promising option for local implementation • Using a decision support tool

Figure 1.3. Suggested setup for the 3-part methodology.

Chapter 5 presents the result of the attempt to develop a decision support tool for selecting SLM technologies together with stakeholders, and reviews its application and levels of success in the multitude of biophysical and socio-economic contexts of the DESIRE study sites. A further analysis, presented in Chapter 6, looked at how the related structured processes facilitated multi-stakeholder learning and the selection of appropriate SLM options for local implementation.

Chapter 7 focuses on the implementation of a thus selected SLM technology in Morocco, where marginal slopes and stony soils challenged the success of the selected Conservation Agriculture technology. This chapter is the main contribution to objective 3 of this study. The thesis concludes with Chapter 8, which presents general conclusions from the entire study, provides a synthesis of major results, and offers a brief outlook and recommendations.

Chapter 2

Experiences in monitoring and assessment of sustainable land management

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Experiences in monitoring and assessment of sustainable land management

Abstract

Although sustainable land management (SLM) is widely promoted to prevent and mitigate land degradation and desertification, its monitoring and assessment (M&A) has received much less attention. This paper compiles methodological approaches which to date have been little reported in the literature. It draws lessons from these experiences and identifies common elements and future pathways as a basis for a global approach. The paper starts with local level methods where the World Overview of Conservation Approaches and Technologies (WOCAT) framework catalogues SLM case studies. This tool has been included in the local level assessment of Land Degradation Assessment in Drylands (LADA) and in the EU-DESIRE project. Complementary site-based approaches can enhance an ecological process-based understanding of SLM variation. At national and sub-national levels, a joint WOCAT/LADA/DESIRE spatial assessment based on land use systems identifies the status and trends of degradation and SLM, including causes, drivers and impacts on ecosystem services. Expert consultation is combined with scientific evidence and enhanced where necessary with secondary data and indicator databases. At the global level, the Global Environment Facility (GEF) knowledge from the land (KM:Land) initiative uses indicators to demonstrate impacts of SLM investments. Key lessons learnt include the need for a multi-scale approach, making use of common indicators and a variety of information sources, including scientific data and local knowledge through participatory methods. Methodological consistencies allow cross-scale analyses, and findings are analysed and documented for use by decision-makers at various levels. Effective M&A of SLM [e.g. for United Nations Convention to Combat Desertification (UNCCD)] requires a comprehensive methodological framework agreed by the major players.

2.1 Introduction

Monitoring and assessment (M&A) has conventionally been focused more on land degradation and desertification than on the sustainable management of land resources (including soil, water, animals and plants). Extensive research efforts have assessed land degradation – often focusing exclusively on soil degradation – in the field (e.g. Stocking and Murnaghan, 2001; Mortimore, 2009). These efforts tend to address the physical processes of degradation (e.g. Ritsema, 2004), its spatial extent and trends (e.g. Oldeman et al., 1991) or its causes and impacts (e.g. Dregne, 2002; Geist and Lambin, 2004). Other efforts have investigated the risks of degradation and desertification (e.g. MEDALUS - Kosmas et al., 1999) or produced recommendations (e.g. Barac et al., 2004) and provided decision support tools or manuals (e.g. Kellner et al., 2003; DESURVEY, 2005). There has been limited assessment of environmental and economic costs of land degradation, except for case studies or focused research (e.g. de Graaff, 1996). These studies have added much to our understanding of the complex problem of land degradation. However, a unified methodology for M&A of land degradation that integrates sustainable land management (SLM), and that can be routinely applied worldwide, is only now beginning to coalesce.

This paper critically compiles current initiatives for the M&A of SLM. Such methodological approaches have been insufficiently discussed in scientific fora, as they have been mainly elaborated by development practitioners, although researchers have also been involved. These approaches have recently been brought together and discussed by an international consortium of scientists in the preparation of the First United Nations Convention to Combat Desertification (UNCCD) Scientific Conference, 22–24

September 2009 in Buenos Aires, Argentina. This paper reviews the current methodological initiatives, draws lessons from these experiences and identifies common elements and future pathways as a basis for a global approach for implementation by the UNCCD.

Land capability classifications emerged in the mid-20th century (Helms, 1992) and can be seen as a forerunner of SLM M&A. Such assessments, identifying biophysically sustainable versus unsustainable uses of particular soils and landscapes, continue to be useful worldwide. They guide society towards optimal land uses as well as indicating options to reduce risks – but they are not designed to provide land quality analysis over time.

In the late-1980s, the Global Assessment of Soil Degradation (GLASOD) produced the first global map of soil degradation (Oldeman et al., 1991), which has been extensively utilized by the UNCCD community. It had, however, a number of limitations. The assessment was conducted at a coarse scale (average 1:15 Million); it was based on expert opinion and its focus was limited to soils. Two editions of a World Atlas on Desertification were published in 1992 and 1997, based on GLASOD and additional data, but at a higher spatial resolution (UNEP, 1997). These were single evaluation exercises at the continental and global scales and oriented towards the dominant environmental narrative of that period — that of a downward spiral of land degradation perceived as being widespread and pervasive (WOCAT, 2007). The World Overview of Conservation Approaches and Technologies (WOCAT) was founded in 1993 as a response to this bias, with a mandate to improve the knowledge base underlying SLM, through gathering information on the application of SLM worldwide. The focus on SLM complements the hitherto technical approach to land management with social and economic dimensions (Hurni, 2000). In response to the encouragement of UNCCD during the fourth Conference of the Parties (COP-4) to assess land degradation using the latest techniques, United Nations Environment Programme (UNEP) and Food and Agriculture Organisation (FAO) launched the Land Degradation Assessment in Drylands project – LADA – in 2001, with the financial support of the Global Environment Facility (GEF). Initially, it focused on land degradation, but the collaboration with WOCAT strengthened the SLM component of LADA, and together they are now fostering a comprehensive and cross-scale methodological approach. Likewise, the M&A of SLM had historically received much less attention from the UNCCD community than the M&A of land degradation. However, over the past two decades, SLM has gained recognition as the key means to combat land degradation, not focusing on soil alone as had been the case in the past, but also focusing on the degradation of water and vegetation (World Bank, 2006; IAASTD, 2008; Liniger and Critchley, 2008). The increased efforts and financial means put into the promotion of SLM require proper monitoring and evaluation methods as well as action. The DESIRE project (2007-2012; www.desire-project.eu) is developing and testing alternative strategies for desertification-vulnerable areas. Like WOCAT, DESIRE advocates an SLM approach based on inventories of local knowledge. Scientists are currently working in 16 study sites in 13 countries with an integrative participatory approach, in close collaboration with local stakeholders as well as having a sound scientific basis for the effectiveness at various scales.

The GEF (2009) has been the largest development initiative fostering SLM as a strategic intervention through its land degradation focal area. SLM is considered in a comprehensive manner, aiming at a global systems approach with mutual benefits for local people and the global environment (Stocking, 2009). GEF is currently developing tools to monitor and assess SLM progress in its project portfolio through its knowledge from the land (KM:Land) initiative. This project utilizes a hybrid SLM conceptual framework (see Figure 2.1) which well suits the methods described in this paper, providing an overview of the cause – effect interactions of degradation and SLM on environment and human well-being. It is termed ‘hybrid’ because it blends elements from two widely-known conceptual frameworks: that of drivers, pressures, states, impacts, responses (DPSIR; Smeets and Weterings, 1999) and the ecosystem services perspective used by the Millennium Ecosystem Assessment (MA, 2005). SLM is considered the ‘response’ to the ‘drivers’, ‘pressures’ and ‘states’ of degradation, which enhances the provision of ecosystem services and thus improves human well-being and reduces poverty. The ‘state’ component can be used as a proxy for changes in ecosystem services and subsequently human well-being, since the typical time frame of an intervention often prevents the measurement or observation of changes at this level.

One of the main tasks for scientific support of SLM is to produce evidence of its impact on natural resources and to assess the implications from such impacts on society, the economy and policy (Hurni et al., 2006). This is urgently needed, as it is now widely acknowledged that SLM has potential major global benefits, not just to counter land degradation but to simultaneously sustain ecological functions, contribute to biodiversity conservation and as a tool in the mitigation of, and adaptation to, climate change (e.g. Gisladottir and Stocking, 2005; Cowie et al., 2011). There is a wealth of knowledge on technologies for prevention and mitigation of land degradation, and rehabilitation of degraded land. Many of these technologies have been applied and tested in the field or on experimental sites to assess their biophysical effectiveness (Bainbridge, 2007), but assessments of their cost-effectiveness, impacts on ecosystem functions and services, on overall ecosystem integrity and on the economy are still weak (Carpenter et al., 2006). Likewise, traditional land use systems and local land management innovations have been inadequately documented or assessed for their combined benefits in terms of productivity, conservation effectiveness and sustainability. However, the success of upscaling SLM depends closely on the cost-effectiveness, the supporting policies and other socio-cultural and economic conditions.

M&A is typically conducted within project settings. While the focus of M&A was conventionally on achievement of project outputs and objectives, attention has recently shifted towards impacts (de Graaff et al., 2007). For example, a practical impact M&A instrument, entailing six steps, was developed by an international group of development agencies, universities and individuals (Herweg and Steiner, 2002). It comprises both observation (monitoring) and interpretation (assessment by stakeholders) of the changing context, and aims at finding plausible indications — not scientific proof — of a project’s impact. The ultimate goal of M&A is to analyse and document findings for use by decision makers at various levels. Learning and decision support tools built on solid information have been developed for various projects and have evolved to become more participatory, multi-stakeholder, multi-institutional and multi-sector. What is still required is more inter- and trans-disciplinary research to come up with a global approach for the M&A of SLM and to provide a more complete and scientifically proven picture of SLM impacts globally.

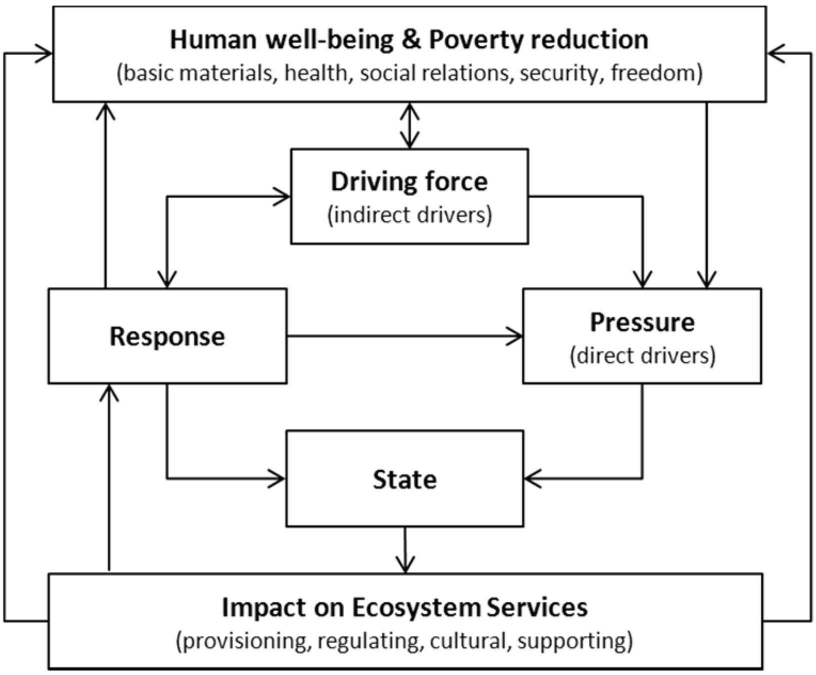

Figure 2.1. Hybrid SLM conceptual framework for monitoring and assessing impacts from SLM interventions, as suggested by KM:Land.

2.2 Current methodological approaches

2.2.1 Monitoring and assessment methods at the local level

Implementation of SLM takes place at the local level, either by individual land users, communities or through technicians. Many investments in SLM have been made within development or research projects not only by providing new technologies, but also through supporting valid traditions or local innovations. A number of these experiences in SLM have been reported or analysed in research papers, project documents or extension manuals (e.g. Barac et al., 2004). Many, if not most, of these have analysed the biophysical effects but at plot scale only. Based on the premise that these SLM experiences are not sufficiently or comprehensively documented, evaluated and shared, the global WOCAT initiative (www.wocat.net) has developed standardized tools and methods to compile and evaluate the biophysical and socio-economic knowledge available on SLM at the local, regional and global scale. Having had an initial focus on soil and water conservation, it has since broadened its scope to embrace SLM. The tools allow SLM specialists (including land users, agricultural advisors, project managers, government officers, etc.) to share their knowledge of SLM implementation in-country and around the world (Schwilch et al., 2007; WOCAT, 2007; Liniger and Critchley, 2008).

The basic concept behind the WOCAT methodology at the local level entails

1. assessing local case studies of successful SLM and their local spread and adoption,
2. providing a standardized framework that allows comparison and sharing beyond the local scale,
3. inclusion of socio-economic as well as biophysical aspects,
4. use of the knowledge of both specialists and land users as data sources, backed up (triangulated) by scientific data where possible and
5. simultaneously using the same tools for both (self-) evaluation and for knowledge sharing.

The key tools at the local level are two questionnaires on SLM technologies and SLM approaches, and their respective databases. These two applied together constitute a case study, which can be as small as one farmer's field or may represent hundreds of square kilometres (catchments, districts, etc). SLM technologies are the physical practices in the field, which are agronomic (e.g. intercropping, contour cultivation, mulching), vegetative (e.g. tree planting, hedge barriers, grass strips), structural (e.g. graded banks or bunds, level bench terraces, dams) or management measures (e.g. land use change, area closure, rotational grazing) that control land degradation and enhance productivity in the field. These measures are often combined to reinforce each other. The questionnaire addresses the specifications of the technology (purpose, classification, design and costs) and the natural and human environment where it is used. It also includes an analysis of the benefits, advantages and disadvantages, economic impacts and acceptance and adoption of the technology. Impacts are approximated through simple scoring by experts, but supplemented with data where available.

The associated SLM approaches are the ways and means of support that help to introduce, implement, adapt and promote those technologies on the ground. An SLM approach involves all participants (policy makers, administrators, experts, technicians, land users, etc; actors at all levels), inputs and means (financial, material, legislative, etc) and know-how (technical, scientific, practical). Questions focus on objectives, operations, participation by land users, financing and direct and indirect subsidies. Analysis involves monitoring and evaluation methods as well as an impact analysis. Successful approaches are the key to the upscaling of technologies over larger areas and more land users.

The use of the WOCAT tools stimulates self-evaluation, as well as learning from comparing experiences within SLM initiatives where, all too often, there is not only insufficient monitoring but also a lack of critical analysis (Liniger et al., 2004; Schwilch et al., 2009). However, monitoring and evaluation of specific SLM implementations have often led to changes and modifications of technologies and approaches, reflected by the fact that SLM is constantly evolving. Successful SLM depends on the flexibility and responsiveness to changing complex ecological and socioeconomic causes of degradation, to analyse what works and why and how to modify and adapt to locally specific circumstances and opportunities (WOCAT, 2007). It is this information about flexibility, adaptation capacity and impact, which has been requested by the end-users of WOCAT to extract from the questionnaires, without investing exhaustively in extra documentation time. Although the questionnaires have been continuously revised, shortened and adapted to better address new challenges – such as ecosystem services, adaptation to climate change and poverty alleviation – work is needed to deal with these issues more comprehensively. Nevertheless, the questionnaires are considered too long and demanding by a number of WOCAT users. This is a barrier to the increased demand of investors to acquire cost and impact data from SLM implementation.

The EU DESIRE project has integrated these local level WOCAT tools into a comprehensive participatory approach with a clear link to the regional level. Subsequent to facilitated stakeholder learning and decision support workshops (Schwilch et al., 2009) are field trials and monitoring, thereafter feeding into regional simulation and scenario models (Fleskens et al., 2009). This allows insights into the causes and effects of SLM strategies on environment and people at the local as well as the regional level. Information on proven and cost-effective SLM strategies adopted and accepted by local stakeholders is funnelled into the policy arena and disseminated to various other stakeholders such as land users, agricultural advisors, governmental authorities, NGOs and scientists. Being only a five-year project (2007 – 2012), the methods and learning from DESIRE must be integrated and continued in long-term programmes to be ultimately effective.

Besides developing an improved mapping methodology (see Section 2), LADA has developed a manual for degradation and SLM assessment at the local level (LADA local), embracing a broad variety of methods. The manual outlines how to (a) conduct field observations, measurements and interviews with land users and key informants, (b) build on available secondary information and (c) how to analyse and report on the findings. The analysis helps to improve understanding of the drivers, causes, impacts and responses with regard to land degradation and SLM. The methodology has been tested with local communities and stakeholders in 3–6 pilot areas in each of the six LADA countries (Argentina, China, Cuba, Senegal, South Africa and Tunisia), providing a wide range of dryland situations and contexts. A team of approximately five people with multi-sectoral expertise needs 2–3 weeks to implement this assessment, including time for analysis and report writing. Despite the rapid nature of the approach, the methodology is designed to be robust enough to provide baseline data on land degradation and improvement for planning, priority setting and subsequent monitoring activities.

Other initiatives to assess and compile SLM experiences at the local level have focused on best practices or success stories such as those by UNEP (2002), FAO (2002), GMCCD (Reij and Steeds, 2003) and IWMI (Penning de Vries et al., 2008). These have been mainly compiled within time bound projects and seldom (if ever) entail long-term monitoring and knowledge management of the findings. Nevertheless, the approaches described above would benefit by adopting complementary elements from these and other assessment and monitoring concepts. One improvement would be to include information on varying land potential and land change mechanisms to help explain success or failure of SLM in different regions, and in different parts of the landscape within a region. Federal management agencies of the United States, for example, use the concept of 'ecological sites' to distinguish fine-scaled land units based on differences in the soil- and climate-based potential. The concept of land potential recognizes that several natural plant communities or agricultural uses are potentially observable on an ecological site, and are therefore potentially attainable. State-and-transition models are then developed to represent the possible changes, ascertained through participatory meetings, field inventories and remote sensing. Alternative states or different dynamic regimes are identified that signal either heightened vulnerability to undesirable change (as defined by the participatory process) or areas in which plant communities and ecosystem services will be difficult to restore (as defined by ecological processes). This information is routinely used to define the likelihood of success or failure of SLM at management scales (Bestelmeyer et al., 2009). Thus, ecological sites and state-and-transition models could complement the WOCAT/LADA approaches with the observations and local knowledge required for a more detailed understanding of ecological mechanisms.

2.2.2 Spatial assessment methods at the national and sub-national level

Just as local assessment of land degradation cannot simply be aggregated to a watershed- or country-level, SLM assessments cannot be extrapolated or upscaled easily or linearly. Local case study assessments will never provide a complete overview of the spatial extent and effectiveness of SLM within a country, province or district due to spatial heterogeneity, off-site effects and cross-scale interactions. Research on cross-scale interactions, for example, has revealed nonlinear relationships between the variables measured locally and attributes of SLM at broader scales (Peters et al., 2004; Ludwig et al., 2007). It is, therefore, important to use separate methods for local and national/global scales, but with the possibility of linking them through a suite of common indicators (see also Reed et al., 2011). Common indicators allow integrating multiple spatial scales, which is essential when appraising ecosystem services; recognizing that many services are provided at the local scale, but driven by changes at national or even global scale. Local level M&A of SLM should, therefore, be linked with mapping at the (sub-) national and global scale in order to upscale local impacts of SLM on the one hand, and to support coarse assessments with local evidence on the other. Additionally, the scale at which assessment of SLM is feasible and logical might not necessarily be the same scale at which reporting (and decision-making) is required. This requires a nested approach in which the methods and results are spatially explicit regarding degradation processes, SLM interventions and ecosystem services affected. This also links to the Dryland Development Paradigm Principle 4 which emphasises the nested structure of the human-environmental systems (Reynolds et al., 2011). The spatial and temporal scale depends on the envisaged level of planning and decision-making. The assessment can be based on a variety of data sources, indicators and methods, including remote sensing, which has become a popular and more powerful method since images became more accurate and affordable over the last decade. It is possible to directly map some land degradation features from remote sensing images, using high resolution data (Bai et al., 2008; Verstraete et al., 2011). The WOCAT/LADA/DESIRE method presented below attempts to map SLM, using participatory approaches backed up by quantitative data and by using cross-scale categorization of land use systems, degradation types, SLM and their impacts on ecosystem services, respectively. Other innovative geospatial methods and approaches are discussed in Buenemann et al. (2011).

For the development of a standardized mapping methodology, WOCAT, LADA and DESIRE joined forces in 2007. The principle of the WOCAT/LADA/DESIRE mapping methodology is that degradation and SLM are mapped on predefined units (described below). This does not mean that the exact spatial location of, for example, water harvesting technologies is delineated on a map, but that rather the extent is indicated as a percentage of a specific map unit. The map units are defined according to the biophysical and socio-economic variables influencing degradation and SLM, respectively, which can be land potential ('ecological sites' as introduced above) or land use. Within the methodology presented here, the mapping units are land use systems within local administrative areas (e.g. districts, municipalities, etc.). National land use systems are defined according to the principles presented in the Global Land Use Systems Map developed by LADA (Nachtergaele and Petri, 2008) and refined by countries at national level. These principles require that, besides biophysical attributes of land use, key socio-economic attributes, such as population density and poverty, are also reflected. This land use system procedure has in-built flexibility to permit more detailed local, provincial or catchment mapping where no land use system map is available at the appropriate scale, as for the DESIRE sites. The mapping methodology is, therefore, applicable at various scales, from village level to national or even regional level (see Figure 2.2). It is the number and size of mapping units which defines the level of detail and focus, and hence the relevant use of the results for decision-making.

The mapping questionnaire is filled out by local experts (extension officers, agronomists, soil and water specialists, etc.) familiar with the area, in consultation with land users, further drawing on various secondary data sources (e.g. maps, statistics). Information is collected on land use (trend in area and in intensity) and on a number of items related to degradation and to SLM. These items cover the same topics for degradation as for SLM; that is they are 'mirrored' as illustrated in the schematic Table 2.1. The hierarchical nesting of observations across locations is illustrated by steps (a), (b), (c) and (d) in Table 2.1 (right column). Local-scale technology observations, such as bunds, low dams or bare fallow, nest hierarchically together in the SLM group 'Water Harvesting'. The hierarchical nesting approach allows the accommodation of broad local diversity while providing meaningful aggregation to higher scale levels. These aggregated observations have already passed through a 'quality assurance' filter through the judgments of the locally-experienced assessment teams, bringing together a large and diverse group of experts. Though originally derived from the GLASOD method, it assesses much smaller land areas with which the experts are familiar, and in more detail, thus improving the quality and accuracy of assessments. The expert consultations are carried out in a systematic and standardized way, in combination with scientific evidence such as analysis on land cover change derived from satellite imagery, normalized difference vegetation index (NDVI) and soil, water and vegetation analysis. Nevertheless, it remains a challenge for research to make optimum use of remote sensing information and incorporate it into this system, notably to calibrate spectral signals with various land degradation and SLM practices, and to assess ecosystem services. The surveys also attempt to diagnose some of the drivers of degradation such as human population and livestock density, consumption patterns, land tenure, poverty, labour availability, market access or civil conflicts.

Table 2.1. Degradation and SLM information gathered through the mapping questionnaire.

Degradation within given land use system *(a)-(g) indicating the questionnaire steps*	**SLM practice within given land use system** *(a)-(k) indicating the questionnaire steps*
(a) Type(s) of degradation (incl. overlaps)	(a) Name of technology
	(b) SLM Group
	(c) Type of measure (agronomic, vegetative, structural, management)
	(d) intention: prevention, mitigation, rehabilitation
(b) Extent (area percentage)	(e) Extent (area percentage)
(c) Degree	(g) Effectiveness
(d) Rate (over past 10 years)	(h) Effectiveness trends
(g) Impact on ecosystem services (type and level)	(i) Impact on ecosystem services (type and level)
(e) Direct causes	
(f) Indirect causes	(f) Degradation addressed
	(j) When was technology installed
	(k) Reference to documented technology in QT or concise details

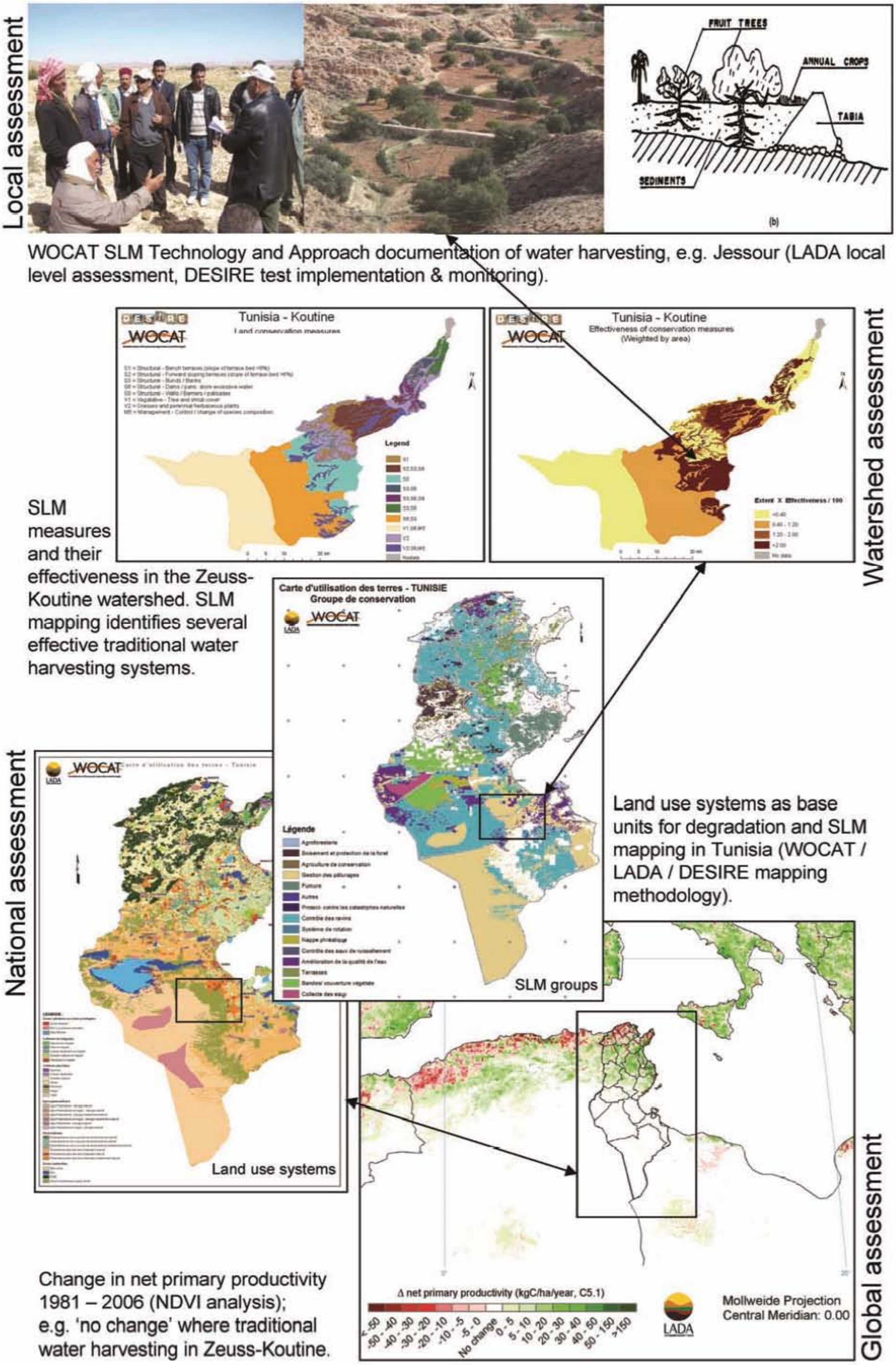

Figure 2.2. WOCAT/LADA/DESIRE methods applied across different spatial scales (example Tunisia. Source: DESIRE-Tunisia, LADA-Tunisia, GLADA).

This WOCAT/LADA/DESIRE mapping and reporting approach for the national and sub-national level would benefit from integrating more existing data sources. The Australian Collaborative Rangelands Information System (ACRIS; www.environment.gov.au/land/rangelands/acris/), for example, was developed to deal with the challenge of integrating large amounts of existing data from disparate sources. Meta-analysis techniques are used to synthesise information from different pastoral monitoring systems plus other monitoring datasets (e.g. climate variability, fire extent and frequency, livestock and kangaroo densities indicating grazing pressure, census and socio-economic survey data). The meta-analysis approaches utilized by ACRIS were successful in producing standardised interpretations from a body of heterogeneous data (Bastin et al., 2009). Such meta-analytical treatments could be used to provide additional quantitative support for the evaluations of the effectiveness of SLM technologies and mapped information derived from expert interviews.

National assessments and monitoring could eventually be based on more detailed quantitative programmes at varying levels of intensity. The United States National Resource Inventory (NRI), for example, is a statistically-based inventory of land cover and land use, based on photointerpretation, field observations and measurements. Each plot is assessed relative to its ecological potential using 17 indicators of three attributes: soil and site stability, hydrological function and biotic integrity (Herrick et al., 2006). National maps of current status based on over 10,000 plots assessed since 2003 are being generated with the primary objective of informing national policy; however, the results are also applied regionally, and the methods are used at scales as fine as individual pastures.

Overall, the WOCAT/LADA/DESIRE methodology provides a reasonably cost-effective tool to assess land degradation, SLM, and – as much as possible – their impacts on ecosystem services at the present time. The LADA experience shows that the mapping (including land use systems classification and technical expertise) can be implemented for approximately US$ 250,000 in a country the size of South Africa. The assessment can be periodically updated at much lower costs to review progress. These approaches can be complemented by data-driven assessments and monitoring in the future, as resources become available.

2.2.3 Global level indicators and knowledge management

At the global level the main interest groups in SLM comprise international organizations and conventions, donor agency programs and international policy makers. These include the UNCCD and the GEF Land Degradation Focal Area. In order to sustain support, one of the UNCCD's key interests is to demonstrate its success by assessing and monitoring progress towards impacts given in the 10-Year Strategic Plan of the Convention (UNCCD, 2008). Consequently, a set of 11 impact indicators was adopted at its last Conference of the Parties (COP-9) for this purpose. Out of those, a sub-set of two impact indicators (the proportion of the population in affected areas living above the poverty line and land cover status) are considered to be the minimum requirement for reporting by affected countries – starting in 2012. The others are considered optional. The methodologies for measuring these indicators are still being developed. The indicator selection process of the UNCCD so far lacks a clear framework.

GEF has invested considerably in a new global and systematic strategy for SLM (Stocking, 2009). To strengthen the management of its investments in its Land Degradation Focal Area, GEF initiated the long-term program termed KM:Land which is executed by the United Nations University – Institute for Water, Environment and Health (UNU-INWEH). A hybrid SLM framework (see Figure 2.1) has been used to formulate indicators at global and at project levels. At the global level, five biophysical and socioeconomic core indicators (land cover, land productivity, water stress, rural poverty and income distribution) were chosen for the purpose of guiding decisions on resource allocation. The indicators are measured from available global datasets and existing methodologies such as those emerging from the global component of LADA (see also Schuster et al., in press). Consistent with the global indicators, project-level indicators are assessed at the (sub-) national level, and are then rolled up to evaluate the aggregate environmental and livelihood impact of investments of the GEF Land Degradation Focal Area. The added value of the KM:Land indicator system is that it provides a convenient linkage between the more context-specific local level indicators with the necessary aggregated indicators to provide information for larger scale comparisons. Thus, this indicator system is designed to support and guide decision-making at the global level, which is directly relevant to UNCCD. Since 2010 all GEF-funded SLM projects have been required to report on these indicators.

While the selected indicators need to simplify the complexity of SLM successes, their changes are influenced by many factors which are outside the project influence (e.g. market, policy, climate, etc.). Tying changes in these indicators to GEF-funded SLM interventions alone is, therefore, problematic. In order to address the problem of attribution and facilitate upscaling of project-level information, it is suggested that the GEF-funded SLM projects apply an approach entailing the following steps.

1. Collect data in a defined project impact area, or for a defined target population,
2. Compare observed changes with control/reference areas,
3. Monitor and assess additional external factors (e.g. rainfall, extreme natural events, human conflict, prices for agricultural products, etc) in order to evaluate the effects of these drivers,
4. Monitor and assess the progress towards creating an enabling policy environment, enhanced institutional capacity at different levels, financial mechanisms for SLM and improved knowledge management to implement SLM and
5. Context-specific interpretation of the data together with national/sub-national stakeholders. A remaining challenge is making the knowledge gained through M&A available to those who need it most, in order to initiate change: these parties may be local land users and/ or decision-makers at various scales. Knowledge management for decision support at the local level has been implemented using the tools presented in this paper within the DESIRE project (Schwilch et al., 2009) and is currently being integrated into a methodological framework (Reed et al., 2011).

Whatever is assessed at the local or (sub-) national level, the link to the global level must be made through common indicators, either aggregated or standardized. WOCAT, LADA, DESIRE and KM:Land have tried to streamline their language and ways of assessing and monitoring SLM in order to develop such common indicators for the global level, while keeping in mind the flexibility required for lower levels. A large number of indicators have been described by the predecessor to DESIRE, the DESERTLINKS project: www.kcl.ac.uk/projects/desertlinks/. DESIRE has supplemented these indicators and is measuring them in 16 study sites. In addition, the DESERTLINKS indicators have now been reviewed and systematized within a database in collaboration with LADA and the University of Sassari (http://nrd.uniss.it/nrd/dis/index.php). The database enables countries to enter their own indicators and assessment methods and to exchange experiences. In order to achieve comparability between countries, the five KM:Land global core indicators given above would ideally become the heart of this database, and be applied and monitored regularly (e.g. every year).

UNCCD and GEF can both play key roles in sharing knowledge about SLM through their reporting mechanisms on a common and accessible global platform and in translating it into the various UN languages.

2.3 Lessons and future directions

The approaches and methods presented in this paper yield a number of lessons that inform the continued development of a global, unified approach to the M&A of SLM. Table 2.2 provides an overview of these methods, their strengths and shortcomings, as well as a suggested pathway towards a common framework.

Table 2.2. Overview of current methodological approaches, their strengths, shortcomings and suggested future pathways.

Spatial level	Approach / method / tool	Major strengths	Shortcomings	Suggested pathway towards a common framework
Local level	WOCAT technologies / approaches (questionnaires + global database)	Participative and comprehensive (self-) assessment, including bio-physical and socio-economic issues; allows knowledge sharing between land users and experts worldwide	Time-consuming; difficult to assess data on costs and benefits and impacts of SLM, one-time assessment	Complement with elements from the ecological sites and state-and-transition models; address global issues more comprehensively
	DESIRE stakeholder workshops	Step-by-step procedure for local stakeholder groups to identify, assess and select SLM for implementation and monitoring; link to regional level through policy integration and modelling for upscaling	Professional facilitation of process required	Strengthen link to regional level with tools listed below; streamline methodological framework (see Reed *et al*., 2011)
	LADA local level assessment of land degradation	Broad variety of tools; extensive guidelines on all tools as well as implementation and reporting procedure; robust, participatory	Time-consuming, complexity requires expert knowledge	Simplify complexity; put stronger focus on SLM and harmonize with WOCAT; make truly participative (integrate DESIRE methods)
	Best Practices and Success Stories (UNEP, FAO, IWMI and others)	Rapid assessment, many case studies	Linked to short-term projects; not standardized	Standardize documentation and evaluation, e.g. through WOCAT
	US Ecological sites and state-and-transition models	Fully explores ecological land potential and mechanisms; assesses likelihood of SLM success	Focus on ecological mechanisms; time-consuming	Integrate into WOCAT / LADA methods where resources and know-how are available
Sub-national to national level	WOCAT / LADA / DESIRE mapping methodology	Cost-effective; participatory; backed up by quantitative data; uses cross-scale categorization of LUS, degradation types, SLM and their impacts on ecosystem services; direct link to WOCAT local case studies	Mainly assessment and not yet a monitoring tool	Better integration of remote sensing data as well as existing data sources
	ACRIS	Integrates large amounts of monitoring data from disparate sources	Highly scientific; requires expert know-how	Add as module to WOCAT / LADA / DESIRE method to make better use of existing data sources
	U.S. NRI	Statistically based; true monitoring tool over longer time periods	Can be costly depending on level of intensity	Use as possible supplement to methods above, if resources are available
Global level	GEF KM:Land	Direct link between project-level indicators and global indicators	Limited to 5 global core indicators and GEF projects	Open up for use outside GEF and harmonise with UNCCD core indicators
	DESERTLINKS / LADA indicators	Allows comparison between countries	Open list of indicators and methods; not very practical or easy-to apply	Assess the 5 GEF global indicators annually and make them the heart of a broader indicator database

Below, we summarize some of the core concepts that we believe are essential elements of an integrated M&A approach, for the UNCCD and others, including various UN environmental conventions or financing mechanisms like GEF.

1. *Common conceptual framework*: The conceptual framework is the foundation to developing a common methodological framework. The hybrid SLM framework of GEF presented in this paper is likely to be broadly acceptable to the UNCCD community because it is simple and based on widely-known, pre-existing frameworks. It integrates the underlying interrelationships of biophysical processes and human activities as well as the causal chain from driving forces to responses and impacts on ecosystems and human wellbeing.
2. *Common methodological framework*: The WOCAT, LADA, DESIRE and KM:Land approaches presented in this paper have made progress towards a common and practical methodological framework, which needs to be further developed and promoted to reflect the complexity of interlinkages between human actions and biophysical processes over time and space. It should include common and standardized tools and methods, facilitating the M&A of SLM, while allowing flexibility and context-specific adaptation of the methods employed. It further requires consistent reporting processes and coordinated knowledge management.
3. *Nested scales*: Multiple and hierarchical scales of assessment are required, while possibly distinguishing the scales needed for assessment from those used for reporting. Spatial explicitness at scales (extents) where it is possible should be envisaged (see Figure 2.2). This requires stratification according to both biophysical and socio-economic variables. The concepts of eco-regions, land use systems and, at a finer scale, ecological sites are useful stratification procedures.
4. *Common indicators and varieties of data sources*: Indicators are essential tools for the evaluation of SLM interventions and should be hierarchical and nested over scales (i.e. reflect processes operating at different scales) and involve consistent methodologies. Preferably, at all scales, a core set of indicators should be applied to assess the state of degradation and the impact and effectiveness of SLM. Reference areas are needed to clearly attribute changes in the environment and livelihoods to SLM interventions. A variety of data sources should be used to measure and identify these indicators. Ideally a linkage of remotely-sensed data with ground-based scientific measurements, as well as local knowledge, should be envisaged.
5. *Participation and interdisciplinarity*: M&A of SLM requires participatory approaches to assess and interpret data, involving a range of stakeholders from land users to SLM-specialists, planners and decision makers, as well as scientists from various disciplines. Participation ensures that the results are agreed upon and used by stakeholders for improving land management and adapting to change. There is growing recognition given to stakeholder involvement, but ‘true’ participation integrating all stakeholders on an equal footing is not easy to achieve. Nevertheless, while it is necessary and important, it should not lead to a disregard of conventional scientific methods or the neglect of the physical limitations of the land determining the different types of use.
6. *Knowledge management from local to international scales*: Knowledge management for effective decision support is a key element of a common framework, but remains a challenge. UNCCD, as a global convention, has to play a key role in supporting global efforts in compiling, managing and disseminating information from M&A of SLM. Standardization of methodologies as advocated in points 2, 3, 4 above enables effective knowledge management.

The methodological approaches from WOCAT, LADA, DESIRE, KM:Land and selected national institutions presented here address most of the elements mentioned above. Further on-going refinement is needed but is restricted by project duration and collaborative processes among the lead agencies. Continued tests of their usefulness, accuracy and practicability will undoubtedly assist in their refinement. Finance remains a major constraint to progress, especially over the long term. Although it is often stated that M&A of SLM is required for regular reporting to UNCCD, both donors and governments are hesitant to make the required commitments and provide the necessary funds and resources. Investment in implementation activities is often more attractive than long term M&A. Greater global support is, therefore, urgently required, for example, through UNCCD or GEF reporting obligations, while the scientific community needs to be prepared to explain the benefits of scientifically-based approaches described here. These have been demonstrated to be economic, practicable and consistent, supporting comparison across localities and nations and enabling global aggregation, while still allowing flexibility in serving the interests of various stakeholders. Another constraint is that research, limited in time, space and thematic scope – and often driven by the urge to develop new methods and findings rather than applying standardized methods – is reluctant to provide the scientific support required. It needs genuine inter- and trans-disciplinary research for the continued development and testing of a global, unified approach to the assessment and monitoring of SLM.

2.4 Conclusions

A number of projects and researchers have invested in developing methods to monitor and assess the complex issue of SLM over the past 10 – 20 years. Some global level initiatives have been presented and discussed in this paper; others may remain unknown and thus unacknowledged. We hope to stimulate the debate on monitoring and assessing SLM that began with the preparations for the first UNCCD Scientific Conference at COP-9. We have described the extensive experience and key lessons from global SLM monitoring initiatives, to ensure that this knowledge is applied and used, with the ultimate goal of supporting the implementation of the UNCCD. WOCAT, LADA, DESIRE and other methods provide important tools and lessons that can be used to address UNCCD monitoring needs at the local and (sub-) national level, while the global SLM indicator system of KM:Land can support global level M&A needs. In order to reduce the burden of reporting and data collection and increase comparability, it is important to move towards harmonized monitoring systems at the global level. The collaboration among many of the initiatives mentioned in this paper is already an important step in this respect, but further efforts are required. Effective M&A of SLM requires accessibility to tools and methods through free access and through training and workshops for a range of stakeholder and researcher groups at various levels. The latter remains a challenge unless a global process, such as the UNCCD, clearly supports a methodological framework including the potential elements outlined here. This would provide far greater insight into the processes and outcomes of efforts to combat land degradation and desertification underway today by both public agencies and by land users themselves. In turn, it would help the UNCCD to monitor progress towards its goals.

Chapter 3

Appraising and selecting conservation measures to mitigate desertification and land degradation based on stakeholder participation and global best practices

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Appraising and selecting conservation measures to mitigate desertification and land degradation based on stakeholder participation and global best practices

Abstract

Most desertification research focuses on degradation assessments without putting sufficient emphasis on prevention and mitigation strategies, although the concept of sustainable land management (SLM) is increasingly being acknowledged. A variety of already applied conservation measures exist at the local level, but they are not adequately recognised, evaluated and shared, either by land users, technicians, researchers, or policy makers. Likewise, collaboration between research and implementation is often insufficient. The aim of this paper is to present a new methodology for a participatory process of appraising and selecting desertification mitigation strategies, and to present first experiences from its application in the EU-funded DESIRE project. The methodology combines a collective learning and decision approach with the use of evaluated global best practices. In three parts, it moves through a concise process, starting with identifying land degradation and locally applied solutions in a stakeholder workshop, leading to assessing local solutions with a standardised evaluation tool, and ending with jointly selecting promising strategies for implementation with the help of a decision support tool. The methodology is currently being applied in 16 study sites. Preliminary analysis from the application of the first part of the methodology shows that the initial stakeholder workshop results in a good basis for stakeholder cooperation, and in promising land conservation practices for further assessment. Study site research teams appreciated the valuable results, as burning issues and promising options emerged from joint reflection. The methodology is suitable to initiate mutual learning among different stakeholder groups and to integrate local and scientific knowledge.

3.1 Introduction

Agricultural advisors in desertification-prone areas are often confronted with the need to find ways to improve land and water productivity in order to support the land users in their local area. How and where can they find best practices or proven strategies to reduce water losses through runoff or evaporation for example? Where can they get new ideas? And how can they proceed in appraising and selecting such identified best options, ideally together with the stakeholders, in order to enhance ownership, feasibility and applicability? These were the questions driving the research presented here.

Over the recent decades, extensive research efforts have been undertaken to assess the extent and physical processes of land degradation and desertification (Stocking and Murnaghan, 2001; Dregne, 2002, Nachtergaele and Licona-Manzur, 2008). While adding essential insights into causes and impacts of desertification and producing scientific recommendations, the overall output has tended to be too fragmented for practical decision support, policy-making and implementation at the local farm level (Engelen, 2003). More recently, research and implementation have focused on sustainable land management (SLM), making it an acknowledged and widely promoted concept (Hurni et al., 2006; World Bank, 2006; IAASTD, 2008), increasingly also being recognised as a means to tackle desertification (Thomas, 2008). SLM involves soil, water, and vegetation adequately supporting land-based production systems for current and future generations. Its key principles are: productivity, security and protection of natural resources, economic viability, and social acceptance. However, despite numerous local and global efforts, desertification and land degradation persist. According to the Millennium Ecosystem Assessment (MA, 2005), 10–20% of drylands are degraded and over 250 million people are directly affected by desertification. The recent global agriculture assessment IAASTD (2008), as well as the 10-year strategic plan to enhance the Convention to Combat Desertification (UNCCD, 2008) stress the required strong collaboration between researchers and land users. It is generally accepted that desertification and land degradation can only be addressed through working partnerships involving scientists, land users, community members and development workers (Seely and Moser, 2004; Stringer et al., 2007; Baartman et al., 2007).

In recent years, much research has been done on the role and importance of collective learning processes in natural resource management (Maarleveld and Dangbégnon, 1999; Schusler et al., 2003; Armitage et al., 2008). In the literature, several overlapping ideas emerge as to how participatory processes can support the management of socio-ecological systems. The main idea is to enable interaction and learning between the two knowledge spheres of specialists and local communities (Stringer et al., 2007; Reed et al., 2007), and it is increasingly recognised that by integrating scientific and local knowledge, more sustainable solutions can be developed. What is lacking so far are concise and easy-to-use methodological frameworks, applicable to developing as well as industrialised countries, which bring together natural and human scientists, government and non-government institutions, policy makers and land users to jointly explore problems and solutions regarding SLM in a mutual learning process and to make informed decisions and test solutions. We argue that so far, desertification research has been too firmly focused on the problem (degradation) side on the one hand, and is usually dealt with by either natural or social scientists on the other hand. According to Thomas (2008), cross-disciplinary research to tackle the complexities of managing socio-ecological systems for multiple goals is still relatively rare and poses severe challenges for the way research is organized. We strongly believe that transdisciplinary, interdisciplinary and participatory research frameworks can and should facilitate SLM decision-making (Dougill et al., 2006; Gonsalves et al., 2005; Stringer et al., 2009).

Our goal is to promote a methodology for participatory SLM appraisal and selection. It guides users through a process, starting from collective learning on desertification problems and respective solutions (Part I), to the description and evaluation of identified local solutions (Part II), and finally to jointly selecting potential solutions for implementation with the help of a decision support tool (Part III). This paper mainly presents the methodology and partly provides first experiences and lessons learnt from its current application in the DESIRE research project.

The methodology was developed within the EU-funded project DESIRE (www.desire-project.eu) and in collaboration with WOCAT. It is currently being applied and tested at 16 DESIRE study sites in 14 countries. DESIRE is a global research initiative to mitigate desertification and remediate degraded land. The 5-year project (2007–2012) aims to establish promising alternative land use and management strategies in 16 degradation and desertification hotspots around the world, based on close collaboration of scientists with local stakeholder groups. The World Overview of Conservation Approaches and Technologies (WOCAT; www.wocat.org) is a long-term global programme and network of SLM specialists. WOCAT has developed a methodology (WOCAT questionnaires and database) to document, evaluate, share, disseminate, and use knowledge about SLM, and has tested it over many years.

Research within the DESIRE project allowed development of a new methodology in which existing WOCAT tools have been integrated with a stakeholder learning approach and a decision support system. In the DESIRE context, the process of appraising and selecting conservation measures is used to agree on measures for test implementation at the respective study site. At least three consecutive agricultural years are necessary for testing measures in the field. Given the project duration of 5 years, a methodology had to be developed which can be applied within a rather short time and in a variety of contexts.

The first section of this paper presents the rationale for the suggested methodology. In the second section, we explain Part I of the appraisal and selection methodology (identifying conservation measures in a stakeholder workshop), followed by first results from the study sites and a discussion. Parts II (assessment) and III (decision support) of the methodology are introduced thereafter, but cannot yet be discussed at this stage, because study sites are currently applying them and results are not yet available.

3.1.1 Rationale of the participatory SLM appraisal and selection methodology

A variety of already applied SLM measures can be found at the local level. However, in some cases neither land users nor researchers are aware of such practices, sometimes used traditionally or by a few innovative land users only. The suggested methodology was developed based on the premise that a wealth of experience in SLM already exists, but has not yet been well enough tapped and shared (WOCAT, 2007). The variety of SLM strategies include concrete agronomic, vegetative, structural and management measures (e.g. no- or minimum-tillage, agroforestry, vegetative strips, terraces, water harvesting structures, area enclosure) as well as an implementation approach, consisting of the ways and means of implementing technical measures on the ground, and considering changing social, economic, institutional and policy factors (WOCAT, 2007).

There are many examples of technologies that have been recommended but do not work technically (Liniger et al., 2004); some are simply not adapted to the local environment or represent overkill in terms of the envisaged impact (e.g. prestige projects with inappropriate terracing or excessive dams). Unfortunately, it is still too often the case that technical experts and scientists recommend technologies to land users which are based neither on local nor other evaluated experience nor on sufficient stakeholder involvement (e.g. certain World Bank projects in China; see also Bennett, 2008). Technocratic approaches have far too often led to implementation failures or non-acceptance. At the same time, there is a move towards promoting SLM mainly through participatory approaches or even purely based on local innovations (Scoones et al., 2008; Wettasinha et al., 2006). But, if local innovations alone drove SLM, why do the problems still persist? We believe that such SLM implementation approaches are sometimes too centred on local knowledge alone, neglecting technical and bio-physical issues as well as the viability of projects (time, personnel, funds). We suggest an SLM appraisal and selection methodology which focuses on the practical process with stakeholders and provides a framework for an efficient, targeted engagement with clear goals and results. We argue that the key to success lies in a concerted effort, bringing together local experience and innovation with ecological and technical expertise and the consideration of socio-economic, legal and institutional framework conditions. Linking scientific, technical expert and local knowledge makes it possible to derive a range of alternative options, including current innovations and new or non-local solutions. Whether new technologies are then accepted and implemented (or modified) by land users or not depends on factors such as cost-effectiveness, severity of degradation, knowledge, enabling framework conditions (e.g. policies and subsidies), and other socio-cultural and economic aspects (de Graaff et al., 2008), also requiring the integration of policy makers, local and regional authorities, civil society organisations and NGOs.

Enhancing applicability, feasibility and ownership of solutions requires the learning of all stakeholders involved. Armitage et al. (2008) suggest learning as an experimental and reflective, learning-by-doing process in which multiple stakeholders collaboratively test and explore management strategies. Successful mechanisms in this respect include the use of interactive techniques and combining a variety of methods from different disciplines, such as stakeholder workshops, focus groups, questionnaires and more participatory methods such as transect walks. In each of these mechanisms, collective learning is facilitated, and information flows between different stakeholders are multi-directional (Stringer et al., 2006). These diverse yet interrelated approaches collectively represent participatory research and development (PR&D) – as a pool of concepts, practices, norms and attitudes that enable people to enhance their knowledge for sustainable agriculture and natural resource management (Gonsalves et al., 2005). It is important to apply an approach that emphasises participation as a process of empowerment, equity, trust and learning, replacing the often-used ''tool-kit'' approach (Reed, 2008). What is required is a joint effort by all concerned stakeholders integrated into a process on an equal footing, where local and external knowledge is negotiated and validated to provide greater depth of understanding and ideas for future SLM directions. The main aim of this research was to develop a framework methodology with tools to support this integration process. One challenge in the development of such a participatory approach within DESIRE was its required applicability in both developing and industrialised countries, as well as in Western democratic and Communist or transition countries. In practice, another specific challenge emerged in applying participatory and learning approaches with mainly bio-physical researchers, with little or no experience in participatory methods. The methodology therefore has to be seen in a triangle of three specific demands: (1) participatory approach and stakeholder involvement, (2) biophysical research advances, and (3) feasibility within project frame (duration, funds, set-up).

Based on the conviction that neither science nor local experimentation alone can lead to sustainable solutions to combat desertification and land degradation processes, the methodology was developed on the following premises (see Figure 3.1).

- *Premise for Part I*: Local land users do have strategies for SLM. Before envisaging new technical solutions to combat desertification and land degradation processes, it is worthwhile to look at what is already applied locally.
  - → Approach: 3-day stakeholder workshop to bring together different stakeholder perspectives and identify existing strategies.
- *Premise for Part II*: Not all local strategies are a priori effective and good; therefore, a detailed assessment of local solutions needs to be done.
  - → Approach: Standardised evaluation of local solutions with WOCAT questionnaires allows sharing of results with other study sites.
- *Premise for Part III*: Out of a basket of options, which consist of evaluated local options and additional options from the global WOCAT database, stakeholders jointly select the best.
  - → Approach: 2-day stakeholder workshop to jointly select, supported by a decision-support tool for comparative analysis and selection, a strategy for implementation at the study site.

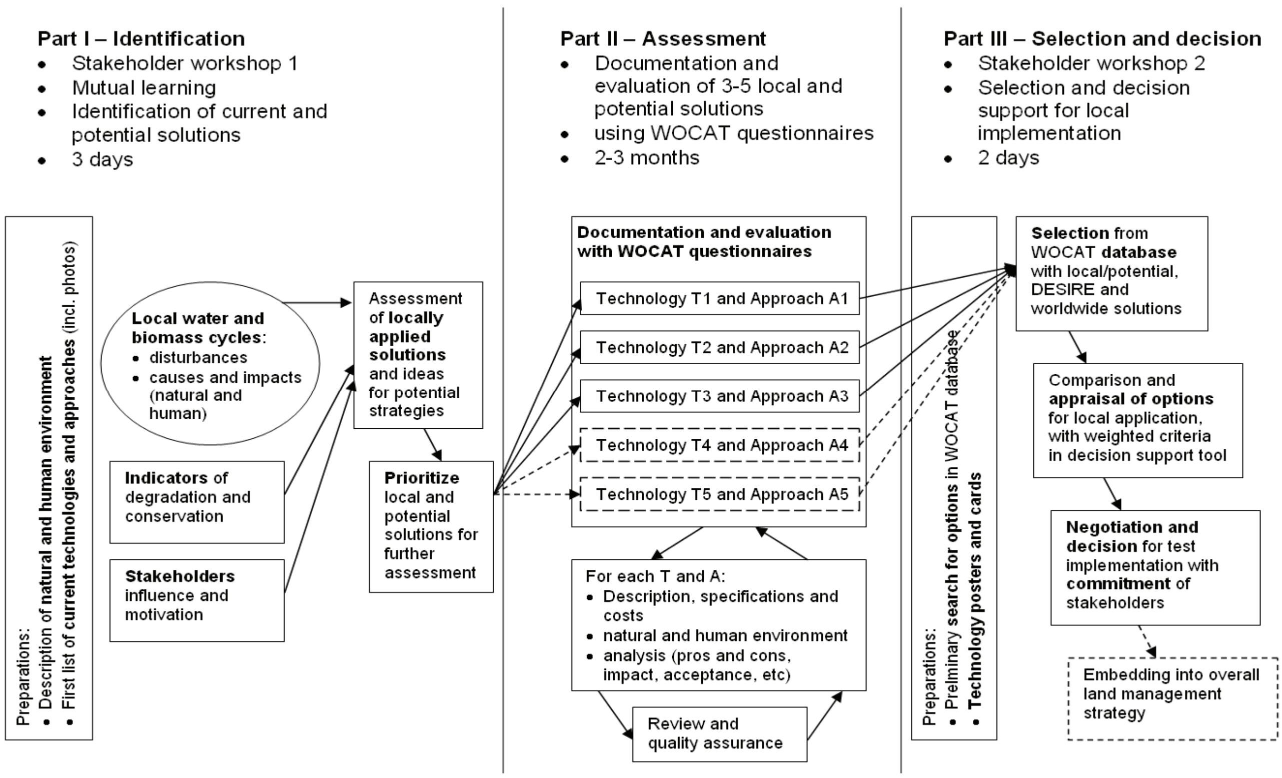

Figure 3.1. Overview of the methodology.

3.2 Appraisal and selection methodology, Part I: identifying conservation measures in a stakeholder workshop

3.2.1 Stakeholder workshop approach

To prepare and initiate the process of appraising and selecting conservation measures for test-implementation, a stakeholder workshop approach aiming at mutual learning was selected, bringing together a diverse range of actors who, traditionally, do not work together to solve problems. Active involvement of the wider stakeholder community can play a crucial role in better consideration of problems by identifying different stakeholder perspectives, providing an active learning arena for all those involved, and providing an interactive basis necessary for generating joined-up thinking (Patel et al., 2007). Developing a shared understanding among involved actors is an important step towards building a common vision of what can and needs to be done to achieve more SLM. Although questions related to relative power, decision-making and social equity cannot be solved within a stakeholder workshop, it does provide a forum for discussing relevant issues (Lundy, 2006).

The initial 3-day stakeholder workshop aims to identify already applied and potential prevention and mitigation strategies in the local context. It brings together scientific and local knowledge while simultaneously supporting a co-learning process oriented towards sustainable development. Objectives of the workshop are: (1) to initiate a mutual learning process by sharing experience and knowledge and jointly reflecting on current and potential problems and solutions related to land degradation and desertification, (2) to create a common understanding of problems, potentials and opportunities by integrating external and internal perceptions, (3) to strengthen trust and collaboration among concerned stakeholders, (4) to identify existing and new strategies to prevent or mitigate land degradation and desertification, and (5) to select a set of these identified strategies for further evaluation and documentation in the next step (Part II).

The stakeholder workshop methodology (Bachmann et al., 2007) was developed at CDE, University of Bern. It is based on experiences with the 'Learning for Sustainability' approach (CDE, 1998; Bachmann, 2003; Rist et al., 2006), where interactive pedagogy and mutual learning between different stakeholders are at the core. The 'Learning for Sustainability' approach is characterised by: (1) *Learning in the local context*: workshops are held in a village or community. All exercises are directly related to the specific local context. (2) *Learning in a heterogeneous group*: participants are mixed in terms of stakeholder groups, age, gender, professional background, etc. Participants learn together and from each other through expressing, discussing and understanding the various perspectives on problems and opportunities at local and regional scales. By integrating local knowledge and external, more scientific or technical knowledge, a more comprehensive and shared understanding of the local context is envisaged. (3) *Multi-stakeholder and multi-level approach*: the group explores economic, ecological and socio-cultural factors and their interrelations; looks at dynamics, processes and trends in space and time; considers framework conditions and their impacts at the local level; and explores relations between different levels of decision-making (household, community, region). (4) *Interactive, process-oriented pedagogy*: methodological diversity in group and plenary exercises favours active and holistic learning. The learning process is facilitated by a workshop moderator who guides the group instead of teaching. Detailed workshop guidelines provide didactic and conceptual guidance and specific exercises.

The approach aims to integrate the complementary competences of the heterogeneous participants and their respective experiences and knowledge. Learning is fostered in a process of dialogue and joint reflection, during which everyone actively confronts his or her own reality with other people's realities. An appreciative working atmosphere, mutual trust, and open-mindedness are conducive conditions for a fruitful, active and inter-active learning process.

The workshop procedure follows a logical and consecutive sequence of specific exercises, each with its own objectives, method, procedure, and expected results (see Table 3.1). The recapitulation and presentation of intermediate workshop results had to be planned due to the assumed constraint of external participants not being able to join for more than the last workshop day. However, most study sites did not make this distinction (for more details see below). Step by step, the exercises lead to a better understanding of the complex web of causes and effects of land degradation in the study site, create awareness of sustainable practices and solutions that are already implemented locally, help to identify additional potential solutions by integrating experience and knowledge of researchers and specialists, and result in a first brief assessment of solutions, and the selection of a few solutions for in-depth assessment in Part II of the appraisal and selection methodology. The role different stakeholder groups play in SLM and their respective levels of motivation for and influence on the implementation of SLM are discussed, and participants start to critically reflect on their own role. This exercise may lead to the conclusion that relevant stakeholder groups are not yet represented in the stakeholder workshop, and that additional efforts are necessary to get them on board for the next project steps. It was a special concern of the designers of the methodology to end the workshop by taking a step back and creating awareness that SLM requires a coherent strategy embedded in a broader context. Developing a 'real SLM strategy' would of course require a much broader societal process of negotiation and concertation.

Table 3.1. Sequence of exercises.

Exercise	Objectives	Methods
Land degradation & land conservation at the study site	Establish personal relation with the topic, presentation of participants and their interest in the topic, create a relaxed working atmosphere	Photo gallery, photo language
Water and biomass cycles - the basis of agricultural production	Understand the water and biomass cycles in the local context; links between the cycles; disturbances, their causes and effects; degradation processes and dynamics (space and time); relevant framework conditions (socio-economic, legal, institutional); identify locally applied solutions to disturbances and land degradation. To raise awareness on the importance of healthy cycles as a basis for agricultural production.	Transect walk → identify local land degradation processes and solutions Visualisation → illustrate cycles with photos from study site; Diagnosis of the cycles
Local indicators	Identify indicators used by local stakeholders to recognize land degradation processes and land conservation respectively.	Plenary discussion with guiding questions
Stakeholders, their motivation for and influence in implementing SLM	Identify stakeholders, their motivation and influence / power concerning the implementation of SLM; identify their relative importance for SLM; identify important stakeholders not yet included in the process; critically reflect on own role	Plenary session: stakeholder analysis
Recapitulation of intermediate workshop results and presentation to external participants	Recapitulate information and conclusions so far, prepare and brief external participants; presentation of local perspectives, get first reactions from external participants (and hints on divergences between local and external views)	Plenary and group work
Assessment of already applied and potential solutions to identified degradation problems	Identify strategies not yet applied but potentially suitable for the local context by integrating the perspective, knowledge and experience of external stakeholders; assess applied and potential strategies; jointly select strategies with highest potential (for further assessment after workshop)	Assessment (costs, benefits, potential, constraints) made in separate groups (local / external participants) Priorisation, selection
Synthesis – Outline of a strategy for SLM	Create awareness of the need for a comprehensive SLM strategy; identify and discuss important elements for a draft outline.	Plenary: Mind map, link with results from previous exercises

3.2.2 Workshop guidelines and workshop moderation

The workshop guidelines (Bachmann et al., 2007) contain detailed information on the workshop set-up and the didactic approach and provide conceptual and methodological guidance for each exercise. Pre-tested and further developed in the Moroccan DESIRE study site, the guidelines are a flexible working instrument for workshop moderators. They are not a blue-print but allow and require flexible use and adaptation to each specific context.

Ideally, a team of two persons co-moderate a stakeholder workshop, one experienced with moderation techniques and participatory methods as the main moderator and a second person with specific knowledge of SLM and agricultural advice. Facilitating the mutual learning process includes ensuring timely and effective organisation of the group's work, fostering a relaxed and productive working atmosphere, and appreciative, respectful, and accepting interpersonal relations, and facilitating the dialogue between participants in such a way that they come up with their own results and conclusions.

The DESIRE project offered a specific training for workshop moderators. As researchers are an own stakeholder group in the learning process, it was requested to engage independent local moderators to avoid role confusion. Nevertheless, most study sites sent their own project personnel to be trained and therefore most workshops have been moderated by researchers instead of independent and experienced facilitators. This resulted in some weaknesses in moderation performance and independence, as moderators were wearing two different hats at the same time. At some study sites it was observed that due to this confusion or mixing roles and stakes, moderators were not neutral enough, were driving the process too strongly, or even started lecturing instead of supporting the group in developing the topic, e.g. the water and biomass cycles. The requested multi-disciplinarity of the moderator team was largely applied, and finally also appreciated, as it was felt necessary to ensure the success of the workshop. A critical point is the tendency observed at certain sites to apply the methodology somehow 'mechanically' without emphasising enough the links between the different topics and exercises. We consider this to be a result of the rather short training for moderators, and in many cases, a lack of adequate experience with participatory approaches, as initially requested.

3.2.3 Workshop duration and participants

The methodology was designed for a workshop duration of 3 days. If possible, all participants should participate for the 3 days, which allows more intensive interaction and exchange among local and external participants. However, during the first and second days, when the focus is on the local context and perspectives, mainly local stakeholders may attend the meeting, while on the third day, external stakeholders join the group bringing in a more regional perspective.

The workshop guidelines recommend composing the group of 6–10 local participants, i.e. land users, representatives of local authorities and community-based organisations living and working in the specific local context, and 4–6 external participants, i.e. researchers and experts from NGOs and GOs. Local stakeholders are not land users only, as is often assumed. It is also recommended to invite representatives of different categories of land users (e.g. large-scale, small-scale, land owners, tenants, pastoralists, etc.), because some conservation technologies or approaches are not appropriate for all categories (e.g. planting trees might not be allowed on leased land). Given the limited time available, the group should not be too big to facilitate active participation and interaction of all participants in the learning process, and the heterogeneity of participants should ensure that different stakeholder perceptions are represented in the process. These specifications are clearly communicated in the workshop guidelines. On this basis, study site teams selected and invited possible workshop participants. Out of the 16 DESIRE study sites, 14 organised a stakeholder workshop; 12 used the suggested workshop methodology and 2 used other approaches (see Table 3.2).

Table 3.2. Stakeholder workshops at the study sites: duration and participants

Study site	Total days	No. of participants	Local (%)	External (%)	Land users in % of total (%)	Women in % of total (%)
Spain, Guadalentín Basin	1	24	62	38	25	25
Portugal, Maçao and Góis	2	17	65	35	18	24
Turkey, Konya Karapinar Plain	3	29	55	45	45	14
Turkey, Eskisehir Plain	3	40	27	73	28	5
Morocco, Mamora / Sehoul	3	23	37	63	29	17
Tunisia, Zeuss-Koutine	3	25	76	24	52	20
Russia, Djanybek	3	25	64	36	8	24
Russia, Novyi, Saratov	3	20	40	60	5	20
China, Loess Plateau	3	12	67	33	42	0
Botswana, Mopipi, Boteti Area	3	34	88	12	88	47
Chile, Secano Interior	2	26	54	46	54	23
Cape Verde, Ribeira Seca Watershed	3	35	64	36	60	44
Average		*26*	*58*	*42*	*38*	*22*
Range		*12-40*	*27-88*	*12–73*	*8-88*	*0-47*
Greece, Crete	1	65	Different approach used			
Greece, Nestos Basin, Maggana	1	40	Different approach used			
Italy, Rendina Basin	No stakeholder workshop					
Mexico, Cointzio Catchment	No stakeholder workshop					

Many DESIRE study sites had to adapt workshop duration and procedure in various ways; some had to shorten it to 1–2 days. In Spain, for instance, where it was impossible to convince local and external stakeholders to participate for more than 1 day, participants regretted during evaluation that there was not enough time for ample discussions. Other study sites conducted 3-day workshops with local and external participants attending for the full three days, and in some cases even the full 3 days were considered to be too short (e.g. in Botswana). The number of participants at the DESIRE study sites varied from 12 to 40 persons, with an average of 26 persons. On average, 58% of the participants were local stakeholders, 38% were land users and 22% were women. But as Table 3.2 shows, variability between the study sites is extremely high!

Previous awareness-raising activities were planned and would have been important, but were hardly able to be conducted due to time constraints and a delay in delivering DESIRE information material developed for this purpose. Some study sites had difficulties motivating certain groups of stakeholders, e.g. in Botswana it was virtually impossible to motivate non-community people to participate, while in Spain, Morocco, and Tunisia difficulties were experienced in motivating farmers; in China it was found to be difficult to get more land users to participate due to the importance of off-farm activities; and in Turkey, participation of female farmers is difficult for cultural reasons. However, at most study sites, the local research team had previously been working with various stakeholders in the region and could rely on already established contacts, and was able to recruit a good number of land users and other participants. To our knowledge, only in Morocco were land users paid an allowance to compensate their loss of working time. Figure 3.2 illustrates the motivation and interest of stakeholders based on explicit remarks made in workshop reports. It shows that despite initial hesitation found at several study sites, the level of interest increased during the stakeholder workshop, and at some study sites participants explicitly wished to be further involved in and kept informed about DESIRE activities.

Stakeholders difficult to motivate	**Initial resistance / hesitation**	**Active and enthusiastic participation**	**Want to be involved; explicit interest in future collaboration**	**Challenges:**
Spain (→ farmers) Morocco (→ farmers) Portugal (→ partly) Tunisia Botswana (→ non-community people)	Portugal Eskisehir	Spain Portugal Karapinar Botswana Chile Cape Verde	Spain Portugal Eskisehir	• How to maintain motivation and dynamism throughout the project? • High expectations from stakeholders (Turkey)

Figure 3.2. Level of interest before, during and after the stakeholder workshop.

3.2.4 Evaluation of stakeholder workshops

Evaluation of workshop reports from 12 study sites revealed the following.

Workshop methodology: Except by Moroccan farmers, who did not like the time spent in discussions, the workshop methodology with its sequence of exercises was generally evaluated positively. Two study sites found it to be quite challenging for local stakeholders: in Tunisia and Botswana it was stated that synthesis steps were very challenging due to the low level of literacy. Other study sites explicitly appreciated the methodology because it fostered informal discussions, which motivated active participation (Portugal); the sequence of steps and exercises allows a systematic and transversal perspective on land degradation causes and possible solutions (Portugal); exercises are logical and well structured (Djanybek, Saratov). Two exercises were particularly appreciated: the photo gallery was highly valued by participants and provoked considerable discussion (Spain); and the water and biomass cycles were considered very good and are now also used for training university students (Djanybek, Saratov).

Mutual learning: One of the objectives of the stakeholder workshop, and perhaps the most important one, is to initiate a mutual learning process among different stakeholders at the study sites. This learning process is mainly based on sharing knowledge and experience and jointly reflecting on current problems and possible solutions. In fact, with the data available, it is not possible to assess what exactly has been learned by different stakeholders, and we can not prove that mutual learning actually took place, but the workshop evaluations give some hints about whether and how a process of mutual learning developed. From Spain, for example, it was explicitly reported that the mutual learning process with a multidisciplinary group was considered especially enriching. All participants were very enthusiastic and participative, they felt they had been able to contribute from their knowledge and experience and that everybody learned from others. At many study sites, participants engaged in long and lively discussions, which the moderators found difficult to stop. In Portugal, where people from two different study sites participated, causing some resistance in the beginning, they found increasing involvement in sharing experiences between people from the two sites during the workshop. In Morocco, where local farmers did not see any benefit and thought there was too much time spent on not very useful discussions, external participants said they learned a lot and had a real opportunity for deep discussions with farmers, while researchers mentioned that the workshop helped them to organise their ideas and check them against farmers' and technicians' knowledge. To summarise, objectives 1 and 2, i.e. initiating a mutual learning process and creating a common understanding of problems, potentials and opportunities, were attained to varying degrees at different study sites. However, it has to be kept in mind that this stakeholder workshop is just the beginning of a longer process of interaction and co-learning.

Workshop process and atmosphere: Five study sites explicitly reported that they had an excellent workshop atmosphere with enthusiasm and a warm ambiance; none said that they did not. A general satisfaction with the process and interaction was expressed in Tunisia, Chile, Botswana, and Cape Verde. At both Turkish sites it was mentioned that (local) stakeholders are not used to participatory approaches and that in workshops, farmers are usually in the role of the recipients of technical know-how. Thus, these farmers especially appreciated being listened to by external participants and having the same rights of expression.

Workshop results: The final result of the first stakeholder workshop was generally valued highly, as in every study site it was possible (1) to establish a good basis for participatory stakeholder cooperation (objective 3), (2) to identify existing and new prevention and mitigation strategies and to select promising land conservation practices for further assessment (objectives 4 and 5), and (3) to define a preliminary pathway for a coherent SLM strategy. The brief assessment of SLM measures made by local and external stakeholders gives a clear picture of the importance and benefits of various measures. The perception of local and external stakeholders regarding limiting factors for SLM and the impact and potential of identified measures seems to be quite similar (at least that is what workshop reports led us to believe). External participants, however, more often consider training and awareness raising a constraint. Some differences are apparent regarding the assessment of economic, ecological and socio-cultural impacts, but less in estimating the overall potential of a specific measure for the local context. Surprisingly, local stakeholders often rank positive impact higher than external participants. It could not be verified whether this is due to wishful thinking or 'hard facts'.

Study site research teams got valuable inputs for the next steps in the project (see Parts II and III), as most burning issues and promising options as well as a wealth of other relevant information emerged from all exercises. This also increased the interest of participants in being involved and collaborating in future DESIRE project activities, which was one of the aims envisaged. Very valuable information was generated on socio-economic and institutional issues and (mostly) unfavourable framework conditions such as demographic problems (rural–urban migration, aging of rural population, absence of young people interested in agriculture and related loss of traditional knowledge, population pressure), the importance, and in other cases the absence of agricultural cooperatives and civil society organisations, the failure of service providers such as extension services, agricultural credit cooperatives or the land board, lack of access to credits for small farmers, lack or poor implementation of laws, lack of or improper subsidies, unfavourable land tenure rights and splitting up of land, etc.

3.2.5 Discussion

Within the DESIRE project the stakeholder workshop is a first step in initiating a mutual learning process and motivating collaboration between study site research teams, local and external stakeholders. It will be followed by next steps, i.e. Part II (in-depth assessment of mitigation strategies) and III (participatory decision-making) of the methodology suggested here, and the implementation and monitoring phase of selected strategies (not presented and discussed in this paper). The short workshop duration of 3 days and its division into a first part with local stakeholders only and a second part with local and external stakeholders as suggested in the workshop guidelines are factors that limit the depth of the process of mutual learning but are not prohibitive. At study sites where stakeholder representation was very unbalanced, i.e. in Botswana (where only one non-community person attended), China (where two separate workshops had to be held), or Saratov (Russia) (where only one farmer attended), it can be assumed that only a very limited mutual learning process between participants occurred. A special effort needs to be made to include more relevant stakeholder groups in the next steps of the project.

Although it must be assumed that due to lack of sufficient experience, time constraints and other factors different kinds of shortcomings occur in workshop moderation, participants were generally positive about the workshop process and workshop results. This might be interpreted as an indication of the importance of and value given to the mere fact of bringing together different stakeholder groups to exchange their ideas, experiences, concerns and knowledge. However, more specific training has to be provided to moderators of future stakeholder workshops.

The use of a participatory approach and methodology proved to be especially challenging in Turkey, Russia, and China, as neither facilitators nor participants were familiar with it. Participatory methods that have evolved in Western democratic contexts are not necessarily transferable to governance structures of (former) Communist countries, as civil society in these countries is usually weak and characterised by low level of citizen participation, of trust between people, private entrepreneurship and democratization (Stringer et al., 2009). On the other hand, the political decision-making system tends to be very top-down. This was reported from China, where two main difficulties had to be faced: (1) the study site team could not directly invite relevant external stakeholders, but only through the organisation managers and (2) land users consider themselves to be executors of decisions made at higher levels and therefore give their opinions in the workshop but leave decisions to others. However, participants at the same time appreciated the workshop for having provided the opportunity to express their opinion and discuss, which is seemingly different from other meetings in China.

From Turkish study sites, it was reported that farmers, probably for the first time in their life, met experts and government officials to discuss together solutions to their problems with equal rights of expression. This might be interpreted as a slight indication for the potential that participatory learning approaches have to weaken and finally transform disadvantageous communication patterns and power relations, and engage in truly collaborative learning (Armitage et al., 2008; Rist et al., 2006; Schusler et al., 2003).

An important outcome of the stakeholder workshops is that local (and external) people become aware of the rich and vast knowledge they can tap and the fact that they already have solutions for SLM. Reflections and insights from the workshops, combined with the will and commitment of participants to actively change things, constitute a basis for identifying and elaborating options for action (Bachmann, 2003).

Linking scientific and local knowledge makes it possible to derive a range of alternative options, including current practices and new or non-local measures, both of which require further assessment – which is the objective of Part II of the methodology.

3.3 Part II: assessment of desertification mitigation strategies using WOCAT questionnaires

3.3.1 The WOCAT methodology

The second part of the suggested methodology (Schwilch et al., 2007) entails evaluating and documenting the identified existing and potential prevention and mitigation strategies (from Part I) in the 2–3 months following the workshop. Comprehensive questionnaires and a database system have been developed within the WOCAT programme (www.wocat.org; Liniger and Schwilch, 2002; WOCAT, 2007).

The WOCAT questionnaires allow teams of researchers and specialists, to document and evaluate together with land users all relevant aspects of technical measures, as well as implementation approaches. Going through this evaluation process greatly enhances understanding of the reasons behind successful local experience – whether introduced by projects, or found in traditional systems – and how to share it among various sites. WOCAT methodology and databases do not offer 'plug-and-play' SLM solutions, where soil and water conservation technologies and approaches can be taken from one place and simply copied to another environment. They provide a proven methodology and a tool to document and evaluate what one is doing in terms of SLM strategies as well as a means to compare one's own experience with those of others. The use of the WOCAT tools stimulates evaluation (self-evaluation as well as learning from comparing experiences) within SLM initiatives where, all too often, there is not only insufficient monitoring but also a lack of critical analysis (Critchley and Liniger, 2007).

The objectives of Part II are: (1) to document and evaluate each identified locally applied technology and approach in a structured and standardized way, (2) to guarantee a certain level of data quality through a review and quality assurance process, and (3) to enter this information into the WOCAT database in order to share it with other sites as well as globally. Strategies to be documented consist of technical measures as well as implementation approaches.

Technologies are understood as agronomic (e.g. intercropping, contour cultivation, mulching), vegetative (e.g. tree planting, hedge barriers, grass strips), structural (e.g. graded banks or bunds, level bench terraces, dams) and management measures (e.g. land use change, area closure, rotational grazing) that control land degradation and enhance productivity in the field. The above-mentioned measures are often combined and thus enhance each other. The questionnaire on technologies addresses the specifications of the technology (purpose, classification, design, and costs) and the natural and human environment where it is used. It also includes an analysis of the benefits, advantages and disadvantages, economic impacts, acceptance, and adoption of the technology.

SLM approaches are ways and means of support that help to introduce, implement, adapt, and apply SLM technologies on the ground. An SLM approach consists of all participants (policy-makers, administrators, experts, technicians, land users, i.e. actors at all levels), inputs and means (financial, material, legislative, etc.), and knowhow (technical, scientific, practical). Questions focus on objectives, operation, participation by land users, financing, and direct and indirect subsidies. Analysis of the described approach involves monitoring and evaluation methods as well as an impact analysis. A questionnaire on technology and a corresponding questionnaire on approach together describe a case study/strategy within a selected area.

Analysis of the type of technical measures identified in Part I at the DESIRE study sites results in 19 agronomic, 10 vegetative, 23 structural and 25 management measures, whereas in 17 cases two types of measures are combined. The variety of identified measures also reflects the diversity of degradation and desertification problems prevalent at the study sites. Some conservation technologies were mentioned at several study sites, such as drip irrigation, which was mentioned in both Russian, both Turkish and the Crete Greece study sites, but was applied so far only in Konya Karapinar (Turkey) and Crete (Greece). Other measures can also be grouped into similar categories, as presented in Table 3.3. The table serves as an overview of identified measures.

The DESIRE study sites are currently (January 2009) working on the documentation and evaluation of identified measures. It is therefore not yet possible to present results from Part II and Part III in this paper.

Table 3.3. Applied and potential SLM measures identified in the DESIRE study sites

Category / group	Applied and potential measures identified at DESIRE study sites
Conservation Agriculture	• minimum and/or contour tillage • no tillage • no till land management practice • nets spread on the soil surface in combination with no tillage
Ploughing management	• contour ploughing • deep ploughing (soil internal drainage improvement) • subsoiling
Intercropping	• interplanting • ley farming system
Rotational system	• crop rotation • rotation of annual cultivations • rotational fodder cultivation
Terraces	• terraces and vegetation strips • building terraced field • land terracing
Eco-agriculture	• shift to ecological agriculture/high quality products • integration of agricultural and ecological systems
Soil / nutrient management	• green manure • liquid manure -> biogas -> fertilizer • gypsum addition • land phyto reclamation (sudan grass) • licorice (Glycyrrhiza) cultivation
Vegetative strips / cover	• strip cropping • green cover in vineyard
Agroforestry	• fruit tree plantation along the contour separated by strips of crops
Forest protection	• implementation of a Forest Intervention Area (ZIF) • prescribed burning • primary tracks
Afforestation	• reforestation • assisted cork oak plantation • tree planting (2 x)
Livestock management	• improvement of animal production • game ranching
Pasture management	• controlled grazing in deciduous woods, alternative to grazing rangeland and pasture • grazing control • rangeland resting *tegdeel* • closure against grazing • fodder crops production
Drainage and irrigation technologies	• drainage system maintenance (groundwater level control) • drainage • irrigation technologies • freshwater transport
Drip irrigation	• drip irrigation (5 x)
Rainwater harvesting	• *jessour* and *tabias* • rainwater harvesting • cisterns • water-proofing
Flood management	• spillway *Massraf Jebed* • recharge units and flood spreading
Dams	• dam construction (2 x)
Energy management	• biogas use as energy source
More general and socio-economic strategies	• slopes and riverbed protection • training & sensitization • institutional and legal capacity strengthening

3.3.2 Assessment process

The questionnaires mainly address specialists in the field of SWC and SLM; it is they who do the documentation and evaluation work. In DESIRE, documentation is done by the (team of) SLM specialists who were already involved in the moderation of the stakeholder workshop (see Part I above). In order to consolidate the information it is important to involve and confront land users with project/ministry/advisory people and with researchers/scientists, as this is crucial especially for the impact assessment. Experience shows that the greater the interaction between providers of information and users, the better the result. Additional sources of information such as project reports, case studies, photos and maps which help to answer the questionnaires are also considered. Knowledgeable reviewers counter-check the data and assess data comprehensiveness, readability and quality. This ensures that documented strategies are understood by a global audience, i.e. people who do not have background information about the local situation. Often, issues self-evident for local SLM specialists are not mentioned or explained, which demolishes the comprehensiveness of a SLM strategy. Therefore, guidance for reviewers is provided, giving hints on most common problems and pitfalls (see also Liniger et al., 2004).

The WOCAT questionnaires were originally designed to document and evaluate actually applied and tested practices. Within DESIRE, potential measures are also included in order to draw on and follow up on ideas expressed by stakeholders in Part I. These are either described in a less detailed manner, for which a standard format was made available, or documented (hypothetically) with the help of the WOCAT questionnaires. From a total of 60 priority measures agreed upon in the stakeholder workshops at 15 DESIRE study sites, 39 are already applied practices, whereas 21 are potential measures. It is apparent that at some study sites, all promising measures have already been applied and in others all are potential only. Among the first group (all applied) are the study sites in Portugal, Nestos Basin, Crete, Morocco, Tunisia, and China, and among the second group (all potential) Djanybek and Chile.

To summarize, the steps to be followed during Part II are: (1) become familiar with the questionnaires on technologies and approaches, and plan the documentation and evaluation process, (2) refine the technologies and approaches to be assessed, (3) identify resource persons and relevant documents, (4) fill in the questionnaires: consult documents and resource persons, (5) enter the data into the database, (6) review: identify possible reviewers and share data with them, (7) quality assurance: revise data by incorporating reviewers' comments and improvements, and (8) deliver an English-language version to WOCAT for inclusion into the global WOCAT database.

The WOCAT questionnaires have recently been thoroughly revised, shortened and adapted to challenging new issues such as ecosystem services, adaptation to climate change, and poverty alleviation. The unique, widely accepted and standardised WOCAT methods are herewith enhanced and embedded in an overall methodology. This allows exchange of valuable knowledge among all stakeholders and among the study sites as well as worldwide, and is also the foundation for the selection and negotiation process in Part III.

3.4 Part III: participatory decision making for implementation of mitigation strategies

3.4.1 Embedded selection and decision support tool

This third part comprises a second stakeholder workshop where promising SLM strategies are selected for implementation at the study site. The available options are based on the locally applied and evaluated strategies as well as on worldwide documented experiences, all of them included in the global best practices database of WOCAT. A comparative selection and decision support tool, which was specifically adapted to the needs of DESIRE, is applied during a second stakeholder workshop. This allows better appreciation and negotiation of remediation strategies and support of the negotiation process concerning the best option(s) for a given human and natural environment. Again facilitated by a workshop moderator, participants conduct a multi-criteria evaluation to rank existing and potential remediation strategies for field trials. This involves stakeholders identifying and weighing relevant criteria (e.g. technical requirements, costs and benefits of implementation, social acceptability, etc.), taking into account the technical, bio-physical, socio-cultural, economic and institutional dimensions. The core of the methodology applied is based on principles of Multi-Criteria Analysis (MCA), a well-known and systematic way of making choices according to objectives and available options. It does not rely on monetary values and can use both qualitative and quantitative assessments (Tenge, 2005).

The methodology applied in this second workshop consists of three main elements. First, the WOCAT database to choose the options or strategies for land conservation. Second, a Decision Support System (DSS) software supporting the single steps in the evaluation and decision-making process. Third, a participatory approach to guide and lead the workshop participants through the evaluation and decision-making process.

Objectives of this second stakeholder workshop are: (1) to select possible implementation options from a vast basket of options, (2) to compare, score and rank these options, (3) to negotiate the best option for implementation, and (4) to decide upon 1–2 strategies for implementation. Participants are the same as in stakeholder workshop 1, and the moderators and SLM specialists again have practical guidelines at hand to plan and conduct the process. The workshop guidelines (Schwilch et al., 2008) consist of didactic guidelines, which formulate learning objectives, and describe a step-by-step procedure for leading the participants through the decision-making process; thematic sheets providing theoretical and conceptual orientation; and instruction sheets on the use of the software. The moderators have to be very careful not to manipulate where they do have a great deal of influence, as for instance during the preparatory work done before the workshop. They need to prepare the first selection step in advance, as this is too demanding (e.g. regarding translation) and time-consuming to be done during the workshop. This entails going through a series of key questions and using a predefined 'search-by-criteria' form to find the most suitable technologies and approaches from the WOCAT database. Key questions allow narrowing down the selection with regard to climate, land use and other crucial issues. After coming up with a manageable number of solutions (i.e. about 5–10), the specialists have to prepare posters and cards illustrating these solutions, based on a predefined format and an automatic retrieval of the data, but possibly with a necessary translation and adaptations to the local context (e.g. what would this measure cost in their situation). This preparatory step is a delicate aspect of the methodology, as the moderators/SLM specialists are asked to anticipate possible outcomes of stakeholder discussions in step 1, to the best of their knowledge. It is anticipated that this is possible as the discussion in step 1 is a follow-up of the work done and discussions held in the first stakeholder workshop, which provide a sound basis. However, the moderators/SLM specialists should carefully explain the purpose and use of the WOCAT database as well as the (preparatory) search process to the participants for transparency enhancement and reduction of mistrust. They should also be open-minded and flexible, as it could happen that the stakeholders focus on something other than the anticipated objective. In this case it will be necessary to make a new search in the database and print the resulting options during the workshop itself.

The moderation issues mentioned here are described in detail in the workshop guidelines, to make the moderators aware of their role and responsibility. Specific training was provided to the DESIRE study sites in conducting Part III of the methodology. The same restrictions apply here as for the first training, i.e. the persons sent to the training were again not experienced and independent moderators, but rather researchers from the study site teams.

3.4.2 Second stakeholder workshop

Basically, the 2-day workshop follows up on what was discussed in workshop 1, including recently acquired knowledge from the documentation and evaluation process (Part II). The workshop steps, their objectives, and methods are shown in Table 3.4.

Table 3.4. Steps during second stakeholder workshop

Step	Objectives	Methods
Review and adjustment of objective(s)	Confirming or reformulating the main objectives of the SLM strategy as initiated in workshop 1, select one objective to focus search of options.	Plenary: recall workshop 1 results; consensus building.
Identification of options	Identifying a range of options (technologies) from the WOCAT global database, fitting the selected objective. Agreeing on 4-7 options for further evaluation in the following steps.	Plenary: posters presenting pre-selected options in detail. Plenary discussion to confirm and reduce selection, or to search for more options in the database.
Identification of relevant evaluation criteria	Agreeing on 9-12 criteria that reflect the most important qualities strategy options must have (e.g. costs, social acceptability, ecological effectiveness, etc.), to be relevant to the local context.	Group work: brainstorming in stakeholder groups; Plenary discussion: Consolidation and finding of common understanding.
Scoring of options	Scoring all options against all criteria (i.e. to assess to which extent the various options fulfil the selected criteria). Make variations transparent in the assessment made by different stakeholder groups.	Group work: scoring all options against all criteria.
Creating a hierarchy and ranking criteria	Assign relative weight by organising criteria in a hierarchical order (importance related to objective) within the three groups 'ecological, 'economic' and 'socio-cultural'.	Plenary: visual ranking.
Analysis and interpretation	Visualizing the relative merits of different options and interpretation of results.	Plenary: explaining and discussing analysis graphs (made by DSS software, see below).
Prioritising of options – negotiation and decision making	Finding final agreement on which option should be selected for test-implementation, ideally scoring high socially, economically and environmentally.	Plenary: negotiation of options.
Embedding into the overall strategy and seeking commitment	Refinement of the draft of an SLM strategy to fit in the option selected and to consider framework conditions. Seeking commitment from all concerned stakeholders regarding their support of the implementation process.	Group work and plenary: identifying commitment within stakeholder groups and plenary discussion.

To be feasible, possible options must fit into the specific bio-physical, economic and socio-cultural context of the respective study site. An option can only be considered sustainable if its evaluation is (more or less) positive with respect to all three dimensions of sustainability: economic, ecological, and socio-cultural. That is, it has to pay off for the farmers implementing it, has to have positive impacts on the land (including soil, water, vegetation, fauna), and has to be acceptable to local actors by fitting into the socio-cultural context and practices. The evaluation therefore requires selecting useful criteria in these three dimensions. They should also clearly vary between the options and be (easily) assessable. To make sure that everybody assesses in the same way, it is crucial to have common understanding among all participants about the meaning of each criterion. Scoring is done in a practical exercise using the previously prepared cards and a 'visualisation ladder' on which stakeholder groups can score all options against one criterion at a time on a scale of seven levels (from very bad to very good). The score 0 is used to indicate a killer criterion, meaning that the option assessed is not viable because of that criterion (e.g. costs above a certain threshold or material required which is not available). The whole process is iterative, i.e. criteria, options, scores and rankings may be revised several times, if necessary.

3.4.3 Use of decision support software

Decision support tools were developed for various purposes (Saaty, 1980; Lawrence et al., 2000; Oxley et al., 2004; Barac et al., 2004; Carlon et al., 2004; ADVISOR, 2004; DESURVEY, 2005; Janssen and van Herwijnen, 2006, various articles in the Journal on Decision Support Systems, etc.) but none seems suitable for finding, assessing and negotiating mitigation options in a simple manner jointly with stakeholders. Many DSS are well suited to the particular problem for which they were originally designed, but generally have a fixed structure or a defined set of data processing and model connection paths, and therefore are rarely suitable to meet the needs of a new application (Argent et al., 2009). Information technology can help a great deal in achieving SLM by providing well-designed and useful tools for decision makers (Kersten et al., 2002). But what was mainly looked for here was an open and flexible tool designed to assist the user in the assessment of options rather than give a solution, being therefore more a kind of discussion support system. The open-source software 'Facilitator' (Heilman et al., 2002) proved to be most suitable for the envisaged purpose, mainly because it is simple and adaptable to almost any situation requiring negotiation and decision by a group of stakeholders. The applied process and support software for engaging stakeholders can resolve issues of natural resource management when there are multiple and possibly conflicting objectives and criteria to consider (Lawrence et al., 2000).

The Facilitator software was adapted to fit our purpose and support the above-described process and be integrated into step III of the methodology. Many steps in the procedure are made on paper and without computer, depending also on the (computer) literacy level of the participants. During the workshop, the computer is used mostly in the background and not directly in work with the stakeholders. Ideally, an assistant or the second moderator feeds the data from each step (results from work done in the different steps) into the Facilitator software. Only calculations for analysis of the assessment really need to be done by computer. The software is used for the mere reason of dealing with the impossibility of handling and processing all the information generated in the assessment process, and this should also be made clear to the participants.

3.5 Conclusion and outlook

Developing this methodology consisted mainly of linking a number of existing tools and methods and integrating them into a coherent and comprehensive evaluation and decision-making process. In principle, it can be applied with the aim of finding strategies for SLM in every local context, whether affected by or highly prone to desertification or any other form of land degradation. However, applicability is limited in socio-political contexts with very strong top-down decision-making and weak or non-existent civil society bodies. The intended process starts with initial co-learning among different stakeholders about degradation and conservation, includes appraisal of existing (local and external) field experience, and ends with the agreed selection of a solution for field trial. In DESIRE, field trials are done together with land users who participated in the workshops and showed willingness and interest in implementation and monitoring. Other relevant stakeholders are involved as much as possible during this subsequent phase.

We believe that the methodology presented here has a great potential to incorporate relevant stakeholders and local and external knowledge throughout the whole process of identifying, testing and validating strategies for SLM. At the same time it is flexible enough to be adapted to specific local or regional conditions. Regularly applied in the sense of a regular reflection and assessment process among different stakeholders, it allows for reconsidering trends and new developments, including recent innovations, and developing strategies to adapt to changing environmental and socio-economic conditions for SLM, such as climate change, or world market turbulence.

DESIRE offers an excellent opportunity to apply this methodology in 16 study sites in desertification-prone areas around the world, providing a chance to test its functionality in a broad range of contexts. Preliminary results presented here show that besides necessary local adaptations to the methodology, various significant alterations have been made by study site teams affecting the quality of the intended mutual learning process. Therefore, in future more specific training and continuous support for the users will be necessary. Despite this shortcoming, stakeholder workshop 1 offered an opportunity to involve a broader range of stakeholders, which itself is already a big achievement for a number of study sites. Analysing the implementation of the first part of the methodology has revealed some strengths and weaknesses, as discussed in this paper, but only after analysis of the second and third parts and after also knowing the outcome of the SLM implementation and monitoring in the field can more be said regarding recommendations and overall applicability.

Each of the three parts offers pronounced challenges to those applying the methodology. First, there is a methodological challenge in the application of such a multi-stakeholder and multi-level approach. Working with a variety of stakeholders involves facing and overcoming certain initial resistance or reluctance, guiding a heterogeneous group in a common development process, and moderating flexibly to accommodate local peculiarities. NRM decision-making demands reflexivity and skilful facilitation; good facilitation of such a process is therefore very critical (Groot, 2002; Critchley et al., 2006). This requires capacity development of moderators and facilitators. The second challenge lies in comprehensive understanding of degradation and conservation aspects, which is a prerequisite for the successful conduct of the methodology. SLM is a complex issue, which calls for collaboration at different levels of decision-making and action, and for integrating local and external knowledge as well as natural and human sciences to develop adequate strategies. As the selection of options is based on the wealth of information available within the region and from outside, it demands information to be fed into the common database, as more available knowledge provides a broader variety for selection.

In addition to DESIRE, the full methodology will also be used by various WOCAT initiatives in different countries. This will allow further evaluation of its implementation by SLM practitioners such as agricultural advisors and development professionals rather than researchers. These experiences will show its worldwide suitability and usefulness – and possible limitations. Further testing and application in any desertification-prone area around the world is intended in order to improve the methodology. Certainly, the complex and multi-stage nature of the approach requires refinement and further critical reflection.

Chapter 4

Sustainable Land Management (SLM) in drylands: documentation and evaluation of desertification mitigation technologies and approaches

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Sustainable Land Management (SLM) in drylands: documentation and evaluation of desertification mitigation technologies and approaches

Abstract

Managing land sustainably is a challenge, especially under harsh climatic conditions such as those found in drylands. The socio-economic situation there can also pose challenges, as dryland regions are often characterised by remoteness, marginality, low-productive farming, weak institutions, and even conflict. With threats from climate change, disputes over water, competing claims on land, and migration increasing worldwide, the demands for Sustainable Land Management (SLM) measures will only increase in the future. Within the EU-funded DESIRE project, researchers and stakeholders jointly identified SLM technologies and approaches in 17 dryland study sites located in the Mediterranean and around the world. In order to evaluate and share their valuable SLM experience, local researchers documented the SLM technologies and approaches in collaboration with land users, utilising the internationally recognised WOCAT questionnaires. This paper provides an analysis of 30 technologies and eight approaches documented, highlighting key issues of SLM in drylands. Careful attention is paid to features that characterise SLM in drylands and make SLM measures especially useful regarding specific threats. Among the achievements attributed to the documented technologies, those mentioned most were diversified and enhanced production and better management of water and soil degradation, whether through water harvesting, improving soil moisture, or reducing runoff. Demonstrating a favourable local-scale cost–benefit relationship was found to be crucial to improving people's livelihoods and preventing further outmigration. More research is needed to support the case study authors' assessments of SLM impacts as well as to provide a solid rationale for investing in SLM.

4.1 Introduction

Managing land sustainably is a huge challenge for land users and other stakeholders around the world. In drylands, characterised by harsh climatic conditions and water scarcity, it is especially difficult to reap benefits from land without degrading resources. Disturbance of dryland ecosystems can quickly lead to severe land degradation and thus desertification. Desertification is defined as "land degradation in arid, semi-arid, and dry subhumid areas resulting from various factors, including climatic fluctuations and human activities" (UNCCD, 2008). It is a vicious cycle in which aridity, land degradation, climate change, and biodiversity loss are strongly interlinked. On average, populations living in drylands lag far behind the rest of the world in terms of human well-being and development indicators (MA, 2005).

In recent years, the term and the concept of Sustainable Land Management (SLM) has been growingly acknowledged and widely promoted as a response to land degradation and desertification. It entails measures of land and water conservation that support land-based production and ecosystems for current and future generations. SLM's key principles are the productivity, security, and protection of natural resources, coupled with economic viability and social acceptability. In drylands in particular, it is very difficult to increase agricultural productivity on existing land – to meet growing demand for food – and at the same time offset yield losses due to climate change (Wegner and Zwart, 2011). While many SLM practices exist and are applied by land users, the upscaling of such practices remains insufficient. Drawing on various studies (Sietz et al., 2011; Bossio et al., 2010), it appears feasible to learn from local SLM experiences and transfer intervention options between similar socio-ecological systems – though drylands display very diverse characteristics (Sietz et al., 2011). Especially in areas where the risks of production failure and land degradation are high, such as in drylands, it has been shown to be easier to build on the experience of farmer innovators – both for new and existing technologies – than to introduce completely new interventions (Thomas, 2008; Critchley et al., 1999).

Within the EU-funded DESIRE project[1], a range of desertification mitigation strategies were documented and evaluated in 17 dryland study sites located in the Mediterranean region and around the world. Researchers and stakeholders jointly identified SLM technologies and approaches used by local land users, collaboratively documenting them with the help of the internationally recognised and standardised WOCAT questionnaires (WOCAT, 2008a,b) in order to evaluate and share their experience. This documentation process formed an integral part of a broader multi-step process consisting of: identifying SLM solutions in a first stakeholder workshop (Schwilch et al., 2009); documenting existing experiences with SLM (this paper); selecting the most promising option in a second stakeholder workshop using a decision support tool (Schwilch et al., 2012a); and finally testing implementation in the field. These steps are embedded in the overall DESIRE framework (Reed et al., 2011). When applied in combination and in sequence, the steps contribute to multi-stakeholder learning for SLM (Schwilch et al., 2012b). After briefly explaining the procedure, this paper aims to provide some analysis of the documented case studies and illuminate the key impacts and common issues of SLM in drylands in order to evaluate how SLM tackles specific desertification threats.

4.2 Methodology and analysis

WOCAT[2] emerged in the early 1990s from the conviction that more was being done to care for land than the general cant on land degradation would suggest. Soil and water conservation (SWC) specialists from all over the world began building a network and recording good land management practices. They eventually developed a method of recording these practices with questionnaires. Later, the focus on SWC was broadened to arrive at the more holistic concept of SLM. SLM can be defined as the use of land resources – including soils, water, animals, and plants – to produce goods that meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions (WOCAT, 2007).

The basic concept behind the WOCAT methodology at the local level entails (Schwilch et al., 2011):

- providing a standardised framework that enables comparison and sharing;
- integrating socio-economic and bio-physical aspects;
- using the knowledge of both specialists and land users as data sources, reinforced by quantitative and scientific data wherever possible; and
- using the same tools for both (self-)evaluation and for knowledge sharing.

WOCAT defines an SLM technology as the agronomic, vegetative, structural, or management measure applied in the field. An SLM approach is defined as the ways and means used to promote and implement a given SLM technology, whether through a project, an indigenous system, or a local initiative. Two separate WOCAT questionnaires are used to record SLM technologies and SLM approaches (WOCAT, 2008a,b). Both questionnaires are divided into three parts, covering general information, specifications, and analysis. The specifications used to describe an SLM technology include its purpose, classification, design, implementation activities, and costs, as well as information about the natural and human environment in which it is applied. Analysis of the SLM technology focuses on the benefits, advantages and disadvantages, economic impacts, acceptance and adoption of the technology. To assess the specifications of the SLM

[1] Desertification Mitigation and Remediation of Land; 2007-2012; www.desire-project.eu
[2] World Overview of Conservation Approaches and Technologies; www.wocat.net

approach, questions focus on objectives, operation, participation by land users, financing, technical support, promotion, and external material support such as direct or indirect subsidies. Analysis of the described SLM approach involves monitoring and evaluation methods as well as impact assessments.

The resulting data is entered into an online database that is freely accessible by the public[3]. Predefined output formats enable viewing and printing the compiled information in a user-friendly format that supports knowledge exchange and compilation of inventories. Building on earlier WOCAT work (WOCAT, 2007), an overview book has already been produced for the DESIRE project (Schwilch et al., 2012c). The data published in that book provides the basis for the present paper. It represents the first scientific evaluation of a set of WOCAT-documented SLM technologies and approaches. Most of the data compiled by the WOCAT questionnaires is qualitative and based on the estimations and assessments of local SLM experts, including land users.

Within the DESIRE project, more than 40 SLM technologies and 20 SLM approaches were initially evaluated and documented. Based primarily on field-testing and the recommendations from study sites, the selection was narrowed to 30 technologies and eight approaches that showed the most promise in the specific dryland context. The documentation of these technologies and approaches was then reviewed and improved in quality. For the purpose of analysis, the 30 technologies were divided into five groups, which are presented in Table 4.1. Each group brings together technologies with similar constituent measures and common names, familiar to most SLM specialists. Comparative analysis was performed based primarily on these five groups and graphically displayed in charts. Statistical analysis was not possible. However, the compiled documentation and comparisons provide insights into the common issues and differences encountered in these dryland SLM case studies. The DESIRE case studies were first characterised by type and environment, before analysing specific impacts related to SLM principles and desertification threats. According to previous assessments of technologies documented using the WOCAT questionnaires, SLM must be based on principles of improved water, soil fertility, plant management, and enhanced microclimates in order to increase land productivity (WOCAT, 2007; Liniger et al., 2011). The DESIRE case studies were analysed to determine whether the documented SLM technologies obeyed these principles and were able to tackle key threats in drylands by means of improved water management, reduced soil degradation, diversified and enhanced production, resilience towards climate change and variability, as well as by providing socio-cultural benefits including conflict mitigation and prevention of outmigration.

4.3 Results and discussion

4.3.1 Characterisation of SLM technologies and approaches in drylands

Out of the 30 technologies documented, 18 are applied on cropland. Only three of the cropland technologies depend on irrigation water – the rest are rainfed. Only two technologies are solely applied on grazing land. Though a majority of dryland areas are used as grazing land – where desertification problems are widespread and severe – grazing land areas are typically neglected due to issues of unclear ownership, access rights, and governmental policies that discourage investments in rangelands (Thomas, 2008).

The technologies listed together in a particular SLM group have similar constituent SLM measures, such as agronomic measures for cropping management, management measures for grazing land technologies and structural measures for water management. The SLM groups cross-slope barriers and forest management consist of various measures, including combinations. An example of a typical combination is the earth-banked terrace from Spain, which is applied together with a vegetative measure – drought-resistant shrubs with good surface cover – to stabilise the structure. Some of the prominent groups of technologies are further described in Boxes 4.1 through 4.4.

[3] www.wocat.net/en/knowledge-base/technologiesapproaches.html

Table 4.1. Sustainable Land Management (SLM) technologies.

SLM group	Country	WOCAT database code	SLM technology	Land use	Measure	Degradation[1]	Stage of intervention	Rainfall (approx. annual average in mm)	Slope flat 0–2% gentle 2–5% moderate 5–8% rolling 8–16% hilly 16–39% steep 30–60% v. steep >60%	Land ownership	Off-farm income (% of all income)
Cropping management	Chile	CHL01	No tillage preceded by subsoiling	cropland	agronomic	Pc	mitigation	695	rolling	individual (titled)	10–50
Includes soil fertility management (benefits of use of organic and inorganic plant nutrients, minimum disturbance of the soil, crop rotation, and permanent soil cover, including agro-forestry systems). They are applied on cropland and mixed land use systems (crop-tree and crop-grazing).	Greece	GRE01	Olive groves under no tillage	cropland / mixed	agronomic	Wt	mitigation	500	rolling	individual (titled)	<10
	Spain	SPA01	Reduced contour tillage of cereals	cropland	agronomic	Ha, Pc, Wt	prevention / mitigation	300	moderate	individual (titled)	>50
	Spain	SPA06	Reduced tillage of almonds and olives	cropland / mixed	agronomic	Wo, Cn, Cp, Bl, Bp	prevention / mitigation	300	moderate	individual (titled)	>50
	Chile	CHL02	Crop rotation with legumes	cropland	agronomic	Cn	prevention	695	moderate	individual (titled)	>50
	Morocco	MOR12	Crop rotation: cereals / fodder legumes (lupin)	cropland	agronomic	Bq	prevention	500	gentle	individual (titled)	<10
	Spain	SPA05	Ecological production of almonds and olives using green manure	cropland / mixed	agronomic	Wo, Cn, Cp, Hq	prevention / mitigation	300	moderate	individual (titled)	>50
	Turkey	TUR04	Fodder crop production	cropland	agronomic	Cn	prevention	400	rolling	individual (titled)	<10
Water management	Tunisia	TUN09	Jessour	cropland	structural	Ha, Wt	mitigation	200	steep	individual (not titled)	>50
Includes rainwater harvesting, improved irrigation efficiency and provision of drinking water for domestic and livestock use. It involves	Tunisia	TUN12	Tabia	cropland / grazing land	structural	Wt	prevention	200	flat/gentle	individual (titled)	>50
	Spain	SPA04	Water harvesting from concentrated runoff for irrigation	cropland / mixed	structural	Ha	prevention / mitigation	300	moderate	individual (titled)	>50

different land uses, mostly related to crop production through irrigation and water harvesting, but also water supply systems. There can be combinations of uses for the same technology, such as provision of irrigation and drinking water.			purposes								
	Greece	GRE05	Transport of freshwater from local streams	cropland	manage-ment	Cs	prevention	500	flat	individual (titled)	10–50
	Tunisia	TUN14	Recharge well	cropland / grazing land	structural	Ha	prevention	200	gentle	state	>50
	Turkey	TUR03	Drip irrigation	cropland	structural	Hg	prevention	400	flat	individual (titled)	<10
	Russia	RUS01	Drip irrigation	cropland	structural	Hs, Hp	mitigation		flat	communal	<10
	Bots-wana	BOT04	Roof rainwater harvesting system	cropland / grazing land	structural	Hg	mitigation	450	gentle	communal	<10
Cross-slope barriers Include measures on sloping land in the form of soil bunds, stone lines, barriers in gullies, vegetative strips and all forms of terraces. They are applied in various land use systems but are especially used for cropland or control of gullies.	China	CHN53	Progressive bench terrace	cropland	structural	Wt	prevention	515	very steep	state	10–50
	Turkey	TUR05	Woven wood fences	cropland	structural	Wt	prevention	400	moderate	individual (titled)	10–50
	Spain	SPA02	Vegetated earth-banked terraces	cropland	structural / vegetative	Wt, Wg, Wo	prevention / mitigation	300	moderate	individual (titled)	>50
	Morocco	MOR14	Olive tree plantations with intercropping	cropland / mixed	vegetative / agronomic	Wt	prevention	500	rolling	individual (titled)	<10
	Cape Verde	CPV06	Aloe Vera Living Barriers	cropland / grazing land	vegetative	Wt, Wg	rehabili-tation	500	steep	individual (titled)	>50
	Mexico	MEX02	Land reclamation by agave forestry with native species	cropland / mixed	vegetative	Wt, Wg, Bc, Bs	rehabili-tation	700	hilly	individual (titled)	>50
	Morocco	MOR15	Gully control by plantation of *Atriplex*	grazing land	vegetative	Wg	rehabili-tation	500	rolling	individual (not titled)	10–50

Grazing land management	Tunisia	TUN11	Rangeland resting	grazing land	management	Bs	mitigation	200	rolling	individual (titled)	>50
Includes controlled grazing and resting periods	Italy	ITA01	Controlled grazing in deciduous woods	forest / grazing land	management	Bc	prevention	500	rolling	individual (not titled)	<10
Forest management	Cape Verde	CPV03	Afforestation	forest / mixed	vegetative	Bc, Bh, Wt, Wg	rehabilitation	600	very steep	state	<10
Includes afforestation, assisted regeneration of forests, and fire control. The biogas technology from Botswana is also assigned to this group, as its major land degradation-related role is to reduce pressure on forest and wood resources.	Morocco	MOR13	Assisted cork oak regeneration	forest	vegetative	Bc	mitigation	400	gentle	state	<10
	Portugal	POR01	Primary strip network system for fuel management	forest / mixed	structural	Bf	prevention	800	hilly	individual (not titled)	>50
	Portugal	POR02	Prescribed fire	forest / grazing land	management	Bf	mitigation	1,500	hilly	communal	-
	Botswana	BOT05	Biogas	forest / mixed	management	Bc	rehabilitation	450	flat	communal	<10

[1]**Degradation types**: (*note: for a complete list of the degradation types in the WOCAT classification system see www.wocat.net*)

B: Biological degradation: reduction of vegetation cover (Bc), loss of habitats (Bh), quantity / biomass decline (Bq), detrimental effects of fires (Bf), quality and species composition / diversity decline (Bs), loss of soil life (Bl), increase of pests / diseases (Bp)

C: Chemical soil deterioration: soil fertility decline / loss of organic matter (Cn), soil pollution (Cp), salinization (Cs)

H: Water degradation: aridification (Ha), change in quantity of surface water (Hs), change in groundwater / aquifer level (Hg), decline of surface water quality (Hp), decline of groundwater quality (Hq)

P: Physical soil deterioration: compaction (Pc), sealing/crusting (Pk)

W: Soil erosion by water: sheet erosion (Wt), gully erosion (Wg), off-site effects like flooding and siltation (Wo)

Rainwater harvesting

A myriad of rainwater harvesting (RWH) technologies exist worldwide – especially in drylands (Biazin et al., 2012) – and the sample presented here only covers a few. The Botswana case study features a roof rainwater harvesting system that mainly benefits the local drinking water supply. The case study in Spain and two in Tunisia feature runoff-harvesting systems that collect water from an upstream catchment area and directly divert it to cropping fields. In that way, the traditional water harvesting structure in Spain considerably increases the 300 mm of annual rainfall by an additional 550 mm. The recharge well example in Tunisia catches and feeds floodwater into the aquifer. Not represented are in-field/in-situ systems, consisting of small structural measures such as holes, pits, bunds, or small basins, constructed for the collection of on-site runoff within the field. (Photo: C. Hauser).

Box 4.1. Rainwater harvesting.

Crop rotation with (fodder) legumes

Examples of legume cropping are applied in crop rotation system in Chile, Morocco, and Turkey, and – as green manure under tree crops – in Spain. While all four examples share the major aim of enhancing soil fertility, their economic purpose varies depending on the prevailing production system. In Spain, the legumes are not harvested but rather completely ploughed under in order to fertilise the soil used for olive and almond production. In Chile, peas are used as vegetables and lupines and vetch are used as fodder. In Turkey and Morocco, all legumes are used as a fodder crop for land users' animals. Haymaking is practiced in the Turkish study site. Especially in integrated cropping and livestock management production systems, as are often found in drylands, crop rotation with fodder legumes has a number of specific benefits. Leguminous crops improve fodder production, as they can be eaten by ruminants either as green fodder or as grain. Their nitrogen-fixation capabilities benefit the next cultivation cycle, while simultaneously improving soil organic matter and soil structure. Soil cover is also considerably enhanced, as these crops often replace a non-vegetated (or even ploughed) fallow period. Due to their invasiveness and extensive root system, legumes are able to grow on poor and stony soils and do not require much water. The leguminous nitrogen-fixating species used include vetch (Vicia sativa, Vicia atropurpurea), sainfoin (Onobrychis), white lupin (lupines albus), narrow-leaf lupin (Lupinus angustifolium and Wonga, an early flowering and high-yielding variety), yellow lupin (Lupinus luteus), peas (Pisum sativum), rocket, and alfalfa. The leguminous plants are often mixed with fodder crops such as maize, oat, wheat, barley, triticale, and fodder beet. Some of their benefits only appear over the long term, such as improved soil structure or organic matter. (Photo: S. Espinoza)

Box 4.2. Crop rotation with (fodder) legumes.

Reduced- or no-tillage technologies

Changes in traditional ploughing practices to reduced- or no-tillage practices were reported in Chile, Spain, and Greece. Two examples relate to cereal production and two are applied under olive and almond orchards. These practices mostly follow two principles of Conservation Agriculture, namely minimum disturbance of the soil and permanent cover (Liniger et al. 2011). The main advantages are on-site conservation of rainwater by reducing surface runoff and evaporation loss (>50%), reducing soil erosion (>50%), fewer tillage operations, and reduced costs. The main difficulties to overcome are: (a) weed control through permanent cover, cutting of weeds and chemical control; (b) possible compaction of the subsoil during the initial period of transition from ploughing to no-tillage; (c) competition for plant residues being used for animal feed; and (d) the costs of new equipment (machinery), even though the maintenance costs are less than with conventional tillage. While water is conserved through reduced runoff and direct evaporation loss, additional water is consumed by the green cover. As a result, the yields of olives and almonds are not increased, but the environment is protected and costs are reduced. Practices of reduced tillage with permanent cover bear great potential in the Mediterranean region due to the large areas under olive and almond plantations there, which are prone to erosion under conventional tillage practices. (Photo: C. Ruiz).

Box 4.3. Reduced- or no-tillage technologies.

Cross-slope barriers

Two major types are represented in DESIRE: one with contour strips of wooden or vegetative barriers of Aloe vera, agave, olives, and Atriplex, and the other consisting of terraces. Contour strips are mainly applied on moderately steep to steep slopes and have two main purposes: (a) reducing surface runoff and soil erosion, and thus soil fertility loss and downstream damages; and (b) accumulating water and nutrients within and above the strips for trees and crops. High establishment and maintenance costs are rewarded when barriers are reinforced with highly productive trees and shrubs. Both terrace examples are used for tree crops (olives in Spain and apples in China). The Loess plateau terraces are built up progressively by expanding the terraced area around the apple trees over a period of 5–10 years, while the terraces in Spain are constructed right from the beginning and reinforced with shrubs and grasses. (Photo: H.P. Liniger).

Box 4.4. Cross-slope barriers.

Examination of the natural and human environment in which the technologies are applied highlights the unfavourable conditions that are typical of dryland areas. Almost all the technologies are applied in semi-arid agro-climatic zones where rainfall is usually not more than 250–500 mm/year. Soil depth is usually shallow, while topsoil organic matter and soil fertility are low. Such is the reality of drylands, where soils are generally less fertile due to less weathering, unfavourable substrates, and the reduced level of biological activity characteristic of arid and semi-arid climates. The extent to which degradation and nutrient mining may have contributed to reduced soil fertility was not assessed. Half of the technologies are applied on slopes greater than 8%, where erosion and water loss are the main degradation problems that must be tackled. Other degradation types – such as fertility depletion, vegetation degradation, or salinization – prevail on gently sloping or flat terrain, where cropping management and water management technologies are mainly applied. Surprisingly, soil crusting and sealing, a phenomena often observed in drylands, was only mentioned in one technology description, belonging to Spain (reduced contour tillage technology).

The SLM technologies documented are mainly applied by land users with small-scale land holdings (57%), who have wealth levels ranging from medium to poor, and who are representative of average land users within their area. The plots of land on which cropping land management technologies and cross-slope barriers are applied are all individually owned and titled. Some of the technologies are implemented on state land for the benefit of private land, such as the recharge well technology found in Tunisia, where private irrigated farms indirectly benefit from the increased groundwater availability. Land ownership and land use rights are key issues hindering or facilitating adoption of SLM technologies; ownership of the land usually facilitates implementation of SLM among land users.

Remoteness and marginality played less of a role at the DESIRE study sites than might be expected. Most sites are located reasonably close to the research centres involved. Access to employment and financial services was poor in most sites, whereas access to education, health, and roads/transport was relatively good. Access to drinking water, sanitation, and markets appeared to vary greatly between the study sites. Off-farm income was very important to most of the land users applying the documented technologies. In about half of the cases documented, the land users depended on off-farm activities for more than 50% of their income. People's access to off-farm employment appeared low in most cases. The rate of off-farm employment would likely be higher if access to such employment were greater. Outmigration played a role at many of the sites (e.g. Portugal, Spain, Tunisia, Morocco, Chile, Russia). In six of the study sites, outmigration was perceived to be constraining SLM by participants of the first stakeholder workshops (Schwilch et al., 2009). It was seen as aggravating the situation rather than reducing pressure on resources, as is often assumed. During the second stakeholder workshops, participants cited the capacity to reduce outmigration as an important criterion when selecting SLM technologies, as aging of the rural population was considered a major problem (Schwilch et al., 2012a). When people migrate away from rural areas, key sources of labour vanish, land management is neglected, and local knowledge of traditional practices gradually diminishes and disappears, as seen in Spain regarding traditional water harvesting practices.

Eight SLM approaches were documented to illustrate implementation of the technologies in the field (see Table 4.2). The approaches ranged from projects for testing and disseminating new technologies to training and awareness-raising campaigns, rural development programmes, and government programmes of forest regulation. In most case studies, control of degradation and desertification were cited as the main objective of the documented approach. Other key objectives mentioned were enhancement of productivity and intensification of production. Finally, improvement of farmers' livelihoods – mainly through increased income – was named as a goal in connection with almost every approach.

Table 4.2. Sustainable Land Management (SLM) approaches.

Country	SLM approach name	Description	WOCAT database code
Spain	Regional rural development programme	Regional development programme to protect natural resources and stimulate rural economies	SPA01
Portugal	Forest Intervention Area (ZIF)	ZIF assembles and organises small forest holders and defines a joint intervention for forest management and protection	POR01
Russia	Concerted thinking on common problems of water scarcity	Testing and disseminating a water saving technology such as drip irrigation	RUS01
Morocco	Development of rainfed agriculture	Development of unfavourable zones by integrating all components which can enhance the production, increase incomes, and provide sustainable natural resource management	MOR14
Tunisia	Dryland watershed management approach	Integrated land and water management approach, including vegetative, management, and agronomic measures	TUN09
Cape Verde	Training, information, and awareness raising	Integration of stakeholders in the implementation of natural resource conservation activities	CPV01
Mexico	Participative actions for economic benefits of agave forestry	Land reclamation with local agave (to produce Mezcal) associated with trees, shrubs, and grasses planted through participative actions for economic benefit	MEX02
Chile	Dissemination of soil conservation technologies in dryland areas	Dissemination of no tillage with subsoiling in the Municipality of Yumbel	CHL02

The success of an approach in promoting and implementing SLM technologies often depends on the extent to which land users' underlying motivations are addressed. Among the eight approaches documented, land users were mainly motivated by the benefits of increased production, profitability, and/or payments and subsidies received (see Figure 4.1). Remarkably, land users in the two approaches documented from Western Europe – Spain and Portugal – were mainly motivated by rules and regulations (fines) or enforcement; this was not the case anywhere else. Aesthetic and environmental consciousness generally appeared to play a minor role in terms of people's motivations.

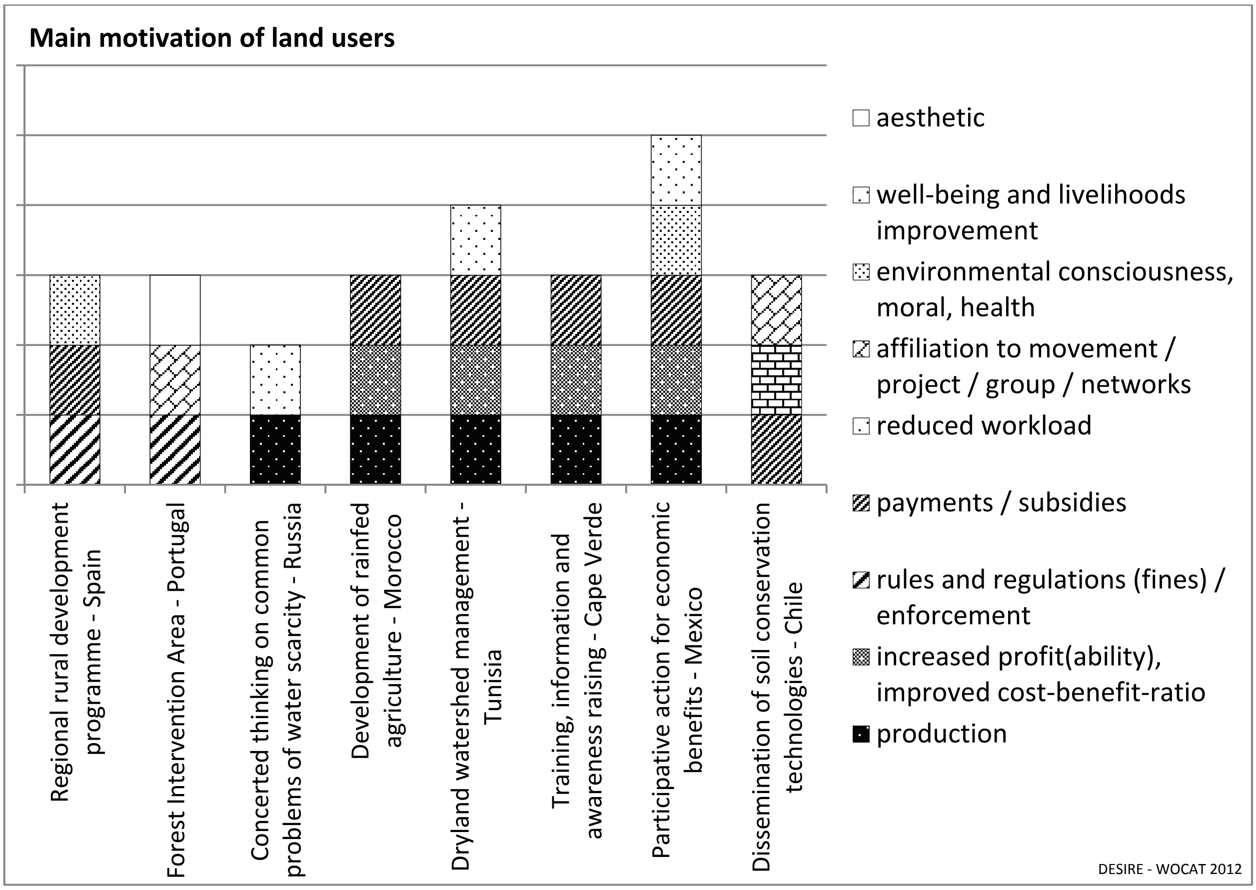

Figure 4.1. Main motivation of land users to implement SLM.

4.3.2 Impacts of SLM technologies with regard to dryland threats

Improved water management

According to the authors of the case studies (see Figure 4.2), at least half of the technologies demonstrated the following ecological impacts: “increased soil moisture”, “reduced surface runoff”, “improved soil cover”, and “reduced soil loss”.

Water availability is the most common factor limiting (food) production in drylands. It is characterised by a mixture of scarcity, extreme variability, long dry seasons, recurrent dry spells and droughts, and occasional floods. Thus, improving water use efficiency to minimise water losses is of the utmost importance (Biazin et al., 2012). The concept of Green Water Use Efficiency (GWUE) helps to assess whether the productive flow of water is maximised, while unproductive water loss is minimised. GWUE is expressed as the fraction of plant transpiration (T) over precipitation (P) (Stroosnijder, 2003; Stroosnijder, 2009). Unproductive water losses include soil evaporation, runoff, and percolation beyond the root zone. To analyse the GWUE of the documented technologies, the following impact parameters were considered: improved soil cover, reduced soil evaporation, increased soil moisture, and reduced surface runoff. It was assumed that technologies showing the highest combined benefit across all parameters would improve GWUE best. The values assigned to these impacts were therefore added together for each technology individually. A total combined value of four or more was considered a measurable improvement, since the impact was high and/or affected more than one parameter. Figure 4.3 shows that 14 technologies appeared to produce measurable improvements. Four technologies showed no impact for any of the parameters. Cropping management and cross-slope barriers were most effective in increasing GWUE. This is due to their high impact in improving soil moisture through in-situ water conservation. Under dryland conditions, this usually leads to increased yields. Surface runoff – a key cause of water loss – was most effectively reduced by improved cropping management and cross-slope barriers. The recharge of the groundwater table/aquifer was mainly an issue for the water management technologies: a small to medium increase was assessed in connection with four technologies in Greece, Spain, and Tunisia, while a high increase was reported regarding the recharge well in Tunisia (being the specific target of that SLM practice). In Nestos, Greece, where salinization of irrigation water (not water quantity) is the biggest problem, increased water quality and reduced salinity were reported impacts of the applied water management technology (transport of freshwater from local streams).

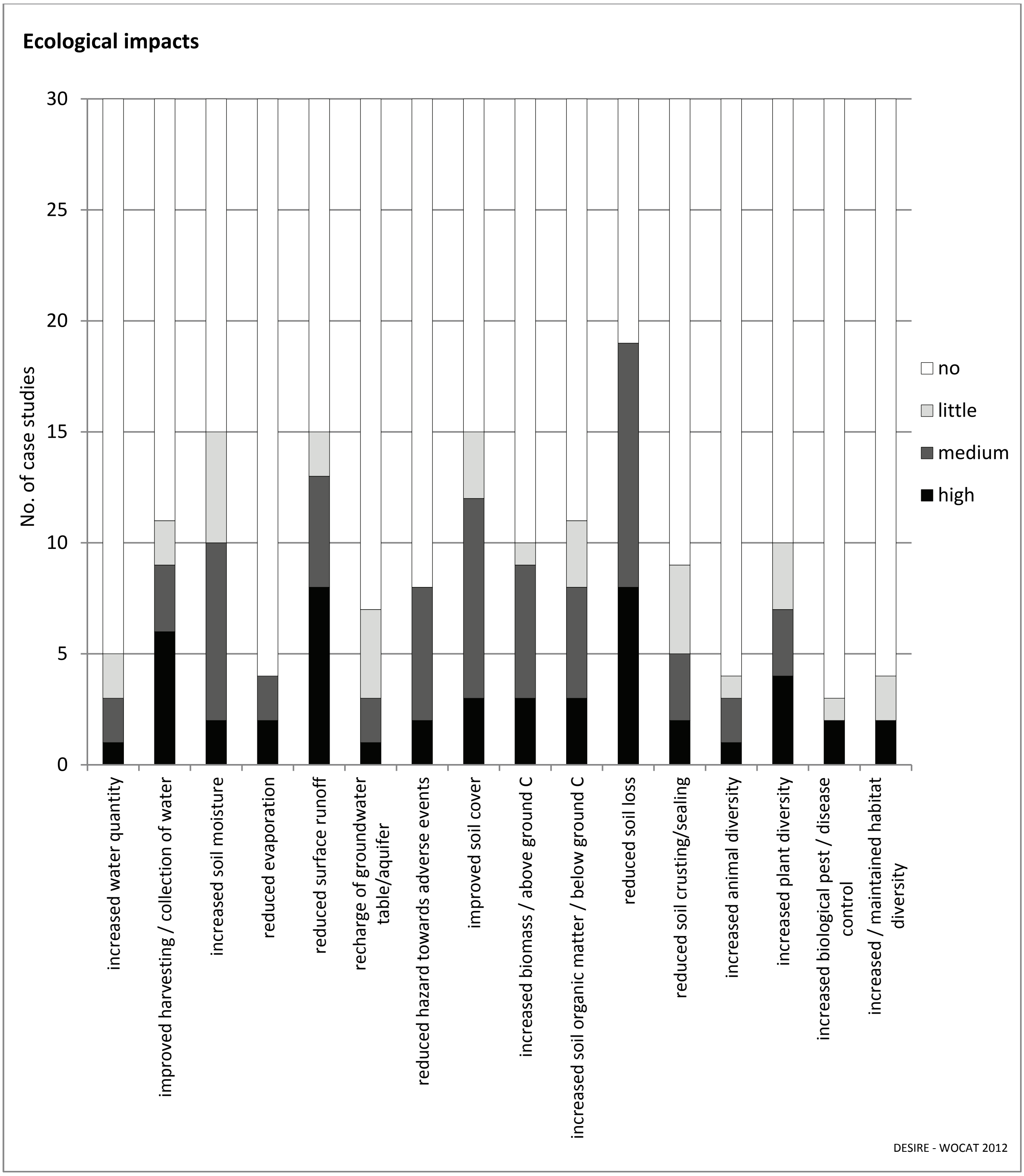

Figure 4.2. Ecological impacts of the SLM technologies.

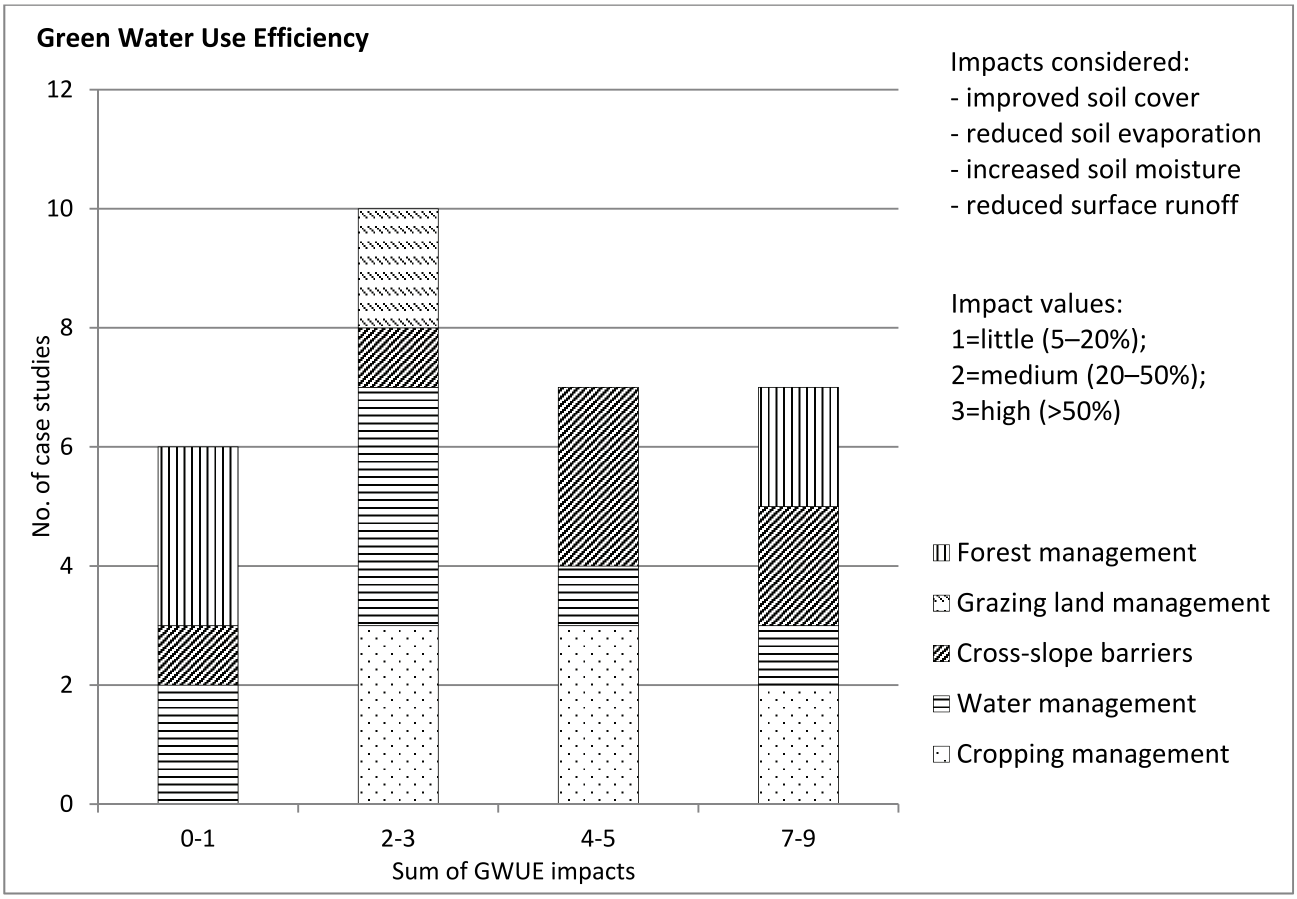

Figure 4.3. Green water use efficiency (GWUE) of SLM technologies.

Half of the case studies reported improved soil cover – typically 20–50% improvement – by means of crops, fodder, weeds, shrubs, or dead material. Though an increase in production was reported in connection with the water management technologies, it apparently did not correspond to an increase in soil cover (level or duration). With only half of the technologies documented in DESIRE reporting improved soil cover, it remains to be explored whether the current understanding of dryland SLM – which puts great emphasis on improving soil cover – should be correspondingly adjusted. Some argue that improved soil cover reduces runoff and evaporation, leaving a greater share of the rainfall for green biomass and enabling a “greening of the land” without compromising (crop) production (Stroosnijder, 2009). However, improved vegetative soil cover may compete with crops for both water and nutrients. And improving soil cover through dead material, such as mulch, may be complicated by fodder requirements or wind. Additionally, farmers may fear pests and diseases caused by use of mulch (Moroccan farmers, oral communication).

Though the greatest water-related impacts were achieved by relatively few technologies – seemingly significant in a desertification context – it should be noted that every technology, save one (prescribed fire from Portugal), displayed some sort of impact on water.

Reduced soil degradation

While the majority of reported benefits were expected to relate to water, more benefits were reported regarding soil loss. Eighteen technologies reportedly reduced soil loss: 10 moderately (20–50%) and eight highly (>50%). However, due to their professional background, there may have been a tendency among the case study authors to focus on soil erosion rather than other issues. For many years and in numerous implementation and research projects, soil erosion was considered to be the main issue that needed to be addressed by soil and water conservation efforts. Though SLM’s focus has since been broadened, soil erosion continues to be emphasised. Even sites that had not initially identified it as a problem reported reduced soil loss, especially in connection with grazing and cropping management technologies (see Figure 4.4). These mainly concern the examples of crop rotation and less so the no- or minimum-tillage technologies. Considering the dryland context, the sites highlighting reduction of erosion must have been experiencing considerable loss of water through runoff. This implies that runoff control is key to soil *and* water conservation. Two technologies did not appear to reduce soil loss, even though soil erosion was indicated as a target problem prior to their application. This concerns “gully control by plantation of *Atriplex*” (Morocco) and “woven wood fences” in Turkey. These were installed only very recently and it will probably take some time for measurable reductions in soil loss to occur.

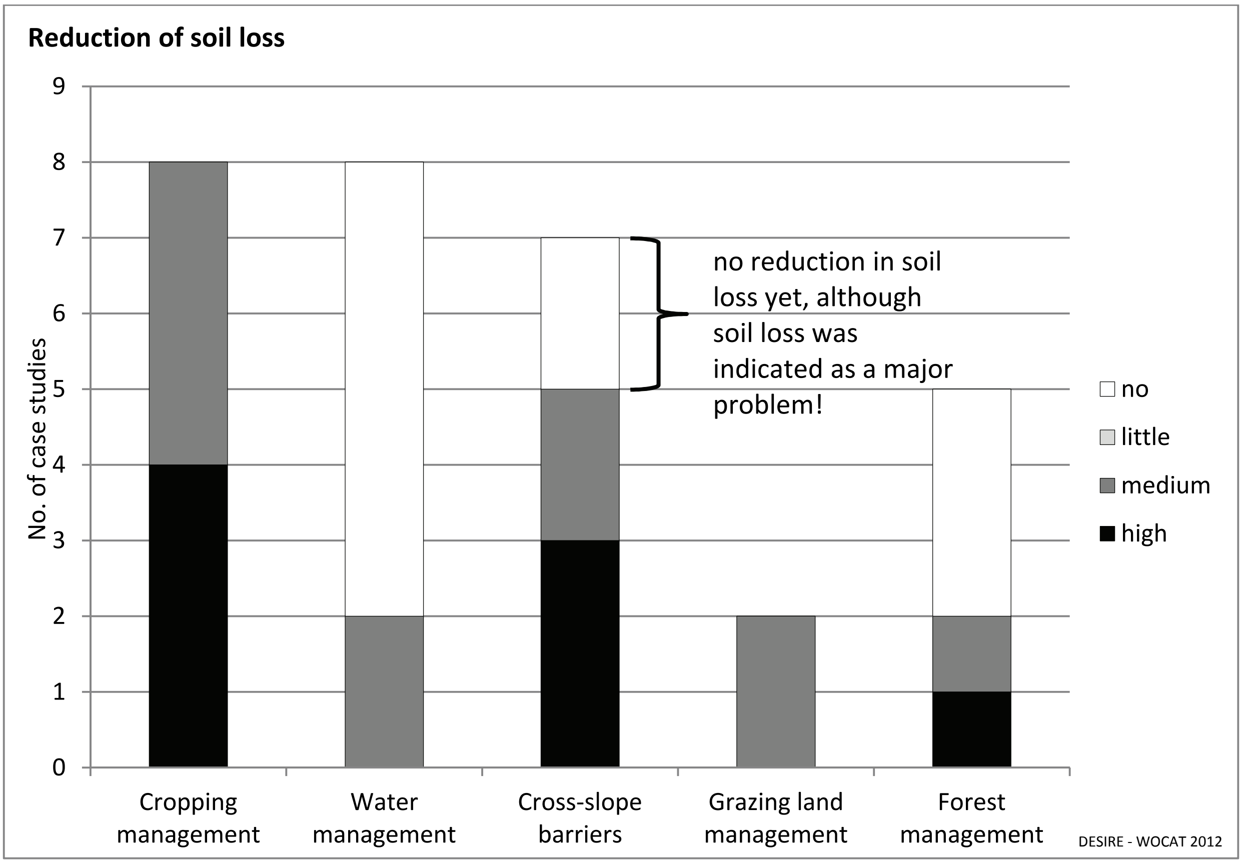

Figure 4.4. Reduction of soil loss.

Most of the technologies that were applied to soils with low organic matter content apparently failed to improve it. This could be due to the long time required to observe an increase in soil organic matter in dryland conditions, to difficulties measuring such changes, or to lack of data. Exceptions were those cropping management technologies that directly aimed to improve soil organic matter. Application of fertiliser is one possible solution for fertility decline: five of the eight cropping management technologies include application of fertiliser. Some of them use organic fertiliser from animal manure; others only apply phosphor because nitrogen is made available with leguminous fallow cropping. Improved biological control of pests and diseases was reported solely in three case studies, namely in connection with “ecological production of almonds and olives using green manure” in Spain (high improvement), “land reclamation with agave forestry” in Mexico (high improvement), and “prescribed fire” in Portugal (little improvement). Infestations of insects and caterpillars that are treated twice yearly were reported in connection with ecological production in Spain. However, ecological pest and disease control is relatively expensive and often requires subsidies, especially in the first few years of implementation. Experiences from elsewhere, such as the pull-and-push system (Liniger et al., 2011), encourage looking for existing pest- and disease-control technologies within the region.

Diversified and enhanced production

Given the bio-physical and socio-economic constraints discussed earlier, production is usually rather low in drylands. Nevertheless, the potential to increase production is great, and areas with very low yields sometimes record the highest gains (Molden et al., 2010). As seen in Figure 4.5, improved production was reported in connection with nearly all of the technologies. This crucially indicates that SLM technologies are generally capable of increasing production and may be used to address increasing demands for food, fodder, and other products. Depending on the land use type, increases were experienced in crop yields, fodder or animal production (e.g. meat, milk), or wood production. Cross-slope barriers appeared to have the highest production benefit. Still, for each group, there were one or two technologies that showed no production benefit, such as the two no-tillage technologies used in olive (and almond) orchards in Spain and Greece. Their benefit relates more to reductions in costs and environmental damage rather than improved production, and a net increase in farm income is still achieved. Other technologies were not assessed regarding agricultural production benefits (e.g. the biogas example). One-third of the documented technologies – mainly those in the water management group – reduced the risk of production failure.

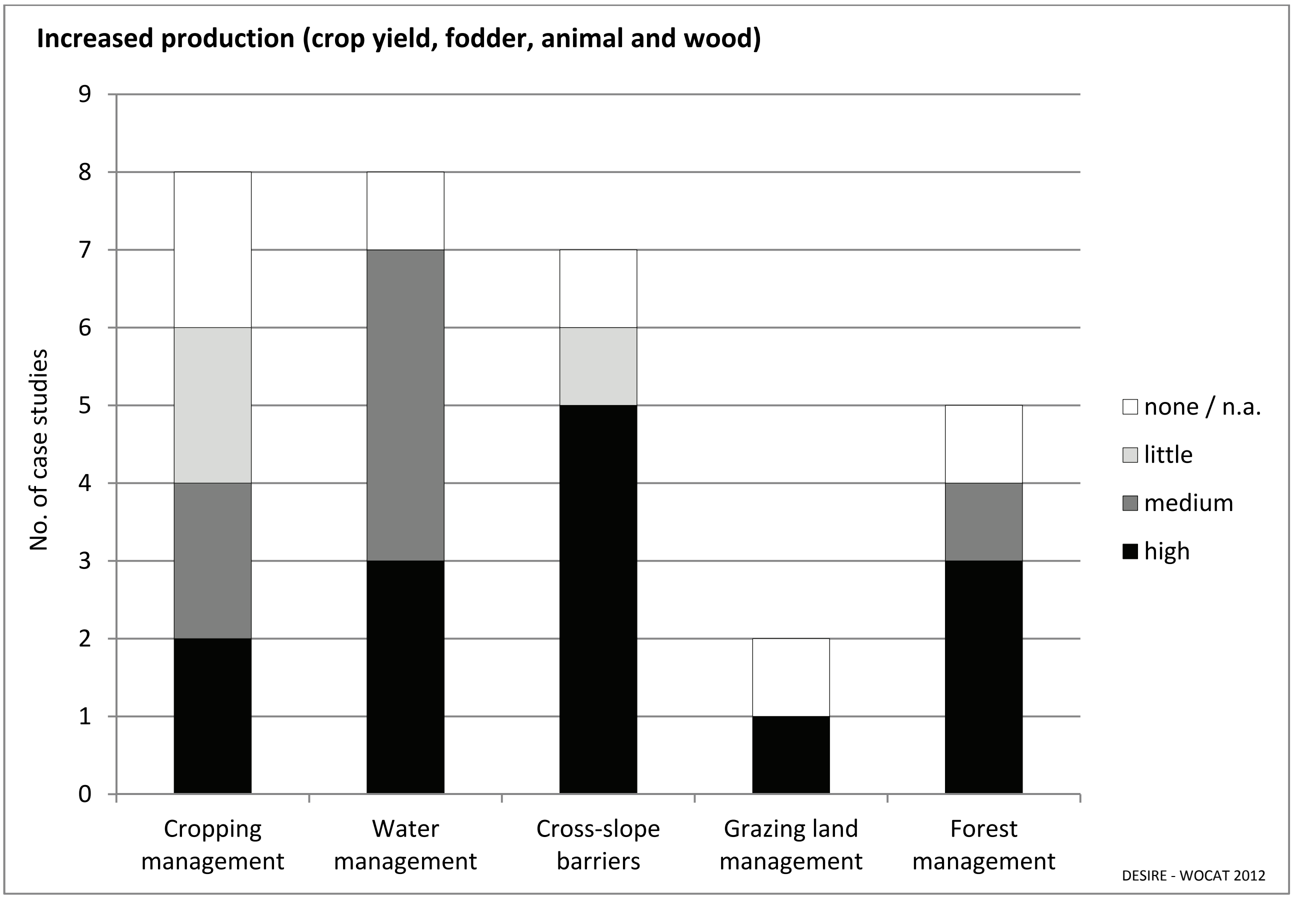

Figure 4.5. Increase in production across the SLM technology groups.

The extent to which this production improvement also raises land users' income depends on the inputs (expenditures) required to apply the technology. Increased incomes due to improved land management were reported in three-quarters of the cases of applied technologies, excluding forest management technologies, for which such analysis is not applicable. Though nine technologies increased land users' expenditures on agricultural inputs – mainly in the cropping management group due to investments in special machinery (e.g. no-tillage) or in seeds (e.g. legumes) – increases in net farm income were still reported.

Diversification of income sources was a reported benefit of five technologies, though only "land reclamation with agave forestry" in Mexico registered a high impact due to new alcohol production. Diversification of agricultural products was also reported in connection with certain technologies, including: "olive tree plantation with intercropping" in Morocco; crop rotation with fodder legumes in Chile, Turkey, and Morocco; "Aloe Vera living barriers" in Cape Verde; and drip irrigation in Russia and Turkey.

Socio-cultural benefits including conflict mitigation and prevention of outmigration

The most frequently reported socio-cultural benefit was "improved conservation/erosion knowledge". Stakeholders appeared to highly value the knowledge they gained by implementing SLM technologies (reported in 80% of the cases). Such knowledge gains typically facilitate further investment in SLM (de Graaff et al., 2008). Another benefit is strengthening of community or national institutions, as reported in connection with forest management technologies, where it appears key.

Whether or not the technologies contributed to improved livelihoods and human well-being was also assessed. Remarkably, a positive impact was reported for every technology, without exception, in this regard. More than half of the technologies reportedly had a medium or high impact, mainly by increasing people's income. Other relevant improvements related to water availability, diversification of food, reduced damage to fields and infrastructure, reduced outmigration, reduced workloads, increased energy, provision of medicinal plants, and reduced risk of wildfires.

Conflict mitigation was reported for seven technologies spread between all the groups, except cropping management. On the other hand, four of the five forest management technologies appeared to increase socio-cultural conflicts, though only slightly. The reasons were manifold, but had to do with restrictions on land use for certain periods or for certain users. For land reclamation with agave forestry, a high increase in conflicts was expected due to the high economic benefits of alcohol production as well as potential alcohol abuse within land users' families.

Outmigration reduction, identified in four sites as a criterion for selecting the SLM technology for test implementation (Schwilch et al., 2012a), was ultimately achieved by two technologies. In Mexico, the technology of land reclamation with agave forestry was found to generate very high incomes, and this "enables farmers' sons to remain in the community and work in the fields"; and in Tunisia, rangeland resting was found to "[combat] rural exodus and [increase] income from agriculture by 20%" by improving fodder and animal production/quality.

Resilience to climate change and variability

Most of the technologies appear capable of tolerating expected climatic variations. In some areas, rainwater availability may actually increase in the future. But in the Mediterranean region, where the majority of the selected case studies are located, most climate prediction scenarios forecast declining rainfall (EEA, 2008).

All of the documented cropping management technologies are considered sensitive to droughts and dry spells. As they often concern annual crops grown with the bare minimum of rain, they are prone to crop failures with even a slight decrease in rainfall. Temporal variability, including periods of drought or delayed starts to the rainy season, can also affect crop growth. Further, these technologies do not enable alternative sources of income, in contrast to agroforestry systems, for example. On the other hand, the SLM technologies that improve soil water may reduce drought sensitivity. About one-third of the technologies (11 out of 30) are reportedly sensitive to seasonal decreases in rainfall. Water management technologies are especially sensitive to floods, as indicated for six of the eight technologies in this group. The challenge for these technologies is designing structures that are strong enough to withstand the power of floods. A reported 83% of the technologies are capable of tolerating extreme events such as storms: the cross-slope barriers, in particular, are designed to cope with such threats. This indicates that good SLM practices are already capable of coping with climatic extremes and potential shifts.

4.3.3 Cost–benefit analysis of the SLM technologies

The costs of SLM technologies are often difficult to assess. Distinguishing normal agricultural inputs from the additional expenses of the SLM technology can be a challenge. Low-cost technologies (below 100 USD/ha)[4] are mostly found in the groups of cropping management and grazing land management – though their maintenance costs can be considerable. The water management technologies are the most expensive (2,000–10,000 USD/ha), but this group also bears the highest potential to increase profits, making the investments very worthwhile. Maintenance costs are usually rather low, i.e., less than 300 USD/ha/year. Costs often restrict poor land users from implementing technologies, even if the investment would pay off in the long run. Subsidies enable them to avoid paying the full cost of establishment or maintenance. Among the studied cases, land users typically either paid almost all the costs of establishment (11 cases with contributions of 90–100%) or almost nothing (nine cases with contributions of 0–10%). Five case studies fell somewhere between these two extremes, while five others had no establishment costs. Overall, land users paid 36% of establishment costs (median value), while the rest was subsidised by project funds or the government. Land users' greatest contribution typically takes the form of labour. However, more than half of the technologies documented were fully maintained at the land users' expense. As with any investment, the benefits must be weighed as well; the costs should not be considered in isolation.

Demonstrating a favourable local-scale cost–benefit relationship is central to the adoption and spread of SLM. This requires accurate assessment of SLM interventions' monetary and non-monetary costs and benefits. Not everyone perceives non-economic costs and benefits the same way. The WOCAT questionnaires could only capture the subjective qualitative assessment of the DESIRE case study authors. For most technologies, the long-term relationship between benefits and costs (of any type) appears to range from positive to very positive, as presented in Figure 4.6. However, the picture is different regarding short-term benefits, which appear to be outweighed by establishment costs for many technologies, in particular those in the water management, cross-slope barrier, and forest management groups (see Figure 4.7). One possible conclusion is that implementation of most SLM technologies will produce negative returns on investment for the first 1–3 years, and that land users will require support from credits, revolving funds, payment for ecosystem services (PES), or other financial mechanisms in order to obtain the economic value of SLM technologies in the long term (5–10 years).

Further, cost–benefit calculations should not focus only on local land users but also on the wider society and economy. This requires examination of the off-site benefits of SLM technologies. Half of the technologies documented in the DESIRE case studies provide off-site benefits, such as reduced damage to neighbours' fields and public/private infrastructure, or reduced downstream flooding. Many of the technologies are situated in mountainous areas and play an important role in regulating water provision for downstream users. More difficult to assess are the contributions of SLM to mitigating climate change (e.g. through carbon sequestration), preventing disasters and environmental threats (e.g. mud flows, flooding), or reducing vulnerability to economic crises.

[4] For certain technologies, costs are indicated per unit rather than per hectare, but in all cases this was comparable to a hectare (e.g. the recharge well in Tunisia benefits one hectare of irrigation land).

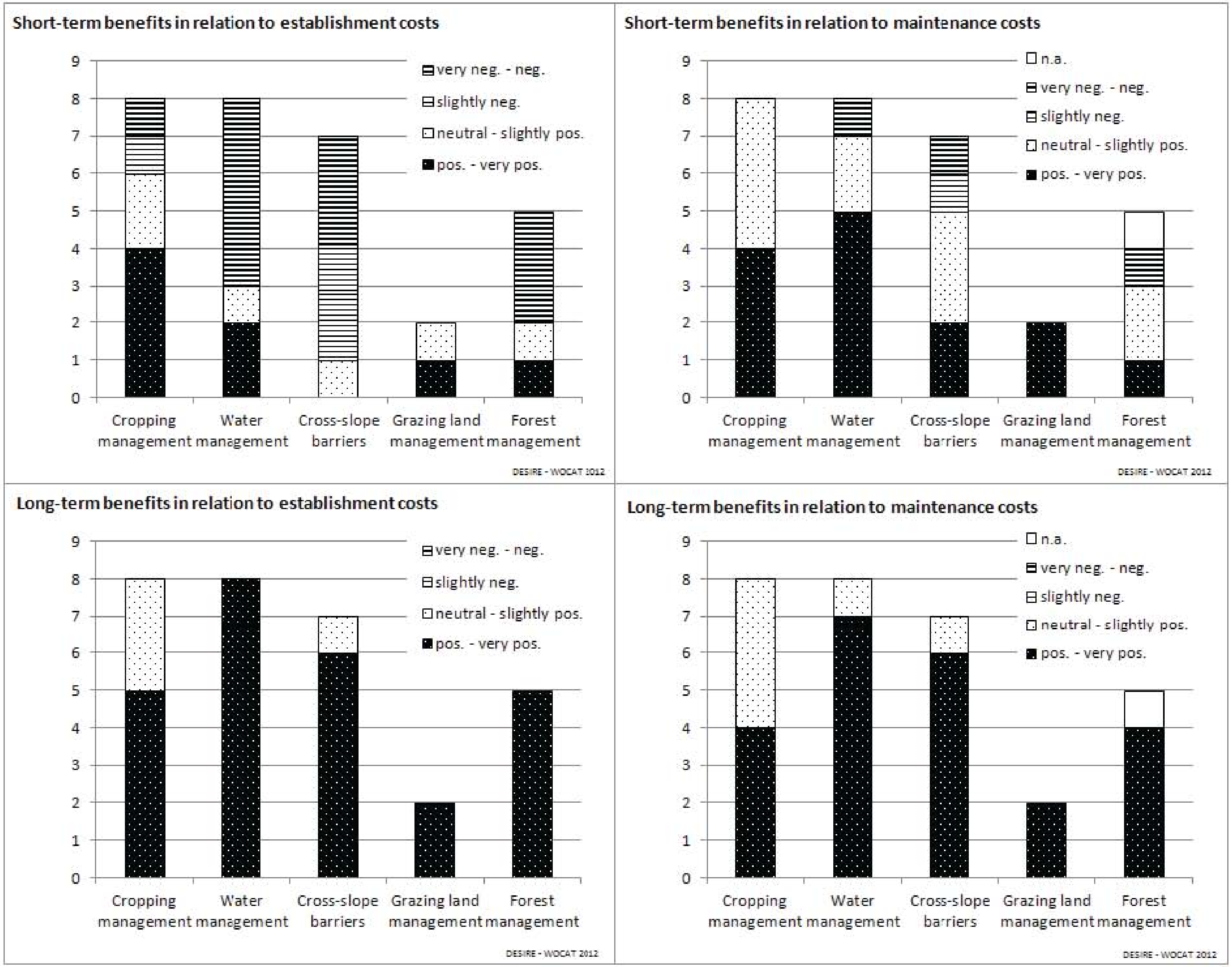

Figure 4.6. Perceived benefits of SLM technologies in the short term and the long term in relation to establishment and maintenance costs.

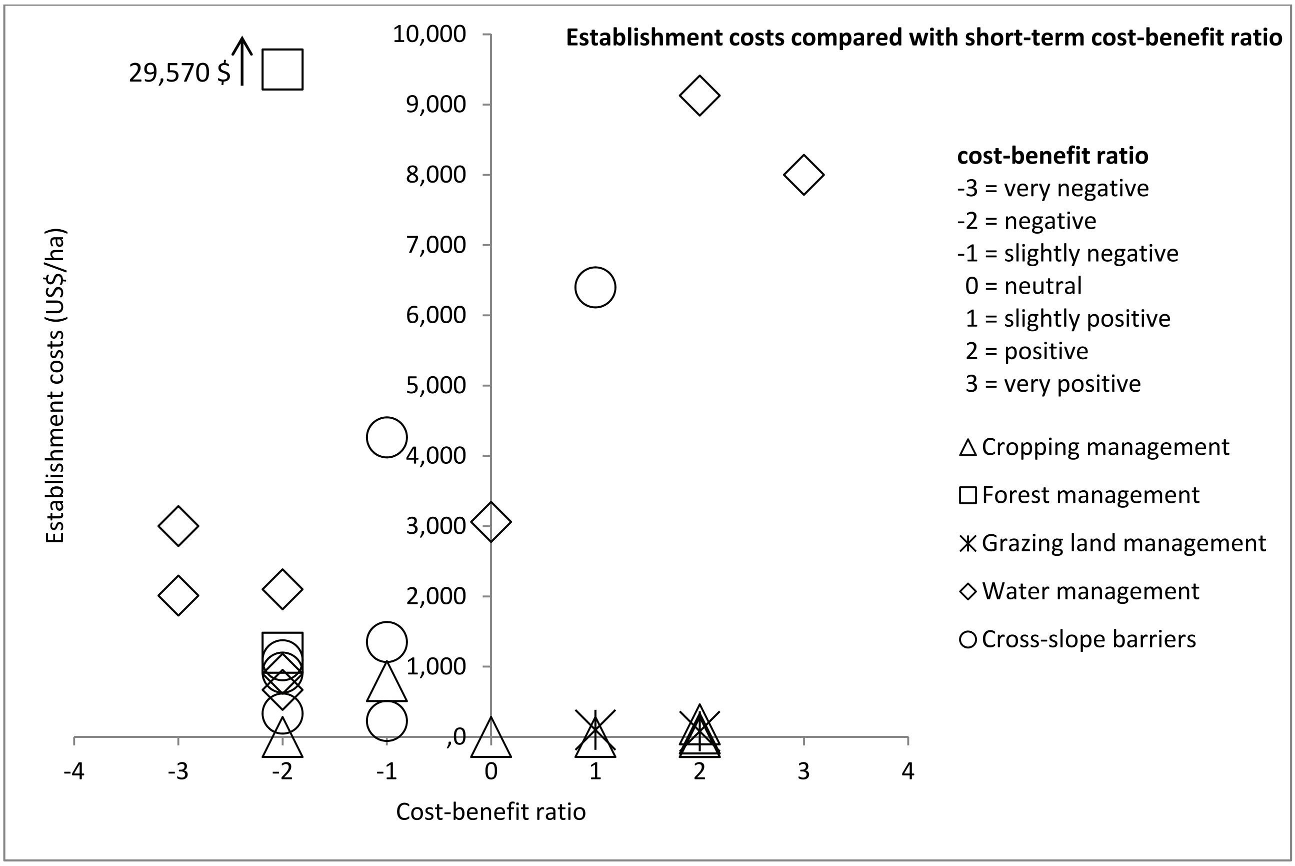

Figure 4.7. Establishment costs in USD/ha compared with short-term cost–benefit ratio.

Inputs and achievements also very much depend on the stage of degradation at which SLM interventions are attempted. The best input–benefit ratio will normally be achieved by measures of prevention, followed by those of mitigation, and finally rehabilitation measures (WOCAT, 2007). The DESIRE case studies confirm this finding: the technologies aimed at rehabilitation display a lower cost–benefit ratio than those aimed at prevention or mitigation. This implies that while the impacts of rehabilitation efforts may be highly visible, their achievements must be critically considered in terms of costs. Of the 30 technologies analysed, only five were described as aimed at rehabilitation; these mainly concerned recovering the lost productivity of highly degraded forest or grazing land by planting high-value trees and shrubs or producing biogas to reduce the pressure on fuelwood. Indeed, a key strength of the SLM technologies applied in these dryland sites is that the majority are aimed at prevention and mitigation. Examples of prevention technologies include crop rotation systems (Chile, Morocco), fire prevention in forests (Portugal), controlled grazing in forests (Italy), water harvesting systems (Tabia from Tunisia), and drip irrigation (Turkey).

4.3.4 Key impacts of dryland SLM approaches

In more than half of the eight DESIRE case studies, the local community was actively involved in all stages of the approach, as seen in Figure 4.8. However, analysis of the DESIRE case studies reveals that most SLM interventions were driven by experts. Only in Mexico and Tunisia was the decision a joint one made by various stakeholders. Moderate to substantial differences in the level of participation of men versus women were reported in most case studies. Men typically perform the hard manual labour in the field and during implementation of SLM measures, while women are more responsible for work in and around the house. Portugal and Russia were the only sites where no gender difference was identified. Remarkably, 40% of the documented households in Cape Verde were headed by women, mainly due to their husbands' migration to other areas or countries. Disadvantaged groups – including the poor or unemployed – are often specifically targeted for involvement in SLM interventions.

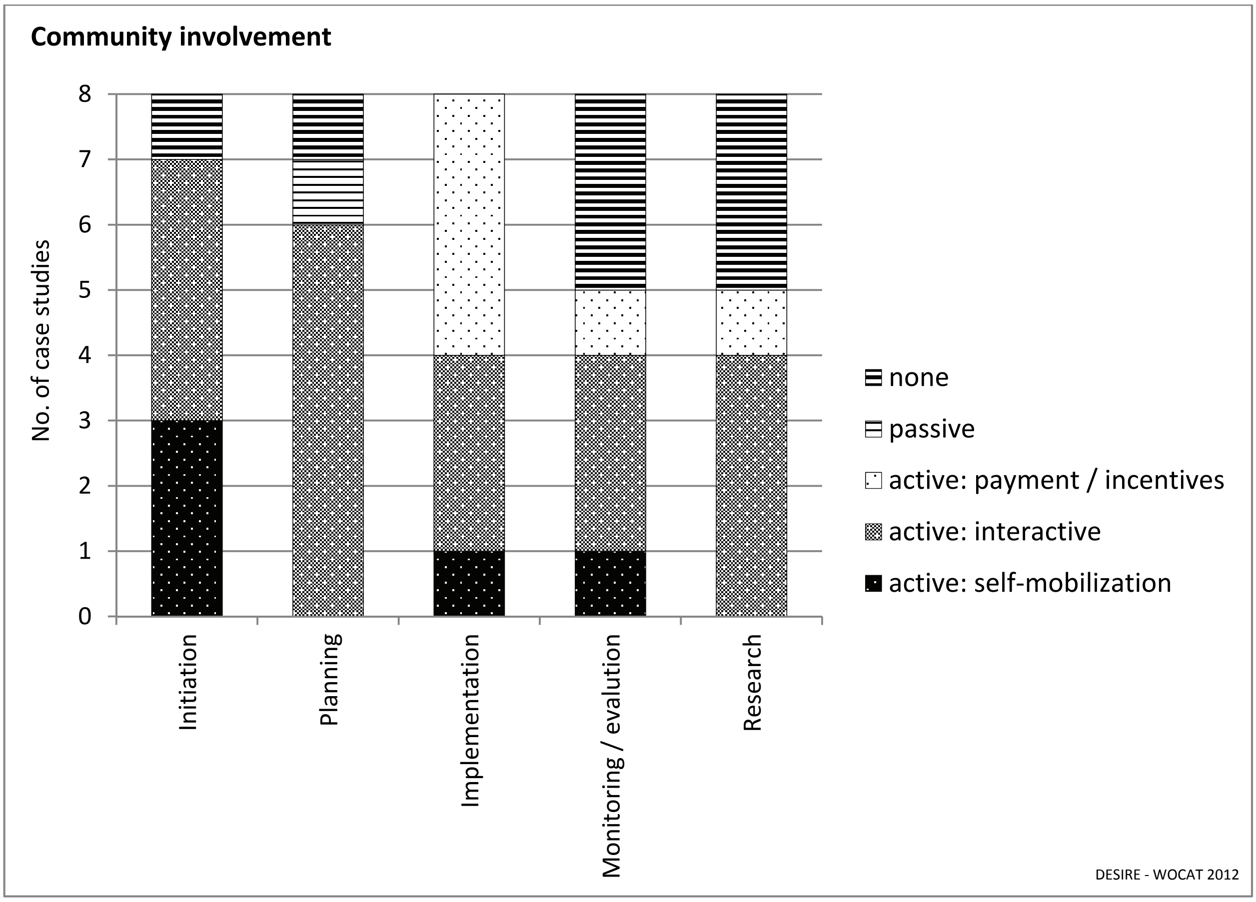

Figure 4.8. Community involvement in different stages of the SLM approach.

Training, advisory services, and research are other key elements of SLM approaches. Training was provided in all eight documented approaches, primarily to land users and field staff/agricultural advisors. Training was provided in the form of public meetings, information sessions, site visits, demonstration areas, on-the-job experience, and farmer-to-farmer exchange. The effectiveness of training and extension services was considered good to excellent in most cases, except in Spain. Apparently, there is a substantial lack of training for land users in Spain. The case study authors write that the extension system there is currently strongly focused on control rather than on advice and training activities. More information and awareness-building efforts are required on behalf of land users, as such information is often only available at the political or research level.

In five cases, the approach was found to greatly improve the sustainable management of land, while moderate improvement was reported in three cases. Most approaches were found to contribute to improved livelihoods, decreased poverty, and improved situations for socially and economically disadvantaged groups. The use of subsidies and their long-term impact on the implementation of SLM were not considered a problem anywhere. On the contrary, in six approaches, the impact of subsidies was considered positive. Only in the Tunisia case study was a decrease in people's willingness to invest in SLM technologies reported when financial support was not provided, as land users had come to rely on being paid for each area treated. Nevertheless, in the Tunisia case and elsewhere (Chile and Spain), it remains uncertain whether land users could continue the SLM approach without support. In the case of Portugal, continuation is impossible without subsidies – the forest owners simply do not have the financial capacity to apply and support the approach activities by themselves. Indeed, none of the eight SLM approaches studied appears fully capable of generating a self-supporting, market-driven mechanism that will guarantee its continuation. This suggests that financial mechanisms are required to support the starting phase of SLM approaches and possibly subsequent phases. Again, such mechanisms could include credits, subsidies, revolving funds, contracts, or PES.

4.4 Discussion

4.4.1 Desertification mitigation

The analyses presented here demonstrate how the documented SLM technologies and their implementation approaches are tackling desertification threats. Table 4.3 summarises the key findings, listing the identified threats, the benefits of given DESIRE SLM technologies, and assessments of their impact. Technically, the assessed SLM practices mainly function by means of controlling runoff and erosion as well as improving ground cover and soil moisture. These mechanisms complement each other and may be considered key functions of SLM technologies in drylands. The generalised overview in Table 4.3 shows that all the groups are successfully tackling the desertification threats, with no group setting itself apart from the others in terms of performance. This suggests that there are no universal "best practices", not even in a specific environmental context such as drylands (Bayala et al., 2012).

Table 4.3. Desertification threats tackled by SLM technologies in the DESIRE project.

Desertification threat	Related SLM benefits	Impact achieved by DESIRE SLM technologies
Water scarcity	Improved water management through increased water quantity, reduced water loss through runoff and evaporation, improved soil moisture, improved water harvesting, recharge of groundwater	High impact, mainly through water management, cropping management, and cross-slope barriers
Soil degradation	Reduced soil loss, reduced crusting and sealing, reduced damage on neighbours' fields and public/private infrastructure	Very high impact, mainly through cropping management and cross-slope barriers, but also through forest and grazing management
Vegetation degradation and low production	Improved soil cover, improved biomass, diversified and enhanced production, improved water use efficiency, improved soil organic matter, improved pest and disease control, reduced risk of production failure, increased farm income	Medium to high impact by all technology groups; water management shows smallest impact
Climate change	Resilience towards climate change and variability through reduced vulnerability towards adverse events, reduced risk of production failure, reduced downstream flooding, diversification of income sources	Medium impact, mainly through water management and cross-slope barriers. Sensitivity of cropping management to droughts and water management to floods
Resource use conflicts, migration	Socio-cultural benefits including conflict mitigation, prevention of outmigration, institution strengthening, improved knowledge of conservation/erosion	Medium to high Impact on improved livelihoods and knowledge through all technology groups; some impact on conflicts and migration by most technology groups

Comparing the list of documented SLM technologies with similar assessments elsewhere (WOCAT, 2007; Liniger et al., 2011), it is striking that the group of soil fertility management technologies appears to be missing. The data analysed here does not confirm the finding, emphasised in the literature (Stroosnijder, 2003), that efficient water management is impossible without improved nutrient management. Though soil fertility is often a major concern of land users, none of the stakeholders suggested technologies to improve soil fertility at the beginning or end of the project. No obvious reason for this was found. It remains unknown whether the stakeholders truly do not consider it a problem or if, indeed, it is not a limiting factor of production. As described above, fertiliser was applied in many of the cropping management technologies. However, other than the nitrogen-fixing leguminous crop rotation / green manure systems, no technologies were applied which specifically sought to improve soil fertility and the nutrient cycle.

The principles of SLM elaborated by Liniger et al. (2011) in the TerrAfrica initiative were only partly confirmed by the present data. Below, the **principles** and some of their indicators (in italics) are used to evaluate the DESIRE data.

1. **Improving water productivity**: This was mostly achieved by *reducing water loss* through reduced surface runoff (15 technologies, mainly cropping management and cross-slope barriers). *Water harvesting* was achieved by five water management technologies specifically aimed at this, of which two were also successfully *maximising water storage* and another was *managing excess water* (Tunisia recharge well).
2. **Improving soil fertility and the nutrient cycle**: Here too, the greatest impact was reported in connection with cropping management technologies and cross-slope barriers. Some aspects, such as *cover* and *soil organic matter improvement*, were also addressed by grazing and forest management technologies. *Application of manure and compost* was very rare (two cases only), while *crop rotation, fallow and intercropping* was reported six times. *Trapping sediments and nutrients* was exclusively found in connection with cross-slope barriers. The water management technologies hardly enhanced soil fertility except through some *reduction of nutrient losses* thanks to improved irrigation.
3. **Improving planting material and plant management**: The four crop rotation case studies (*mixed plant systems, selection of seeds*) were most successful in this area. *Weed management* was key to the four no- or reduced-tillage technologies. Two of the forest management examples and one of the cross-slope barriers also benefitted from *synergies between different plants*. No benefits were reported for water management technologies with respect to this principle.
4. **Creating a favourable micro-climate**: as this principle mostly relates to improved cover, it was not assessed separately.

Overall, the cropping management technologies and the cross-slope barriers appear best at addressing the first three principles, while the water management technologies are mainly focused on improving water availability.

One possible criticism of the above principles is that they are too focused on cropland. The two forest fire prevention technologies, for example, do not appear to have any place among the principles. Technologies related to alternative energy sources (such as biogas) also do not seem to fit. Thus, the addition of two more principles is recommended.

5. **Protecting against extreme events and shifts**: fire prevention, diversification of production, permanent cover, adjusting agricultural and ecological systems within a landscape, etc.
6. **Reducing pressure on resources by providing alternatives:** biogas rather than fuelwood, energy saving stoves, etc.

4.4.2 WOCAT assessment

What is the added value of evaluating and documenting SLM technologies and approaches with the WOCAT tools? While using the WOCAT tools to document and evaluate may be demanding, the DESIRE project showed how doing so enriches the experience of users, that is, the experts and land users who supply the information. A DESIRE study site researcher described it as follows: “The questionnaires force the user to go through all aspects/issues and to talk to numerous people (land users, administrators)”. The process enables gaining new insights into applied technologies and approaches and serves as a tool for self-evaluation. The knowledge gained on degradation and conservation is great and facilitates further investments in SLM. This confirms the need for and the benefit of the WOCAT methodology. Further, the documented case studies are simultaneously made available worldwide by means of a shared, online database.

Nevertheless, the DESIRE data review process revealed some clear bottlenecks, echoing the findings of an earlier evaluation (Liniger et al., 2004). For example, the information provided by case study authors is often not concise enough to be understood by an external readership. There are also gaps and inconsistencies in the information provided that must be sorted out in an interactive way, comprising several review – improvement cycles. Considerable effort is required to enhance the quality of the documentation, including language editing, the addition of high-quality photos and drawings as well as improved explanation of facts that might be self-evident to local readers but not to an international audience. Further, it is generally very difficult to quantify the costs and benefits of SLM technologies and approaches. This has been highlighted in the WOCAT network before, and the DESIRE project further confirms it. This is especially the case where there are no additional costs versus a conventional form of land management, but rather a reduction of costs, as found in the case of reduced- or no-till technologies. Usually, WOCAT assesses costs of technology implementation that are additional to ordinary field operations, but when the field operations are partly the same as the technology (as in Conservation Agriculture), all activities should be individually considered and compared, making assessment especially complex and difficult. Further, while it is very important to calculate the direct costs or financial benefits of SLM technologies to land users, other factors are crucial to the decision of whether to adopt SLM (de Graaff et al., 2008; Schneider et al., 2010). One must consider the combined economic, social-cultural, and ecological benefits, accounting for trade-offs as well as off-site effects.

Overall, analysis of data obtained with the WOCAT questionnaires enables field-level observations from different sites to be pulled together and systematically compared. The present paper has sought to analyse a specific subset of the WOCAT database – the DESIRE SLM technologies and approaches – in a scientific way. This has posed some challenges and revealed some limitations. Identification and assessment of SLM impacts was the primary aim, however, a major limitation of the WOCAT methodology was observed in this area: the WOCAT questionnaire suggests a list of potential SLM impacts that may be individually selected, complemented, and assessed by users and case study authors. However, this means that only those impacts that are selected by multiple authors may be compared across technologies. Further, even if an impact was not selected, it may still have occurred. It may not have been selected simply because it did not seem important to the author, did not appear relevant in the context, or was not assessed and remains unaccounted for. For example, if several technologies – including a forest management technology – are compared regarding their impact on soil moisture, the forest management technology may not show an impact simply because it was not relevant and was therefore not assessed. Further, many SLM impacts are interrelated, such as increased water quantity and improved harvesting of water, or improved soil cover and reduced soil evaporation. It then depends on the perspective of the case study author if one or the other or both are indicated, which again has a diluting effect on the comparison of technologies.

Indeed, the perspective and perception of the case study authors are prevalent throughout the documentation, especially regarding the impact assessment. The results can be markedly subjective in this area, particularly if no quantitative data are available. In the DESIRE project, a tendency to stress bio-physical impacts such as soil erosion was found, likely due to the professional background of the case study authors. Further, as observed elsewhere (Liniger et al., 2004), there is a risk that case study authors may overestimate desired impacts and ignore negative impacts. This latter effect may be minimised by including stakeholder perspectives, namely the opinion of land users. Thus, the WOCAT methodology specifically encourages SLM specialists to question their own understanding and consult with land users when documenting SLM experiences.

Despite the difficulty of analysing data compiled with the WOCAT questionnaire in a scientifically robust way, the breadth and comprehensiveness of WOCAT's SLM assessments exceed similar efforts. SLM assessments by others either focus solely on a specific technology group (Biazin et al., 2012; Giller et al., 2009; Rockström et al., 2009), bio-physical aspects (Sahrawat et al., 2010; Ward et al., 2012), or economic productivity (Bayala et al., 2012; Farooq et al., 2011). Still others compare whole farming systems – for example, dairy farms versus arable farms (van Passel and Meul, 2012) – necessitating adoption of an entirely different system, something many farmers will reject.

Requiring case study authors to provide more quantitative data, especially regarding impact assessment, could further enhance the usefulness of the holistic information compiled using the WOCAT questionnaires. More research is needed to reinforce their expert valuations of SLM impacts and provide the necessary rationale for investing in SLM. Some of the other limitations identified can be minimised by hiring a team of reviewers to ensure the quality of the data, looking for inconsistencies and contradictions.

4.5 Conclusions

Stakeholders and researchers at the DESIRE study sites considered application of the WOCAT methodology within the DESIRE project valuable, and its use in the project also greatly benefitted the global WOCAT database. Thanks to the collaboration, case studies from hitherto underrepresented regions (such as the Mediterranean) and important degradation problems (such as forest fires) have been made available to a global audience.

The present paper has identified several key aspects of successful SLM technologies and approaches in drylands. It confirms, in part, the proposed solutions to land and water degradation presented by Bossio et al. (2010), including focusing on smallholder agriculture and resource-conserving practices as well as enhancing the multi-functionality of agricultural landscapes. Indeed, most SLM technologies are applied by small-scale land users, a group that is often underestimated regarding their investment and innovation as well as their role in worldwide agricultural production (IAASTD, 2009; Wegner and Zwart, 2011). Further, some – but not all – of the SLM principles presented in earlier WOCAT publications were confirmed by the present analyses. Finally, all of the SLM technologies documented at the DESIRE sites were shown to tackle important desertification threats, and the SLM approaches documented were shown to facilitate SLM implementation, if given sufficient support through government subsidies or systems of reward for provision of ecosystem services.

Chapter 5

Decision support for selecting SLM technologies with stakeholders

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Decision support for selecting SLM technologies with stakeholders

Abstract

Sustainable Land Management (SLM) is a classic multi-stakeholder issue, concerning individual and community land users, agricultural advisors, natural resource managers, government authorities, civil society, and researchers alike. Selecting appropriate SLM technologies for implementation requires an approach capable of integrating the diverse knowledge, perceptions, and judgements of stakeholders. Time and resource constraints often impede the development of contextualised, targeted, and sophisticated Decision Support Systems (DSS). The EU-DESIRE research project provided an excellent opportunity to develop and test a generic decision support system, and overall methodology, using it to assist 14 study site teams in selecting the most promising SLM option(s) in a stakeholder workshop, for eventual test implementation in the field. Special attention was paid to screening local innovations, selecting and adapting potential SLM technologies, and the decision-making process regarding effective implementation. This paper reviews application of the DESIRE-DSS in a variety of biophysical and socio-economic contexts, finding it to be well structured, holistic, and relatively easy-to-apply. The built-in global database of SLM options provides knowledge from various environments, while the use of simple software enables easy calculation and visualisation of results. The scoring and negotiation of each option's sustainability forces stakeholders to consider and acknowledge each other's positions and opinions, ensuring that the final choice is well-accepted. The methodology includes seeking commitments from stakeholders to implement the selected option(s). Challenges include the complexity of the issues at hand and the need for capable moderators. Yet positive outcomes and user feedback confirm that the DESIRE-DSS is an easy-to-use stepwise methodology for facilitation of decision-focused participatory processes.

5.1 Introduction

Now a widely acknowledged concept, Sustainable Land Management (SLM) represents a response to many environmental threats, especially land degradation and desertification, climate change, biodiversity loss, and food insecurity. However, realising SLM on the ground is challenging, and selection of appropriate SLM technologies and approaches is a crucial, yet difficult task. Agricultural advisors, authorities, and land users should examine the SLM options and carefully weigh the pros and cons of each regarding local implementation. Thereby attention should be paid to the role of the respective stakeholders. Unfortunately, in practice, accurate screening of viable options is frequently either ignored or done solely by specialised researchers and experts. This often leads to recommendation of technologically and ecologically sound SLM measures that nevertheless lack financial feasibility or socio-cultural acceptance. Recently, there has been a shift towards recognition and support of participatory approaches involving all stakeholders (Pound et al., 2003). More stakeholder involvement supports sharing of knowledge and experiences, but does not automatically lead to selection of better solutions. Though decision support systems have been developed for different purposes, it has remained difficult to find one specific system suitable for identifying, assessing, and negotiating SLM options in a simple manner together with stakeholders. There is a general lack of guidance for decision-makers as to how to structure effective, participatory processes to select the best option (Kellon and Arvai, 2011).

The research project described here aided development of a generic selection and decision support system, and overall methodology, especially for SLM. Special attention was given to screening local innovations, selecting and adapting potential SLM technologies, and decision-making regarding effective implementation. Specifically, the methodology includes screening the options supplied by the WOCAT (World Overview of Conservation Approaches and Technologies; www.wocat.net) database[1] of SLM technologies, providing guidance through a comparative assessment of the options, and supporting the negotiation process regarding identification and implementation of the most promising option(s) for a given human and natural environment. The research was conducted within the EU-funded DESIRE project (2007-2012; www.desire-project.eu), a global research initiative to mitigate desertification and remediate degraded land. The new decision support methodology – Part III of an integrated, comprehensive methodology (see Fig. 5.1) – was tested in 14 study sites in desertification-prone areas. The aim of this paper is to present and evaluate the applied decision support methodology, summarise key findings, and describe important lessons from application of the methodology.

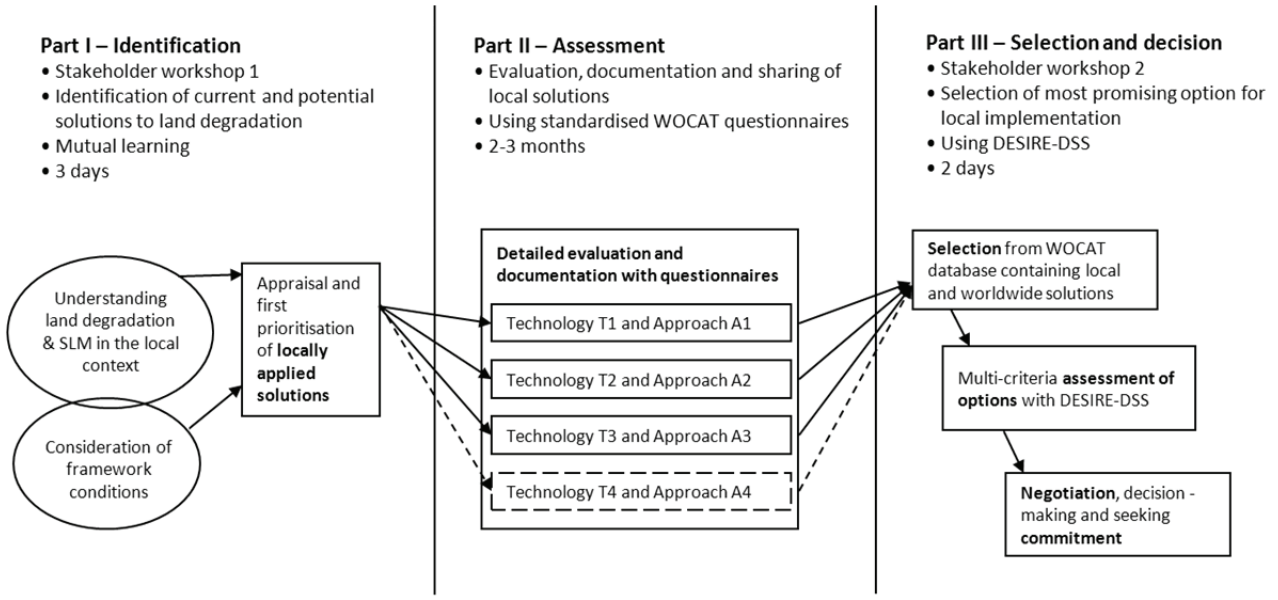

Figure 5.1. The DESIRE three-step methodology for the identification, assessment, and selection of SLM strategies (simplified from Schwilch et al., 2009). Part III is the main subject of this chapter.

5.2 SLM decision-making at the local level

SLM is best achieved through a combination of effective SLM technologies, implemented via appropriate SLM approaches, and supported by adequate socio-economic, legal, and institutional frameworks (Schwilch et al., 2011; WOCAT, 2007). These are the key ingredients of a sound SLM strategy. Developing an SLM strategy requires careful selection of alternatives and making decisions based on evaluation of diverse options according to multiple objectives and criteria. In sustainable natural resource management, a balance must be found between the three dimensions of sustainability – ecological, economic, and socio-cultural – and their objectives and criteria, rendering decision-making highly complex. Though many scientists and project managers are aware of this, practice continues to lag behind theory and recommendations, as other research presented in this journal has shown (de Graaff et al., 2008; Lestrelin et al., 2011; Nunes et al., 2011). Main objectives drive the screening of possible options and determine their overall evaluation; specific criteria – weighted according to importance – are used to determine the degree to which each option matches the objectives (Janssen and van Herwijnen, 2006). Working with many stakeholders simultaneously, a crucial requirement when addressing a complex issue like land management, adds another dimension to the decision-making process.

[1] Over the past 20 years, WOCAT's global network of SLM specialists has put together a wealth of worldwide information on SLM approaches, SLM technologies, and the areas they apply to.

5.2.1 Existing decision support methods

Multi-Criteria Analysis (MCA), Multi-Criteria Decision Analysis (MCDA), and Multi-Criteria Decision-Making (MCDM) are more or less synonymous decision support methods developed for complex problems. They account for trade-offs between multiple objectives, reflect multiple criteria, and involve both quantitative and qualitative data to evaluate either "continuous" or "discrete" types of options (Jeffreys, 2002). Many studies and reviews have looked at the various decision support methods and their application, particularly in the fields of forest management and planning (Ananda and Herath, 2009; Diaz-Balteiro and Romero, 2008; Guitouni and Martel, 1998; Kangas and Kangas, 2005; Kellon and Arvai, 2011; Mendoza and Martins, 2006). The case of community-owned forests steered MCDM developers towards group decision-making (GDM) approaches. Another term that similarly considers the prevalence of multiple objectives is Multi-Objective Decision Support System (MODSS), which emerged from the recognition of the interconnected objectives in ecology and society. Jeffreys describes the way the methods relate as follows: "MCA is the tool for processing, weighting and aggregating the data that describe an issue, whereas MODSS is the process by which the data are selected and framed, reflecting the multiple needs and objectives of society" (Jeffreys, 2002:44).

Several studies of these methods and their application show that assessing options in such interactive, participatory, and process-focused decision environments is effective, enables people's intuitive decision-making procedure through a structured and rational process, and fosters discussions and negotiations between the stakeholders involved (Ananda and Herath, 2009; Balana et al., 2010; Janssen and van Herwijnen, 2006). Opponents of such methods argue that they are prone to manipulation, are very technocratic, and provide a false sense of accuracy (Janssen, 2001 in Kodikara, 2008). However, "effective visual tools can be used to reflect the information provided back to the decision-makers, for example by using a graphical presentation of an inferred value function or of an aggregated evaluation result" (Janssen and van Herwijnen, 2006:22). In this way, good software – featuring visual and interactive tools – aids transparency and enables moderators and stakeholders to focus on judgements, choices, and discussions rather than on extensive calculations.

Advanced computer-based decision support systems exist for various purposes and levels, for example, for urban planning, river basin management, water resource planning, and selection of crop varieties. Yet not many decision support systems exist for local land management. One bottleneck of such highly sophisticated systems is their data requirements, which often exceed the capabilities of many planning units or levels. Other constraints include high costs and dependency on IT specialists and programmers. Such systems may be more objective and accurate, but are typically less transparent than stakeholder-based decision aids. Thus, mistrust and suspicion may hamper the implementation of decisions reached in such a way. In addition, entirely software-based decision support systems tend to become an endpoint within the decision-making process and therefore get disconnected from it (Lawrence et al., 2001), leaving their developers as the sole users. Or it may happen that the issue at stake changes over time due to context dynamics or transforming stakeholder agendas, especially in the case of policymakers, rendering the software tool out-dated by the time it is ready (Oxley et al., 2004).

5.2.2 A generic DSS embedded in a decision environment

Despite the variety of simple and complex MCDA and DSS methods available, no single system is perfect or applicable in all decision-making situations; selecting the right one can be a challenge (Guitouni and Martel, 1998). In response to this, a group of researchers from Australia and the US developed a generic multi-objective decision support system called the "Facilitator" (Heilman et al., 2002). It is an open source tool that enables adaptations to specific contexts and the addition of new components without requiring that its existing components be rebuilt from scratch to accommodate the changes. Lawrence et al. (2001) suggest embedding the decision framework – in which a DSS like the Facilitator is used as an analysis tool –

into a broader decision environment, where the individual constituent parts are recognised and clearly connected. These constituent parts include “an effective process for stakeholder representation and involvement; the consideration and integration of biophysical, social, economic and cultural impacts; compliance with existing legislations and policies; access to information and expert opinions, and the use of visualisation technology to communicate complex spatial and temporal impacts” (Lawrence et al., 2001:1613). Ananda and Herath (2009) emphasise that future research should develop guidelines that foster true collaborative decision practices. The methodology described below is intended to address this need. Further, decision support systems have not been specifically developed to assist selection of SLM technologies to combat land degradation and desertification, whereby natural resources are at stake. For this purpose, a flexible framework is needed that supports decision-making with readily available, manageable data, and takes account of locally available SLM knowledge and experiences as well as external or new options. Access to knowledge from outside the local context is not always equally available to all stakeholders, and often depends on the support that land users receive from the government, for example, in the form of advisory services, professional training, or technical and financial support. True, effective collaborations and partnerships between stakeholders are the only way to bring land users’ generations of local experience and innovation together with scientists’ up-to-date ecological and technical expertise. Such collaboration needs to be present from the very start, beginning with the definition of the problem. But methods to support problem design are rare in multi-criteria decision-making (Janssen and van Herwijnen, 2006) and existing decision support methods often lack effective support for the selection and definition of options or alternatives to be compared. The decision support methodology presented here addresses this challenge by building on two elements: the WOCAT database of SLM options and a participatory problem assessment conducted in a stakeholder workshop (see Section 5.3.1 below).

Whether the SLM measures selected will be implemented or not strongly depends on factors like cost-effectiveness, the severity of land degradation, available knowledge, and enabling framework conditions (e.g., policies, subsidy schemes). As such, these issues are very relevant when initially comparing SLM options and must be included as criteria in comparative analysis tools. Making evaluations in a multi-stakeholder setting helps to ensure that decisions accurately weigh the different options, balancing short-term economic and long-term societal and environmental goals.

5.3 Materials and methods

5.3.1 The DESIRE decision support methodology

The DESIRE research project aimed at selecting, testing, and upscaling SLM strategies to mitigate desertification (DESIRE, 2011; Reed et al., 2011). It provided an excellent opportunity to develop and test a generic decision support methodology, considering all the issues described above. The aim was to support 14 study site teams in selecting an appropriate SLM option following assessment of the context, stakeholders, and desertification indicators. The decision for a particular SLM technology was then followed up with test implementation in the field, thorough monitoring, and upscaling through modelling of regional effects and dissemination.

The overall methodology consists of three constituent parts (see Fig. 5.1): initial joint identification of problems and existing SLM solutions (Part I); evaluation and documentation of the identified locally available SLM technologies (Part II); participatory decision support in selection of potential SLM options for test implementation (Part III). The overall methodology and a thorough analysis of experiences with implementing Part I have been presented in Schwilch et al. (2009). The present paper focuses on Part III – the decision support process – hereafter called the DESIRE-DSS.

The DESIRE-DSS uses the following tools and approaches.

1. The WOCAT database containing SLM technology options from within the given local context as well as a wide range of options from other contexts around the world.
2. The Facilitator, a Multi-Objective Decision Support System (MODSS) and open source software (slightly adapted for the DESIRE context), which supports certain steps of the evaluation and decision-making process.
3. A participatory approach to guide the multi-criteria evaluation process and subsequent decision-making regarding SLM technologies to be field-tested.

Target groups include stakeholders from the local level – such as land users, representatives of local authorities, interest groups, local NGOs – and external stakeholders, for example researchers or development professionals belonging to NGOs or GOs. Attempts were always made to obtain a well-balanced group of stakeholders. The DESIRE-DSS is applied in a two-day workshop, facilitated by a moderator and structured according to a sequence of clearly defined steps as presented below.

Step 1. Setting the objectives
The goal of Step 1 is to reach a consensus regarding which objective(s) to focus on when selecting options for test implementation.

Step 2. Identification of alternative options
The objectives of Step 2 are twofold: (a) to identify with the help of the WOCAT database a range of options, namely, to agree on between four and seven feasible and promising SLM technologies that fit the selected objectives; and (b) to graphically represent these potential options for a better and shared understanding. The WOCAT technologies database contains data obtained through the standardised and internationally recognised WOCAT questionnaire on SLM technologies (currently 310 technologies from 44 countries) and offers a means to present and share documented experiences in a visually attractive summary format.

Step 3. Identification of relevant criteria for evaluation
Step 3 aims at identifying and agreeing on a set of 9 - 12 criteria (ecological, economic, and socio-cultural) per objective (as chosen in Step 1), relevant to the local context, according to which the different options can be evaluated. The criteria should reflect the most important qualities that each option ought to have for the three sustainability dimensions, and should also include offsite considerations. A set of criteria should be concise yet complete (all aspects represented, but defined as compactly as possible), operational (the criteria should be measurable), and non-redundant (no major overlap between criteria). The criteria are brainstormed in groups, then discussed and prioritised in a plenary. Reaching a common understanding of each criterion is crucial for the next step.

Step 4. Scoring the options
The main objective of Step 4 is to assess the extent to which each SLM option fulfils the different criteria identified in Step 3. A secondary objective is for the stakeholders to get to know each other's viewpoints and perceptions when assigning scores/values to the options, thereby enhancing knowledge exchange and mutual learning. The scoring is initially done in small stakeholder groups with participants relying on their own expertise in addition to detailed assessment data from the WOCAT database. Later, major scoring discrepancies between stakeholder groups are discussed and attempts are made to reach a consensus on each.

Step 5. Creating a hierarchy and ranking criteria

Instead of directly assigning quantitative weights to each criterion as is common in other DSS, in the DESIRE-DSS stakeholders simply rank the criteria in order of importance or preference, which is much easier and saves time. Higher ranked criteria are given more weight than lower ranked criteria, or criteria may be grouped as equally important. The approach is based on the hierarchy tree of decision criteria developed by Yakowitz and Weltz (1998). It requires grouping different criteria into separate categories, thereby avoiding bias caused by having too many criteria of one type (e.g., environmental) compared to other considerations (e.g., economic or socio-cultural).

Step 6. Analysis and interpretation

The objectives of Step 6 are to visualise the relative merits of the different options and to interpret the results. This step is done with the help of the Facilitator software, which normalises the scores between 0 and 1 according a selected score function (see Section 5.4.4) and combines it with decision rules developed by Yakowitz and Weltz (1998). The software produces graphs that visually represent the merits of the options. In addition to the overall graph, separate graphs are generated for each sustainability dimension.

Step 7. Prioritisation of options – negotiation and decision-making

In order to reach a final agreement on which options to select for (test) implementation, the results need to be negotiated among the stakeholders, especially regarding the potential need for compensation of sustainability between the three dimensions. This is the step in which the actual decision for one or more SLM options is made; it builds, of course, on the previous steps that were meant to support structured discussions and produce an informed decision rather than an accidental one.

Step 8. Embedding into an overall SLM strategy

The objective of Step 8 is to ensure that the options selected match the local SLM strategy and that framework conditions are considered. This includes seeking commitments from the stakeholders regarding subsequent pilot implementation of the selected SLM options.

5.3.2 Stakeholder workshops in the DESIRE study sites

The DESIRE-DSS was successfully applied in 14 DESIRE study sites. Table 5.1 presents the study site locations, the issues, and the types of stakeholders who participated in the workshops.

Ideally, the same participants take part in the first (Part I) and the second stakeholder workshops (Part III). However, this did not always occur in the cases described here. Such discontinuity of participation can be problematic, as it makes it difficult to follow up important discussions and conclusions from the first workshop. Participants may end up lacking the same basis upon which to make sound decisions, possibly putting the coherence of the process at risk. The main reasons found for discontinuity of participation were: high turnover of institution staff; institutions sending different participants to each workshop; loss of interest among some participants; time constraints, and poor workshop timing.

Members of the study site teams – researchers namely – moderated all the workshops, after receiving training in the methodology. However, the developers of the methodology recommend against this, since researchers themselves are stakeholders in the process and should carefully avoid mixing up their multiple roles (for more on this point see Schwilch et al., 2009).

Table 5.1. The DESIRE study sites and participants of DESIRE-DSS stakeholder workshops.

#	Study site [a]	Desertification Problem	Total	Thereof women	Thereof external [b]	Thereof land users	Participants participated in WS1 [c]	Reference
1	Spain, Guadalentin	Drought, soil erosion by water	15	27%	20%	53%	73%	López et al., 2009
2	Portugal, Mação and Goís	Forest fire, vegetation degradation, soil erosion by water	12	33%	17%	8%	58%	Coelho et al., 2009
4	Greece, Crete	Soil erosion by water, overgrazing, drought	8		75%	25%	n.a.	Kosmas et al., 2009
5	Greece, Nestos Basin	Salinization, irrigation problems	11	0%	27%	45%	55%	Diamantis et al., 2009
6	Turkey, Karapinar	Soil erosion by wind, drought, grazing problems	22	0%	27%	73%	50%	Zengin et al., 2009
7	Turkey, Eskisehir	Soil erosion by water	17	12%	41%	59%	82%	Tolay et al., 2009
8	Morocco, Sehoul	Soil erosion by water, gullying, drought, urbanisation pressure	30	27%	60%	13%	37%	Laouina et al., 2009
9	Tunisia, Zeuss-Koutine	Drought, competition for scarce water resources	27	19%	30%	48%	93%	Sghaier et al., 2009
10	Russia, Djanybek	Water logging caused by over irrigation, salinization in depressions	17	35%	29%	18%	76%	Zeiliguer et al., 2009a
11	Russia, Novy	Salinization, water logging and leaching of chemicals caused by over irrigation	24	8%	21%	17%	25%	Zeiliguer et al., 2009b
12	China, Loess Plateau	Soil erosion by water	14	14%	29%	21%	7%	Wang et al., 2009
13	Botswana, Boteti	Overgrazing, soil erosion by wind	18	39%	17%	67%	61%	Magole et al., 2009
15	Chile, Secano Interior	Soil erosion by water, gullying	22	32%		41%	52%	Ruiz et al., 2009
16	Cape Verde, Santiago Island	Soil erosion by water, drought, flash floods, dam siltation	28	21%	36%	32%	89%	Tavares et al., 2009

[a] Study sites # 3 (Italy, Rendina Basin) and # 14 (Mexico, Cointzio catchment) did not apply the DESIRE-DSS method

[b] External participants: researchers, development professionals, representatives of regional authorities, etc. Local participants: land users, representatives of local authorities, local NGOs, etc.

[c] WS1 = first stakeholder workshop (Part I)

5.3.3 Data analysis

In order to evaluate the outcome of the application in the 14 DESIRE study sites, data were collected using two methods: (a) evaluation of workshop reports from study sites; (b) study site feedback obtained via oral and written questions administered to study site teams.

The 14 study sites provided a workshop report following a predefined format. The data collected through these reports primarily included information about the results and conclusions of individual steps, but also about the options selected for test implementation, the evaluation of workshop participants and moderators, difficulties encountered, changes made, and recommendations.

While the workshop reports mainly focused on the results of individual steps, additional background information about the success or difficulties of the methodology was collected from the study sites. Informal interviews at project meetings and short questionnaires were used to obtain feedback from all 14 study sites. Strength, weaknesses and challenges of the DESIRE-DSS application were finally drawn by the authors.

5.4 Results and discussion of the DESIRE-DSS application

5.4.1 Setting the objectives

The chosen objectives ranged from protecting natural resources or developing agriculture in general to mitigating saline agricultural soils or wind erosion on pasture land in particular. Many of them focussed on conservation of soil and water. Table 5.2 gives an overview of the issues discussed.

Table 5.2. Objectives as selected at the study sites.

Issue	Objectives	Study site
Protecting natural resources	Land management practices for protecting natural resources	Greece (Crete)
	Land resources conservation	Chile
Mitigating land deg. / desertification	Mitigate land degradation and desertification effects	Cape Verde
Developing agriculture	Sustainable development of agriculture	Morocco
Soil conservation	Reduce soil erosion	Spain
	Increase soil fertility	Spain
	Soil quality conservation against salinization and water erosion	Russia (Novy)
	Soil conservation against water erosion	Russia (Djanybek)
	Protection of dry-farming areas from water erosion	Turkey (Eskisehir)
	Water and soil conservation	Tunisia
Water conservation	Reduce water loss	Spain
	Improvement of water mobilisation and management	Cape Verde
	Reduce water loss	China
	Fresh water conservation and effective use	Russia (Djanybek)
	Water and soil conservation	Tunisia
	Prevention of rapid drop in groundwater table	Turkey (Karapinar)
Mitigating salinization	Soil quality conservation against salinization and water erosion	Russia (Novy)
	Reclamation of saline and sodic soils	Greece (Nestos)
Forest protection	Reduction of burned area	Portugal
	Reduce the depletion of trees	Botswana
Pasture protection	Mitigate wind erosion on pasturelands	Turkey (Karapinar)
	Rehabilitation of pasturelands	Turkey (Eskisehir)

At three sites, different objectives – for example, for different land use types (cropland versus pasture land) – were identified and maintained throughout the process. This was shown to be possible and manageable, though it required twice the work of other sites. Further, managing a higher workload without extending the workshop duration likely compromised the quality of the stakeholders' deliberation process. As such, the authors recommend conducting separate workshops for each objective or running two parallel workshops, if possible.

5.4.2 Identification of alternative options

The preparatory screening of the WOCAT database for suitable SLM technology options enabled retrieval of a limited number of potential alternatives that fit both the local context and the main objective of each site. The richness of the global WOCAT database and available local options enabled sufficient range of choice. However, additional (mainly Mediterranean) SLM technologies documented by the other DESIRE study sites would have been an asset, but most study sites did not manage to enter the data in time. At nearly every site, locally applied technologies figured into the range of options considered. This may be interpreted as resulting from the first stakeholder workshop, which emphasised pre-selection of locally applied solutions, based on the belief that local solutions are often the best adapted. However, this may have precluded consideration of external options during the second stakeholder workshop, as participants had already discussed their local options and possibly favoured what they already knew. As a possible result, not all study sites considered options from outside their own context, namely, from other areas or countries. In some cases, nothing suitable was found in the WOCAT database. Portugal, for example, faces a specific degradation problem due to forest fires – something not yet covered in the database. Others found the available options insufficient, not applicable, or not advanced enough for the socio-economic conditions of their study site. It is true that the WOCAT database contains a limited number of case studies and thus cannot supply alternatives for every specific context. However, the authors also detected a certain unquestioned prejudice against solutions coming from developing countries. In fact, these measures are generally well-tested, cheap, and adaptable to different contexts.

In order to present and explain the pre-selected potential options to stakeholders at the workshops, it was recommended that illustrative posters bearing key relevant information in the local language be printed from the database. However, only a few study sites (Chile, Portugal, and Spain) prepared such posters. Most sites used projectors or written summaries to introduce and explain the options. Fig. 5.2 shows two poster examples.

Following presentation of the potentially viable options, workshop participants had to agree (or vote) on a final set of options to be assessed. Further, using options from external contexts usually requires certain adaptations, for example regarding plant species, ploughing equipment, or slope conditions. Some study sites optimised the range of options to fit their needs by either redefining certain measures according to broader categories or integrating similar measures into one technology (e.g., integrating all vegetative measures into one technology independent of plant species).

Figure 5.2. Examples of technologies in poster format from Portugal (left) and Chile (right).

5.4.3 Identification of relevant criteria for evaluation

Step 3 was often done in brainstorming sessions, where participants were asked to write the most relevant criteria on cards, which were then grouped and ranked in a plenary session. In many cases the brainstorming was done in separate subgroups, for example, farmers and non-farmers, enabling participants to identify and describe criteria in their own words. Not surprisingly, many of the study sites selected similar criteria. Most sites focused on increasing crop yields and decreasing soil erosion. The most frequently cited criteria in each sustainability category are listed below, as well as some (in italics) that one might expect to appear more often in such desertification contexts. Participants' overwhelming emphasis on soil erosion issues might be seen as a lack of awareness about the crucial role that vegetation plays in evaporation reduction and drought resistance in desertification-prone contexts.

Economic/production

- Increasing crop yields: 11x (in some cases explicitly including farm income increases)
- Increasing farm income: 8x
- Low costs of implementation/expenses of inputs: 8x
- Diversification of products/activities: 6x
- Increasing fodder/animal production: 6x

Ecological

- Decreasing/preventing soil erosion: 14x
- Increasing plant diversity/biodiversity: 6x
- Increasing organic matter content of soil: 6x
- Increasing water availability/quantity: 6x; plus 2x under "offsite"

- Improving/rehabilitating groundwater, river, and pond water: 5x
- Decreasing salinity/reducing risk of soil salinization: 5x
- *Increasing soil cover: only 3x*
- *Reducing evaporation: only 2x*
- *Drought resistance: only 1x*

Socio-cultural

- Promotion of association, neighbourhood solidarity; community/institutional strengthening: 7x
- Increasing food security: 6x
- Capacity building; increasing knowledge of conservation/erosion: 6x
- Increasing employment opportunities: 4x under “socio-cultural”, plus 3x under “economic”
- Reducing outmigration: 5x

Offsite:

- Various effects mentioned by four sites (Russia and Turkey), such as reducing damage to infrastructure/neighbouring fields, reducing river water demand, or suitability for dissemination

5.4.4 Scoring the options

The scoring of options according to the selected criteria was typically done in two groups, often land users versus other stakeholders. In order to conduct the scoring exercise practically and easily, the workshop guidelines suggest the use of a visual scoring tool: a paper ladder, on which small cards representing the different options (each with a photograph) may be placed along the score range depending on their performance for one criterion at a time (see Fig. 5.3). Nevertheless, many sites preferred working directly with a matrix table, despite its greater complexity. It is unclear why the suggested visualisation tool was not used more often. Possible key reasons include time constraints or that the moderators were not convinced that such a simple tool would facilitate the scoring work, in other words, they regarded it as unnecessary or too simple.

Figure 5.3. Rating the options concerning the criteria “maintenance costs” with the help of the scoring tool in Portugal (Photo: G. Schwilch).

Five study sites used a default scoring system ranging from rank 1 (very bad) to rank 7 (very good); six sites preferred ranking 1 to 5; three sites preferred ranking 1 to 10. Many study sites preferred a narrower scoring range, likely because it is easier and possibly more accurate, since estimates, not actual data, are typically used to justify specific scores. A rank of zero, indicating a "killer score" that eliminates an option from consideration, was used in three sites.

The Facilitator software normalises these scores to a scale of 0.0 – 1.0. Its scoring function is set to "more is better" by default, applying a straight line score function. The default setting was considered easier to work with than if each criterion were to use a different scoring function. Costs, for example, were therefore not assessed as "more is worse"; instead, they were adapted into criteria like "low-cost implementation" and scored accordingly.

In half of the study sites, finding a consensus on the scores assigned in the subgroups was transparent and occurred, as recommended, in a plenary discussion. By contrast, some sites simply averaged the scores or continued the decision-making process in the separate subgroups, both of which unfortunately precluded learning from other groups' positions, and opinions. Scoring the options through negotiation – getting to know each other's perceptions and gaining an understanding of the criteria different stakeholders may have – is an important step in the process. It can only occur successfully if group differences are made explicit. Differences in scoring between stakeholder groups in the study sites were found for farmers versus non-farmers (e.g., in Spain, Turkey-Eskisehir, Russia, and Cape Verde) as well as according to age group (e.g., in Greece). A statement from the Moroccan study site illustrates a key value of this step: "The scoring and its differences among stakeholders required discussions about the validity of every option with regard to the various criteria".

5.4.5 Creating a hierarchy and ranking criteria

Hierarchically ranking the criteria according to the three recommended sustainability dimensions (economic/production, ecological, socio-cultural) was done at all study sites. To expedite the process, some sites performed this step when initially selecting criteria (Step 3), though a more detailed understanding of the criteria gained after scoring would have been useful. Many sites likely underestimated the importance of the ranking in terms of its effect on the results of the Facilitator software. In fact, the ranking applies a weight to each criterion. Only the Portugal site considered ranking the main categories (economic, ecological, and socio-cultural) in addition to ranking the criteria belonging to these categories. By equalising the main categories in the ranking procedure, they ensured that no category was ranked above another in the overall result, for instance, economic criteria were not ranked above ecological criteria. Though this point should be looked at more carefully in the future, all the study sites correctly interpreted their results by separately examining each category before coming to an overall conclusion (see also Section 5.4.7).

5.4.6 Analysis and interpretation

In Step 6, the Facilitator software was used to visualise the relative merits of the different options and to interpret the scoring results.

The width of the bar in the Facilitator graph and its location relative to other options need to be interpreted and discussed with the stakeholders in order to understand the overall performance of each option. In most cases, there was no obvious favourite, as only options that have no overlap with other options appear distinctively better. Thus, careful interpretation and proper negotiation of results is imperative.

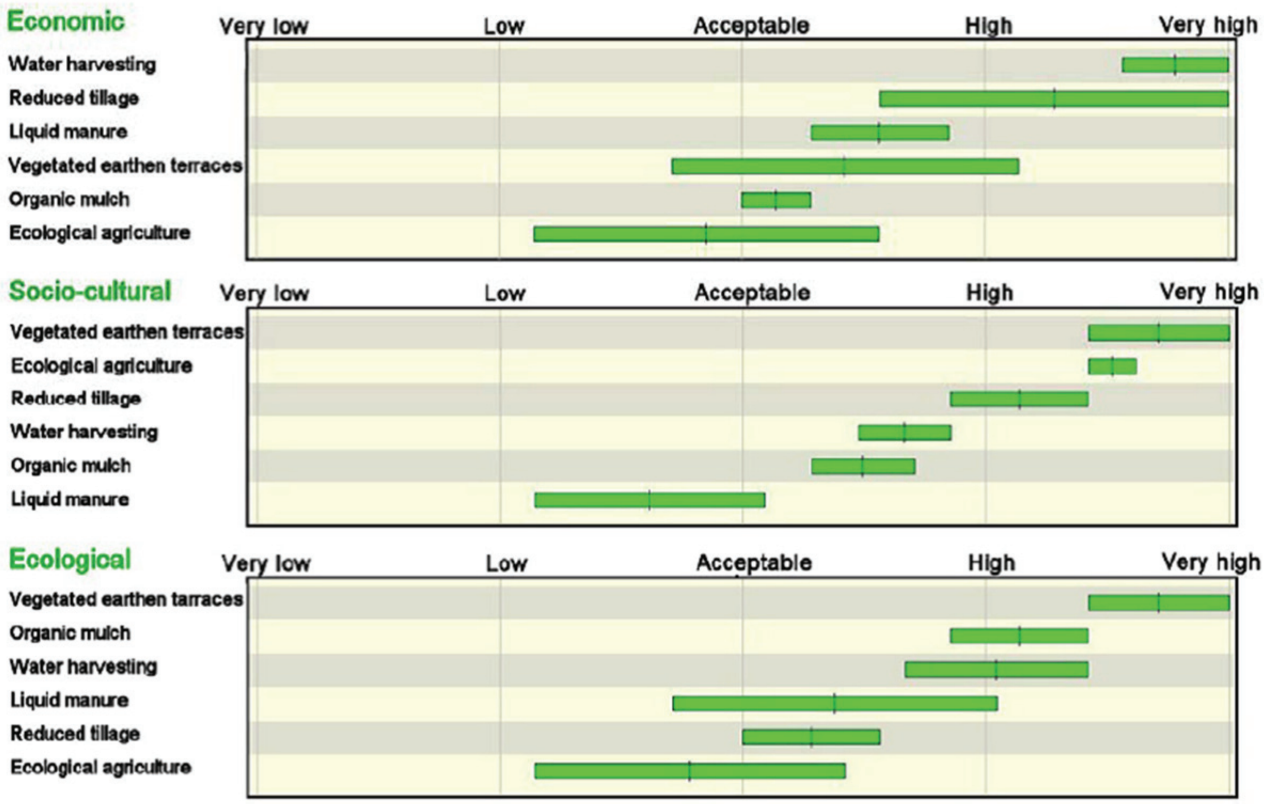

Figure 5.4: Analysis graphs as presented and adapted from the DESIRE Facilitator software in Spain (Illustration: J. de Vente). Individual SLM options are each represented by a bar. The width of the bar indicates the range of scores that a given option received, and the bar's position indicates its performance relative to the other options.

Fig. 5.4 shows a graph from Spain, adapted as recommended with qualitative range names (from "very low" to "acceptable" to "very high"), which are easier for stakeholders to understand than figures. Had the options been displayed alphabetically rather than according to their scores, it would have been even easier to compare the options across the three categories socio-cultural, economic, and ecological. Though a few study sites either struggled with the software or the interpretation of the results, all eventually applied it successfully. Below are some illustrative statements from the workshop reports:

"It took several attempts to finally realise success and display results for participants to review. It needs to be stated, however, that once we got the tool right, it came across as powerful and fascinating for the participants, as for the most part it confirmed their scoring." (Botswana)

"The DESIRE Facilitator software was used to objectively present the combined result of all opinions and for all criteria. It should be emphasised that the moderators always tried to be totally independent and did not participate at any time in the scoring process. So all the graphs obtained here reproduce exclusively the decisions, opinions, and desires expressed by the participants in a consensual way. After the presentation of these results, a passionate discussion took place regarding the hierarchy of water and soil measures as presented. The moderators explained that the opinion of each individual does not necessarily correspond to the overall results, which consider the opinion of all participants and all criteria used in the evaluation process. At the end of the clarifications and debate, the majority of the participants understood and agreed with the results." (Cape Verde)

"At first sight, several of the participants did not believe the results as presented in the graphs. Some participants even suspected that the data were manipulated by the workshop organisers. Therefore, the methodology behind the whole selection process and especially the Facilitator software was explained again, step by step. At the end of the explanation and discussion, the vast majority of the participants understood and agreed with the results as presented." (Spain)

These statements show that the use of the Facilitator software and the interpretation of the resulting graphs pose a challenge to the moderators and need to be done carefully. However, it was also reported that the software helps to explain the evaluations to stakeholders and to make the participants think in a structured way. Most workshop reports indicate that the moderators facilitated sound and careful analyses and interpretation. This is a prerequisite for the discussion in the next step, making Step 6 a key step for informed negotiation and decision-making.

5.4.7 Prioritisation of options – negotiation and decision-making

Step 7 is the logical consequence of Step 6 and was often not clearly separated, since the discussions about the graphs produced by the Facilitator naturally flow into decision-making. In some cases, the graphs clearly showed options that scored best. In other cases, this was not obvious and more extensive discussion and negotiation among the stakeholders was required. The stakeholders had to clarify whether, in a specific context, it was more important that a given option score better economically, socio-culturally, or ecologically. This provided an excellent opportunity to discuss such basic principles with stakeholders, though it simultaneously proved to be a challenging task. In most cases, the final results – the decisions for particular SLM technologies – appeared reasonably based on the preceding steps.

Occasionally, the participants wished it were possible to implement all the options (at pilot scale). According to a statement from the site in Spain: "*all the participants agreed that, in fact, all six conservation measures are viable and worth implementing in the field. A combination of these measures would be ideal.*" This might especially be the case where a clear favourite cannot be identified, and different options appear best for different specific situations within the area. At a few sites, financial constraints prevented decisions for preferred options. Such cases underscore the importance of carefully selecting relevant criteria for inclusion in the scoring and analysis, in particular criteria that reflect financial limitations. In Botswana, for example, budgetary criteria were not considered. While it would have been possible to iterate the process of criteria selection and scoring at this point in the DESIRE-DSS, time usually proves a constraint. Table 5.3 presents the SLM technologies that were finally selected by the study sites.

Examination of the decision-making in Step 7 makes it possible to judge whether certain sustainability dimensions were considered more important than others. In general, an option must score above 0.5 on the normalised scale in order to qualify as sufficiently good. Strong sustainability is achieved if an option scores above 0.5 in all three sustainability dimensions. If an option is selected whose overall score is above 0.5 based on an average obtained from good scores in two dimensions and a compensated low score in the third dimension, it is considered to exhibit weak sustainability (Dietz and Neumayer, 2007; Sattler et al., 2010).

In most sites, the results were clear with options that scored well in all three sustainability dimensions, though there may have been a general tendency to score optimistically rather than critically. Solely in three sites, the stakeholders had to settle for an option with weak sustainability. In Portugal, for example, only one option scored above 0.5 in both the ecological and the economic dimensions, and no option scored well enough in all three dimensions. The participants finally selected "preventive forestry", though it scored below 0.5 in the economic dimension, and "prescribed fire", which scored high enough solely in the economic dimension. In China, an option was initially chosen that did not score sufficiently, however, it was later abandoned for financial reasons. As a result, the final choice in China featured strong sustainability, and it was unclear why it was not selected at first. In Tunisia, the most preferred option featured strong sustainability, but the additional options selected for implementation displayed weak sustainability. Overall, no tendency was found in terms of participants' preferring options that scored highly in one particular dimension.

Table 5.3. Overview of technologies selected and implemented.

Study site	Selected technology	Test implementation	Land use
Spain	Reduced tillage	Reduced Tillage with disc-plough	Annual cropping (dryland cereals)
	Vegetated earthen-terraces	--	
	Ecological agriculture	Green manure through seeding of cereals and *Vicia sativa*	Tree cropping (dryland almond)
	Use of liquid manure as fertiliser	--	
	Organic mulch	Straw mulch to reduce evapotranspiration	Tree cropping (dryland almond)
	Traditional water harvesting structures	Traditional water harvesting (earthen wall to divert water)	Tree cropping (dryland almond)
Portugal	Prescribed fire	Prescribed fire	Extensive grazing (shrubland)
	Preventive forestry	Preventive forestry through strategic management of fuel strips	Forest (mainly pines, some eucalyptus)
Greece (Crete)	No tillage	No tillage, with and without application of herbicides	Tree cropping (olive)
Greece (Nestos)	Transport of freshwater from local streams instead (of saline groundwater)	Transport of freshwater from local streams	Annual cropping
Turkey (Karapinar)	*Caragana korschinskii* planting	Strip cropping, mulching	Annual cropping
	No-till technology	Zero tillage	Annual cropping
Turkey (Eskisehir)	Fanya juu terraces Stone bund of Tigray Contour planting	Sediment fences (woven branches) and contour tillage	Annual cropping
	Caragana Korshinskii planting	--	
Morocco	Vegetative strips	--	
	Treatment of gullies	Gully treatment with *Atriplex* plantation	Grazing
	--	Mulching and minimum tillage	Annual cropping
Tunisia	Tabia and jessour	Tabia and jessour runoff water harvesting technique	Tree cropping (olives), grazing
	--	Gabion check dams (flood water harvesting)	Tree cropping (olives), grazing
	(Enclosure)	Rangeland resting (enclosure)	Grazing
	Flood spreading and recharge units	Recharge wells	Tree cropping (olives), grazing
	Cisterns	--	
Russia (Djanybek)	Drip irrigation with supplied water	Drip irrigation	Annual cropping (vegetables)
Russia (Novy)	Drip irrigation	Drip irrigation	Annual cropping (vegetables)
China	Level bench terrace	--	
	Reforestation	--	
	--	Residue mulching (and contour ploughing)	Annual cropping (maize, millet)
	--	Infiltration contour ditch and grass planting	Tree cropping (orchard terrace)
Botswana	Biogas	Biogas to conserve woody vegetation	Grazing land (dung)
Chile	Zero tillage approach	No tillage in combination with crop rotation & subsoiling, contour strips, infiltration trenches or barrier hedges	Annual cropping
Cape Verde	Afforestation	Afforestation/agroforestry	Annual cropping (maize and bean)
	Vegetative barriers	Vegetative barriers with *Leucaena, Aloe Vera, Cajanus Cajan*	Annual cropping (maize and bean)

5.4.8 *Embedding into an overall SLM strategy*

Refining the overall SLM strategy draft that was developed in the first workshop proved difficult in most study sites. Embedding the concrete measures chosen into a broader political, socio-cultural, and economic context was a huge challenge for both the study site teams and the stakeholders. It was clearly impossible to develop comprehensive, coherent SLM strategies in so short a time with limited stakeholder representation. As such, the main aim of the strategy discussions was that of sensitising study site teams and workshop participants to the importance of considering the broader context in which they act, make decisions, select SLM options, and, especially, implement concrete SLM measures. Nevertheless, some sites achieved considerable results.

At eight out of 14 study sites, the stakeholders made commitments to support the test implementation phases. This is a very valuable and important step for creating stakeholder ownership of, and interest in, a given SLM project and its results. At some study sites, very detailed lists of who would do what were elaborated. However, at most sites, commitments were made in a more general way. In Turkey, governmental stakeholders who wanted to support the process still found it difficult to commit themselves or their institution, since they did not have the authority to do so, especially in terms of promising financial support. Such difficulties are likely to be found in many contexts.

5.4.9 *Implementation of selected technologies*

Most study sites eventually implemented the SLM technologies they chose in the second stakeholder workshop, as seen in Table 5.3. Two sites were unable to implement everything they had chosen, as they had selected multiple technologies. In Morocco, no farmer could be found who was willing to test the preferred vegetative strips on his land. This casts some doubt on the site's decision-making process and the involvement of farmers. Indeed, it was difficult to motivate farmers to participate in the workshop since their prospects for the future appear more connected to the nearby city than to agriculture. Further, their attachment to conventional land management systems was stronger than anticipated. Ultimately, the option perceived as second best was tested together with another option suggested by the researchers.

Before implementation could begin in Eskisehir (Turkey), the technologies chosen from the WOCAT global database required a lot of adaptation to the local context, including terraces with a ditch below, stone bunds, and contour planting leading into contour barriers with woven branches (and contour tillage). This was a consequence of the stakeholders' decision to work directly with technologies found in the database, opting to consider the necessary adaptations only after they had decided which ones to test. This finally caused frustrations, as the preferred option could not be implemented due to the unavailability of stones. The case underscores the importance of making preliminary adaptations to external options before scoring them, or at least considering potential key constraints during the scoring process. Indeed, if appropriate assessment criteria are selected at the outset, the unfeasibility of certain options will be detected early in the process. In this case, the criterion "expenses of inputs" was actually applied, but the costs of transporting stones from elsewhere were either ignored or simply overlooked.

In two other sites, the research team had already started to implement a selected technology before the workshop, and the stakeholder process only served to confirm their choice.

5.4.10 *Evaluation*

Workshop evaluation is an integral part of the workshop methodology. In general, the feedback on the workshop methodology was very positive, as indicated in the workshop reports. Most workshops reported that the participants were interested and liked the methodology, that participation was active and good, and that the working atmosphere was relaxed. More detailed feedback was obtained through informal interviews with the study site teams. Overall, the study site researchers judged the decision support methodology very favourably, often to their own surprise, as some were initially rather sceptical and critical of it (especially the natural scientists who had no prior experience with participatory approaches). The Portuguese team even went on to employ the decision support methodology on three subsequent occasions, finding it useful each time. Table 5.4 presents the study site researchers' appraisal, in their own words, of the strengths and weaknesses of the DESIRE-DSS.

Table 5.4: Judgement of the study site researchers regarding quality of decision support

Strengths	Weaknesses
• Good tool, very interesting • Very easy tool to compare different technologies • Technology selection and scoring exercise was very enjoyable, also for land users • Scoring is a strength, as it is otherwise difficult to quantify impacts • Helped to take good decision, facilitated our task. • The decision support methodology is strong in showing the results of the workshop • Analysis and display of software is really powerful – it worked wonders for our low literacy group • Facilitator looks complicated but is useful to explain results to the stakeholders • Easy handling, excellent visualisation • Use of Facilitator software and database has helped to get consensus • Better appreciation of potential strategies • Allows finding the optimum option for the local human and natural environment • Considers all sustainability dimensions, each criteria separated • Helps the stakeholders to think structured • More holistic than other approaches • The methodology is suitable to initiate interaction between different stakeholder groups and to integrate local and scientific knowledge • Technologies from database considered interesting because they are already implemented with results • Allows to discuss costs • Result can be shown to stakeholders, so they trust and feel better	• Not suited to remote areas (highly technical and needs electricity) • Difficult to work with participants with a low educational level • Running the software did pose a few problems • Time constraints didn't allow to use the Facilitator • Stakeholders hoped to get more technologies from other places • Farmers had the impression that the process was not totally transparent • Sometimes difficult to interpret the graphs • Stakeholders sometimes got bored due to too much information

5.5 Overall discussion and appraisal of the DESIRE-DSS

Supporting decisions on selection of SLM technologies together with stakeholders, in a structured and easy manner, is a challenging task. This was confirmed by the results of this study, in which a new comprehensive decision support methodology was applied in 14 different contexts around the world. The excellent opportunity provided by the DESIRE research project – a sort of "global laboratory" – enabled researchers to test the methodology in diverse real-world situations.

Based on the feedback from the study sites and the authors' own impressions from the workshop reports and oral communications, the following strengths, weaknesses, and challenges have been identified.

Strengths

1. A well-structured and holistic procedure: breaking down the decision-making process into a series of steps makes it possible to conduct a clearly structured process with stakeholders. Application at the study sites revealed the steps to be clear and manageable overall, and showed that the DESIRE-DSS can help stakeholders make decisions that balance economic, ecological, and socio-cultural considerations.
2. Independence of the method from context and issue: the DESIRE-DSS is applicable in almost any socio-economic or ecological context in the world. It is also independent of any particular subject matter, though certain aspects – such as use of the WOCAT database as an option pool – would require adaptation to topics other than SLM. On the other hand, the authors regard focussing on the emerging and holistic concept of SLM and linking it to existing tools like the WOCAT database to be particular strengths of the method.
3. Easy calculation and visualisation of results: the Facilitator software is very useful in calculating the weighted criteria in combination with the scores, a task that would be difficult to do manually. The resulting bars enable visual comparison of the options assessed.
4. Building understanding and awareness of other stakeholders' views: Each stakeholder group has an equal say in scoring, and the process of negotiating the scores in order to reach a consensus facilitates discussion of different points of view and opinions. This encourages participants to listen to the arguments of other stakeholders, prompts them to change their perspective and mind set, and enhances respect and understanding for other stakeholders' perceptions. While there are no guarantees, this at least provides a basis for making decisions that will be widely accepted. Finally, the integral process of seeking stakeholder commitments creates a sense of ownership of the implemented choices.

Weaknesses

1. Rigidity of the procedure: though cited as a strength above, the structured procedure may also be seen as a weakness, as individual steps cannot be skipped – for example, due to time constraints – without compromising the overall results of the process.
2. Software bugs: the version of the Facilitator software applied was not as easy-to-use as expected; it still had some bugs.
3. Limited knowledge exchange between study sites: conservative attitudes towards unfamiliar technologies and the fact that options from other contexts only enter the process in the second workshop – after local options have been discussed at length in the first workshop – carry the risk that these external options are overlooked or not given enough consideration.

Challenges

1. Options from other contexts require careful consideration regarding adaptation: Selecting external options from the WOCAT database in Step 2 demands a good understanding of SLM principles, appropriate knowledge of the local situation, and experience to judge if the options may be successfully adapted to the local context.
2. Proper use of decision support software: Moderators must clearly understand the potential and limitations of the Facilitator software, must grasp its purpose and reasonable use, and must be capable of properly interpreting and explaining the resulting graphs in order to avoid false expectations or mistrust among stakeholders.
3. The role of the moderator: The step-by-step process, where each step builds upon the results of the previous step, is challenging for moderators – and stakeholders – to implement. The methodology greatly depends on moderators' ability to guide stakeholders through the process. It is also up to moderators to address power inequalities between stakeholders. According to Kellon and Arvai (2011): "It is the responsibility of facilitators to provide the best-possible context or structure for decision-making". The well-structured methodology and detailed guidelines for moderators support them in exactly this task.
4. Properly integrating all three parts of the overall methodology: The methodology of the second stakeholder workshop (Part III) – and the overall methodology of the whole process – demand continuity from Part I through Part III in terms of the composition of stakeholders, the SLM objectives emphasised, and the options selected. Careful attention must be given to the initial stakeholder analysis in order to enable a better understanding of how stakeholders can be motivated to participate, and how they can be shown what the benefits of the process are for them.

One possible critique of the DESIRE-DSS is that it is too simple, and fails to address the full complexity of agriculture by focussing mainly on SLM technologies rather than agricultural systems or farmers' livelihoods/households overall. However, the DESIRE-DSS does incorporate knowledge about the local agricultural system and local livelihoods thanks to the expertise of the researchers and stakeholders who participate in the process. This includes their various perceptions of reality and what is desirable for the future (van Paassen et al., 2007). Nevertheless, the DESIRE-DSS could also be enhanced and supplied with extensive research data/databases – in complement to the knowledge of participating stakeholders and experts – providing an even greater scientific foundation upon which to base decisions.

Researchers elsewhere have concluded that it is rarely efficient or realistic to develop a specific DSS for a specific topic or context from scratch, or to reuse existing methods in a new situation (Oxley et al., 2004; van Paassen et al., 2007). Yet where sufficient time and funds are available, it certainly seems possible to develop a successful, targeted DSS in collaboration with stakeholders, in particular when development of the DSS is not the sole or even the primary aim, but simply a means to improved understanding and practice for all involved (Jakku and Thorburn, 2010).

5.6 Conclusions

Overall, the step-by-step methodology described in this paper is fairly easy-to-apply and, when done properly, helps to successfully facilitate joint decision-making processes among stakeholders. The feedback from users and the positive outcomes confirm the capacity of the methodology to successfully guide decision-focused participatory processes. Indeed, the methodology presented above appears to fill an important gap noted by Kellon and Arvai (2011) and others. Kellon and Arvai (2011) describe the following issues as being crucial for higher quality decision-making: recognising and adapting to the constructive nature of judgements; ensuring that the basis for decision-making is both realistic and relevant; expanding the definition of expertise to account for local and traditional knowledge; adopting decision-focused stakeholder deliberation over public participation; and proceeding with decision-making in the face of complexity and uncertainty. Based on the results of applying its methodology in 14 study sites around the world, the DESIRE-DSS appears capable of successfully addressing these issues.

Stakeholder participation in decision-making is essential. If the process is well structured and transparent, stakeholder involvement can lead to more effective, stable decisions. Nevertheless, more research is needed to evaluate "whether decisions emerging from participatory processes are perceived to be more holistic and representative of diverse values and needs, and whether this has the capacity to enhance public trust in the decision-making process" (Reed, 2008). Providing opportunities for scientific experts and local stakeholders to share their knowledge, on an equal footing – as in the DESIRE-DSS – appears to be a step in the right direction. The long-term sustainability of decisions reached in such a way remains to be seen and should be evaluated at a later stage. Increasingly, such processes are acknowledged for their impact on stakeholder learning, an issue discussed in a related paper (Schwilch et al., 2012b).

SLM is a highly complex issue, and the decisions that it requires are a challenge for everyone involved. By providing a structure and facilitating corresponding decision-making processes, the DESIRE-DSS appears capable of making a long-term contribution to the advancement of SLM.

Chapter 6

A structured multi-stakeholder learning process for sustainable land management

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A structured multi-stakeholder learning process for sustainable land management

Abstract

There are many, often competing, options for Sustainable Land Management (SLM). Each must be assessed – and sometimes negotiated – prior to implementation. Participatory, multi-stakeholder approaches to identification and selection of SLM options are increasingly popular, often motivated by social learning and empowerment goals. Yet there are few practical tools for facilitating processes in which land managers may share, select, and decide on the most appropriate SLM options. The research presented here aims to close the gap between the theory and the practice of stakeholder participation/learning in SLM decision-making processes. The paper describes a three-part participatory methodology for selecting SLM options that was tested in 14 desertification-prone study sites within the EU-DESIRE project. Cross-site analysis and in-depth evaluation of the Moroccan and Portuguese sites were used to evaluate how well the proposed process facilitated stakeholder learning and selection of appropriate SLM options for local implementation. The structured nature of the process – starting with SLM goal setting – was found to facilitate mutual understanding and collaboration between stakeholders. The deliberation process led to a high degree of consensus over the outcome and, though not an initial aim, it fostered social learning in many cases. This solution-oriented methodology is applicable in a wide range of contexts and may be implemented with limited time and resources.

6.1 Introduction

Worldwide, land degradation and desertification are key environmental threats, especially in drylands (Millennium Ecosystem Assessment, 2005). The United Nations Convention on Combating Desertification (UNCCD, 1994) is tackling the threats from a global perspective, yet acknowledges that they require local-scale solutions. The most promising response to emerge in the last twenty years is the concept of Sustainable Land Management (SLM), which addresses technical and ecological aspects as well as economic and socio-cultural dimensions (Hurni et al, 2006; IAASTAD, 2008). Emerging from the concept of Soil and Water Conservation (SWC) as a technical task, SLM encourages an integrated, holistic perspective on land management (Schwilch et al., 2011). While SLM is increasingly promoted at the policy and development cooperation level (World Bank, 2006), its actual use remains limited to a minority of innovative land users and those practicing sustainable traditional systems (WOCAT, 2007; Critchley, 2007). Various implementation and research projects (GEF, 2009; Zdruli et al., 2010) have addressed the challenge of upscaling SLM, providing numerous recommendations and possible approaches. They range from sophisticated decision support systems (Ananda and Herath, 2009; Kellon and Arva, 2011) to improved enabling environments (policies, subsidies) (Akhtar-Schuster et al., 2011) and promotion of social or sustainability-oriented learning processes (Rist et al., 2006; Reed et al., 2010; Tàbara and Pahl-Wostl, 2007; Armitage et al., 2008; Leeuwis and Pyburn, 2002). While all are useful and cover many key aspects, there is an apparent lack of a practical, structured (yet flexible) methodology for fostering SLM in diverse contexts.

6.1.1 Multi-stakeholder participation and social learning

Much attention has been given to the role and participation of stakeholders. Collaborating with land users and other stakeholders is now considered a precondition for successful SLM. While the traditional concept of knowledge and technology transfer – from researchers to agricultural advisors, and then to land users –

is still practiced in many areas, the shortcomings of this one-way approach are increasingly acknowledged (Fry et al., 2003; Gabathuler et al., 2011). Multi-stakeholder approaches have become increasingly popular, which integrate land users, technicians, governmental and non-governmental officials, and decision makers at all levels – locally, nationally, and even globally (Bouwen and Taillieu, 2004; Hemmati, 2002; Hurni, 2000). Similar approaches also exist in other sectors such as environmental and community planning (e.g., Wates, 2000; Stevens et al., 2010), tourism destination planning (e.g., Wray, 2011), spatial and urban planning (e.g. Healey, 1997; Innes, 1996), and transport (e.g., Bickerstaff and Walker, 2005). Appeals have been made to integrate stakeholder perspectives, beginning with the design of SLM projects all the way through to implementation and monitoring (Chess and Purcell, 1999; Gonsalves et al., 2005), ensuring that their knowledge is fully integrated throughout the process (Stringer et al., 2007). Transdisciplinary approaches are gaining in importance in development research (Rist et al., 2007; Pohl et al., 2010; Roux et al., 2010). Though stakeholder involvement is clearly important, it does not *ipso facto* guarantee better SLM practices (Scott, 2011).

Indeed, “simple” stakeholder participation is increasingly seen as insufficient, and attention has shifted to social learning as a key issue (Armitage et al., 2008; Reed et al., 2010). Social learning – a philosophy emphasising participatory processes of social change – has gained prominence in projects and studies on sustainable agriculture and natural resource management (Schneider et al., 2009) as well as in monitoring and evaluation of impacts (Cundill and Fabricius, 2009). Within the scientific literature, various movements or groups of authors may be distinguished: On the one hand, there are those who lean towards the natural sciences and wish to promote “adaptive co-management” within natural resource management, such as Armitage et al., 2008; Berkes, 2009; Cundill and Fabricius, 2009; Reed et al., 2010; Pahl-Wostl et al., 2008; Tàbara and Pahl-Wostl, 2007; and Schusler et al., 2003. On the other hand, there are various authors – often social scientists – who focus on “lifeworlds” and livelihood learning, and emphase the sustainable development of agriculture and farmer collaboration for development (Rist et al., 2006; Röling and Wagemakers, 2000; Warner, 2008). Both movements acknowledge that social learning remains inadequately defined and that there is a lack of consensus as to its meaning and theoretical basis. Reed et al. (2010) recently made a new attempt to define social learning as: “a change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions between actors within social networks.” Schneider et al. (2009) suggest that social learning comprises co-production of knowledge by land users, technicians, and researchers through a shared learning space, and that this is essential for jointly moving towards more SLM. Some researchers expand the social learning concept to include people’s actions, not just changes in their understanding (Pahl-Wostl et al., 2008; van Bommel et al., 2009; Garmendia and Stagl, 2010). Critically missing from this literature are suggested ways of assessing whether, and to what extent, social learning is actually taking place.

6.1.2 Need for a practical methodology

While the theoretical debate continues about the definition and concept basis of social learning, there is an immediate need for practical tools that enable stakeholder learning and foster SLM. However it is defined, social learning should be embedded in structures and processes that enable joint action (Schusler et al., 2003). Facilitating action towards implementation of SLM demands a targeted process that goes beyond analysis and discussion of problems of land degradation and desertification. The research and activities described here represent the efforts towards development of a tool that closes the relevant gap between scientific theory and practical implementation. Previous attempts have come up short for a variety of reasons: time requirements on participants, financial constraints, wishful thinking regarding stakeholder collaboration, the unavailability of well-trained and neutral moderators, unclear targets, unclear procedures, methods tailored to a single context, use of simplified cause – effect decision chains to address complex problems, or unrealistic expectations regarding broader impacts based on individual project results.

The present research arose from the request for a practical methodology that would enable selection of SLM strategies at a range of dryland study sites for later implementation and testing as part of the EU Framework 6 Desertification Mitigation and Remediation of Land (DESIRE) project. Challenges included the usual constraints: time restrictions, minimal financial resources, and the limited availability of facilitators and experts. A pragmatic approach was adopted since (i) it would likely apply to future SLM selection processes that face similar challenges and (ii) no ready-made method was available that suited the diverse natural and human environments included in the DESIRE project.

After a brief description of the research methods and the approach developed in the EU-DESIRE project, the results of applying the DESIRE methodology are presented and discussed. To begin, stakeholders' participation and interactions are analysed. Next, stakeholder learning and facilitation of SLM are explored. Following this, participants' overall feedback on the methodology is analysed. Finally, stakeholders' perceptions of this new methodology for selecting SLM strategies is assessed as well as the multi-stakeholder learning that took place.

6.2 Research design

The activities presented in this paper were conducted in the context of the EU research project DESIRE. Though rooted in the natural sciences, the research project design sought to enable close collaboration with stakeholders. A transdisciplinary approach was chosen, making it possible to involve stakeholders from the early stages. Transdisciplinary methods are especially appropriate when searching for solutions to "real-world" challenges such as SLM, which have a high degree of complexity, uncertainty, and controversy (Schneider et al., 2009; Nowotny et al., 2001; Rist et al., 2006). Due to the diverse environmental, economic, and socio-cultural contexts of the 16 DESIRE study sites – located in seven Mediterranean (Portugal, Spain, Italy, Greece, Turkey, Tunisia, Morocco) and six other (Russia, China, Botswana, Cape Verde, Mexico, Chile) countries prone to desertification – it was important to adopt a methodological approach that could be applied and adjusted to fit very different conditions.

6.2.1 Process of selecting SLM options together with stakeholders

The DESIRE research project aimed at selecting, testing, and upscaling SLM strategies to mitigate desertification (DESIRE, 2011; Reed et al., 2011). During the project, a methodology was sought that would support the study site teams in selecting an appropriate SLM option, following assessment of the context, stakeholders, and desertification indicators. The decision for a particular SLM technology was followed up with test implementation in the field, thorough monitoring, and upscaling via modelling of regional effects and dissemination of results.

The overall SLM selection methodology consists of three constituent parts (see Figure 6.1): initial joint identification of problems and existing solutions (Part I); evaluation and documentation of locally available SLM technologies (Part II); participatory decision support for selection of potential options to be test implemented (Part III).

The methodology and steps have been described in greater detail in Schwilch et al. (2009) together with an analysis of experiences on the application of Part I. The decision support process of Part III is presented and analysed in Schwilch et al. (2012). The present paper focuses on the overall results regarding facilitation of SLM and multi-stakeholder learning. The premises, objectives, applied methodologies, and intended stakeholder learning of all three parts are summarised in Table 6.1.

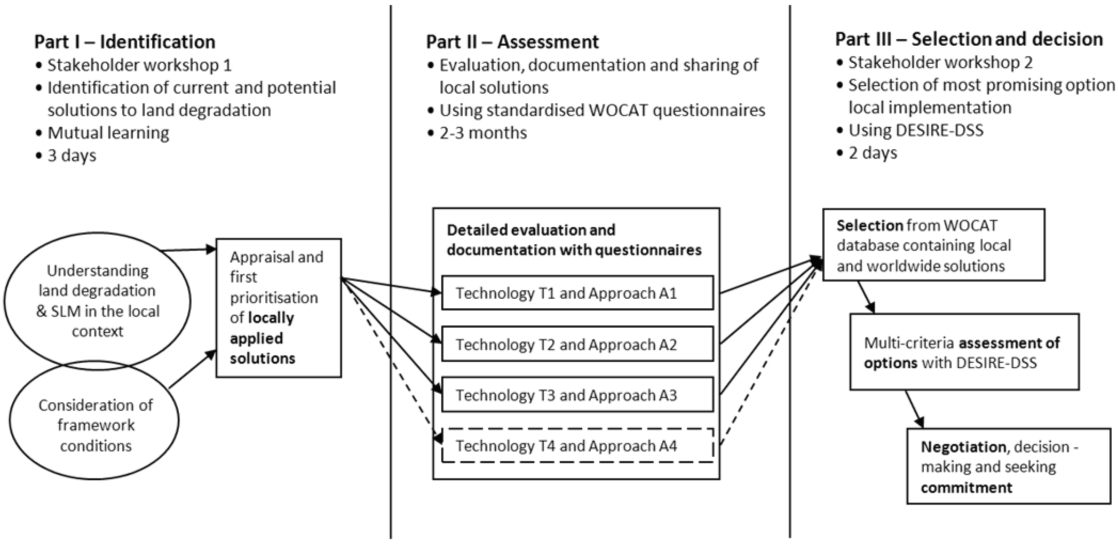

Figure 6.1. The three-part methodology for identification, assessment, and selection of SLM strategies (simplified from Schwilch et al, 2009).

Table 6.1. Stakeholder learning aims of the three-part DESIRE SLM selection methodology.

	Part I: Identification	**Part II: Assessment**	**Part III: Selection**
Premise	Local land users likely have existing SLM strategies; before proposing new solutions to combat land degradation, it is useful to look at what is already being locally applied	Not all local strategies are *a priori* effective and good; detailed assessment of local solutions is key	Stakeholders jointly select the best option from a range of choices, including carefully assessed local options and those from the global WOCAT database
SLM objectives	Identification of land degradation problems as well as existing and potential solutions in the local context	Assessing local solutions with a standardised evaluation and documentation tool	Selection and decision regarding SLM option for test implementation
Learning objectives	Initiate a mutual learning process; establish a common understanding of problems, potentials, and opportunities; initiate trust and collaboration	Joint reflection on SLM solutions; appraisal of ecological, economic, and socio-cultural advantages and disadvantages; exchange of SLM knowledge worldwide	Share perceptions of potential solutions; ponder criteria for assessment of SLM options; negotiate sustainability dimensions; make joint decisions
Methodology	Three-day stakeholder workshop based on the Learning for Sustainability approach; series of exercises: photo gallery, transect walk, diagnosis of water and biomass cycle, indicator identification, stakeholder analysis, preliminary assessment of solutions, outline of SLM strategy	WOCAT questionnaires on SLM technologies and SLM approaches enable a comprehensive review of experiences and sharing results with other study sites – and worldwide – via an open-access database	Two-day stakeholder workshop – aided by a decision support tool for comparative analysis and selection – to facilitate joint decisions regarding SLM strategies for implementation at the study site
References and further reading	Gabathuler et al., 2011; Schwilch et al., 2009	WOCAT, 2008a,b; WOCAT, 2007; Schwilch et al., 2011	Schwilch et al., 2012a

Comprehensive guidelines exist for each part (http://www.desire-his.eu/en/potential-strategies). The DESIRE study site teams received training in how to conduct them. Target groups include local-level stakeholders – such as land users, local technicians, representatives of local authorities, interest groups, local NGOs – as well as external stakeholders, such as researchers and development professionals (NGOs, GOs). Researchers are also considered stakeholders.

In a supplementary study, stakeholders at the sites in Morocco and Portugal were given an opportunity to further discuss selected and already implemented SLM options in a one-day monitoring initiation workshop (Santos, 2010). The aim was to bring the stakeholders together and jointly identify, select, and measure a set of environmental indicators in the field and to agree on a participatory monitoring schedule.

6.2.2 Data and methods of analysis

The suggested methodology was applied in 14 out of the 16 DESIRE study sites. To evaluate outcomes, an explorative research design was employed and data were collected using (a) study site feedback and (b) in-depth semi-structured interviews with stakeholders from Morocco and Portugal. Content analysis according to Flick (2005) was used to analyse the data in a qualitative manner.

Study site feedback

Study site teams' feedback on the overall three-part methodology was obtained via a short questionnaire and informal interviews and discussions at project meetings. In this way, it was possible to get inputs from all 14 study sites that applied the methodology (100%) regarding participants' initial expectations, their impression of the overall methodology and individual steps, their satisfaction with the outcome, their recommendations for improvements, their general conclusions, and whether or not they actually implemented the selected SLM technology. In addition, 11 researchers/teams (79%) provided information about their learning, their own contributions, their opinion about the composition of the group, their perception of conflicts and agreements, their assessment of the potential of the outcome, and the way their understanding changed throughout the process. It is important to note that this data solely reflects the researchers' perspective, not that of the other stakeholders.

Since the methodological approach is interdisciplinary and comprehensive, team members' professional backgrounds are crucial; the involvement of social scientists or those with prior experience in participatory processes is an asset. The teams in question were mainly composed of environmental scientists with backgrounds in agronomy, ecology, forestry, hydrology, geography, geology, soil science, etc. A smaller number of social scientists were involved in the work, including sociologists, human geographers, and economists. The range of team compositions encompassed:

- Mixed teams with a wealth of experience conducting participatory approaches (3 sites)
- Mixed teams where some members had prior exposure to participatory approaches (2 sites)
- Teams consisting mainly of natural scientists, with 1–2 researchers from the social sciences, all with no previous exposure to participatory approaches (3 sites)
- Teams consisting only of natural scientists, with minimal prior exposure to participatory approaches (2 sites)
- Teams consisting only of natural scientists, with no prior exposure to participatory approaches (4 sites)

Stakeholder interviews

In Morocco and Portugal, in-depth semi-structured interviews with various stakeholders revealed information about their involvement; their motivation and expectations; their learning, personal contribution, and changes in their understanding; their opinion of the group composition, conflicts, and agreements; and their perception of the methodology and the results. Interviewees were randomly selected from three main stakeholder categories, identified via a brief stakeholder analyses in the first workshops. The results presented below distinguish between the following stakeholder categories: land users (e.g., farmers in Morocco, or forest owners in Portugal); technicians (e.g., agriculture and forest specialists from government institutions and associations), and researchers belonging to each of the DESIRE study site teams.

Morocco and Portugal were selected as study sites since they represent various land use types – agro-pastoralism in Morocco and forestry and shrubland management in Portugal – have contrasting socio-cultural, economic, and political settings, yet have biophysical conditions that are comparable. In contrast to Morocco, all participants in Portugal had some prior experience with consultation processes or, in some cases, with participatory approaches. Those with prior experience may have perceived the methodology much differently, as they had something to measure it against.

The five people interviewed in Portugal – representing 42% of the stakeholders – comprised a land user, a researcher, two representatives of a local forest association, and one representative of the national forest authority. All participated in parts I, II, and III, except for the individual from the national forest authority, who solely participated in Part III.

The ten people interviewed in Morocco – representing 33% of the stakeholders – comprised two farmers, four researchers, and four technicians from governmental agricultural and forest services. To varying degrees, all the stakeholders were eventually involved in the subsequent test implementation phase. Many also participated in the corresponding monitoring workshops. Thirty-one evaluation forms completed by all participants in the three monitoring workshops provided further insights into stakeholders' perceptions.

6.3 Results: presentation and discussion

6.3.1 Participation, group composition, and interaction

Stakeholder associations: do they promote participation?

Identifying and stimulating people's motivation to participate in stakeholder processes is a crucial, yet challenging task. Since it is not always possible to adequately compensate them for their time, their interest must be sustained by other means. When asked about their reasons for participating, various stakeholder groups (70% of participants) cited the topic itself (SLM) as a motivating factor. In the Moroccan study site region, farmers' participation appeared to be constrained by the scarcity of farmer associations. By contrast, forestland owners in Portugal are well organised and representatives of their associations readily participated in the workshops. Santos (2010) examined participant types and preconditions for their later involvement in monitoring initiation workshops; she identified two main positive factors determining their interest, preparedness, and active involvement: landownership and membership in a civil society organisation. Stakeholders who own land are sometimes motivated to actively participate in local deliberations on land management issues. Nevertheless, persistent disinterest, absenteeism, and lack of investment among certain landowners in Portugal remain key obstacles to SLM on forestland in the region (Valente et al., 2011; Ribeiro et al., 2011). People's membership in a civil society organisation is typically linked with experience in actively participating in meetings and expressing ideas and opinions. Finally, individuals whose interests are represented by a broader civil society organisation may feel more powerful, motivating them to take action and get involved.

Group composition: balance and continuity of stakeholders

Most study sites achieved a relatively balanced group composition of local and regional representatives, governmental and non-governmental officials, and land users. Working in small groups of 10 to 20 people proved effective. Nevertheless, competent moderators who facilitate, push, and maintain the process were seen as indispensable.

Some study sites were unable to retain the same participants for the entire process. This applied to farmers and land users as well as to representatives of governmental and non-governmental organisations. Researchers in Morocco felt that this lack of continuity hampered the discussions and the overall process.

Overall, interviewees in Morocco and Portugal did not identify any category of participants that they felt disrupted, or was unnecessary to the process. Solely in Morocco, two stakeholders complained that there were too many participants with unclear roles, such as assistants or students, though workshop moderators ascribed them an important role as facilitators between farmers and senior researchers, especially during breaks. Nevertheless, one technician observed that "*the high presence of scientific people intimidated the farmers and made it difficult for them to express themselves*". While the desire of researchers and students to participate in and observe such "real-world" processes is understandable, achieving a good balance of participants appears to be paramount. Participation of observers and helpers should likely be limited to a level considered comfortable by other stakeholders.

Conflicts of interest: role of workshop process in mitigating conflict

No major conflicts of interest arose that impaired the participatory process at any of the study sites, even in cases of latent disagreement over use of resources. One Moroccan farmer cited the research-project context as a potential advantage: "*The atmosphere was relaxed. There were no conflicts mainly because there was nothing to distribute (e.g., material)*". Judging by the workshop evaluations and stakeholder feedback, participants generally appreciated the diverse viewpoints, visions, and opinions expressed as well as the balancing effect of the structured process, which enabled them to discuss their views and avoid impasses. Despite apparent power inequalities between the categories of stakeholders involved – for example, in contributing to and influencing decision making (Armitage et al., 2008; Hemmati, 2002) – such imbalances were not seen as an obstacle in the workshop process. A researcher in Portugal stated: "*Usually the representatives of national authorities have more power, appearing to represent more than one stakeholder. The locals fear this, giving rise to power imbalances. [In the DESIRE workshops] this effect was compensated by the high number of local participants*."

In the event that certain participants sought to influence others during the DESIRE workshops, moderators were credited with balancing out the process by emphasising that the content of stakeholders' suggestions counted most, not their position or perceived power. Indeed, there is a risk that certain interest groups might misuse stakeholder workshops as a platform to influence others and promote a particular ideology (Cooke and Kothari, 2001). This did not appear to be an issue at the study sites. The structured procedure and the workshop moderators appeared to preclude specific individuals or ideas from dominating.

6.3.2 Stakeholder learning

Learning between participants: a bias in favour of experts

Overall, all researchers in both Portugal and Morocco said that they learned the most from local stakeholders, land users in particular. 90% of the researchers at the other study sites confirmed this finding, emphasising how much they learned from local stakeholders' perspectives, once again highlighting land users. They particularly appreciated land users' integrated knowledge about the environment and their perception of challenges and solutions. The researchers especially realised that finding applicable and valid solutions to complex problems such as desertification requires analysis from different perspectives and must be done in consultation with the stakeholders concerned. The researchers learned from land users' practical experiences, their understanding and perception of the degradation and conservation processes, and their planning strategies. And, in the words of the researchers, they learned "*how to talk to them*".

Some researchers claimed to have acquired a "*new ability to listen to and translate the opinions and knowledge of end users into scientific understanding of processes*". This attests to researchers' increased awareness of the value of stakeholder workshops, as well as how challenging they can be, requiring thorough preparation.

On balance, the researchers and technicians appear to have learned more from each other and from the land users than the land users learned from them. Though land users in Morocco did mention things they learned from other stakeholders in later interviews, they initially claimed to have "*learned nothing*" or something too specific to apply to their own experience. Some claimed things went too fast to be understood. This might be attributed to the education gap between stakeholders in Morocco or to the perceived dominance of academic knowledge over land users' empirical knowledge. In both cases, the moderator's ability to carefully balance stakeholders' capacities and power is crucial.

In contrast to Morocco, land users in Portugal claimed to have learned from the other stakeholder participants from the outset. Other DESIRE sites also indicated such learning on the part of land users, even where education levels differed as they did in Morocco. In Cape Verde, for example, land users were grateful to learn about various SLM technologies and how they are applied in other areas and countries. In Botswana, land users were eager to participate and learn from other stakeholders.

Perceived significance of contributions: local stakeholders underestimate themselves

Almost all the participants in Morocco and Portugal (90%) felt that they were able to express their opinions freely and were able to contribute something that the others could learn from. The land users made valuable contributions based on their local and practical knowledge, yet often underestimated their importance. Other studies (Bachmann, 2003) have confirmed that stakeholders with lower education levels are generally less aware of their own contribution to such processes. In the monitoring initiation workshops as well, many local participants had little notion of how much they contributed. While they acknowledged having a voice in the discussions, they often failed to recognise that they had taught others in addition to learning themselves. Nevertheless, they acknowledged exchanging information and influencing the result.

The technicians typically cited making contributions based on their field experience and technical knowledge. This was only partly recognised and acknowledged by the other participants.

Aside from explaining external technologies, the researchers saw their own contribution as mainly that of reflecting other participants' ideas and guiding the deliberation process. Researchers at other study sites echoed this sentiment, perceiving themselves as guiding the process rather than presenting facts. This might be contrasted with widespread societal assumptions that it is researchers who deliver the solutions to problems. Nevertheless, at some sites, researchers were occasionally observed to be teaching rather than listening and discussing.

Improved SLM understanding: no fundamental change, but deepening knowledge

Indications of what participants actually learned could be found in their statements about changed understandings of SLM and the usefulness of their new knowledge for SLM implementation. While many (80%) claimed to have learned from each other and the process itself, it appears that most (90%) participants already had a general understanding of the basic principles and that for 45% this did not improve significantly. This may also be seen as proof that the participating stakeholders were indeed those playing key roles in local desertification issues. Further, since they already had lots of experience and knowledge of the issues, they might be seen as less likely to change their perception or acknowledge changes in their understanding.

Land users in particular had difficulty specifying what they had learned. Land users in Morocco could not identify a direct use for their new SLM knowledge. However, land users in Portugal did specify having learned about developing and applying technologies to combat desertification.

All the technicians in Portugal and Morocco believed what they learned was useful, perhaps not for their current daily tasks, but for future work and in the sense of continuing education. A representative of the Portuguese national forest authority, for example, felt his knowledge of Sustainable Forest Management had increased, giving him more confidence to act in similar situations and areas of forest degradation. Others appreciated the opportunity to talk and connect with colleagues in the same field, and to collaborate directly with institutions that they usually work parallel to.

All the researchers considered what they learned to be useful for their future work, suggesting it provided them methods to make their research more applicable. Some researchers claimed to have a newfound grasp of the extent of desertification problems, the urgent demand for integrated solutions, and the socio-cultural and economic obstacles to certain SLM technologies. Researchers at the other study sites echoed these statements, suggesting that their understanding had changed and deepened during the process. They stated, for example, that they had come to see the challenges as much more complex than previously anticipated. Others claimed to have realised that studying and analysing SLM technologies was not enough to understand and successfully combat desertification, but that it requires getting engaged and involved in field implementation as well as meeting with the local stakeholders.

Learning issues: going beyond SLM

"*I very much liked the moderator and his way of moderating the workshop. I learned about the way of moderating a workshop and how to involve everybody. I also learned about vegetative and agronomic measures for soil restoration, e.g., crop rotation, vegetative techniques, etc. I learned something from every participant and I found everyone's contributions very interesting.*" These words of a Moroccan engineer from the provincial government nicely summarise the two main areas that stakeholders mentioned having learned about: (a) SLM and how to combat desertification in their region; and, (b) a methodology for achieving a common understanding of a complex issue and jointly selecting a possible solution. Point (b) was not originally intended per se, but is a welcome development. The researchers particularly appreciated the methodology, stating that it was useful for their own professional work. Various technicians (50%) also singled out the methodology as having taught them something, citing, for example, the "*organised process of sharing perspectives and ideas*" or "*the advantages of systematic discussions for analysis of arguments and for finding solutions*". This also indicates that the participants learned from the moderators and the way they implemented the workshop approach. One land user in Portugal claimed that the approach had taught him about the need for partnership and knowledge sharing to find a consensus.

6.3.3 SLM advancement

Agreement over SLM outcome: group consensus

Achieving a solid understanding of SLM is a basic requirement for its facilitation; agreeing on SLM technologies to implement in the field is the next step. The stakeholders all expressed the view that decisions for or against certain technologies were reached as a group. As one land user in Portugal put it: "*The group consensus led to a decision and the methodology helped achieve it.*" A land user in Morocco claimed to have learned from the group aspect: "*The process helped us reach a decision. I learned that it is better to make decisions as a group, because many ideas may be combined that would never occur to one person alone*".

Participants also noted how the second workshop made it possible to arrive at a decision on the supposedly best option based on the common ground established in the first workshop, in which a multitude of ideas were shared. The structured process and coordinated steps enabled final selection of SLM technologies for test implementation and ensured their overall acceptance by participants, as was confirmed by nearly all (90%) of the interviewees. Seeking commitments from all participants, an integral part of the process, facilitates agreement and increases the likelihood that chosen technologies will be implemented. According to a researcher in Cape Verde: "*Not only does the process help reach a consensus regarding which technology to implement, it also helps identify how each partner will contribute to the implementation*".

Perceived potential of selected SLM technology: appropriate and feasible solutions

The outcome of the selection process is as important (if not more important than) the selection process itself. How do participants judge the potential of the selected SLM technologies? All the stakeholders in Portugal and Morocco were optimistic about their selected technologies' potential to combat land degradation and desertification in their area. In Portugal, the SLM technologies "preventive forestry through strategic management of fuel strips" and "prescribed fire" were selected and eventually implemented. Stakeholders felt these SLM technologies would prevent forest fires and, consequently, prevent land degradation and improve profitability for landowners, potentially contributing to reversing outward migration. One land user emphasised that continuing research should monitor the performance and constraints of the selected SLM measure.

In Morocco, the selected technologies included "gully treatment", "vegetative strips", and "cereal residue cover and minimum tillage". The technicians saw these technologies as providing an effective solution for a small investment. The researchers were more sceptical about their likely impact and their potential for dissemination due to various social constraints.

Researchers at the other study sites were also optimistic about the chosen solutions' potential to benefit land users and the area, while combating land degradation and desertification (see Schwilch et al., 2012a, for details about all the SLM options selected). The researchers noted that all the stakeholders – including themselves – agreed with the final decision: "*It is based on both experience and scientific evidence"*.

Efficiency of process to facilitate SLM: time and structural limitations

All the study sites succeeded in selecting a promising SLM technology for test implementation. Participants noted how the structured process helped them achieve this aim in a rather short time (see also section 3.4 on "overall feedback"). Nevertheless, the timing and time investment required for such SLM facilitation processes remains a challenge. Two of the recommendations that emerged among study site researchers were:

- shorten the time required for the stakeholder workshops
- provide more time for discussing technology options

While the two recommendations appear to contradict one another, they both point to what may be the burning issue of participatory research: true participation and mutual knowledge exchange takes time, which is often in short supply among project implementers and stakeholders. Further, fostering close collaboration between researchers and stakeholders demands commitment and frequent contact. One technician in Morocco complained about the amount of time that elapsed between workshops, which appeared to diminish the approach's usefulness: "*After three months without contact, one forgets about the project. Especially for the farmers, this is a very long period. If something takes too long, it loses credibility among them. The farmers think we're wasting their time, while we get paid*". While the time between workshops was exceptional in Morocco, the technician's comment highlights how important it is for researchers to keep regular contact and devote enough time to collaboration, especially as this may help validate the time input demanded of land users and other stakeholders. This was an issue for the farmers in Morocco, according to one researcher: "*The farmers don't like to work a full day only with their head, talking and discussing… [It gives them the impression] that the researchers have earned a lot of money, while they have lost and wasted their time*." Though such land users are directly affected by land degradation, they may have the impression that researchers are imposing the SLM facilitation process to benefit themselves. At least initially, the time invested by land users has more social than economic significance for them and may only be exploited by a few. Better involvement of all stakeholders in the design of the process would be required, demanding yet more time of everyone.

6.3.4 Overall feedback about the methodology

Satisfaction versus expectations

Reviewing the specific expectations shared by stakeholders in Morocco and Portugal, it is apparent, and not surprising, that most primarily hoped to learn new ideas and achieve a useful result in terms of implementation. Satisfaction with the outcome was generally high, as all stakeholders felt that the most promising option was chosen, even if its implementation and replication might prove challenging. At the end of the collaboration, one land user in Morocco who was initially uninterested and was urged to participate stated, "*Afterwards I was pleased and felt I would have missed something had I not come*".

All the DESIRE study site teams described the methodology and their satisfaction with the outcome in positive terms: "very good", "high", etc. The coincidence of expected and real results was indicated as being "90–100%", i.e., "*reaching the desired level of satisfaction*". Participants described it as a "*great and innovative DESIRE project component*" featuring "*good workshops that went very well*". Table 6.2 lists the expectations of the study site teams as well as how well their expectations were met (though only for those who mentioned specific expectations – general statements of satisfaction were excluded). It reveals that even sceptical (mostly natural) scientists were impressed by the outcome and the strengths of the methodology. The difficulties faced by some study sites are also apparent, however, such as insufficient motivation and involvement of land users.

Table 6.2. Satisfaction versus expectations as expressed by study site teams.

Expectation	Count*	Satisfaction
Generally high interest in the learning approach; "*to get to know more than what was written in the project proposal"*	2x	*"It was a pleasant surprise to see how well this methodology worked in our country"*
No experience in participatory work and therefore low expectations; "*it doesn't sound very useful (e.g., games with stakeholders)"*	2x	The methodology helped to make stakeholders think and talk about their situation and identify problems, perceptions, and solutions; *"it really worked because stakeholders are part of the project and the decision"*
To help study sites conduct the project and run workshops efficiently; "*to learn about and get engaged in such a process"*	4x	The workshops succeeded due to innovative training and sound guidance on the methodology; "*it was extremely useful to know what to do when facing participants"*
Motivate stakeholders to participate in the project; *"to increase the interest of decision makers, researchers, and end users"*	2x	Stakeholders generally involved, but farmer attendance rather weak; *"in practice, it is not easy to get the stakeholders into the meeting and involve them in discussions"*
Knowledge exchange and co-learning between partners; *"a method to work with stakeholders and researchers"*	3x	*"Great component for fostering partnership between land users and researchers"*
Find a good SLM solution; answer the question "*which technology is the best for our research site?"*	4x	It proved a systematic and flexible tool for evaluating and finding the best SLM technology; *"the step-by-step process helps to arrive at a decision"*
Increased capacity to evaluate strategies, standardised across study sites; *"evaluation of existing and potential SLM"*	2x	It enables good documentation of evaluation results, though many details are required; *"the knowledge of the land users gets documented"*

** Counting how many times the expectation was mentioned by study site teams, out of 14 study sites*

Strengths and weaknesses of the methodology

When asked what they liked most or least about individual steps, the study site teams demonstrated a high level of agreement. In addition to being very satisfied with the method and the outcome in general (see below), their appraisals of individual methodological items were often identical. Table 6.3 gives an overview of the strengths and weaknesses of the three steps and their methodological elements as perceived by the researchers. The work with the water and biomass cycle in the first workshop and the scoring exercise in the second workshop were clear favourites. Both represent key parts of the workshops, which may explain participants' high level of satisfaction with their methodology. Participants also mentioned consensus finding and commitment seeking as highlights.

Table 6.3. Strengths and weaknesses of the SLM selection methodology cited by study site teams.

	Overall methodology	Part I: Identification	Part II: Assessment	Part III: Selection
Strengths	• a focused, useful, and appealing process; interesting for all involved • a progressive method for conducting a truly participative debate from start to finish • well-structured, logical steps that offer flexibility • well-guided workshops that encourage participation and sharing knowledge/opinion • stimulates valuable interaction between stakeholder groups and integration of local and scientific knowledge • democratic; gives everyone a voice without manipulating • adequate to follow the work; very useful guidelines • clear impact of each step due to stepwise deliverables	• the work with water and biomass cycles revealed illiterate land users' rich knowledge • the two cycles enabled stakeholders to consider processes, problems, and causes • the field transect enabled stakeholders to express their viewpoints • the work with photos was useful for land users • helpful initial assessment of existing solutions	• a useful and important tool • questionnaires ensure consideration of all aspects • ensures that land users' knowledge is documen-ted, something others fail to do • provides a comprehensive knowledge base • analysis and appraisal of approaches/technologies frame discussions	• technology selection/scoring exercises were interesting and enjoyable, also for land users, and occurred in an atmosphere of trust • very easy tool to compare potential strategies; helped stakeholders think in a structured way and reach a consensus • facilitated decision-making and worked well even for those low literacy • analysis and visualisation with decision support software is powerful and enriching • enables identification of best option for the local human/natural environment, considering all sustainability dimensions (including costs) • more holistic than other approaches • technologies from database appealing since already tested
Weaknesses	• raises expectations among land users that cannot be met (due to financial constraints) • both workshops are very long • acquiring engaged participants and more government support are key challenges	• connection between local and outside stakeholders compromised as the latter arrived on day two • boring compared to second workshop as much more had to be explained • strategy development was tedious	• documentation appears too academic, disrupting participatory process • difficult to get land users' view • long and costly • demands detailed (often unavailable) information	• good tool, but not suited to remote areas (needs electricity) • stakeholders hoped to acquire more technologies from other places • farmers felt the process lacked full transparency • the software did pose a few problems • interpreting the graphs sometimes difficult • stakeholders occasionally bored by glut of information

Based on the feedback of participants in Morocco and Portugal, the likes and dislikes of the stakeholder groups may be summarised as follows:

- **Land users** most enjoyed the field visits and the work with the photos in the first workshop, as these helped them to explain the phenomena in the field and learn about the problems and solutions.
- **Technicians** especially liked the moderated multidisciplinary and inter-institutional process, as it enabled improved understanding and discussion of different possible solutions, people's perceptions of the solutions, and their significance according to ecological, economic, and socio-cultural dimensions. Many stated that thinking and working according to these three dimensions was unusual for them. One engineer from a Portuguese national authority described his favourite workshop activity as follows: "*I most enjoyed the criteria-selection exercise; it was interesting to note people's different concepts. Multidisciplinarity reveals differing views of the same thing. It was interesting to articulate the differences, then to work to reach consensus*."
- **Researchers** also liked the structured and efficient methodology, singling out the work with the cycles (workshop 1) and the scoring exercise (workshop 2) as highlights. They especially appreciated the chance to work directly with stakeholders. In the words of one researcher in Portugal: "*Certain things arise when working with local stakeholders; aspects we would otherwise fail to consider*". For example, researchers expected restoration of burned areas to be the main priority of local land users and technicians. However, their main priority turned out to be preventing and mitigating large fires in the future, and their knowledge of the scale and complexity of the problem surprised researchers.

Only a handful of things were mentioned that the stakeholders disliked. (Half of the respondents did not identify anything that they disliked.) These included the long amount of time between the two workshops; the second workshop being less dynamic as it took place indoors; and, difficulties gaining commitments from participants who had to respect institutional hierarchies. The researchers in Morocco found the illustrations of external technologies difficult to understand and not useful for the farmers, though they acknowledged that the work with the photos "*got the participants talking*". Further, at most of the other DESIRE sites, the work with the photos was considered a major strength of the methodology (see above).

Overall feedback and recommendations

No major differences were found between the various stakeholder groups in Morocco and Portugal regarding their general assessments, which were overwhelmingly positive. Involving stakeholders from start to finish was cited by many as distinguishing the approach from others and as being a key to its success. The incremental progression according to clearly defined steps was seen as drawing out specific and complex ideas and contributions from stakeholders, rather than general inputs or evaluations that might be less useful. The work with the water and biomass cycle in the first workshop, for instance, enabled workshop moderators to obtain information from the stakeholders without requiring them to qualify things positively or negatively. At times, however, facilitating such complex contributions can be a challenge for workshop moderators. The moderator of the second workshop in Morocco had this to say: "*The way we communicate is very important. It is essential. Particularly with the farmers [finding the right way of communicating] takes some doing. Drawing out the farmers' ideas was not easy*."

Overall feedback from the other DESIRE sites was similarly positive. When asked what sets the DESIRE approach apart from other projects in their area, all but one study site researcher highlighted the participatory process and the involvement of all stakeholders. The two stakeholder workshops described in this paper build the core of that participatory process. Participants at half of the study sites cited the joint selection and decision process as a key innovation (*DESIRE, 2010)*.

At many sites, stakeholders suggested continuing the collaboration through a third stakeholder workshop within the DESIRE project. The idea of a third workshop was adopted by the DESIRE management and organised at all study sites. It enabled review and discussion of implementation as well as modelling of results and further dissemination of the SLM technologies tested. The authors see the stakeholders' request for continued collaboration as a successful outcome of the participatory process. Positive feedback received in the third stakeholder workshop clearly emphasised the value and benefits of the participatory and inclusive approach (8 study sites), having the opportunity to learn from other participants (4 study sites), and the generation of policy contributions (3 study sites). Negative feedback focussed on lower levels of engagement from land managers (5 study sites), the time-consuming nature of the process (2 study sites), and concerns about whether there would be resources available to continue or build on the research in the future (2 study sites).

Many of the researchers even suggested that the methodology should be adopted as the standard SLM selection methodology and replicated elsewhere. They saw it as enabling both stakeholder participation and scientific rigor, while systematising knowledge in a manner useful to practitioners and researchers. Certain ideas, principles, and tools of the methodology have already been replicated in Portugal: the decision support component was successfully applied three times in other areas. Many other study site teams indicated plans to use the methodology in other projects. The Tunisian team recommended extensively disseminating the methodology through large-scale programmes and trainings in many regions. A Spanish researcher highlighted the methodology's flexibility: "*The approach appears useful for deciding upon and applying innovations in any field – not just agriculture – where different types of stakeholders are involved*".

6.4 Discussion of key issues

6.4.1 Facilitating SLM

Given the multiple benefits of SLM (FAO, 2011) and the growing cost of ignoring land degradation, more SLM strategies must be promoted and implemented that preserve land and water resources worldwide while sustaining production. Knowing what type of SLM is most appropriate in a given region is the key to successful, targeted interventions. Since promotion of SLM was a primary aim in the development of the methodology described here, the main emphasis was put on solutions (SLM) rather than problems (degradation, desertification) throughout the process. Enabling more and better SLM requires decision-making and implementation processes that foster the efficient, targeted collaboration of all relevant stakeholders. Research from the water-resource sector shows that sustainable management decisions demand extensive, systematic, and structured stakeholder engagement in order to deliberate over stakeholders' diverse, and at times opposing, perspectives and values (Lennox et al., 2011). Such stakeholder involvement ensures that all options are considered and that decisions balance short-term economic and long-term societal and environmental goals. Stakeholders must be included in the negotiation of sustainability goals, the selection of relevant SLM strategies, and the selection of indicators for progress monitoring. Fostering SLM, moving it beyond simple promotion of technologies (Nkonya et al., 2011), and maximising its benefit to human well-being demands structured, participatory approaches.

The pragmatic, practice-oriented methodology described here proved suitable in a number of diverse settings. It was applicable in all environments tested, within the given time and resource constraints. The findings also confirm a crucial observation made by others: a difficult trade-off must be made between enabling stakeholders to meaningfully participate in decision-making and respecting their limited time and resources (Proctor and Drechsler, 2006; Lennox et al., 2011). Nevertheless, as the results from Portugal and Morocco show, the presented methodology may be used to guide this challenging collaborative search for appropriate SLM practices in differing socio-economic settings. Successful application of the methodology by 14 study site teams in highly diverse contexts further confirms this.

The SLM technologies that were finally selected for test implementation appear very promising. Though in some cases SLM technologies were selected that were already used in the area, the process was important for three reasons. First, it helped stakeholders recognise that SLM solutions are available locally and that outside (technical) solutions are not always necessary. Second, these locally available solutions were carefully assessed and attached value during the process. Third, the interaction and learning process facilitates future collaboration and joint action for SLM.

Whether each of the SLM technologies selected will be successfully upscaled cannot be concluded at this point. While SLM strategies that are adapted to the local context bear great potential for upscaling and replication, much still depends on the presence or absence of an enabling environment. The enabling environment includes institutional, policy, and legal frameworks as well as capacity building, training, and financial or material support (WOCAT, 2007). Though each of these aspects is considered in the process described, they all require additional attention during follow-up to ultimately facilitate the spread of SLM. In many countries, existing extension and advisory services have been reduced or weakened in recent decades; they must be restored to support the upscaling of SLM (Liniger et al., 2011). Beyond this, incentive schemes and other ways of promoting SLM must also be considered.

6.4.2 Facilitating social learning

Is it possible to determine whether social learning took place at the DESIRE study sites? Reed et al. (2010) have identified three basic requirements for social learning. Each is briefly discussed below with regard to the results of the DESIRE sites:

1. *A change in understanding has taken place in the individuals involved, either on the surface or at a deeper level*.
   Almost all the participants in the DESIRE process claimed to have learned from each other. The majority also stated that their understanding of land degradation and SLM had improved. This requirement appears to have been fulfilled;
2. *The learning has gone beyond the individual to become situated within wider social units or communities of practice*.
   Whether the ideas and attitudes learned by the DESIRE participants were transferred to peers cannot be conclusively determined without additional research. Further, as the participants' positions in their communities and beyond were not assessed, it is difficult to determine whether their participation optimised the likelihood of broader social learning. At least among the stakeholder group represented by researchers – the study site teams – the results presented here show that learning went beyond the individual. Nevertheless, this requirement appears insufficiently fulfilled;
3. *Learning occurred through social interactions and processes between actors within a social network, either through direct interaction or through other media*.
   The two workshops in the DESIRE process facilitated social interaction through knowledge exchange and deliberation. The second workshop in particular emerged as a platform for deliberation and negotiation of perceptions and values (see 6.3.2 on "stakeholder learning"). It was found that learning was more effectively facilitated where strong social networks, such as civil society organisations, were already in place. Though the conditions appear to have been met to facilitate this aspect of social learning, and some qualitative evidence suggests it occurred in part, more in-depth evaluation would be necessary to determine the extent to which such learning took place. This requirement appears to have been fulfilled in part.

Based on these three requirements, one might consider that social learning was partially achieved at the DESIRE study sites. However, to determine whether these identified processes of social learning also led to fundamental transformations of cognitive, social, and emotional competences among the actors involved – as required by scientists such as Rist et al. (2006) and Schneider et al. (2009) – would require more in-depth study. Other important aspects of social learning include whether stakeholders' understanding of each other's perceptions and needs has improved (Garmendia and Stagl, 2010) and the extent to which their perceptions and objectives have been aligned through the process (Oxley et al., 2004). In the context of sustainability, the “silent voices” of future generations, non-human species, and other unrepresented groups should also be included in these objectives and efforts towards harmonisation. In this SLM selection methodology, such silent voices are included to a certain degree since stakeholders are required to assess SLM options according to the three sustainability dimensions. Finally, initial alignment of stakeholders’ perceptions and objectives definitely occurred. According to one participant in Morocco: “*Initially, the stakeholders were mainly concerned about their own interests. The farmers and the technical administrators thought about their immediate profits from the workshops. Gradually they shifted their views towards the interests of the entire zone affected by desertification and everybody openly exchanged ideas*.”

Due to complexity of the concept and shortcomings discussed above, the authors prefer to speak of “multi-stakeholder learning”, rather than “social learning”, in connection with the DESIRE process. Nevertheless, as different stakeholders and their organisations were “*linked through sharing time and space together*” (Schneider et al., 2009), implementation of the DESIRE methodology certainly created initial spaces for social learning.

6.5 Conclusions

Based on the results of its application and the feedback of participants, the SLM selection methodology appears to facilitate effective multi-stakeholder learning processes that contribute to more sustainable management of land. From start to finish, the process is highly solution-oriented by emphasising SLM rather than land degradation and combining a local, participatory approach with global knowledge sharing. The methodology manages to be well structured yet highly flexible. As described here, it is applicable in a wide range of contexts with limited time and resources, such as project settings. Nevertheless, such complex learning processes are challenging to accommodate in short-term research projects, as learning takes time. In the case of the DESIRE research project, providing initial training in the methodology to researchers and project staff was key. The training enabled researchers from single-discipline (mainly natural sciences) backgrounds to apply a holistic approach and tackle a complex problem together with a variety of stakeholders.

Though it was not a primary aim, application of the DESIRE methodology also fostered some social learning. The participants’ feedback attests to clear achievements in multi-stakeholder learning. The integrated group processes of deliberation and commitment seeking facilitated a high level of agreement among stakeholders and instilled a sense of responsibility in each regarding implementation of the SLM options selected.

Several key ingredients of successful multi-stakeholder learning were identified, including jointly reflecting on a clearly articulated issue – set in a specific context – and ensuring sufficient time and continuity to build trust.

For the land users, the work in the field and the visualisation tools turned out to be essential, since these activities reflect their reality and include hands-on testing. For the researchers, professionals, and technicians, getting to know the different perceptions of the various stakeholders proved most rewarding. Focussing on the three sustainability dimensions and the linkages between them helped make it possible to capture the complexity of SLM. This required that local stakeholders were engaged from the start and encouraged to accompany the process through field implementation. The researchers’ role in the process differed from prevailing assumptions about what their contribution ought to be. They primarily helped articulate and complement others’ ideas and guided the deliberation process, rather than simply presenting scientific facts. Nevertheless, the contributions of science are also needed and the participative process should not be misused to justify inaction due to uncertainty. In related research that is currently ongoing, researchers are considering how stakeholder participation affects the uptake of SLM and other beneficial environmental outcomes, by comparing the DESIRE approach with a range of other participatory processes.

Due to the short-term, pilot character of the DESIRE project, not all the aims of the methodology could be fully realised. As such, some DESIRE researchers suggested incorporating the methodology into governmental structures and regional initiatives. Indeed, long-term, institutional embedding of such processes would appear to offer the most promise, but will require commitment of human and financial resources. It is not enough to idealise and promote participatory approaches and learning processes – time and resources must be provided and long-term partnerships must be established. Facilitation of long-term engagement and dialogue among stakeholders is crucial. This will require expanded training of researchers, SLM specialists, agricultural advisors, governmental staff, and others in application of the SLM selection methodology. Large-scale application of the methodology would increase the likelihood of substantial improvements in the sustainable management of land.

Chapter 7

Challenging conservation agriculture on marginal slopes in Sehoul, Morocco

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Challenging Conservation Agriculture on marginal slopes in Sehoul, Morocco

Abstract

In Sehoul, Morocco, the use of marginal land for agriculture became a necessity for the local population due to increased poverty and the occupation of the best land by new owners. Desertification poses an additional threat to agricultural production on marginal slopes, which are often stony and degraded. In a participatory process embedded in the EU DESIRE research project, potential sustainable land management measures were selected to address land degradation and desertification. Promising experiences with no-tillage practices elsewhere in Morocco had motivated the Moroccan government to promote Conservation Agriculture throughout the country. This combination of crop rotation, minimal soil disturbance, and soil cover maintenance, however, had not yet been tested on sloping degraded land. Field trials of grazing enclosure combined with no or minimum tillage were conducted on the plots of two farmers, and trial results were analysed based on stakeholders' criteria. Results suggest that increased soil cover with barley residues improved rainwater use efficiency and yields only slightly, although soil water was generally enhanced. Soil moisture measurements revealed that no-tillage was favourable mainly at soil depths of 5 cm and in connection with low-rainfall events (< 20 mm); under these circumstances, moisture content was generally higher under no-tillage than under conventional tillage. Moreover, stakeholder discussion showed that farmers in Sehoul are primarily interested in animal husbandry and reluctant to change the current grazing system. Implementation of Conservation Agriculture is thus challenged both by the degraded, sloping, and stony nature of the land and by the socio-economic circumstances in Sehoul.

7.1 Introduction

Water shortage and land degradation pose challenges for land users in arid, semi-arid, and even subhumid areas and make the land in these areas prone to desertification. Land and water degradation have become a global concern and are expected to intensify in dry areas of resource-poor countries as a result of anthropogenic interventions and increasing extreme weather events due to climate change (Qadir et al., 2011). Numerous assessments have shown that in many dryland areas the functionality of land resources in terms of providing goods and services such as food, forage, fuel, and fibre is significantly declining (Bossio et al., 2007). Simultaneously, the pressure on marginal land with unfavourable agricultural conditions in terms of steep slopes, poor soils, unreliable precipitation, and remoteness is increasing in dryland areas under population pressure. Climate change, combined with increased demands for land and land products, add further urgency to the need for effective use of marginal land resources. Intensification and expansion of land use in marginal areas often have a negative impact, in particular on the water balance in the fields. A deteriorated water balance is characterised by increased water losses through runoff, drainage, and evaporation, while plant-available water is reduced, leading to less transpiration and less primary production. This leaves the soil exposed, and fewer crop residues return into the soil. Physical soil properties such as infiltration capacity and water holding capacity start to deteriorate, triggering a negative spiral towards less and less biomass production and, eventually, desertification (Stroosnijder, 2009). Especially eroded stony slopes are at risk of never reverting back to sufficient vegetal production, even if protected for a long time, as examples from Spain have shown (Garcia Ruiz, 2010).

In order to effectively mitigate land degradation and desertification, sustainable land management (SLM) in drylands must first and foremost tackle water scarcity. The focus of SLM options should therefore be on improving infiltration and reducing soil moisture losses. The amount of water lost through evaporation in dryland areas is generally underestimated (Njeru, 2005). Thus, SLM aims to conserve water as much as it seeks to conserve soil. Research in dryland areas also suggests that nutrients are even more critical to production than water (Stroosnijder, 2003; Rockström et al., 2009; Molden et al., 2010). Responding to these insights, Conservation Agriculture – that is, the combination of crop rotation, minimal soil disturbance, and soil cover maintenance – is a promising concept and an SLM practice now widely recognised and steadily spreading throughout the world (Derpsch, 2008). But Conservation Agriculture adoption in drylands faces critical challenges linked to water scarcity and drought hazard, low biomass production, and acute competition between conflicting uses including soil cover, animal fodder, cooking/heating fuel, and others (Rockström et al., 2009; Kassam and Friedrich, 2011).

The EU-funded DESIRE research project (www.desire-project.eu) sought strategies to combat desertification in 17 study sites around the Mediterranean and in other regions of the world with similar climates. All sites went through a participatory process to choose the SLM option considered the most promising in their specific natural and human environment for subsequent test implementation (Schwilch et al., 2009; Schwilch et al., 2012a). The Moroccan DESIRE study site was located in the commune of Sehoul, about 30 km south-east of the national capital of Rabat, in an area where desertification poses a threat to marginal and often stony slopes. The use of marginal land by the local population of Sehoul became necessary due to increased poverty, and because the best stretches of land had been occupied by outsiders – initially, during Morocco’s colonisation, by Frenchmen, and later by new owners from the cities. Before that, marginal land had been used only for grazing. The new state ownership of the forest since 1917, with restrictions on forest use for grazing, and the use of flat and high-potential areas for crop production led to an increase of the pressure on the remaining grazing areas.

In North Africa, Conservation Agriculture practices have been promoted particularly in Morocco and Tunisia. By 2009 they covered no more than 4,000 and 6,000 ha, respectively (Derpsch et al., 2010). Nonetheless, promising experiences with no-tillage practices in some areas of Morocco have motivated the Moroccan government to promote Conservation Agriculture throughout the country from the mid^{-1}990s onwards (Mrabet, 2008). Long-term experiments have shown that Conservation Agriculture improves soil properties, that it out-yields conventional agriculture, especially in dry years, and that it is highly profitable, because it usually saves costs due to reduced use of machinery and lower operating expenses, while at the same time increasing crop performance (Mrabet, 2008). In light of its environmental advantages it is thus viewed as an appropriate means to combat desertification as well as enhance climate change adaptation.

Recognising that livestock is an essential component of Moroccan semi-arid rainfed agricultural systems, Moroccan researchers have suggested a 3-year rotation of wheat/barley, forage, and fallow, which simultaneously satisfies needs regarding water storage, wheat/barley yields, and soil fertility (Mrabet, 2008). However, the success of Conservation Agriculture depends on the combination of crop rotation, minimal soil disturbance, and soil cover. Crop rotation alone, as it was observed in some parts of Sehoul, fails to maintain soil organic matter, which continues to decline due to continuing conventional tillage (Ibno Namr and Mrabet, 2004). Prior to the present study, Conservation Agriculture in Morocco had not yet been tested on sloping and marginal land, where its application was likely to be more difficult due to steepness and deteriorated soil conditions. The present study aimed to narrow this gap and contribute to the ongoing discussion about these issues.

This paper presents some insights into the potential of Conservation Agriculture applied on marginal and stony slopes in Sehoul. It evaluates its applicability and tests whether better soil cover and minimised soil disturbance specifically lead to increased production and an improved water balance. On-farm trial results are assessed and discussed based on stakeholders’ criteria. These were defined during the participatory process of selecting an appropriate SLM option, and integrate the ecological, economic, and socio-cultural dimensions of sustainability.

7.2 Materials and methods

7.2.1 Study site

The research was conducted in the commune of Sehoul in the Rabat-Salé-Zenmour-Zaer Region south-east of Rabat, at two locations known as Hannanat and Jyahna (Figure 7.1). The Sehoul plateau with its incised valleys, which is part of the Palaeozoic Atlantic Meseta, is located between the Mamora forest in the north and the Grou valley in the south-west. The area has a semi-arid Mediterranean climate, with an annual average rainfall of 400–500 mm, mainly falling during late autumn, winter, and early spring.

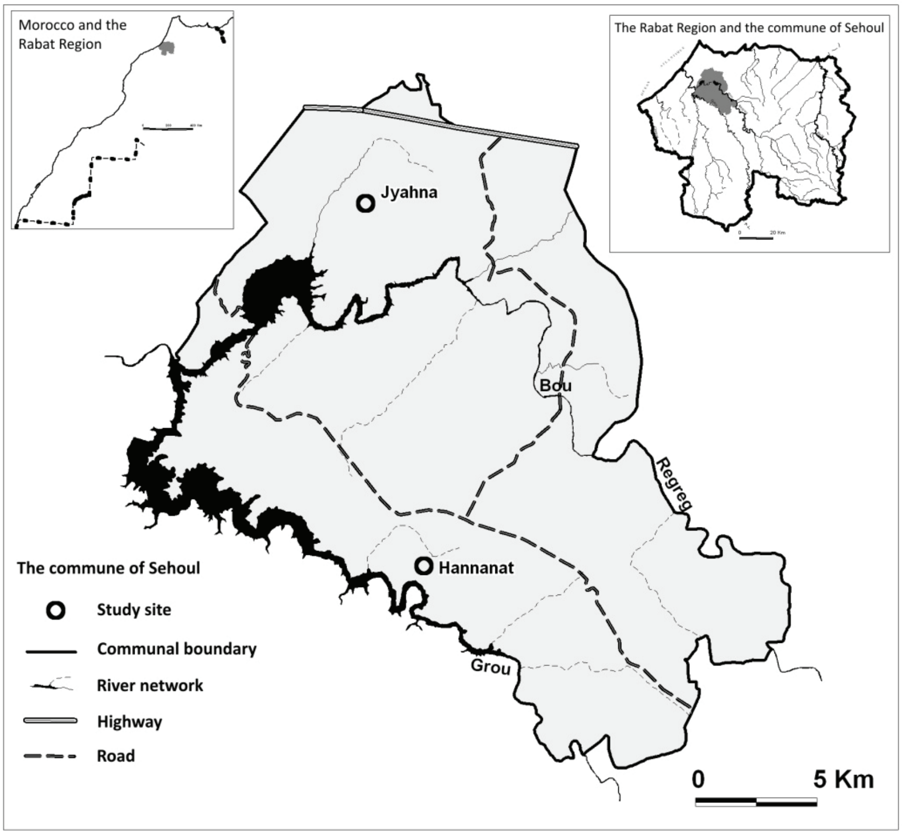

Figure 7.1 Study site locations in Hannanat and Jyahna, near Sehoul, Morocco

The original land uses were open cork oak forest on the leached soils of the plateau, and conifers (*Tetraclinis articulate*) associated with olea on the slopes; the latter were used for charcoal supply and grazing. Grazing land was largely converted to crop production in the 1930s, in the course of colonisation. French expatriates, followed by Moroccan city dwellers, began to occupy the better and flatter areas for commercial cereal production, while the traditionally agro-pastoralist local population was forced to give up cultivation of the good-quality land on gentle slopes and cultivate the steeper slopes on its margins, instead. Population growth and contracts between local farmers and investors from the cities led to an increase in the number of sheep and goats, which added pressure on the natural resources of cultivated land as well as forest and shrubland (Laouina et al., 2010).

At present, cropping is dominated by rainfed winter cereals, with minor areas of spring crops such as corn and beans. Fallow periods are diminishing. Eighty-two per cent of the land users are small-scale farmers (i.e. farmers with less than 10 ha); they use 43% of the land in the area. They mostly use animal traction for ploughing on slopes. Fertiliser application is rare, and crop residues and grains are used as feed. Free grazing – which plays a role in fertilising the land – disappeared progressively with the increasing use of fences, the spread of irrigation, and permanent occupation of land by city dwellers. Many valley bottoms that had been used for summer grazing were recently lost to water storage dams, further increasing the pressure on the remaining marginal slopes. Intensification of agriculture based on fruit plantations, modern breeding, and irrigation of vegetables are options reserved for large-scale farmers with sufficient financial resources.

In a participatory process, local stakeholders and researchers jointly identified the most promising SLM technologies to address SLM needs in the area, and selected several of them for subsequent test implementation (see process description below for more details). Two farmers – one in Hannanat and one in Jyahna – agreed to have tests carried out on their fields. An action research approach was chosen to design the experimental setup. This resulted in a number of important constraints. For example, in order to minimise economic risks, experiments were conducted only in marginal areas. These were characterised by steep slopes, high stone contents, and an advanced degradation status. However, given that such marginal slopes are widespread in the area, the experiment can still be considered representative; moreover, it allowed testing the efficiency of the chosen SLM measures on highly degraded land. For details regarding the test plots analysed and presented in this paper, see Table 7.1.

Table 7.1. Characteristics of the two study sites near Sehoul, Morocco.

	Hannanat	**Jyahna**
Location	25 km south-east of Rabat, south of Sehoul (Oulad Azzouz), north of Oued Grou	17 km east (south-east) of Rabat, north of Oued Bouregreg
Altitude	220 m a.s.l.	140 m a.s.l.
Exposition	South-east	North-west
Slope	15%	15%
Soil type	Fersialitic (red) soil Texture: sandy loam with stones	Fersialitic (red) soil Texture: loamy sand with stones
Soil texture	Stones (> 2 mm): 20 % Sand (2–0.05 mm): 35% Silt (0.05–0.002 mm): 28% Clay (< 0.002 mm): 17%	(not analysed)
Surface stoniness	34% (> 5 mm)	12% (> 5 mm)
Size	Approx. 500 m^2	Approx. 500 m^2
Photo	 (12 April 2011)	 (18 April 2009)
Land use	2010–2011: Barley 2009–2010: Barley 2008–2009: Barley 2007–2008: Fallow 2006–2007: Wheat	2010–2011: no data 2009–2010: Barley 2008–2009: Barley 2007–2008: Barley 2006–2007: Wheat 2005–2008: Fallow Before: Eucalyptus plantation
Usual tillage type	Mechanised on flat areas, animal traction on the steep parts	Animal traction
Major cash crops of land user	Wheat, grapes, livestock	Irrigated vegetables and mint

7.2.2 Treatments and measurements

We tested two components of the Conservation Agriculture technology: minimal soil disturbance and increased soil cover.

1. Minimal soil disturbance consisted of direct seeding with no tillage and minimum tillage. The aims were to enhance soil organic matter, soil structure, and soil fauna and flora. The resulting increased porosity is expected to improve the soil's capacity to absorb and retain water for enhanced plant growth. Special machinery is usually required for direct seeding. We used a special animal traction seeder provided by the National Agronomic Research Institute (INRA) of Settat, which had been constructed specifically for demonstration purposes. Seeding was preceded by herbicide application. Minimum tillage was carried out using a traditional plough. The control situation for this component was conventional ploughing.
2. Increased soil cover consisted of fencing to prevent grazing (area enclosure). The aim was to keep a high level of vegetation cover throughout the dry season and to reduce the erosive effects of the first rains in autumn. Leaving minimum soil cover in the dry season is generally expected to increase infiltration and reduce runoff and evaporation during the next rainy season. This applies especially in cases where the farmer decides to leave the field fallow during the cropping season. Soil properties may improve as a result of the additional organic matter, improved infiltration, and water conservation. Despite these expected benefits, farmers usually prefer to plough or burn residues to avoid weed propagation. The control situation for this component was open grazing of residues.

The setup of the treatments was challenging due to various factors, including bureaucratic and other hurdles in obtaining support from experts (e.g. from national research institutions or agricultural services), time constraints, changing local researchers, and the reluctance of one of the farmers to collaborate. The relationship with this farmer remained tense, as he feared to lose ownership of the land, presumed cash flows from the international experts, and generally mistrusted researchers. All these constraints led to a minimised setup and limited replication of treatments and measurements (Table 7.2).

Table 7.2. Description of plots and dynamic uses of the land (2009–2011) at the two study sites near Sehoul, Morocco.

	Hannanat			**Jyahna**			
	1 (control)	2 (western part)	3 (eastern part)	1 (control)	2 (upper part)	3 (middle part)	4 (lower part)
Dry season[1] 2009	Full grazing	No grazing	No grazing	Full grazing	No grazing	No grazing	No grazing
Cropping season[2] 2009–2010	Fallow	Direct seeding after herbicide treatment	Conventional ploughing (20–25 cm)	Fallow	Direct seeding after herbicide treatment	Minimum tillage (5–10 cm)	Conventional ploughing
Dry season[1] 2010	Full grazing	No grazing	No grazing	Full grazing	No grazing	No grazing	No grazing
Cropping season[2] 2010–2011	Fallow	Minimum tillage (5–10 cm)	Conventional ploughing (20–25 cm)	No data[3]	No data[3]	No data[3]	No data[3]

[1] *Dry season: May–November*

[2] *Cropping season: December–April*

[3] *Farmer refused further cooperation*

The three and four treatments at the two sites, respectively, were monitored using a total of 20 soil water measurement points at three soil depths (5, 15, and 30 cm). The monitoring points were distributed randomly, but mostly in the middle of the treatment plot. Soil moisture was recorded at an hourly interval. We used the low-budget, pre-calibrated EC-5 frequency domain reflectometer (FDR) sensors of Decagon Devices (Pullman, WA). These sensors measure the volumetric water content of the soil by measuring the dielectric constant of the soil, which is a sensitive measure of water content. The installation of these sensors was complicated by the high stone content of the soil and the related air gaps. However, evidence found in the literature indicates that measurements of the dielectric constant in a coarse textured soil with a high stone content hardly deviate from measurements in a mineral soil (Drungil et al., 1998). Daily precipitation data were obtained from a nearby (10 km) rainfall station until a new meteorological station was installed at the Hannanat site in November 2010. Cover estimates were made at irregular time intervals, and production was assessed based on yield weighing. Details of all parameters measured are presented in Table 7.3.

Table 7.3. Measurements at the two study sites near Sehoul, Morocco.

	Hannanat	**Jyahna**
Soil moisture	10 FDR sensors at 5 cm / 15 cm / 30 cm depth, hourly intervals	10 FDR sensors at 5 cm / 15 cm / 30 cm depth, hourly intervals
Meteorological data	Rainfall Station Aguibat-Ezziar at 10.2 km distance (daily intervals); from 10 November 2010 onwards, meteorological station at 250 m distance (at 5-minute intervals)	Rainfall Station Aguibat-Ezziar at 15.4 km distance (daily intervals)
Biomass / production	End of cropping season: weight of grains and straw biomass, 1-m^2 samples	–
Cover	Estimates of percentage of vegetation cover, stones, and bare soil, 9 times	Estimates of percentage of vegetation cover, stones, and bare soil, 2 times

7.2.3 Participatory process

The on-farm test implementation was embedded in a process of participatory identification, assessment, and decision-making. The overall methodology applied in all DESIRE study sites consisted of three parts: initial joint identification of problems and existing SLM solutions in a first stakeholder workshop (Part I); evaluation and documentation of the identified locally available SLM technologies (Part II); participatory decision support in a second stakeholder workshop for the selection of potential SLM options for subsequent test implementation (Part III). The overall methodology and a thorough analysis of experiences from all DESIRE study sites are presented in Schwilch et al. (2009) and Schwilch et al. (2012a,b). The process is solution-oriented from beginning to end, emphasising SLM rather than land degradation and combining a local participatory process with global experience. Feedback from users and positive outcomes have confirmed the methodology's capacity to successfully guide decision-focused participatory processes (Schwilch et al., 2012a).

After the initial stakeholder workshop (Part I) in Sehoul, a number of SLM technologies were selected for further assessment (Part II) using the WOCAT questionnaires (www.wocat.net). The technologies assessed in this way included fruit tree plantations along the contours, separated by strips of legumes and cereals; fodder cultivation and pasture improvement; and gully rehabilitation with Eucalyptus plantations and check dams.

Based on these evaluations, the participants of the second stakeholder workshop (Part III) selected the most promising options for local test implementation. Land users generally preferred options that would not drastically change their current practices of cereal cropping and grazing. The final choice, therefore, included SLM technologies to improve grazing and cropland, namely plantation of fodder shrubs

(*Atriplex halimus*) for gully rehabilitation on grazing slopes, permanent grass strips between annual cropping, and a combination of crop residues and minimum tillage (Laouina et al., 2009). The field experimentation of the latter is the example discussed in this paper.

Prior to the DESIRE project, the Sehoul region had benefited from a Development Project for Rainfed Agriculture (Projet de Mise en Valeur des Terres en Bour – PMVB). This had given rise to somewhat excessive expectations among farmers towards the government or other programmes, although the technologies suggested by the PMVB were not applied. As a result, it was fairly difficult to find land users who were both willing and interested to collaborate with a research project that did not offer any clear prospective economic benefits.

The criteria for selecting the most promising technology as identified by the stakeholders during the second workshop are presented in Table 7.4. They served as a basis for evaluating the success of the tested SLM technology. Based on the scope of this paper, one of the ecological criteria – namely soil water retention – is considered more closely than the others.

Table 7.4. Criteria for sustainable land management (SLM) technology selection as identified by stakeholders in Sehoul, Morocco.

Economic	Ecological	Socio-cultural
1. Low costs of implementation of the SLM technology	5. Improved water retention in soil	9. Enhanced social cohesion/organisation of population
2. Improved agricultural yields	6. Higher density of vegetation cover	10. Creation of employment opportunities
3. Improved animal production	7. Improved fertility	11. Higher valuation of land properties
4. Increased income	8. Reduced soil loss	12. Reduction of workload and availability of time for other activities

Data gathered during the participatory process consisted of workshop reports (Laouina et al., 2007; Laouina et al., 2009); semi-structured interviews with ten stakeholders conducted in order to analyse the overall 3-part methodology (as described in Schwilch et al., 2012b); numerous conversations with farmers, technicians, and researchers during field visits and meetings at administrative offices; participatory observation during stakeholder workshops and field trials; DESIRE project documents (posters at meetings, annual reports, etc.); and WOCAT questionnaires filled in after trial implementation.

7.2.4 Data analyses

Analysis was performed on two types of data.

1. Data from on-farm trials: soil moisture, precipitation, cover, production, etc. (details see section 7.2.2).
2. Supporting data collected during the participatory process: workshop reports, documentation of SLM technologies and approaches, participatory observations, and collaboration with farmers and institutions (details see section 7.2.3).

Analysis was constrained by the above-mentioned limitations in the setup and in replication. However, replications over time during the running time of the experiments, that is, from May 2009 until September 2011, allowed identifying patterns of soil wetting and drying under different treatments.

Seasonal averages of the soil moisture content (θ) per depth and treatment as well as the total water in mm for the top 40 cm of soil were calculated in order to compare the various dry season and cropping season treatments. To analyse the evolution of soil moisture in more detail, two-monthly graphs were produced for autumn (end of dry season, October to December), winter (early cropping season, January to February), and spring (late cropping season, March to April).

The increase in water content from the onset of rain and the decrease of water content after the peak were calculated for each rainfall event over the whole observation period. Four values per event for θ_{min} (before rainfall), θ_{max}, (maximum soil moisture after rainfall), θ_{end24} (24 h after the onset of rain) and θ_{end48} (48 h after the onset of rain) were manually extracted from the data files. The timing of the θ_{end} readings was determined based on visual data interpretation at the point where the decrease of soil moisture after rain had diminished to almost zero (after 48 h). These soil moisture changes during and after rainfall events were statistically analysed using the R open-source software package (www.r-project.org/). One-way independent ANOVAs were used to test the significance of the difference between treatments in soil moisture changes during and after rainfall (with a confidence value of 0.05).

Content analysis was used for qualitative analysis of the data on the participatory process. Most of the results from the workshop reports and the semi-structured interviews were presented in Schwilch et al. (2012b). Part of them are used here and complemented with other sources as listed above.

The analysis of the field trial results presented in the "Results" section was based on the selection criteria as identified by the stakeholders (see Table 7.4). This had the advantage that stakeholder opinions were taken into account throughout the monitoring and analysis phase, and that all three dimensions of sustainability were considered for evaluation.

7.3 Results

7.3.1 Process of identification, appraisal and selection of SLM options

The main problems of degradation as identified by the local stakeholders during the first workshop included the following (Laouina et al., 2007).

- Delayed precipitation in autumn and early dryness in spring led to a decrease in water availability, a shorter growing season, and a reduction of grain yields and vegetation cover.
- Intense and heavy rainfall in autumn, at a time when the soil is completely bare, caused severe soil erosion.
- Overexploitation of wells and increased runoff on the fields caused the water table to decline.
- The vegetation cover was reduced and degraded inside the forest as well, and cork oak degraded beyond regeneration.

The participatory process revealed that farmers in Sehoul are primarily interested in animal husbandry. For this reason, for example, crop residues compete with fodder, and cover management is only an option in years with sufficient biomass production; otherwise any plant biomass is completely used up for the animals. The stakeholders and, more specifically, the farmers also explained that more ploughing, especially repeated ploughing before seeding, results in higher production. Thus, their opinion was in contradiction to the philosophy of minimum tillage.

Alternatives include producing vegetables or fruit for the market. Vegetables require irrigation, better soil, and less steep land, and fruit trees such as olives or figs demand high initial investment and fairly good soils. Both alternatives require fencing to avoid grazing. Although the nearby city market of Rabat-Salé provides scope for such investments, at the same time, farmers are becoming increasingly detached from their land: they see their future in the city rather than in agriculture. This renders the promotion of SLM under current land use virtually impossible. Farmers close to Rabat hope to sell their land to rich urban inhabitants. Only wealthier farmers with access to water and capital might consider using their land for high-value horticultural crops under drip irrigation.

Participatory observation and numerous conversations with farmers and local researchers revealed another precarious development in this regard: although many rural children receive a school education, they lag behind their age-mates from the city regarding professional education and, therefore, have minimal chances in the urban job market. Still, the city is where they are drawn to by the prospects of modern life and welfare. At the same time, they are no longer engaged on their parents' farms and lose their agricultural background and skills while "oscillating on their mopeds" between the city and their home farms.

7.3.2 Field testing of the SLM technology

Application of direct seeder

In May 2009, when the experiments started, the fields at both sites were briefly grazed, allowing the sheep to eat the grains and part of the residues, but still leaving a full soil cover and stubbles about 50 cm in height. In December, prior to the onset of the first rains – which were delayed in 2009 – the remaining vegetation was treated with herbicides. Barley seeds were then sown using an animal-drawn no-tillage plough (Figure 7.2).

Figure 7.2. Seeding barley using an animal-drawn direct seeder in Sehoul, Morocco (Photo by M. Sfa).

Figure 7.3. Straw accumulations beneath the direct seeder (Photo by M. Sfa).

Seeding in this way posed several challenges. The seeder itself kept "jumping" due to the stoniness of the soil; the large amount of mulch material (straw) caused this material to accumulate underneath the seeder, hampering and frequently blocking it, as shown in Figure 7.3.

These factors resulted in numerous seeds remaining on top of the soil or straw, exposed to birds. In addition, the test plots were seeded slightly earlier than the surrounding fields, causing the birds to exceptionally concentrate precisely on those fields and thus leading to a significant loss. However, seeding was successful in some sections of both test plots. Due to the above-mentioned problems using the direct seeder, it was decided to modify the trial from no-tillage to minimum tillage in the second cropping period (December 2010 to April 2011) at the Hannanat site.

Soil water retention (selection criterion 5)

Enclosure versus grazing

To obtain a rough comparison of the effects of enclosure and of grazing at the two sites, we calculated seasonal averages of soil moisture content (SMC) for the top 40 cm layer (Figure 7.4).

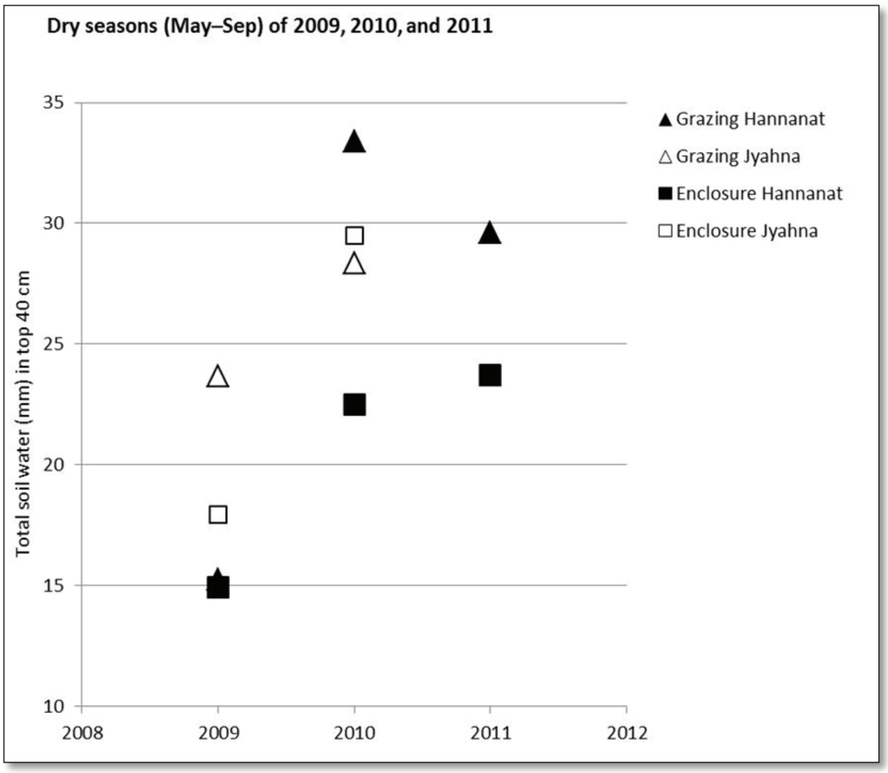

Figure 7.4. Total soil water (mm) in the top 40 cm of the soil profile in grazed and enclosed fields, averaged over the dry seasons, for Hannanat and Jyahna, near Sehoul, Morocco.

A higher SMC was recorded under grazing than under enclosure, where the previous crop had been left as mulch and grazing had been prevented. This seemingly paradox result can be explained by the development of certain perennial grasses (see also Figure 7.11) which evaporated the water and dried out the soil in the enclosed areas. In the grazed field, the soil was bared and transpiration stopped. This suggests that grazing can help to conserve water.

A delayed start of the rainy season with scattered small and medium showers (Figure 7.5) forced the farmers to wait until mid-December to plough and seed their fields.

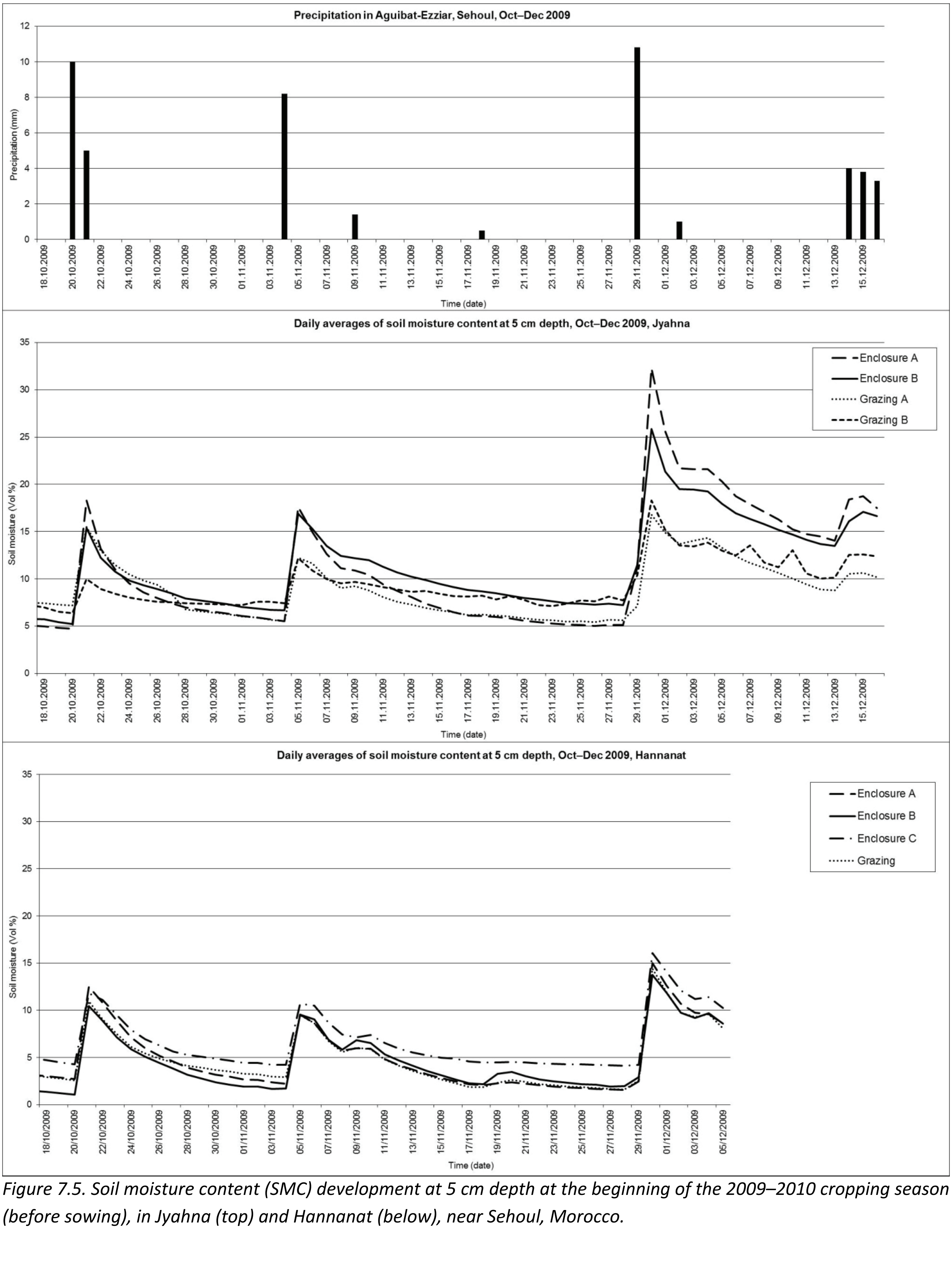

Figure 7.5. Soil moisture content (SMC) development at 5 cm depth at the beginning of the 2009–2010 cropping season (before sowing), in Jyahna (top) and Hannanat (below), near Sehoul, Morocco.

The development of SMC at 5 cm depth gives an indication of the possible effects of enclosure and of grazing on the infiltration of the first rains in autumn, as presented in Figure 7.5. At the Jyahna site, the soil moisture situation under enclosure was clearly preferable compared to grazing, particularly with respect to the impacts of the November showers. In Hannanat, no clear differences could be observed. Under enclosure, crop residues (and weeds) from the previous seasons were more or less intact, protecting the soil against raindrop impact. Under grazing there was less protecting biomass; however, observations suggested that the presence of cattle and sheep had both negative and positive consequences for the soil surface. On the one hand, it was compacted as a result of trampling, but, on the other hand, animal droppings appeared to have stimulated soil fauna burrowing activities, which created macro pores and thus improved infiltration capacity.

The water infiltrated after these first showers quickly reached a depth of 5 cm, but was insufficient to wet the soil at 30 cm depth at the Hannanat site. The difference between the two sites might be due to differences in runoff and/or in rainfall, as rainfall may vary over the distance from the rain gauge to both sites. However, the reaction of the SMC sensor at 5 cm depth suggests that runoff was low. Although no runoff measurements were available to validate this assumption, runoff amounts can be expected to be small, since small to medium showers are usually not very intensive. After being wetted, the soil at 5 cm depth started drying out at an almost exponentially decreasing rate. This confirms evaporation theory with its first and second stages of drying (Stroosnijder, 1987). The gradient of exponential decay varies slightly between treatments, but no firm conclusion can be drawn in this regard. The expected effect of enclosure and grazing on infiltration during the first rains could be observed at Jyahna, but not at Hannanat. Additional consideration must be given to the fact that, by comparison to what had been observed in other years, an abundance of fodder after the exceptionally wet winter of 2008/2009 relieved the situation of overgrazing for the reference situation in autumn 2009.

No-tillage / minimum tillage versus conventional tillage

For this comparison, as well, the first step was to calculate seasonal averages of SMC for the top 40 cm layer to obtain a rough overview of the effects of the various treatments. Figure 7.6 suggests that no or minimum tillage was more favourable regarding SMC than conventional tillage. A permanent cover reducing soil evaporation caused no-tillage/minimum tillage to perform in a similar way as fallow.

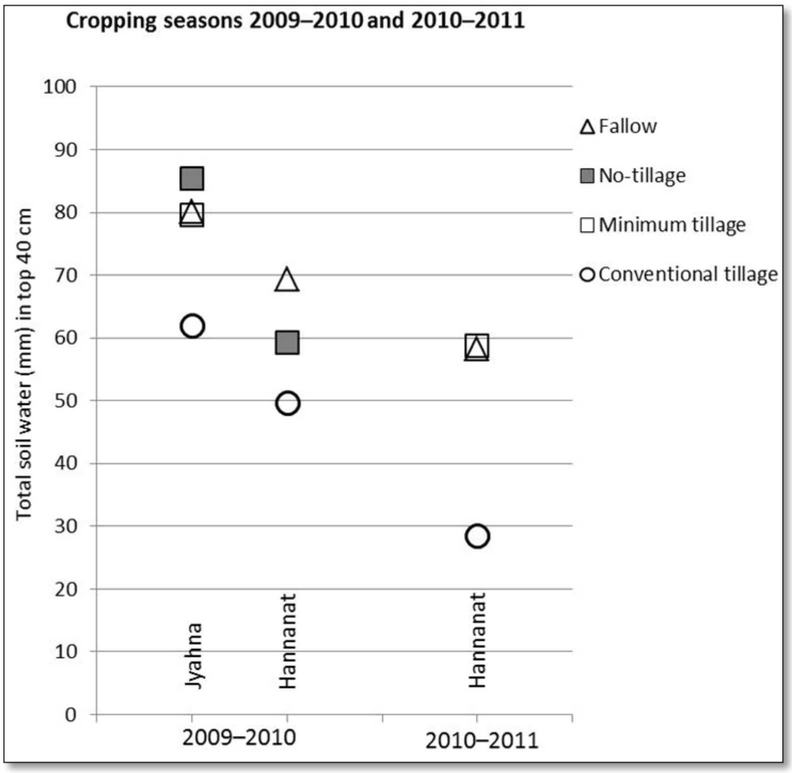

Figure 7.6. Total soil water (mm) in the top 40 cm of the soil profile per treatment and averaged over the cropping seasons for Hannanat and Jyahna, near Sehoul, Morocco.

Figure 7.7 presents the development of SMC during the first phase of early crop growth (December 2009 to January 2010). The diagram shows that substantial rainfall occurred at the end of December 2009. SMC at 5 and 15 cm depth quickly reached Field Capacity (FC) values. FC values were not determined directly, but can be interpreted from the dynamic curves. FC at 5 cm is about 20 Vol%, at 15 cm about 22 Vol% (curves not shown), and at 30 cm about 30 Vol%. The latter value can be observed in Figure 7.7 for the fallow case. The difference in FC is due to clay content increasing with depth. If the top 40 cm of the soil has reached FC, there will be about 100 mm of stored water. This is about equal to the amount of rain at the end of December. Figure 7.7 confirms the finding from the seasonal averages that conventional tillage led to lower SMC than the other treatments. The difference between the fallow and the no-tillage treatments suggests that water might be lost as runoff under no-tillage.

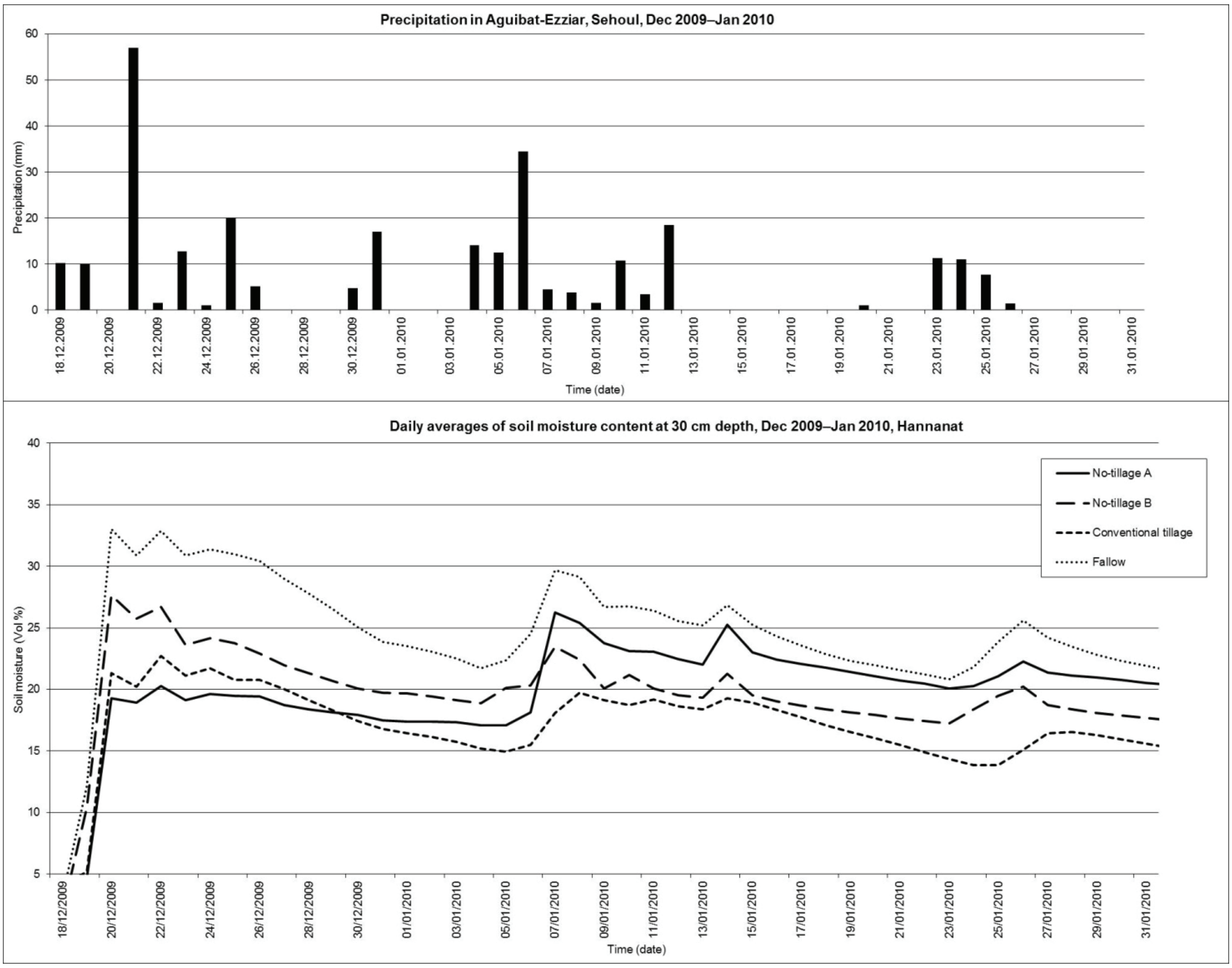

Figure 7.7. Soil moisture content (SMC) development at 30 cm depth during the 2009–2010 cropping season in Hannanat, Morocco.

Between 14 and 22 January 2010 there was no rain at all. This allows using the measured decrease in SMC to estimate daily evapotranspiration (ET). Table 7.5 shows that ET under conventional tillage was about 2.9 mm/day, while under no-tillage it was only 2.4 mm/day. Since ET is a composite value of plant transpiration (T) and soil evaporation (E), E can only be concluded if T is known. Although T was not measured directly, its value can be inferred from the measured yield. Since the yield under no-tillage was higher than under conventional tillage (see below), it is safe to assume that E under no-tillage is lower than under conventional tillage.

Table 7.5. Estimation of evapotranspiration (ET) using dynamic soil moisture content (SMC) data at 5, 15, and 30 cm depth in Hannanat, Morocco.

	SMC 14 Jan	SMC 22 Jan	ΔSMC (in vol%)	ΔSM (in mm)	ET (mm/day)	Yield (in kg/ha)
Conventional						
5 cm	19	9	10	– 10.0		
15 cm	19[1]	12[1]	5	– 7.5		
30 cm	19	15	4	– 6.0		
Top 40 cm				– 23.5	2.9	1605
No-tillage						
5 cm	19	13	6	– 6.0		
15 cm	20	16	4	– 6.0		
30 cm	25	20	5	– 7.5		
Top 40 cm				– 19.5	2.4	1776

[1] *interpolated*

Figure 7.8 shows dynamic SMC during the last phase of the rainy season. At first, SMC increased steadily due to abundant rainfall in the second and third weeks of February. Under no-tillage treatment, FC was surpassed, followed by rapid drainage. Under conventional tillage, less moisture reached a depth of 30 cm. Field observations suggested that more runoff was generated in the fields under conventional tillage due to soil crusting. This effect was mitigated under no-tillage since the soil had been better protected with soil cover. Estimation of ET after 10 days of dry weather was repeated for the time between 12 and 22 March 2010. Conventional tillage showed considerably higher ET (3.8 mm/day) than no-tillage (2.8 mm/day). These values were higher than in January because the crop was further developed. Based on an estimation of the daily growth rate, it can be assumed that less than 1 mm was lost through T, while the remainder of soil water loss can be attributed to E. No-tillage therefore seems to reduce the loss of precious soil water via soil evaporation.

In general, the situation of conventional tillage is the one with the lowest soil moisture content throughout the cropping season and at all depths. Fallow often shows a higher absolute moisture content, but with more rapid declines after rainfalls.

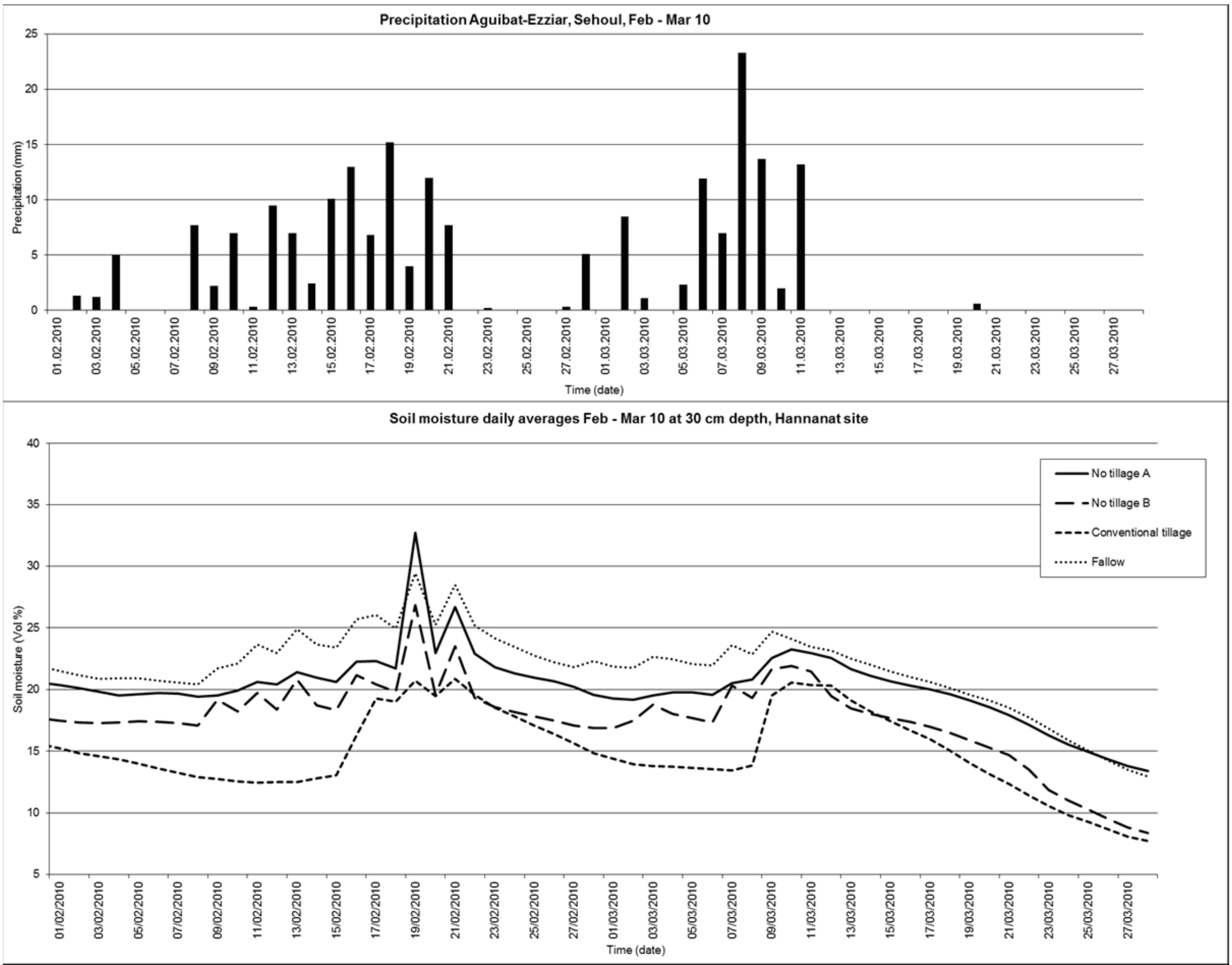

Figure 7.8. Soil moisture content (SMC) development at 30 cm depth at the end of the 2009–2010 cropping season in Hannanat, Morocco.

Overall, the observations regarding SMC development at various soil depths can be summarised as follows.

- At 5 cm: No-tillage and minimum tillage resulted in higher SMC than conventional tillage and fallow in most cases, except during the cropping season of 2010–2011 at Hannanat, when fallow performed best.
- At 15 cm: Hardly any differences observed.
- At 30 cm: No-tillage and minimum tillage resulted in higher SMC than conventional tillage; at Hannanat, fallow often performed best, whereas conventional tillage was clearly worst.

Another option for providing evidence of the influence of the treatments on SMC is to look at the reaction of SMC to single rainfall events. The increase in water content from the onset of rain and the decrease of water content after the peak both give an indication of various soil-water-related functions, such as infiltration, soil evaporation, and water holding capacity. These magnitudes were plotted for all rainfall events during the observation period (cropping seasons only) and for the various treatments. Differences were most obvious in the case of small rainfall events below 10 mm and for the comparison of conventional tillage with no-tillage (Figure 7.9). The steepness of the lines in Figure 7.9 gives an indication of the response of soil moisture to rainfall (increase), as well as of water retention 24 hours after the onset of rain (initial section of decrease) and 48 hours after the onset of rain (second section of decrease). Figure 7.9 suggests a better response to small rainfall events in no-tillage areas, both at 5 cm and at 30 cm depth, compared to conventional tillage.

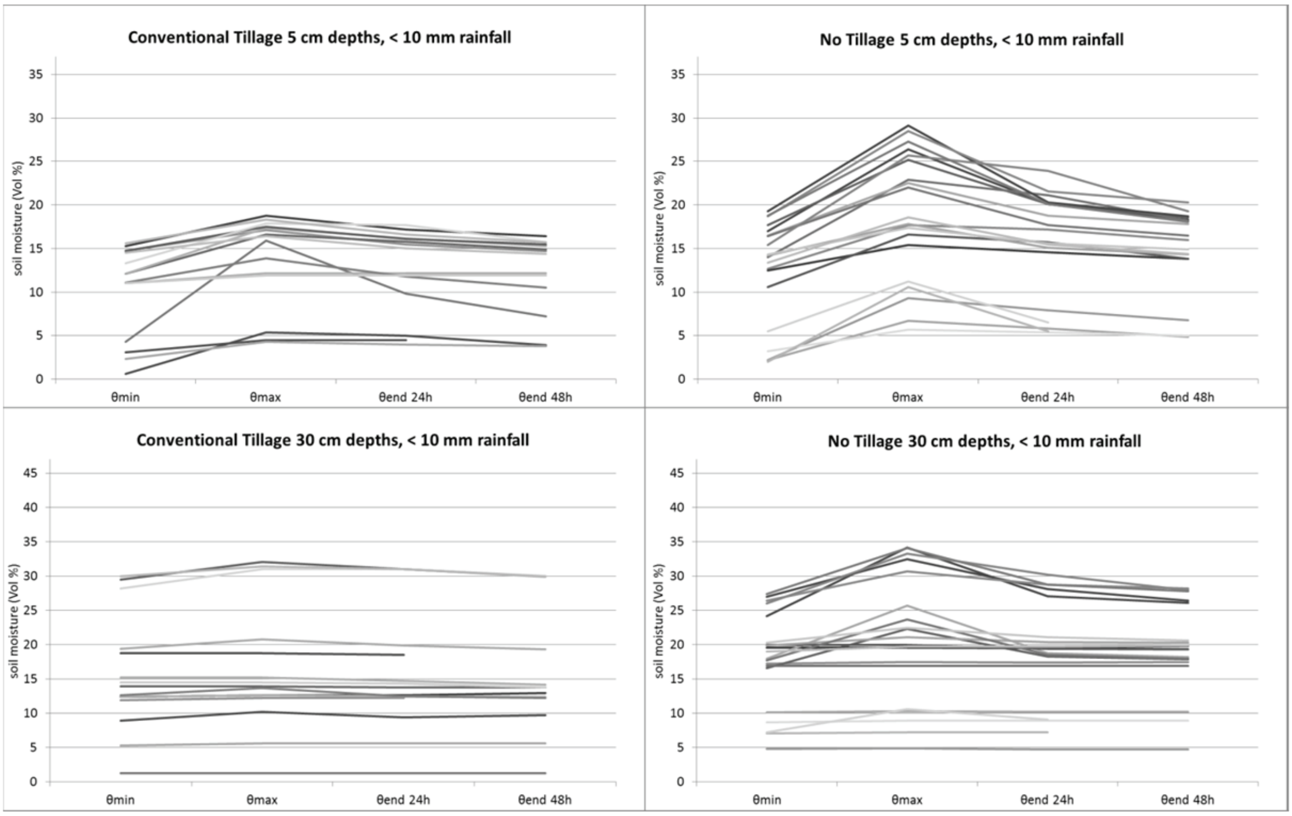

Figure 7.9. Changes in soil moisture content (SMC) at depths of 5 cm (top) and 30 cm (bottom) for events with less than 10 mm of rainfall during the cropping season, comparing conventional tillage (left) with no-tillage (right) for Sehoul, Morocco; ϑ_{min} = soil moisture before rainfall, ϑ_{max} = maximum soil moisture after rainfall, ϑ_{end} 24h = soil moisture 24 h after onset of rain, ϑ_{end} 48h = soil moisture 48 h after onset of rain.

To evaluate whether the treatments had a significant influence, the increases in SMC were analysed for the various rainfall regimes (< 10 mm, 10–20 mm, 20–50 mm, > 50 mm) and are shown in Figure 7.10.

Soil moisture increases from the onset of the rainfall to the peak of soil moisture (θ_{max} - θ_{min}) revealed the following.

- At 5 cm depth and with little rainfall (< 10 mm), no-tillage and minimum tillage both achieved significantly greater increases in moisture compared to conventional tillage (confidence value of 0.01). For 10–20 mm rainfall events, no-tillage still performed clearly better than conventional tillage (confidence value of 0.05). No significant difference could be found between treatments in the case of larger rainfall events, as well as between the fallow treatment and any of the other treatments for rainfall events of all magnitudes.
- At 30 cm depth, a significant difference was found between no-tillage and conventional tillage in cases where rainfall was below 10 mm (confidence value of 0.05).

Although these results relate to fairly small rainfall amounts (less than 20 mm), they might nonetheless be important for crop performance, as 11 of the 30 rainfall events recorded during the analysed cropping seasons ranged below 10 mm, and another 10 ranged below 20 mm.

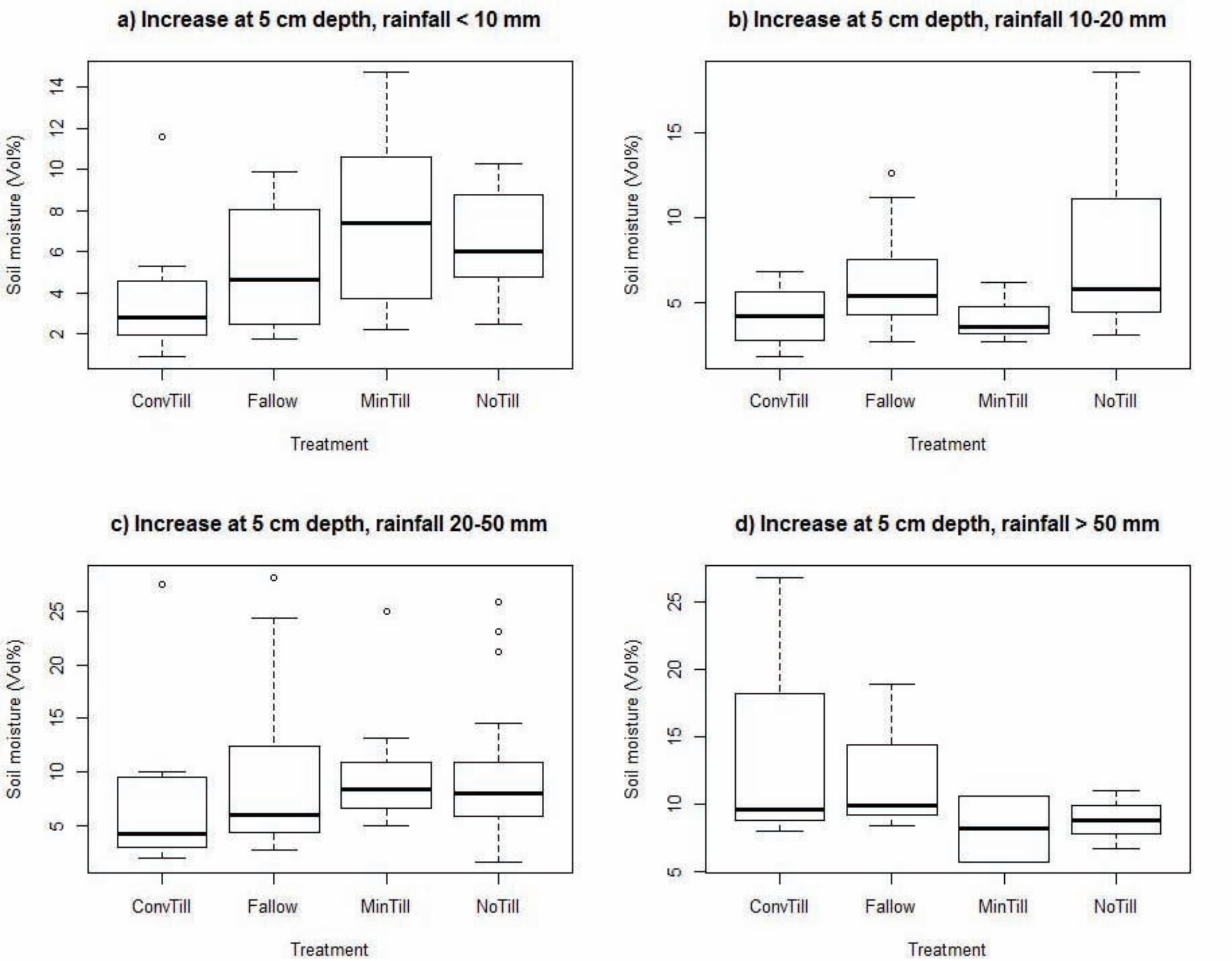

Figure 7.10. Box plots of soil moisture increase after rainfall events of < 10 mm (top left), 10–20 mm (top right), 20–50 mm (bottom left) and > 50 mm (bottom right) for Sehoul, Morocco; ConvTill = Conventional tillage, MinTill = Minimum tillage, NoTill = No-tillage.

Vegetation cover (selection criterion 6)

Vegetation cover was considerably higher within the fenced plots, especially at the end of the dry season, when the surroundings were completely grazed. Figure 7.11 presents a comparison of the fenced plot in Hannanat, where the crop residues from the previous cropping season acted as mulch, with its grazed surroundings. The increase in perennial herbs also resulted in a higher biodiversity, with 20 species / m^2 in the mulch plot compared to 13 species / m^2 in the grazed area.

The improved cover on the fenced plots at the end of the dry season proved important in protecting the soil against the first rains in October to December, which are usually heavy and intense (Laouina et al., 2010). This observation is supported by the above soil moisture data. Further confirmation was received from the farmers. One of them stated that “crop residues (straw) keep the soil open. Usually, the soil is closed [at the end of the dry season]. The straw cover allows infiltration. I have observed this here, especially this year when there was a lot of rain. Next to the enclosed plot numerous rills developed and this shows me that the straw cover is protecting the soil” (oral communication, 12 June 2010).

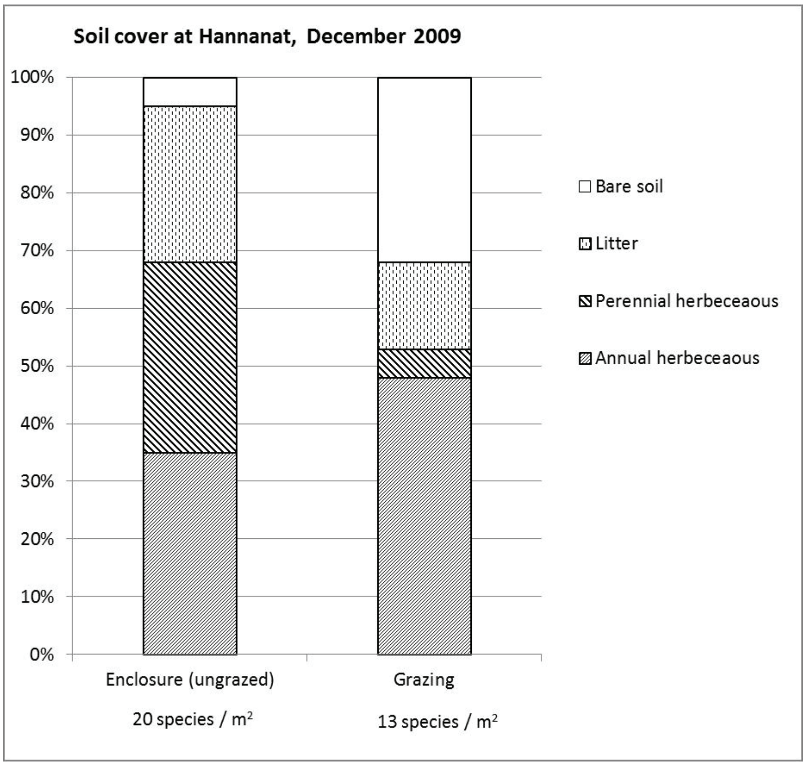

Figure 7.11. Soil cover at Hannanat, Morocco, at the end of the dry season, for grazed and ungrazed fields.

Agricultural yields and animal production (selection criteria 2 and 3)

Crops produced on marginal slopes are normally used as animal fodder only. For this reason, the analysis focuses on the production of both grains and straw biomass (total biomass). Production after the first growing season (2009–2010) exhibited small differences between the various treatments. On the no-tillage plot at Hannanat, production amounted to 544 kg / ha of barley grains and 1232 kg / ha of straw biomass, while the plot under conventional tillage produced 503 kg / ha of barley grains and 1102 kg / ha of straw biomass. These measurements are based on 1-m^2 samples taken where crop growth was satisfactory (i.e. not where the seeds had been eaten by birds, see above). The better performance of no-tillage was also visible in the field, as the grains were bigger and the plants higher than on the conventionally ploughed plot. In addition, there were fewer weeds under no-tillage due to the herbicide applied before seeding. On the conventionally tilled plot, the weeds had been ploughed into the soil, but had shown strong and immediate regrowth. Overall, production values on the test plots were very low compared to a nearby wheat field on non-degraded flat land with good-quality soil, which achieved 1130 kg / ha of grains and 3611 kg / ha of straw biomass – that is, triple the amounts produced on the test plots.

It has to be noted at this point that the owner of one of the test plots for these experiments, supported by a local agricultural engineer, expressed the fear that crop residues ploughed into the soil cause fungal attacks in the soil, necessitating subsequent treatment. This problem, however, can be avoided by crop rotation, as noted by the owner of the test plot at the other site (*oral communications, 18 March 2009 and 21 November 2009*).

Animal production not only benefits from increased fodder production, but at the same time also suffers from the exclusion, due to fencing, from areas previously used for grazing. Given the small size of the trial plots, this did not pose a problem for the participating farmers and their livestock. If fencing were upscaled, however, this might even increase the pressure on other natural resources in the area, such as the oak forest on the plateau.

Costs and socio-cultural results (selection criteria 1, 4, and 9–12)

Table 7.6 presents costs and benefits for the no-tillage experiment. It is evident that the fencing costs of 6520 Dirham (587 EUR) make this technology an expensive one. However, fencing was only necessary for the experimental plot and would not be required if farmers decided to apply the technology on larger fields, in which case grazing would be controlled through social agreement.

Table 7.6. Costs and benefits for the field trials at the two study sites near Sehoul, Morocco
(in Moroccan Dirham; 1 Dh = 0.09 EUR)

	No-tillage	Dh / ha	Conventional tillage	Dh / ha
A) Costs				
Recurrent and short-term	Renting direct seeder	2000	Renting tractor	1000
	Herbicide	900		
	Seeds	800	Seeds	800
	Labour	600[1]	Labour	200
	Subtotal	4300	Subtotal	2000
One-time (establishment) and long-term	Fence	5200	Fence	5200
	Stakes	1320	Stakes	1320
	Annual total	10820	Annual total	8520
	Annual total in 6 years	5387	Annual total in 6 years	3087
B) Benefits				
Recurrent and short-term	Grain yield	2176	Grain yield	2020
	Fodder yield	616	Fodder yield	551
	Pasture reduction	-960	Pasture reduction	-960
	Annual total	1832	Annual total	1611
Long-term	Soil and water improvements, off-site benefits	750		
	Improved biodiversity	750		
	Grain yield	6000	Grain yield	4000
	Fodder yield	1000	Fodder yield	1000
	Pasture reduction	-960	Pasture reduction	-960
	Annual total in 6 years	7540	Annual total in 6 years	4040

[1]*due to herbicide application and difficulties in working with the direct seeder*

Due to fencing, the cost–benefit ratio of the experiment was clearly negative for the first year. But even if fencing costs are excluded from the calculation, no-tillage still remains more expensive than conventional tillage. This is due to the higher costs of renting the direct seeder and purchasing the herbicide, as well as the additional labour input for herbicide application and as a result of difficulties in seeding. In terms of costs, therefore, the no-tillage technology is unfavourable under the given conditions with stony slopes and poor access to direct-seeding machinery.

Only when the costs are weighed against the longer-term benefits of an estimated gradual yield increase up to the level achieved on the surrounding better-quality land, as well as other long-term benefits, such as improvements in soil structure and soil water, soil loss reduction, and improved biodiversity, does the balance for no-tillage become beneficial compared to conventional tillage or fallow.

- No-tillage: 2153 Dh/ha/y
- Conventional tillage: 953 Dh/ha/y
- Grazed fallow: 960 Dh/ha/y

Based on the research presented in this paper, little can be said about the test results regarding the four socio-cultural criteria (for details, see Table 7.4). The workload under no or minimum tillage might be reduced as a result of no or less ploughing, although this has not been the case in the field trial due to the difficulties posed by the stony slope. All other criteria can only be assessed in the long term and if the technology is applied more widely. An increased awareness of degradation and enhanced conservation knowledge, however, was noted during the evaluation of technologies based on WOCAT questionnaires. This has been attributed to the participatory approach of the study.

7.4 Discussion

Although the results are limited in scope and clarity, some evidence nonetheless emerges. Compared to conventional tillage, the no-tillage and minimum tillage experiments mostly showed an improved soil water balance. This is especially the case at 5 cm depth and for small rainfall events (below 20 mm). A possible conclusion from these results is that soil infiltration was enhanced under no-tillage and minimum tillage compared to conventional tillage. It is also possible, however, that no-tillage and minimum tillage reduced evaporation, better conserving the water in the topsoil, whereas the soil under conventional tillage might have dried out more rapidly, thereby preventing small showers from reaching a depth of 5 cm.

However, fallow had positive effects on soil water as well, owing to an important herb cover being retained throughout the year; stones might have functioned as an additional protective cover (stone mulch) against soil water evaporation. The disadvantage of fallow, which meant that the land was heavily grazed during the dry season, was that in autumn, when rainfall is most intense, it had a reduced infiltration rate and generated more runoff due to soil sealing. Previous studies in the same area showed that fallow land produces more runoff but less soil loss than cropped land (Laouina et al., 2003).

Leaving mulch on the fields and protecting the area from grazing was expected to preserve soil moisture and allow infiltration and storage of the important first rains. Nevertheless, at the beginning of the cropping season, high moisture content was also observed in fallow land, as it had remained undisturbed. We can therefore conclude that it is this undisturbed condition that also renders the no-tillage technology clearly more profitable regarding soil water than conventional tillage. This is true even when considering the observation that ploughing along the contour under conventional tillage led to the formation of small ridges, leaving a rough surface that enabled infiltration. Similar findings resulted from studies in East and southern Africa, which showed that the non-inversion tillage strategy, whether implemented as no-tillage or as minimum tillage, is most effective in terms of *in situ* moisture conservation and is therefore the most important component of Conservation Agriculture in dryland agro-ecosystems, actually constituting a kind of water harvesting strategy (Rockström et al., 2009). Especially in dry years, yields were also reported to be higher under no or minimum tillage in semi-arid regions of Mediterranean Europe (Farooq et al., 2011). It should further be noted that the beneficial effects of no or minimum tillage – such as improved soil structure or higher organic matter contents – evolve gradually, becoming measurable only after 4–5 years.

Despite indications that soil water content is generally improved as a result of area enclosure in the dry season, the extent of this improvement might not be sufficient to have an impact on production. Studies in Ethiopia have shown that although mulching generally improves soil water content, it does not increase yields or improve the efficiency of rainwater use (Araya and Stroosnijder, 2010). In drylands with distinct dry periods of several months, increased cover is not necessarily required during the dry period. Research from Australia confirms that high potential evapotranspiration and low rainfall over these months prevents improved cover from retaining soil moisture, and its impact on the evaporation rate lasts for a maximum of a few days after rainfall (Ward et al., 2012). Against this background, it is not justifiable to exclude considerable amounts of precious fodder material from use, leaving it to decay in the scorching sun, while the soil is dried out completely all the same. This is confirmed by another study which states that "in many African mixed farming systems, particularly in the semi-arid areas where livestock are of great importance, the costs of retaining crop residues as a mulch may be too great in relation to the potential benefits that are often difficult to quantify" (Giller et al., 2009). On the other hand, it is important for the soil to be protected by some kind of cover at the end of the dry season, when the first rains hit the ground. In other studies, as well, farmers were encouraged to leave crop residue as mulch or to introduce leguminous intercrops, but neither mulch nor any significant cover crop was successfully achieved (Rockström et al., 2009). Even though the authors of these studies showed that Conservation Agriculture "can work in water scarcity prone farming systems without full mulch cover" (Rockström et al., 2009: 30), they admit that it remains an important component.

One of the greatest constraints on no-tillage on these marginal lands is the slope gradient and the high presence of stones. These prevent the direct seeder from correctly placing the seeds in the soil and closing the seed rill after passing. As a result, the success rate of the seeds is heavily reduced, and seeds are left accessible to birds. For this reason, the circumstances seem to require some form of tillage; minimum tillage, however, might be sufficient. The results achieved under minimum tillage look promising with regard to both seed establishment and soil moisture. Nevertheless, land users were not really convinced by the results. The small increase in grain and straw yield was not sufficient for them, and the soil showed no visible improvement after so short a time. Moreover, the need for fencing was perceived as a major threat and was met with strong objections, since free grazing is a traditionally enforced right. There is, however, already an increasing tendency towards fencing in the Sehoul region to confirm ownership as well as to establish fruit tree plantations. This further increases the pressure to graze livestock on the more marginal slopes, and might therefore be one of the reasons why land users in Sehoul are afraid of losing these marginal grazing lands.

These findings call for a broader perspective than an individual farmer's plot. This need is confirmed by long-term research in India, which has shown that sustainable production is possible in dryland agriculture if it integrates soil and water conservation with livestock nutrient management at the catchment scale (Sahrawat et al., 2010). Large-scale application of minimum tillage would entail a complete revision of land management in Sehoul, including strategies such as controlled grazing (with or without fencing) and cut-and-carry harvesting of fodder. Furthermore, it would also require regulations on the use of the remaining natural forest areas in order to prevent increased pressure as a result of reduced access elsewhere.

To date, no variables have been found which could satisfactorily explain the adoption of Conservation Agriculture (Knowler and Bradshaw, 2007) or soil and water conservation in general (de Graaff et al., 2008). For this reason, efforts to promote Conservation Agriculture have to be tailored to the locations and contexts in question. However, de Graaff et al. found that farmers who have some knowledge about natural resource management invest significantly more time in soil and water conservation measures. This competence was inadequate in Sehoul prior to the study presented in this paper, but has apparently increased owing to the participatory approach taken in this study, as several stakeholders have reported. The involvement of a variety of stakeholders in identifying land management problems and solutions allowed conducting the research trials in close collaboration with partners engaged in the dissemination of SLM technologies. This proved to be successful in other similar action research projects, as presented by Rockström et al. (Rockström et al., 2009).

7.5 Conclusions

Due to the limited setup of this study, the indicative conclusions drawn above require further and longer-term research in order to be developed into more strongly grounded and evidence-based recommendations. However, the embedded nature of the study and the close collaboration with stakeholders successfully ensured that the results reflected land users' requirements and expectations.

The results show that better soil cover and minimised soil disturbance improve the water balance and production under some circumstances only. A major limitation is the stony nature of the soils, which proved to be unsuitable for no-tillage with direct seeding and also created difficulties for minimum tillage. Another limitation is the need to retain crop residues as mulch. As expressed by various stakeholders, the land users' priorities lie with animal husbandry, and they are reluctant to change the current grazing system.

Although the results indicate that Conservation Agriculture has beneficial ecological impacts, the socio-economic impacts are insufficient. The nearby city is currently seen as a threat due to its dazzling alternative job options – which, however, are not really accessible to the illiterate rural poor. The younger generations in particular appear to be losing their agricultural knowledge before gaining a foothold in the city's job market. At the same time, the vicinity of a city implies access to markets and to agricultural inputs and services. Moreover, the agro-climatic conditions of Sehoul are favourable compared to other drylands in the world, with adequate rainfall in many years.

Overall, Conservation Agriculture remains a challenge in this context characterised by degraded and stony slopes, the temptations of the nearby city, and a strong preference for the traditional agro-pastoral system. Thus, the search for suitable SLM technologies has to be continued in this region, involving key stakeholders. Investments might be required to improve advisory services and government support, or to establish rewarding schemes for compensating ecosystem services.

Chapter 8

Synthesis

Synthesis

8.1 The research questions

The main body of the present research consists of the development and application of a comprehensive methodological framework for integrating stakeholders in the appraisal of sustainable land management (SLM) strategies (objective 1) and selecting the most promising SLM technologies for local test implementation (objective 2). The framework was developed on the basis of various existing tools, some of which are reviewed in Chapter 2. The new framework complements these tools, which are generally categorised under the term of monitoring and assessment, with participatory elements (Chapter 3), a comprehensive documentation and evaluation of existing SLM strategies (Chapter 4), and a decision support tool for local application in order to test and finally upscale SLM (Chapter 5). The outcome of this process facilitated multi-stakeholder learning, as evaluated and presented in Chapter 6. Overall, the research outcomes presented in these chapters provide extensive answers to the research questions related to objectives 1 and 2 of this study. They confirm the first hypothesis that a widely applicable and practical methodology which integrates a broad range of stakeholders from the start allows a comprehensive appraisal of local as well as external SLM strategies. They also support the second hypothesis, showing that the newly developed decision support tool is considered innovative and successfully guides decision-makers in selecting appropriate SLM options for local implementation, leading to increased acceptance of, and commitment to, SLM on the ground.

Objective 3 concerned the test implementation and monitoring of one specific SLM technology in Morocco. Based on the assumption that on-farm trials and monitoring leads to a better understanding of the functioning of SLM, the aim was to integrate field research and participatory monitoring tools with in-depth environmental impact assessment. Results are presented in Chapter 7. However, the participatory monitoring did not work out as intended, which is why Chapter 7 focuses more on findings showing that better soil cover and minimised soil disturbance lead to an improved water balance in drylands, which was the second premise related to this objective.

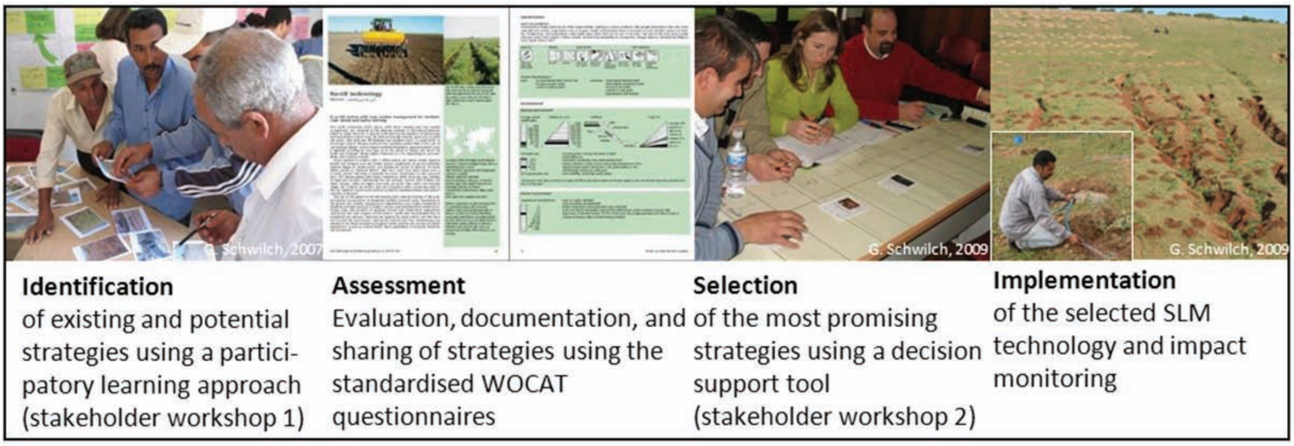

Figure 8.1. Structured process for identifying, assessing, selecting, and implementing SLM strategies.

Taken together, the chapters of this thesis cover the entire cycle of activities involved in a process of effective desertification mitigation, from the initial assessment and appraisal of SLM options and the selection of viable options together with stakeholders to the implementation of the selected options and monitoring of their impacts (Figure 8.1). Although the description of each single part and the findings regarding its application reveal valuable outcomes, it is only the combination of all parts that makes the proposed methodology an innovative and comprehensive tool for mitigating desertification.

This synthesis chapter offers more detailed reflections on certain aspects of the research findings presented in the preceding chapters, such as the 3-part methodology (section 8.2), monitoring and assessment (section 8.3), stakeholder collaboration and learning (section 8.4), decision support (section 8.5), and desertification mitigation by means of SLM technologies and approaches (section 8.6). This is followed by a review of challenges and limitations of the proposed methodological framework (section 8.7) and an assessment of its overall impact (section 8.8). The chapter concludes with an outlook and recommendations (section 8.9).

8.2 The 3-part methodology

The 3 parts of the proposed methodological framework comprise (1) identification, (2) assessment, and (3) selection of SLM strategies for subsequent field testing. Developing a generic methodology applicable in all 17 DESIRE study sites was a challenge, given the diversity of contexts and the variety of researchers participating in DESIRE. Chapters 3, 4, and 5 indicate that the proposed 3-part methodology can, indeed, be implemented in diverse environmental and socio-economic contexts, and that it was well received by researchers as well as other stakeholders. Additional independent application of the methodology by participants outside the DESIRE project further indicates its usefulness and outreach.

Nevertheless, pronounced challenges remain to be overcome by those who apply the methodology, as discussed in Chapter 3. This includes methodological challenges for process facilitators as well as thematic challenges for all involved. Desertification mitigation continues to be a complex issue, and becomes even more so when dealt with in a comprehensive and solution-oriented manner.

Application of the proposed methodology in the DESIRE study sites has also clearly confirmed the need for specific training and continued support of users. The DESIRE study site researchers – often with single-discipline backgrounds (mostly in natural sciences) – received training within the project, enabling them to apply this comprehensive approach and tackle a complex problem together with a variety of stakeholders. Any future attempts to apply the methodology will necessitate such specific training as well. Although the DESIRE project has ended, some support might still be available through the WOCAT network (www.wocat.net), which has adopted and begun to promote the proposed 3-part methodology.

The 3-part methodology developed within the present research has also been included in a methodological framework for cross-scale knowledge management (Reed et al., in press). This suggests that it is compatible with other tools and methods, and that it offers comprehensive coverage within the scope of its focused aim.

8.3 Monitoring and assessment

The role of science in monitoring and assessing desertification as well as conservation – that is, SLM – is to produce evidence of their impacts on natural resources and to assess the implications these impacts have for society, the economy, and policy (Hurni et al., 2006). However, sophisticated and detailed assessment is not always possible, as it is often expensive and time-consuming and depends on the availability of skilled experts. Accuracy and comprehensiveness need to be adequately balanced, taking into account the full range of impacts on the ecological, economic, and socio-cultural dimensions of sustainability. Although numerous well-tested methodologies exist for monitoring and assessing single aspects of these impacts, rapid and at the same time comprehensive approaches were lacking at the outset of this research, especially regarding the impacts of SLM. The costs and benefits involved in SLM are usually not sufficiently considered, and the focus frequently remains on desertification, while positive achievements of ongoing SLM efforts are neglected. The methodological framework and related tools presented in this study have proven to be economic, practicable, and consistent, supporting comparison across localities and nations and at the same time allowing for flexibility in serving the interests of various stakeholders.

Effective monitoring and assessment of SLM requires accessibility of tools and methods, which can be achieved by means of free access and training for a range of stakeholder and researcher groups. This has been fulfilled within the present research. Integrating regional, national, and international levels, however, will remain a challenge unless a global process, such as UNCCD, clearly endorses a methodological framework that covers the elements and tools outlined in this study (see also section 8.7 on scale challenges and limitations, as well as outlook and recommendations in section 8.9).

The analysis of SLM technologies documented in DESIRE has revealed that more field research is needed to back up expert valuation of SLM impacts and provide the necessary motivation and arguments for investment in SLM. Moreover, there is a need for more quantitative data; this can be obtained by monitoring SLM technologies where they are implemented, that is, at the field level and together with the relevant land users. The study in Morocco (Chapter 7) has shown that this is demanding on both researchers and land users, and that a careful study setup is crucial. Nonetheless, field-based research remains the most important source of monitoring and assessment data. Accordingly, monitoring and assessment requires sufficient resources and long-term commitment.

8.4 Stakeholder collaboration and social learning

Although participatory approaches and social learning are enjoying increasing popularity, there is a mismatch between participatory standards initiated at an international level and the national and local contexts in which they are applied (Stringer et al., 2007). This is especially true when it comes to implementing the UNCCD. National and local political culture has a decisive influence on collaboration between decision-makers and local stakeholders. In many cases, the implementation of participatory approaches is impaired by the given political system, the legal and institutional setup, as well as social and cultural norms and customs. This was confirmed during application of the participatory approach in the present study. The political and socio-economic contexts of the study sites could not have been more diverse, ranging from former Communist countries to Western welfare nations and some of the least developed countries. Aside from certain obvious adaptations of the generic methodology to the local circumstances, the study site teams made various additional modifications, resulting, for example, in unbalanced group composition or shortened workshop durations. These modifications seriously affected the quality of the intended mutual learning process (see Chapter 3).

Despite these limitations, the proposed 3-part methodology appears to facilitate effective multi-stakeholder learning processes that contribute to more sustainable management of land. It stands out from other participatory approaches in that it is solution-oriented and combines local participatory processes with global knowledge sharing. Its analysis in Chapter 6 reveals several key elements of successful multi-stakeholder learning:

- Joint reflection upon a clearly articulated issue (within a specific context)
- Sufficient time and continuity for building trust
- Unrestricted and thorough scientific contributions

In the literature, social learning is currently regarded as a key element on the pathway to sustainability, and "it has been proposed as a process to overcome difficulties in decision-making processes related to natural resource management" (Garmendia and Stagl, 2010). Over the last years, many new studies emerged which aimed at initiating social learning or reflected on its outcomes (Albert et al., 2012; Pahl-Wostl et al., 2008; Schneider et al., 2009; van Bommel et al., 2009; van Paassen et al., 2011). In some cases, the investments required to trigger social learning were enormous (e.g. complex computer models, time-consuming stakeholder activities, etc.), leading to the question of whether it cannot be achieved more easily. Although it was beyond the scope of this study to examine whether the proposed methodology indeed resulted in genuine social learning, evidence suggests that this might be achieved in the long term, based on repeated application of the methodology. The methodology certainly offers a practical and economical way of bringing stakeholders together, getting them to talk to each other, and initiating mutual learning. This is undoubtedly very important and a first step in the right direction, considering that even in situations with a functioning agricultural advisory service in place, advisors are frequently not really familiar with land-users' situations and reasoning (van Paassen et al., 2011). Right from the beginning of the process, all stakeholders contribute their own perspectives and types of knowledge and develop a common understanding of prevalent desertification problems as well as existing and potential solutions. Joint deliberation on each other's perspectives and types of knowledge enhances learning processes (Garmendia and Stagl, 2010) and thus facilitates the creation of new responses to the threat of desertification.

Differing priorities may point to a conflict of interest among stakeholders. In this regard, application of the 3-part methodology in the Boteti District of Botswana revealed that "the participatory approach facilitated a close working relationship between the research team and local communities, which translated into strong local ownership of the adopted SLM strategies" (Perkins et al., in press). In the same site "there was a very high land user appreciation of what they referred to as the 'DESIRE project process' of solving land use and management problems. […] They further applauded the process for promoting cooperation among various stakeholders and for affording them the opportunity to learn about the various remediation strategies from DESIRE experts" (Perkins et al., in press).

8.5 Decision support

The decision support methodology developed within this study is discussed extensively in Chapter 5. Its application in all DESIRE study sites revealed that the methodology is easy to apply, well-structured, and at the same time highly flexible. It has the capacity to successfully guide a decision-focused participatory process. Its strength is to include stakeholders on an equal footing while at the same time balancing the different dimensions of sustainability. Perkins et al. (in press) describe this in the following words: "The use of multi-criteria evaluation makes the reasons why participants selected particular SLM options transparent, and it is interesting to note that despite considerable disagreement over the ecological benefits of game ranching, it was prioritised by participants primarily for socio-cultural and economic reasons. This emphasises the need to consider the socio-cultural and economic aspects of land degradation and SLM alongside environmental dimensions. The contrast between the results of this research and previous research in the area may therefore reflect a difference in the relative priority that researchers and local stakeholders give to these different dimensions of sustainability" (Perkins et al., in press).

Whether or not the proposed decision support methodology indeed led to more effective decisions, however, cannot be answered clearly. More research would be needed to evaluate the outcomes of the decisions taken, their impact on the ground, and the long-term sustainability of the selected technologies. Nonetheless, at this point, indications regarding the strength of the decisions taken at the second stakeholder workshops in each study site can be extracted from the conclusions drawn at the end of the DESIRE project. These were obtained by organising a third stakeholder workshop in each study site, enabling stakeholders to review evidence from field trials and models and to use this information to prioritise remediation strategies for regional dissemination. The results of this final evaluation give an indication of both (i) the value of the decisions taken at the second workshops in each site and (ii) the successfulness of the test implementation. A small number of field trials showed that the selected remediation strategies were not as effective as stakeholders had initially believed; in most cases, however, evidence from field trials supported the stakeholders' initial appraisal, and their priority ranking of remediation options changed little in response to the evidence they were presented with (Reed et al., 2012a). The technologies were evaluated using the same criteria as in the second stakeholder workshops. Table 8.1 provides an overview of the technologies prioritised at the second workshops, those tested in field trials, and the final prioritisation at the third workshops.

8.6 Mitigating desertification by means of SLM technologies and approaches

Table 8.1 shows all SLM technologies discussed and prioritised during the DESIRE process. What was finally compared and evaluated across sites (see Chapter 4) includes only a subset of these. The 30 technologies and 8 approaches were selected based on the completeness of their description and their relevance in the DESIRE process (i.e. so as to ensure a wide variety of SLM strategies, study sites, land use types, degradation types, etc.). Most of these SLM technologies were also field-tested during DESIRE, and their documentation was updated based on the monitoring of this experience. Some SLM technologies were documented for the first time only after the field trials, using WOCAT questionnaires.

All of the studied technologies and approaches tackle the identified threats of desertification. The most prominent ecological impacts were “increased soil moisture”, “reduced surface runoff”, “improved soil cover”, and “reduced soil loss”, confirming that water is the most common limiting factor to production in drylands due to a mixture of its scarcity and extreme variability. Improving water use efficiency is thus of utmost importance (Biazin et al., 2011; Stroosnijder, 2009; Liniger et al., 2011), along with providing socio-economic benefits.

It has to be noted, however, that it was the most promising options – selected by the stakeholders for this very reason – which were documented and evaluated, thus leading to an inherent bias towards positive results. The SLM technology discussed in Chapter 7, for example, was not included in the cross-site analysis, as results were not sufficiently promising. Although it led to a better soil cover and minimised soil disturbance, thereby partly improving the water balance and slightly increasing production, it was not favoured due to practical problems with stony slopes and insufficient socio-economic benefits.

The results from this study – and DESIRE in general – clearly confirm that there is no such thing as “best practices” of SLM which could be successfully applied to combat desertification in all dryland areas (Bayala et al., 2012; WOCAT, 2007). The biophysical and socio-economic contexts vary too much from site to site, even if the focus is reduced to drylands and a desertification context. Nonetheless, it is possible to distinguish certain patterns, clusters, or syndromes of problems (Sietz et al., 2011; Hurni et al., 2004), and it is the similarities at this level that allow learning from each other and modifying, adapting, and possibly combining solutions that were successfully applied in another site. This step of adaptation, however, requires a multi-stakeholder evaluation and selection process as suggested in this study.

Bayala et al. (2012) suggest three pathways: (1) ensuring that projects/programmes and stakeholders are exposed to multiple options which they can test and select from; (2) promoting local experimentation to encourage the development of more nuanced and context-specific recommendations; and (3) continuing research aimed at understanding processes and principles, with a view to designing interventions that are feasible within a particular context. Together, these efforts will reduce the risks faced by land users that are inherent in the promotion of “one-size-fits-all” technologies (Bayala et al., 2012). Although the study by Bayala et al. focused on Conservation Agriculture in drylands of West Africa only, the present study has, once more, confirmed that this applies worldwide and to all SLM options.

Table 8.1: SLM technologies prioritised at the second stakeholder workshop, tested in field trials, and prioritised at the third workshop in each study site.

Study site	Priority order 2nd workshop	Test implementation	Priority order 3rd workshop	Comments
Spain	Vegetated earthen terraces	–	Green manure in almond orchards	Green manure most effective (reduced soil and water loss and increased farm income), relatively simple and economically feasible. *Boqueras* require initial investment. Straw mulch was not effective during field testing.
	Traditional water harvesting structures	Traditional water harvesting (earthen wall to divert water)	Reduced tillage in cereal and almond fields	
	Reduced tillage	Reduced tillage using disc plough	Traditional water harvesting (Boquera)	
	Organic mulch	Straw mulch to reduce evapotranspiration	Organic mulch to reduce water losses	
	Ecological agriculture	Green manure		
Portugal (Mação and Góis)	Preventive forestry	Preventive forestry through strategic management of fuel strips	Primary strip network system for fuel management	The final scores compared with the results from the second workshop were higher, probably due to increased know-how from test implementations.
	Prescribed fire	Prescribed fire	Prescribed fire	
Italy	(No technology prioritisation)			
Greece (Crete)	No tillage	No tillage, with and without application of herbicides		
Greece (Nestos)	Transport of freshwater from local streams to replace saline groundwater (for irrigation)	Transport of freshwater from local streams	Transport of freshwater from local streams	Participants were even more in favour of the technology after debating the benefits during the third workshop.
Turkey (Karapınar)	No tillage	No tillage	Fallow with stubble farming	Project staff added stubble farming technology and replaced no-tillage technology with minimum tillage.
	Pressurised irrigation	Strip cropping, mulching	Fallow without stubble farming	
	Caragana korshinskii planting (on grazing land)		Minimum tillage	
Turkey (Eskişehir)	Contour planting	Contour tillage	Wooden fences with soil bund	Vegetation and stones were replaced by fencing on soil bunds for field trials. Wooden fences increased crop yield and reduced risks to production, but incurred significant installation costs.
	Stone bunds	Sediment fences (woven branches)	Contour tillage	
	Fanya juu terraces			
Morocco	Vegetative strips in crop rotation	–	Olive and fig trees; *Cactus opuntia* and runoff water harvesting	The economic criteria of yield and income, already used in the second workshop, were evaluated as more important than any other.
	Treatment of gullies	Gully treatment with *Atriplex* plantation	Protection of grazing land, forests and former cultivated areas	
	Olive trees and runoff water harvesting		Gully treatment	
	–	Mulching and minimum tillage		
Tunisia	*Tabia* and *jessour*	*Tabia* and *jessour* runoff water harvesting	Flood spreading and recharge units	The focus was on technologies that have direct impacts on farmers' income. Most technologies scored

	Flood spreading and recharge units	Recharge wells	Supplement irrigation	lower after field trials and modelling, reflecting either dissatisfaction or an initial overestimation of impacts.
	Supplement irrigation		Medicinal herbal and aromatic plants	
	Cisterns	–	Cisterns	
	(Enclosure)	Rangeland resting (enclosure)		
Russia (Djanybek)	Drip irrigation with supplied water	Drip irrigation	Drip irrigation	Prioritisation in second workshop different for two villages.
	Grazing land management by rotation	–	Impermeabilisation of the bed of water storage capacities	
	Tree plantations	–	–	
	Snow melt water harvesting	–	–	
Russia (Novy)	Precision irrigation	–	Drip irrigation	
	Drip irrigation	Drip irrigation	Green manure	
	Reduction of infiltration losses from water supply channels	–	Drainage of irrigated agricultural fields	
	–	–	Phytoreclamation	
China	Check dams for land	Check dams	Check dams	The three strategies prioritised during the initial workshop were assessed to be clearly the most important options in this region given their benefits.
	Reforestation	–	Reforestation	
	Level bench terrace	Infiltration contour ditch and grass planting	Terraces	
	–	Residue mulching (and contour ploughing)		
	–			
Botswana	Game ranching	–	Biogas production	Only biogas was tested and evaluated during the 3rd workshop.
	Biogas production	Biogas to conserve woody vegetation		
	Rainwater harvesting	–		
	Solar cookers	–		
Mexico		Agave forestry	Agave forestry	Agave forestry was proposed as a new technology during field trials only.
	Agronomic measures (fallow, residue mulching)	Agronomic measures	Wood saver ovens	
	Wood saver ovens	Wood saver ovens	Agronomic measures	
	Runoff control in gullies	Runoff control in gullies (stone dams)	Runoff control in gullies	
Chile	No tillage	No tillage in combination with crop rotation and subsoiling, contour strips, infiltration trenches	No tillage with subsoiling	
	Agroforestry		Crop rotation with legumes	
	Crop rotation with legumes		Agroforestry	
Cape Verde	Afforestation	Afforestation/agroforestry		Only the pigeon pea technology was evaluated during the third workshop
	Vegetative barriers	Vegetative barriers with *Leucaena*, *Aloe Vera*, *Cajanus cajan*	Vegetative barriers with *Canjanus cajan* (pigeon pea)	

Sources: Study site workshop reports; own investigations; Reed et al., 2012

The study of SLM options within DESIRE also points to another important issue. In many sites, the selected options indeed led to an increase in production, but this increase remained fairly limited. Land users in highly vulnerable zones such as drylands already face high risks of production (e.g. due to high variability of precipitation from year to year) and are therefore reluctant to undertake another bold venture, unless their interest is raised by persuasive and short-term benefits. For this reason, an SLM technology that is to be successfully applied in drylands has to be equally beneficial in economic terms as in terms of reducing risks. This has been confirmed by the study in Morocco (Chapter 7), which showed that farmers were not ready to take the risk of changing their production system based on rather weak evidence from short-term research trials.

Although successful SLM technologies and approaches are a suitable way of tackling desertification at the local level, upscaling them in order to achieve larger-scale impacts remains a major challenge. Along with collective actions at the local scale, this also requires the creation of an enabling environment at the envisioned larger scale (Kessler and Stroosnijder, 2010; Akhtar-Schuster et al., 2011).

8.7 Challenges and limitations

Transdisciplinary research

Research for sustainable development faces specific challenges, which include the need to address power relations, integrating different perspectives and facilitating knowledge co-production towards sustainability (Pohl et al., 2010). These challenges were confirmed in the present study as much as during application of the resulting methodology in the DESIRE study sites, where the local researchers were at the forefront. However, the additional time required for transdisciplinary interaction yielded more valid results, as well as the possibility of checking results in reality by triangulating different interpretations of the same problem (Enengel et al., 2012). What is needed is research that integrates the purposes of learning to simultaneously enhance the process under study, accountability to stakeholders, and scientific development (Sterk et al., 2009).

Although only part of the present PhD study was conducted in a truly transdisciplinary manner, all of the work was strongly related to transdisciplinarity through the application of the developed methodology in the DESIRE study sites. The scientific work for this study was thus not only challenged by the uncertainties inherent in close collaboration with local stakeholders, but also by the multitude of expectations and views held by the DESIRE researchers. Given the broad variety of disciplines they came from, it was difficult to raise their interest and commit them to the proposed methodology and its implementation, which, according to the study design, had to be carried out by these very same researchers in their various sites.

Enengel et al. (2012) analysed transdisciplinary doctoral theses and found that this type of work requires a high level of flexibility as well as stringent research management in order to maintain control over the process and fulfil the individual requirements for doctoral qualification. Such doctoral projects should therefore be seen as open interaction processes that are characterised by uncertainty, while acknowledging the heavy dependency on the commitment and schedules of numerous actors (Enengel et al., 2012). Additionally, the publication of trans- and interdisciplinary research results is challenged by the way in which today’s world of science focuses on articles in mono-disciplinary journals.

Commitment

Common and well-known challenges to participatory approaches are time and resource constraints. These often limit the successful integration of relevant stakeholders into the process and thereby prevent outcomes from influencing higher-level decision-making. The findings of this study indicate that there is a need for personal involvement of decision-makers, requiring them to invest their scarce time. This observation has been confirmed in a similar study conducted in Germany (Albert et al., 2012). Albert et al. also stress the importance of provisioning appropriate funding and the need for local decision-makers to develop a feeling of ownership of the process. Indeed, the same holds true for all stakeholders, including researchers. The role of the researchers involved in the DESIRE process was very important, as it was they who drove the whole process in the study sites. Some study site teams managed to maintain a good and close relationship with stakeholders throughout the entire process, while others were less committed. Large time gaps between workshops and long periods in which stakeholders heard nothing from the research teams and had no up-to-date information about the process hampered stakeholders' trust in the process. In Morocco, for example, stakeholders complained about the missing relationship, as expressed by a technician from a local service centre: "*I was very motivated for the first workshop, but then there more than a year went by until the second one took place. And there was no contact and no written report in the meantime. It looked like nothing would happen. […] After 3 months without contact, one thinks that the project no longer exists. […] If something takes too long it loses credibility.*" In other sites, contact with stakeholders was intense and highly appreciated, such as in Portugal and Spain. One conclusion drawn from reviewing the experiences in all sites is that the level of commitment and dedication of the persons driving the process is key. Any research stands or falls with the personality of the scientist, but transdisciplinary research and participatory approaches crucially depend on it.

Scale and sustainability

This study and the resulting methodological framework clearly focus on the local level, ranging from single fields to small watersheds or communal administrative units. Nevertheless, higher-level decision-makers were involved and included as much as possible – for example by means of the participatory stakeholder workshops, for which they were regarded as important stakeholders too. However, in order for the process to become even more effective in mitigating desertification, it should be fully embedded into higher-scale decision-making. This could best be achieved both through repeated application in all local units of a higher administrative unit and by using additional complementary tools based on mapping and remote sensing (see also Chapter 2; Winslow et al., 2012). However, certain issues cannot simply be aggregated, but emerge only at a certain scale or show non-linear relationships. Spatial heterogeneity, off-site effects, and cross-scale interactions pose challenges to upscaling local SLM options and their implementation processes. This requires an ecosystem approach and might lead to debating and deliberating over ecosystem services among users at a variety of scales. In addition, time scales play an important role as well in moving towards more sustainable management of land. Anticipated and observed long-term impacts are crucial to sustainable systems. These issues are, indeed, addressed in the process suggested in this study; nonetheless, the process might benefit from this being made more explicit throughout all steps.

The various manifestations of SLM processes, as well as the ways in which they are perceived and valued by stakeholders, vary over time and space. These contexts depend on the definition of the human–environment system focused upon, and they include the societal context within which the normative concept of sustainability continuously changes.

Assessing SLM technologies and approaches in terms of their sustainability remains a challenge. It requires an integrated and comprehensive assessment of impacts over the long term, which might be achieved if the documentation and evaluation methodology is applied repeatedly at a certain time interval (e.g. every 5 years). However, results from this study (see Chapter 4) suggest that the proposed methodology might not be in-depth enough and needs to be complemented by monitoring selected indicators at a higher level of accuracy.

8.8 Overall impact

This study included the development of an SLM appraisal and selection methodology which focuses on the practical process of collaboration with stakeholders and provides a framework for an efficient, targeted engagement with clear goals and results. The participatory process brings together "technological and expert" options and local practices and innovations, while both are critically reviewed and appraised within the given ecological, economic, and socio-cultural context. The key to success lay in the concerted effort and in the production of scientific knowledge with a view to finding a balance between local knowledge and technical expertise as well as between socio-cultural, economic, and ecological impacts of SLM. In this respect, deliberative multi-stakeholder approaches that enhance learning are key to developing new responses to threats.

This PhD study was fully embedded in the DESIRE project, as the 3-part methodology was a central part of the project workflow. The DESIRE methodological approach, together with the documented SLM case studies, are presented in the book *Desire for Greener Land – Options for Sustainable Land management in Drylands* (Schwilch et al., 2012c). The major results of DESIRE will be published in three journal special issues. All project results are also available on the DESIRE Harmonised Information System (www.desire-his.eu), and many of the results, in particular from this thesis, were processed into a number of info briefs, policy briefs, posters, and presentations for both scientific and lay audiences. The proposed methodological framework or elements thereof have also been used and acknowledged by other projects and institutions, as well as in the literature (CDE, 2010; FAO, 2011; Liniger et al., 2011; Reed et al., in press). Overall, this study reached a high number of people concerned with desertification, including UNCCD.

The current plea for a stronger role of science within UNCCD is accompanied by claims for science to "raise awareness, assess the current situation, and develop future scenarios to inform policy options based on state-of-the-art scientific assessments" (Thomas et al., 2012). By proposing a methodology to identify and select concrete options for SLM, the present study actually went beyond simply meeting this request. Close collaboration of researchers with practitioners and commitment to jointly working towards more sustainable management of land is needed at the local level and beyond in order for SLM to have an impact on the ground and contribute to fulfilling the targets of the convention. Impacts of science might be more effective and might remain under closer control by the scientific community if researchers directly engage with stakeholders and policymakers, rather than simply exposing results – through scientific publications – to use, misuse, or suppression by politicians.

8.9 Outlook and recommendations

Has this study simply repeated and confirmed what has been requested for many years – that is, that upscaling SLM requires a participatory process to evaluate and recommend suitable SLM options? On the one hand, it has; but on the other hand, no comprehensive and at the same time easily applicable and economical methodology which could be repeated at any location and over many years has previously been suggested. Only if such a methodology can be mainstreamed into governmental structures and regional initiatives, will it finally have an impact on the ground and beyond selected fields of project exponents. This, again, will require commitments in terms of human and financial resources. It cannot be made explicit enough that research has to move beyond simply idealising and promoting participatory approaches and learning processes. Researchers must also advocate the provision of time and resources and the establishment of long-term partnerships by both scientific and policymaking bodies. But the scientific community, limited in time, space, and thematic scope – and often driven by the urge to develop new methods and findings rather than applying standardised methods – is reluctant to provide the scientific support required (see also Chapter 2). In-depth and long-term field-based research is important, but requires sufficient resources and long-term commitment in order to provide adequate evidence and data for monitoring.

The outcome of this research is not limited to the desertification problem only. The methodology developed and suggested is appropriate and useful to tackle land degradation anywhere in the world. This is in line with the argument that UNCCD should broaden its focus to encompass all ecosystems and climatic zones in order to gain more attention (Thomas et al., 2012).

Several more specific recommendations for UNCCD are presented in Chapter 2, based on a core concept for an integrated monitoring and assessment approach developed together with an international group of experts and on the request of UNCCD. The six requirements presented there were confirmed by the present study to be valid for successful monitoring and assessment: (1) common conceptual framework, (2) common methodological framework, (3) nested scales, (4) common indicators and variety of data sources, (5) participation and interdisciplinarity, and (6) knowledge management from local to international scales. The WOCAT technologies and approaches questionnaires and databases as well as the DESIRE stakeholder workshops are two of the methods for which ways of integrating them into a common framework are proposed. This common framework could provide insights into the outcomes of efforts to mitigate desertification and could help UNCCD to monitor progress towards its goals.

Box 8.1 presents the main conclusions as formulated for the book *Desire for Greener Land* (Schwilch et al., 2012c). They are derived to a large extent from this thesis and form a useful summary of recommendations based on this research.

Main conclusions from the DESIRE project that are of relevance to policymakers:

- SLM options need to be developed and evaluated by capitalising on close collaboration between scientists and stakeholders, and by tailoring options to local needs and priorities.
- It is important to consider local knowledge and traditional approaches to land management alongside the latest technologies emerging from the research community, and to work to combine insights from both of these sources.
- A structured process in which stakeholders work together at a local level to identify, evaluate, and select SLM options for field testing has proven to be effective. The implementation and monitoring phase needs to take into account the criteria for success as identified by stakeholders during the participatory planning process.
- Standardised assessment and documentation using WOCAT tools allows an evaluation of current practices, a comparison of implemented SLM technologies and approaches across sites, and mutual sharing of experiences through a variety of formats.
- Rigorous impact assessment is required to evaluate whether the expected biophysical and socio-economic benefits have been realised.
- SLM has multiple ecological, economic, and social benefits which go beyond the potential to reduce land degradation and desertification; for example, it also addresses the global concerns of water scarcity, resource use efficiency, energy supply, food security, poverty alleviation, climate change and biodiversity conservation.
- Taking into account these multiple benefits, investments in SLM are usually completely justified; they may require funding schemes from the private and public sectors, especially when involving small-scale land users and marginalised people.

Box 8.1. Main conclusions for policy makers (source: Schwilch et al., 2012).

The last item in Box 8.1 points to an important and promising future pathway. Negotiation of and deliberation over ecosystem services might be the key to boosting SLM beyond the local scale, while at the same time compensating land users for their crucial efforts in combatting desertification. The methodological framework and its tools developed in this study might allow advancing towards more sustainable decisions on SLM strategies that are accepted among stakeholders.

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Summary

Fragile dryland ecosystems are characterised by water scarcity and harsh climatic conditions. Disturbances in these ecosystems can easily result in widespread and severe land degradation and thus desertification. Combined with global issues such as climate change, economic disparities, migration, and competing claims on land, this often leads to a vicious cycle of aridity, land degradation, and productivity loss. In addition to the harsh environmental conditions limiting land productivity, the socio-economic situation in drylands can pose challenges as well, given that these regions are often characterised by remoteness, marginality, low-productivity farming, weak institutions, and even conflict. Managing land sustainably under such conditions is a challenge which concerns land users and other stakeholders, policymakers, and researchers alike. Desertification research has traditionally focused on degradation assessments, whereas prevention and mitigation strategies have not sufficiently been emphasised, although the concept of sustainable land management (SLM) is increasingly being acknowledged (Chapter 1).

The present research was embedded in the EU FP6 research project DESIRE (Desertification Mitigation and Remediation of Land – a Global Approach for Local Solutions; 2007–2012). DESIRE aimed to establish promising alternative land use and management strategies in 17 areas affected by land degradation and desertification around the world. Project work was based on close collaboration of scientists with local stakeholder groups. The study sites served as a global laboratory for developing and applying new methods of science – stakeholder collaboration and trialling traditional and innovative approaches to combating desertification.

Chapter 2 offers a compilation and review of a number of methodological approaches to monitoring and assessing SLM which to date have been little reported in the literature. Lessons are drawn from these experiences, and common elements and future pathways are identified as a basis for a global approach. The local-level methods of the World Overview of Conservation Approaches and Technologies (WOCAT) framework serve to catalogue SLM technologies and approaches as case studies. This tool was included in the local-level Land Degradation Assessment in Drylands (LADA) as well as in the DESIRE project. Complementary site-based approaches can enhance an ecological process-based understanding of SLM variation. At national and sub-national levels, a joint WOCAT/LADA/DESIRE spatial assessment based on land use systems can be used to identify the status and trends of degradation and SLM, including causes, drivers, and impacts on ecosystem services. Expert consultation is combined with scientific evidence and, where necessary, enhanced with secondary data and indicator databases. Key lessons learnt include the need for a multi-scale approach, for using common indicators, and for drawing on a variety of information sources, including scientific data and local knowledge, by means of participatory methods. Methodological consistency allows for cross-scale analyses, and findings can be analysed and documented for use by decision-makers at various levels. Effective monitoring and assessment of SLM (e.g. for the United Nations Convention to Combat Desertification, UNCCD) requires a comprehensive methodological framework agreed upon and adopted by the major players.

Although a variety of conservation measures are already applied at the local level, they are not adequately recognised, evaluated, and shared by land users, technicians, researchers, and policymakers. Likewise, collaboration between researchers and implementers is often insufficient. Chapter 3 presents a new methodological framework for a participatory process of appraising and selecting desertification mitigation strategies, and outlines first experiences from its application in the DESIRE project. The methodology – a key product developed within this PhD study – combines a collective learning and decision-making approach with the use of evaluated global best practices. It moves through a concise process in three parts, starting out with the identification of land degradation and locally applied solutions in a stakeholder workshop, followed by an assessment of local solutions using a standardised evaluation tool, and ending with the joint selection of promising strategies for implementation with the help of a

decision support tool. A preliminary analysis of the application of the first part of the methodology showed that the initial stakeholder workshop resulted in a good basis for stakeholder cooperation and yielded promising land conservation practices for further assessment. Study site research teams appreciated the results, which they considered particularly valuable because urgent issues and promising options had emerged from joint reflection. The methodology was found to be suitable for initiating mutual learning among different stakeholder groups, as well as for integrating local and scientific knowledge.

The thus identified SLM practices were then documented and evaluated by local researchers in collaboration with land users and using the internationally recognised and standardised WOCAT questionnaires. These in-depth assessments of 30 technologies and 8 approaches are analysed and compared across the DESIRE study sites in Chapter 4, highlighting key issues of SLM in drylands. Careful attention is paid to features which specifically characterise SLM in drylands and make SLM practices especially useful regarding the identified threats. Among the achievements attributed to the documented technologies, those mentioned most were diversified and enhanced production, as well as better management of water and soil degradation, whether by means of water harvesting, by improving soil moisture, or by reducing runoff. Demonstrating a favourable local-scale cost–benefit relationship was found to be crucial to improving people's livelihoods and preventing further outmigration. However, it was also found that more research is needed to support the case study authors' assessments of SLM impacts as well as to provide a solid rationale for investments in SLM.

There are many and often competing options for SLM, and each must be assessed – and sometimes negotiated – prior to implementation. This makes SLM a classic multi-stakeholder issue which concerns individual and community land users, agricultural advisors, natural resource managers, government authorities, civil society, and researchers alike. Selecting appropriate SLM technologies for implementation thus requires an approach that is capable of integrating the diverse knowledge, perceptions, and judgements of the different stakeholders involved. Time and resource constraints often impede the development of contextualised, targeted, and sophisticated decision support systems. The DESIRE research project provided an excellent opportunity to develop and test a generic decision support methodology, using it to assist the study site teams in selecting, together with stakeholders in a stakeholder workshop, the most promising SLM option(s) for subsequent test implementation in the field (Chapter 5). Special attention was paid to the screening of local innovations, the selection and adaptation of potential SLM technologies, and the decision-making process determining which options are to be implemented. Chapter 5 reviews the application of the DESIRE decision support methodology in a variety of biophysical and socio-economic contexts, finding it to be well-structured, comprehensive, and relatively easy to apply. The built-in global database of SLM options provided knowledge from various environments, while the use of simple software allowed for easy calculation and visualisation of results. The scoring and negotiation of each option's sustainability forced stakeholders to consider and acknowledge each other's positions and opinions, ensuring that the final choice was well-accepted. The methodology included seeking commitments from stakeholders to implement the selected option(s). Challenges included the complexity of the issues at hand and the need for skilled moderators. Nonetheless, positive outcomes and user feedback confirmed that the DESIRE decision support methodology is an easy-to-use stepwise methodology for facilitating decision-focused participatory processes.

Participatory and multi-stakeholder approaches are increasingly motivated by social learning and empowerment goals. Yet there remains a lack of practical tools for facilitating such processes. The research presented here aimed to close the gap between the theory and the practice of stakeholder participation and learning in decision-making processes concerned with SLM. Chapter 6 analyses and describes how the 3-part participatory methodology for selecting SLM options contributed to multi-stakeholder learning. Cross-site analysis and in-depth evaluation of the Moroccan and Portuguese sites were used to evaluate how well the proposed process facilitated stakeholder learning and the selection of appropriate SLM options for local implementation. The structured nature of the process – starting with the joint setting of SLM goals – was found to facilitate mutual understanding and collaboration between stakeholders. The deliberation process led to a high degree of consensus over the outcome and, although this had not been an initial aim, in many cases also fostered social learning. This solution-oriented methodology is applicable in a wide range of contexts and can be implemented with limited time and resources.

Chapter 7 presents insights into the field implementation of one of the selected SLM measures in Sehoul, Morocco. The Moroccan DESIRE study site was located near the city of Rabat, in an area where desertification poses a threat to marginal and often stony and degraded slopes. The use of marginal and stony land by the local population had become necessary due to increased poverty and the occupation of the best stretches of land by new owners. The land use change from grazing to cropping caused a deterioration of the field water balance, characterised by increased water loss through runoff, drainage, and evaporation, and resulting in less primary production. Promising experiences with no-tillage practices elsewhere in Morocco had motivated the Moroccan government to promote Conservation Agriculture throughout the country. This combination of crop rotation, minimal soil disturbance, and soil cover maintenance, however, had not yet been tested on sloping degraded land. The field trial results showed that covering the soil with crop residues neither improved yields nor increased rainwater use efficiency, although soil water was generally enhanced. Soil moisture measurements revealed that no-tillage was favourable mainly at soil depths of 5 cm and in connection with low-rainfall events (< 20 mm); under these circumstances, moisture content was generally higher under no-tillage than under conventional tillage. Moreover, farmers in Sehoul were found to be primarily interested in animal husbandry, and both crop residues and grains were used as feed. Chapter 7 concludes with lessons learnt from the on-farm trials in Sehoul.

The synthesis (Chapter 8) offers more detailed reflection on certain key aspects of the research findings, such as the 3-part methodology, monitoring and assessment, stakeholder collaboration and learning, decision support, and desertification mitigation by means of SLM technologies and approaches. This is followed by a review of challenges and limitations of the proposed methodological framework and an assessment of its overall impact. The chapter concludes with an outlook and recommendations. One major conclusion is that research needs to move beyond simply idealising and promoting participatory approaches and learning processes: in addition, researchers must also advocate the provision of time and resources and the establishment of long-term partnerships by both scientific and policymaking bodies. In-depth and long-term field-based research remains important, but it requires sufficient resources and long-term commitment in order to provide adequate evidence. The methodology developed within this thesis is not limited to desertification; it is appropriate and useful for tackling land degradation anywhere in the world and for advancing towards more sustainable decisions on SLM strategies with a higher acceptance among stakeholders. Negotiation of, and deliberation over, ecosystem services might be the key to boosting SLM beyond the local scale, while at the same time compensating land users for their crucial efforts to combat desertification.

Samenvatting

Verstoringen in fragiele ecosystemen in droge gebieden met watertekorten en extreme klimatologische omstandigheden kunnen leiden tot landdegradatie en verwoestijning. Op deze wijze ontstaat een vicieuze cirkel van droogte, landdegradatie en verlies van landbouwkundige productiviteit, die versterkt wordt door actuele mondiale vraagstukken zoals klimaatverandering, de ongelijke welvaartsverdeling, migratie en concurrerend landgebruik. De productiviteit van landbouwgrond in deze gebieden wordt beperkt door de fysieke kenmerken van de productie-omgeving. Maar ook de sociaaleconomische situatie staat onder druk door isolement, marginalisering, lage landbouwopbrengsten, zwakke instituties of conflicten tussen bevolkingsgroepen. Het waarborgen van duurzaam landgebruik in dergelijke condities is een uitdaging voor landgebruikers, beleidsmakers, wetenschappers en andere belanghebbenden. Wetenschappelijk onderzoek naar verwoestijning heeft zich geconcentreerd op het vaststellen van landdegradatie, en onvoldoende aandacht gehad voor strategieën voor preventie en mitigatie, hoewel het nut en de noodzaak van duurzaam landgebruik (‘Sustainable Land Management’, SLM) in toenemende mate worden onderkend (Hoofdstuk 1).

Dit onderzoek was onderdeel van het onderzoeksproject DESIRE (‘Desertification Mitigation and Remediation of Land - a Global Approach for Local Solutions’; looptijd 2007 – 2012), gefinancierd door de Europese Unie in het 6e Kaderprogramma. Het DESIRE-project had tot doel alternatieve landgebruiks- en beheer strategieën te ontwerpen in 17 gebieden in de wereld met kenmerken van landdegradatie en verwoestijning, in hechte samenwerkingsverbanden van wetenschappers en lokale belanghebbenden. Deze gebieden fungeerden als een mondiale proeftuin voor het ontwikkelen en toepassen van nieuwe vormen van samenwerking tussen wetenschappers en belanghebbenden, en voor het uittesten van traditionele en innovatieve manieren om verwoestijning tegen te gaan.

Enkele minder bekende benaderingen voor het monitoren en vaststellen (M&A) van duurzaam landgebruik (SLM) werden onderzocht en beoordeeld in hoofdstuk 2. Leerpunten, gemeenschappelijke elementen uit deze benaderingen en mogelijke ontwikkelingsrichtingen werden geïdentificeerd om tot een globale benadering te komen. Op de lokale onderzoek schaal werden methoden gebruikt uit de World Overview of Conservation Approaches and Technologies (WOCAT), waarbij technologieën en implementatiemethoden voor duurzaam landgebruik (‘SLM Technologies’ en ‘SLM Approaches’) uit de WOCAT catalogus werden gebruikt als case studies. Dit instrument werd gebruikt voor het inventariseren van landdegradatie op lokale schaal in de Land Degradation Assessment in Drylands (LADA) en in het EU-DESIRE project. In aanvulling daarop bleek dat locatie-gebonden benaderingen inzicht konden geven in de ecologische processen die de variatie in duurzaam landgebruik (SLM) bepalen. Op nationaal en sub-nationaal niveau werden de status en trends in landdegradatie en duurzaam landgebruik onderzocht met de gekoppelde methoden uit WOCAT, LADA en DESIRE, waarbij gebruik wordt gemaakt van een ruimtelijke indeling in landgebruikssystemen (‘Land Use Systems’). Hierbij worden ook de oorzaken van landdegradatie, de drijfveren en de impacts op ecosysteemdiensten in beeld gebracht. Het bevragen van deskundigen werd gecombineerd met wetenschappelijk bewijs, en waar nodig aangevuld met gegevens uit secondaire bronnen en gegevensbestanden van indicatoren. De belangrijkste leerpunten zijn de noodzaak voor een benadering op verschillende schaalniveaus, waarbij algemeen erkende indicatoren gebruikt worden en een breed scala aan informatiebronnen, waaronder wetenschappelijke onderzoeksgegevens en lokale kennis die via participatieve methoden wordt ingewonnen. Door de consistentie van de gebruikte methoden was een overkoepelende analyse op verschillende schaalniveaus mogelijk. De resultaten werden geanalyseerd en gedocumenteerd voor de politiek-bestuurlijke besluitvorming op verschillende niveaus. Een effectieve monitoring en vaststelling (M&A) van duurzaam landgebruik (SLM), zoals voor de VN-conventie voor het tegengaan van verwoestijning (UNCCD), vraagt om een integraal raamwerk van methoden waarover de belangrijkste spelers het eens zijn.

Diverse maatregelen voor bodem- en waterconservering worden al toegepast op lokaal niveau, maar deze maatregelen worden nog onvoldoende onderkend, geëvalueerd en gecommuniceerd tussen groepen van landgebruikers, technici, onderzoekers en beleidsmakers. Ook is er vaak onvoldoende samenwerking tussen onderzoek en uitvoering. Het doel van hoofdstuk 3 was om een nieuwe participatieve methode te presenteren waarmee strategieën voor het tegengaan van verwoestijning gewaardeerd en geselecteerd kunnen worden, en om de eerste ervaringen met de toepassing van deze methode in het DESIRE project te demonstreren. In de methode worden een collectief leerproces en een besluitvormingsprocedure gebruikt in combinatie met informatie over beheersmaatregelen waarvan de werking is aangetoond op verschillende plaatsen in de wereld. De methode bestaat uit drie delen. In het eerste deel worden in een stakeholder workshop problemen als gevolg van landdegradatie geïdentificeerd, evenals bestaande beheersmaatregelen op lokaal niveau. In het tweede deel worden lokale oplossingen geëvalueerd met een gestandaardiseerd instrument. In het derde deel worden kansrijke strategieën geselecteerd met behulp van een beslissingsondersteunend instrument. Een voorlopige analyse van de toepassing van het eerste deel van de methode toonde aan dat in de eerste stakeholder workshop een goede basis gelegd werd voor samenwerking tussen belanghebbenden, en dat een voorlopige selectie van kansrijke bodem- en waterconserveringsmaatregelen bereikt werd. De onderzoeksteams in de studiegebieden toonden waardering voor de resultaten, die voortkwamen uit een gezamenlijke reflectie op knelpunten en veelbelovende opties. De methode bleek geschikt om groepen actoren van elkaar te laten leren, en om lokale en wetenschappelijke kennis te integreren.

De beheersmaatregelen voor duurzaam landgebruik (‘SLM practices’) die geïdentificeerd warden in het participatieve proces werden vervolgens gedocumenteerd en geëvalueerd door lokale onderzoekers in samenwerking met landgebruikers. Hierbij werden de gestandaardiseerde en internationaal geaccepteerde WOCAT enquêtes gebruikt. De resulterende beschrijvingen van 30 SLM ‘technologies’ en 8 SLM ‘approaches’ werden geanalyseerd en vergeleken tussen de studiegebieden in hoofdstuk 4. Hieruit volgden algemene aandachtspunten voor duurzaam landgebruik in droge gebieden. Waardevolle kenmerken van duurzaam landgebruik in droge gebieden werden benadrukt op basis van de belangrijkste bedreigingen als gevolg van landdegradatie. De resultaten die in de meeste gedocumenteerde ‘SLM technologies’ genoemd werden omvatten het verhogen van de landbouwkundige productie door diversificatie, en het beheer van water- en landdegradatie door technieken voor het (tijdelijk) opvangen van water (‘water harvesting’), het verbeteren van bodemvochtcondities en het beperken van oppervlakkige afstroming. Een kosten-batenanalyse op lokaal niveau bleek cruciaal te zijn om levensstandaarden en welzijn te vergroten, en het wegtrekken van mensen tegen te gaan. Ook bleek dat meer onderzoek nodig is om deskundigenoordelen over duurzaam landgebruik te onderbouwen, en om daarmee investeringen in duurzaam landgebruik te motiveren.

Er bestaan meerdere, vaak concurrerende, SLM opties en ze moeten allemaal worden beoordeeld en soms moet er over worden onderhandeld voor daadwerkelijke implementatie. In die zin is SLM een typische stakeholder kwestie, die zowel individuele als gemeenschappen van landgebruikers, landbouwkundige adviseurs, beheerders van natuurlijke rijkdommen, de overheid, de publieke sector en onderzoekers aangaat. Het selecteren en implementeren van geschikte SLM technologieën vereist daarom een benadering die uiteenlopende vormen van kennis, percepties en beoordelingen van betrokkenen kan integreren. Maar een beperkte hoeveelheid tijd en geld belemmert vaak de ontwikkeling van een verfijnd Decision Support System (DSS). Het DESIRE research project vormde een uitstekende gelegenheid om een tijdens de stakeholder workshops een bestaand, generiek DSS toe te passen en te testen om de meest veelbelovende SLM opties te selecteren voor implementatie in het veld (zie Hoofdstuk 5). Speciale aandacht werd besteed aan het screenen van lokale innovaties, het selecteren en aanpassen van potentiele SLM technologieën en het beslis proces betreffende effectieve implementatie. Hoofdstuk 5 besprak de toepassing van het DESIRE-DSS in een verscheidenheid van biofysische en socio-economische contexten.

Geconcludeerd kan worden dat de toepassing van dit DSS goed gestructureerd is, holistisch en relatief makkelijk toepasbaar. De geïntegreerde, globale database van SLM opties voorzag in kennis van verschillende milieus terwijl het gebruik van eenvoudige software berekening en visualisatie van de resultaten vergemakkelijkte. De betrokkenen werden tijdens het beoordelen van de score en de duurzaamheid van elke optie gedwongen rekening te houden met ieders positie en mening. Dit zorgde er voor dat de uiteindelijke keuze door iedereen geaccepteerd kon worden. De gebruikte methode hield dus rekening met het zoeken naar overeenstemming tussen de betrokkenen om de geselecteerde optie(s) geïmplementeerd te krijgen. De uitdaging werd gevormd door een combinatie van de complexiteit van de zaken die speelden en de noodzaak van het vinden van capabele moderators. De uiteindelijke resultaten samen met de feedback van deelnemers bevestigd dat de gebruikte DESIRE-DSS een gemakkelijk te gebruiken, stap voor stap methode is die goed ingezet kan worden bij het faciliteren van oplossingsgerichte, participatieve processen.

Participatieve, multi-stakeholder benaderingen worden in toenemende mate gemotiveerd door 'social learning' en empowerment doelen. Toch bestaat er een tekort aan praktische hulpmiddelen om dergelijke processen te faciliteren. In hoofdstuk 6 werd de manier waarop de 3-delige participatieve methode voor het selecteren van SLM opties bijdroeg aan het multi-stakeholder leerproces, geanalyseerd en beschreven. Onderlinge analyse en diepgaande evaluatie van de Marokkaanse en Portugese studiegebieden werd gebruikt om te evalueren hoe goed het voorgestelde proces voor ondersteuning kon zorgen tijdens de selectie van toepasselijke SLM opties voor lokale implementatie. De gestructureerde aard van het proces – dat begint met het bepalen van de SLM doelstellingen – droeg bij aan wederzijds begrip en samenwerking tussen betrokkenen. Het overlegmodel dat werd gebruikt leidde naar een hoge mate van overeenstemming over de uitslag en droeg in veel gevallen bij aan 'social learning', hoewel dit niet een van de doelstellingen was. Deze oplossingsgerichte methode is toepasbaar in een brede range van toepassingsgebieden en kan met beperkte middelen in een kort tijdsbestek worden geïmplementeerd.

Hoofdstuk 7 gaf inzicht in de veld implementatie van een van de geselecteerde SLM maatregelen in Sehoul, Marokko. Het Marokkaanse DESIRE studiegebied is gelokaliseerd in een gebied waar vaak stenige en gedegradeerde hellingen worden bedreigd door verwoestijning. Het gebruik van marginaal, stenige bodem door de lokale bevolking werd noodzakelijk door de toenemende armoede en gebruik van de beste stukken land door nieuwe eigenaren. Het veranderend landgebruik van begrazing in gewasteelt veroorzaakte een achteruitgang van de waterbalans op veldniveau en werd gekarakteriseerd door een toenemend verlies van water door run-off, drainage en verdamping wat uiteindelijk resulteerde in afnemende primaire productie. Veelbelovende ervaringen met no-tillage technieken op andere plaatsen in Marokko motiveerde de Marokkaanse overheid in het hele land om Conservation Agriculture te promoten. De combonatie van gewas-rotatie, minimale verstoring van de bodem en het zoveel mogelijk bedekt houden van de bodem is nog niet getest op gedegradeerde hellingen. Resultaten van veldproeven toont aan dat het bedekt laten van de bodem met plantresten noch de opbrengst noch de regenwater efficiency verbeterde, hoewel over het algemeen de hoeveelheid bodemvocht toenam. Bodemvocht metingen hebben aangetoond dat no-tillage technieken voornamelijk effect hebben op 5 cm bodemdiepte en bij lage hoeveelheden regenval (< 5mm), waar de hoeveelheid bodemvocht over het algemeen hoger was dan bij conventionele bodem bewerkingstechnieken. Bovendien waren boeren in Sehoul voornamelijk geïnteresseerd in veehouderij en werden oogstresten en granen gebruikt als veevoer. De in dit hoofdstukken beschreven veldproeven, uitgevoerd op boerderijen in de buurt van Rabat, leverde wijze lessen op. Sommige sleutel elementen uit de onderzoeksbevindingen, zoals de 3-stap methode, monitoring en waarneming, de samenwerking en het leerproces van de belanghebbenden, beslissingsondersteuning en bestrijding van verwoestijning met SLM technologieën en benaderingen werden meer gedetailleerd bediscussieerd en bekeken in de synthese in hoofdstuk 8. Voordat werd gekeken naar de uiteindelijke impact en er conclusies werden getrokken en aanbevelingen werden gedaan, werden eerst de uitdagingen en beperkingen gepresenteerd. Hieruit volgde dat onderzoek verder moet gaan dan het eenvoudigweg idealiseren en promoten van participatieve benaderingen en leerprocessen. Tijd en geld moeten beschikbaar zijn en lange termijn vennootschappen gevormd, zowel vanuit de wetenschap als in de beleidswereld. Diepgaand en langdurig veldonderzoek blijft belangrijk, maar vereist voldoende bronnen en betrokkenheid op langere termijn om voldoende bewijs te kunnen verzamelen. De methodologie die in deze thesis is ontwikkeld beperkt zich niet tot verwoestijning maar is lijkt geschikt en bruikbaar om land degradatie overal ter wereld aan te kunnen pakken. Het bevordert de selectie van duurzame SLM strategieën die ook door de betrokkenen worden geaccepteerd. Onderhandelingen en overleg over ecosystem services kan de sleutel zijn tot het opschalen van SLM voorbij de lokale schaal terwijl tegelijkertijd landgebruikers worden gecompenseerd voor hun cruciale inspanningen om verwoestijning te bestrijden.

PE&RC PhD Education Certificate

With the educational activities listed below the PhD candidate has complied with the educational requirements set by the C.T. de Wit Graduate School for Production Ecology and Resource Conservation (PE&RC) which comprises of a minimum total of 32 ECTS (= 22 weeks of activities)

Review of literature (4.5 ECTS)
- Literature review on stakeholder involvement, decision support systems and impact assessment (2008)

Writing of project proposal (4.5 ECTS)
- Promising strategies to mitigate desertification: appraisal, decision support and impact assessment (2008)

Post-graduate courses (4.5 ECTS)
- Sustainable development research; CDE, Bern (2010)
- Participatory forest management as practice and performance; FNP, Wageningen (2011)

Invited review of (unpublished) journal manuscript (2 ECTS)
- Environmental Management: SWC impact assessment (2010)
- Land Degradation & Development: indicators of SLM benefits (2011)

Deficiency, refresh, brush-up courses (1.5 ECTS)
- Master field course in sustainable land management; Institute of Geography, University of Bern (2010)

Competence strengthening / skills courses (3.2 ECTS)
- Successful completion of PhD; University of Bern (2010)
- Research workshop on qualitative methods of social sciences; University of Bern (2010)
- Project management in a research context; University of Bern (2011)
- Introduction to data analysis with R; University of Bern (2012)

Discussion groups / local seminars / other scientific meetings (5 ECTS)
- Annual DESIRE meetings & workshops: general meetings Cape Verde (2008); Turkey (2008); Morocco (2009); China (2010); Spain (2011)
- NRM and Climate Change; Bern (2008)
- Forum SLM: Climate Change as a Challenge to Soil and Land Management; presentation; Bern (2009)
- Forum SLM: Rewarding Sustainable Soil and Land Management in the Face of Climate Change; Bern (2010)
- North-South Forum on Green Economy; Bern (2010)

International symposia, workshops and conferences (8.7 ECTS)
- Annual WOCAT Workshop and Steering Meetings (WWSM); presentation; Gwatt, Switzerland (2008)
- European Geoscience Union (EGU) General Meeting; presentation; Vienna, Austria (2008)
- International Soil Conservation Organization (ISCO) Conference; presentation; Budapest, Hungary (2008)
- International Conference on research for Development; poster; Bern, Switzerland (2008)
- Annual WOCAT Workshop and Steering Meetings (WWSM); presentation; Ifrane/Rabat, Morocco (2009)
- International Conference Tropentag; presentation; Zürich, Switzerland (2010)
- International Conference on Transdiciplinary Research; presentation; Geneva, Switzerland (2010)

Curriculum vitae and author's publications

Gudrun Schwilch was born on 26 June 1970 in Lucerne, Switzerland, where she grew up and finished high school in 1990. She then studied geography (major) and anthropology (minor) at the University of Bern. Her main focus was on physical geography, ecology, and sustainable development. For her MSc diploma thesis on "Land use in the Simen Mountains, Ethiopia" she spent four months doing fieldwork in Ethiopia. She started to work as a research assistant at the Centre for Development and Environment (CDE) already during her studies; at that time, she was in charge of GIS work within the "Simen Mountains Baseline Study" (Ethiopia). After obtaining her MSc diploma in early 1996, she took on a position as a research scientist at CDE and became involved in two major research and development projects. One was the "Natural Resource Monitoring, Modelling and Management" project in the Ewaso Ng'iro Basin, Kenya. She was responsible for database development, interpretation of scientific data, and GIS, and travelled to Kenya on several missions, spending a total of about 8 months there. The second project was the "World Overview of Conservation Approaches and Technologies" (WOCAT), a global programme for Sustainable Land Management. She was responsible for methodology development and database design and supported the overall project coordination. She conducted several training workshops and co-organised annual meetings in various countries, including Kyrgyzstan, Tajikistan, Turkey, India, South Africa, Nepal, and the Philippines.

In 2006 she became involved in developing the proposal for the EU FP6 research project DESIRE ("Desertification Mitigation and Remediation of Land"), which was successfully launched in 2007. During the 5 years of DESIRE she was responsible for the project's working block 3 on "Defining potential prevention and mitigation strategies". It is within this project that she was admitted as a Sandwich PhD Student in the Land Degradation and Development (LDD) group of Wageningen University. In the meantime she continued to work in her position as a senior research scientist at CDE. Following a restructuring of CDE, she successfully applied for the position of a head of cluster at CDE in late 2011. She is now responsible for the "Natural Resources and Ecosystem Services" cluster.

She lives in Mittelhäusern near Bern, Switzerland, with her husband and their three children, and can be contacted at gudrun.schwilch@cde.unibe.ch or gudrun.schwilch@bluewin.ch.

Selected publications

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