ARAB FUND FOR ECONOMIC
& SOCIAL DEVELOPMENT

PROJECT
Sustainability and Operationalization of Established Regional Agricultural Research Centers in Five Arab Countries

SUB-PROJECT
RESTORATION OF BADIA ECOSYSTEM SERVICES FOR ENHANCED COMMUNITY LIVELIHOOD

Annual progress report 2016

Activity led by CLAUDIO ZUCCA

Deliverable N. 6.

"Towards an integrated monitoring framework to assess the effectiveness of land restoration interventions in Badia"

Deliverable N. 7.

"Towards a framework to enhance the impact of land restoration in Badia. Concept note"

This activity contributed to RESEARCH PROGRAM ON Dryland Systems

INDEX

Foreword

This report was produced in the frame of the Project titled "Sustainability and Operationalization of Established Regional Agricultural Research Centers in Five Arab Countries", funded by the Arab Fund for Economic & Social Development and implemented by ICARDA.

The research was conducted in the context of the specific sub-project titled "Restoration of Badia ecosystem services for enhanced community livelihood", an interdisciplinary activity aimed at developing conceptual frameworks and scientific knowledge on the effectiveness of land restoration interventions implemented in the dry rangeland ecosystems, with particular focus on the Jordanian Badia.

This report is the first annual progress report of a specific project Activity that was launched during the second quarter of 2016 and that has two objectives to be achieved by the end of the third project year (2018), contingent on budget availability:

1. Develop an integrated monitoring plan to assess and monitor and restoration interventions' effectiveness, and
2. Develop a framework to enhance the impact of land restoration interventions.

This report targets the two preliminary products (defined as deliverables 6 and 7 within the approved AFESD project) to be achieved by the end of year 1 (December 2016) under the above objectives:

- Deliverable N. 6 (Objective 1). "Towards an integrated monitoring framework to assess the effectiveness of land restoration interventions in Badia."
- Deliverable N. 7 (Objective 2). "Towards a framework to enhance the impact of land restoration in Badia. Concept note."

Deliverables 6 and 7 coincide with Sections 3 and 4 of this report, respectively.

The technical collaboration provided by Mr. Pietro Bartolini in the frame of this reporting work is here acknowledged.

1. Background and scientific objectives

The Central and West Asia and North Africa (CWANA) region encompasses large areas of arid and semi-arid zones. These are areas where rainfall, relative to the level of evapotranspiration, is inadequate to sustain reliable crop production. Most of the arid and semi-arid zones of the CWANA region are rangelands and are characterized by wide variability in rainfall and temperature, and frequent droughts. The increased demand for meat in the region has driven an increase in livestock numbers, particularly the number of sheep and goat witnessed a continuous increase since 1990. The 24-year average since 1990 was 2.742 million heads, fluctuating due to many events and factors that affected Jordan including the Gulf war, the devaluation of the Jordanian dinar, the waves of droughts that hit Jordan and the changes in the government policies (MOE, 2015). This process has also led to changes in herding systems. It is estimated that only 2% of livestock herders in Jordan Badia are still nomadic, and that 80% of them own a truck, tractor, or car (Davies et al., 2010). Increasing cultivation (e.g., barley) by bringing into production lands from steppe and desert rangelands that may not be suited to cropping. The increase in grazing pressure and cultivation of traditional and fragile grazing lands has led to severe degradation of these resources. Consequently, the region is either affected or severely threatened by desertification (MOE, 2015). The new plan to combat desertification in Jordan (MOE, 2015) reported that the rangelands in Jordan provided over the last 24 years a sum of JD404 million in terms of direct saved costs of animal feed evaluated at the prices of 2013, and stated that continuing the current practices without any new measures/projects will result in huge economic losses that may even exceed hundreds of million dinars.

During the last decades, mitigating such processes and restoring land productivity in Badia have been a priority of the Jordanian Government, which develop a number of policies to support this purpose (e.g., the National Environmental Action Plan of 1995, the National Agenda 21 of 2000, the Aligned 2015-2020 National Plan to Combat Desertification in Jordan).

Considerable investments have been made by national and international programs aimed at restoring Badia rangelands. Among the most important are the National Programme for Rangeland Rehabilitation and Development (1999-2006) and the more recent Badia Restoration program (BRP) established in 2008 with the Ministry of Environment (MoENV) as National Focal Point (NFP). The latter was funded by the Governing Council of the United Nations Compensation Commission (UNCC). Its original goal was to rehabilitate the ecological productivity of the Badia ecosystems for wildlife and sustainable grazing, by restoring the vegetation composition, structure and sustainability to allow wildlife populations to rebuild, and to provide a foundation for sustainable grazing practices across the Badia region.

During the same years (2004-2009) the Integrated Water and Land Management Program of ICARDA implemented the project Water Benchmarks of CWANA (Community-

Based Optimization of the Management of Scarce Water Resources in Agriculture in Central and West Asia and North Africa). The project was primarily funded by AFESD. It identified a "Badia benchmark site" and developed a research focused on the "Rehabilitation and Integrated Management of Dry Rangelands Environments with Water Harvesting" (Karrou et al., 2011). Such research tested a set of rangeland rehabilitation approaches within a small catchment, in the proximity of the Mharib and Al-Majidyya villages (approximately 30 km South-East to Amman; with an annual precipitation of 130 to 150 mm). The work was conducted in close collaboration with Jordanian NARS and institutions and contributed to generate state of art knowledge and to develop capacities.

However, although the knowledge developed with the Benchmark project was taken as a methodological reference by local institutions to design restoration interventions later promoted in the frame of the BRP (among others) interventions, the overall achievements to date were not considered as fully satisfying, e.g., by the internal evaluation process set by the BRP itself.

This research activity stems from an appraisal of the current progress of rangeland restoration in Badia that was purposely conducted during 2016 by an ICARDA team, and targets three identified research needs:

1. The indicators of achievements adopted in the frame of the current implementation processes were mainly technical and operational; although monitoring of several biophysical indicators was foreseen, a sound approach to integrate such information and to evaluate the overall ecological impact was not developed.

2. The interdisciplinary dimension of the approaches originally promoted by the Benchmark project (and others) did not seem to be adequately reflected in the present restoration strategy; particularly, the low level of adoption and commitment observed at the level of the beneficiary communities requires more in-depth understanding and specific action.

3. The need to support the design of an effective out/upscaling strategy that can better adapt the currently adopted technical schemes to the varying bio-physical contexts, and flexibly integrate alternative techniques and approaches that may best fit the field conditions.

The scientific objective of this project Activity is to develop tools to contribute to fill the above gaps 1) and 3), by:

i) Drafting integrated assessment methods (protocol) and scaling concepts, based on literature review and preliminary field observations (review of literature and concepts are the main target of 2016).

ii) Conducting targeted tests on a sample of sites in different Badia's agro-ecologies to identify possible adaptations needed according to the contexts (in 2017-2018).

iii) Drawing lessons, to refine the assessment protocols and to outline a conceptual framework to support scaling strategies (by 2018).

2. Rational: Lessons from real world achievements

The concrete realizations of the restoration programs undertaken in Badia, particularly the BRP (still on-going), offer a unique opportunity for an "assess to learn" research approach based on a large number (multi-sample) of real world observations. Failure cases in restoration were undoubtedly linked to several causes, among which poor post-intervention management by the communities was most often indicated as the main one. However this perspective, besides implicitly implying a poor engagement of the target communities, would assume that the technical effectiveness of the interventions was out of question.

Both aspects should instead be investigated, along with the relationships between them, by developing suitable ex-post evaluation methods.

The BRP Implementation started in 2011. A Community Action Plan (CAP) was approved in 2012 for the 2012-2025 period. The best scenario target was set to rehabilitate and restore 10% of the total area of the entire Badia, or 7,100 km^2, in which 12 watersheds were selected. As part of this process a livestock destocking strategy was proposed that would bring the stocking down to the rates recommended by the Governing Council of the UNCC, thereby contributing to restoration of grazing lands by providing proper incentives, increasing livestock productivity, improving veterinary services, and upgrading animal husbandry practices.

To date, some thousands hectares have been rehabilitated. Besides various "point" interventions (e.g., dams, ponds, check dams, and water diversion and spreading structures), the methods selected for the rehabilitation over large areas were the following:

(a) Micro-catchment water harvesting techniques using the Vallerani machine (http://teca.fao.org/read/8757);
(b) Planting of native fodder shrubs under micro-catchment water harvesting (WH) techniques;
(c) Protection and managed grazing.

ICARDA has extensive experience in rangeland restoration based on micro-catchment water harvesting in drylands, having contributed substantially to the development and adaptation of the Vallerani implement (that Jordan's NCARE transferred to the BRP), in the frame of both the above-mentioned Benchmark project and in other projects that include the Water and Land Initiative (WLI) funded by USAID (on-going). ICARDA also conducted extensive research and demonstrations in Jordan's Badia to optimize the integration of fodder shrub plantation in micro-catchment pits, taking into consideration species selection, seedling production, plantation density, establishment methods, and grazing management. ICARDA's livestock production team has considerable experience in sustainable intensification of small ruminant systems in drylands – increasing productivity through germplasm selection, improved management, and the sustainable use of natural resources. In addition, ICARDA has experience in promotion of uptake and adoption of sustainable land management (SLM) by farmers, community-based grazing management (e.g., UNESCO-funded SUMAMAD project) and economic valuation of large-scale rangeland restoration (e.g., Economy of Land Degradation – ELD - Jordan case study).

However, there is a lack of integrated studies at the landscape scale targeting the impact of the interventions on the provisioning and regulating ecosystem services in Badia, and thus on the livelihoods of the communities that are dependent on these services. This research will contribute towards filling this gap.

3. D1. Towards integrated assessment protocols

A broad review of dry rangeland rehabilitation and restoration literature was conducted during 2016. Some of the most recent papers selected are listed in the references section of this report. The review indicated that developing an integrated set of indicators across disciplines, spatial and temporal scales is both a priority and a scientific challenge in the assessment of restoration. Integration is needed both within the main disciplinary fields (e.g., soil) and between them.

The comprehensive review by Costantini et al. (2016) points out the need for "within-interdisciplinarity" in restoration assessment. It discusses several soil indicators which can be used to assess the effectiveness of ecological restoration in dryland ecosystems at different spatial and temporal scales, and underlines that in many cases the indicator sets are too homogeneous, or narrow (e.g., only chemical soil properties, or only physical attributes are used in monitoring). Two main conclusions are drawn by the paper: (i) the success of restoration projects relies on a proper understanding of their ecology, namely the relationships between soil, plants, hydrology, climate, and land management at different scales, which are particularly complex due to the heterogeneous pattern of ecosystems functioning in drylands, and (ii) the selection of the most suitable soil indicators follows a clear identification of the different and sometimes competing ecosystem services that the project is aimed at restoring. The soil itself has to be considered as a living ecosystem, an open and interconnected part of the wider ecosystem, requiring an interdisciplinary approach.

The global review conducted by Marques et al. (2016) takes a wider perspective. It outlines the multidimensional impacts on the overall ecosystem services that sustainable land management strategies, technologies and approaches have under varying natural and social contexts. A typology of sustainable land management interventions and systems is targeted, particularly addressing water and soil management and the rehabilitation of ecosystem services in croplands, rangelands, and forests. The study recognizes that there are many instances of effective biophysical land restoration or rehabilitation measures in small scale projects. It however points out that circumstances such as poverty, weak institutions and policies, or inefficient uptake of scientific knowledge and adaptation can hinder the effective upscaling of such measures, and the long-term maintenance of proven sustainable use of soil and water. Strategies to enhance voluntary adoption by farmers are crucial and require strong community engagement. The provision of the right socio-economic incentives and involvement of farmers and communities from the very first stage of the intervention are key ingredients to scaling up sustainable land management practices, and to monitoring and maintaining these practices in the long run. Beyond the technical and the socio-economic aspects of sustainable land management, an enabling environment with strengthened institutions and more effective policies in place is crucial for successful adoption. This constitutes the fundamental basis upon which national and local governance structures can promote and implement well-informed land use decisions. The paper states that, particularly on rangelands, a participatory structure of programs and stakeholder involvement has proven to be of critical importance in facilitating the implementation of the restoration measures.

The analysis of how the community of practice actually uses the assessment indicators made available by science not only confirms that integration is needed, but shows that a strong case needs to be built to promote the adoption of integrated approaches by users (Nunes et al., 2016). A group of international researchers collaborating within the framework of a European trans-national cooperation network (COST Action ES1104) conducted a survey to shed light on gaps for better alignment between science and practice. The online survey directed toward restoration practitioners around the Mediterranean Basin, analyzed 36 restoration projects, mostly from the drylands. Although many of the projects were conducted in forest ecosystems, the research was very important from the methodological point of view. The study found poor monitoring of the projects' progress as one of the main shortcomings. In 22 percent of the projects surveyed, restoration success was never evaluated, while long-term (at least 6 years) evaluation was performed in a mere 31 percent of the cases, using primarily plant diversity and cover as indicators. The papers notes that absent or deficient monitoring prevents the understanding of restoration trajectories, which precludes adaptive management strategies needed to enable effectively functioning ecosystems. The survey found use of sub-optimal materials in many cases, and non-native species in 47 percent of cases. This was driven by factors such as faster growth rate, lower price, easy commercial availability, and/or aesthetical value, highlighting that operational restoration decisions are driven by multiple factors not necessarily aligned with the technical goals. Finally, the survey revealed high variability among practices and highlighted the need for improved scientific assistance to users to enhance the real-word impact of best-restoration practices.

The latter is one of the important reasons behind this research: the need to complement traditional research with a scientific evaluation of what/how the users do in the real world.

When attention shifts towards out/up scaling restoration practices in drylands, additional considerations become central that can only be dealt with in a landscape perspective and that are related to spatial patterns and variability.

Spatial differentiation of restoration interventions involves recognizing the heterogeneity of the landscape based on a suite of factors and mapping their distribution to understand the pattern and degree of variation. As an example, in arid areas, plant spatial distribution is generally patchy and more influenced by local soil conditions and slope aspect than in humid areas (Costantini et al., 2016). The spatial pattern of vegetation causes discontinuities in biomass production, affects soil fertility, and interacts with trophic chains, including soil microorganisms and rate of decomposition, giving origin, as an example, to the so-called "islands of fertility". Restoration strategies and techniques can and should be adapted to spatial differentiation and the spatial patterns to allow more effective spatial targeting of restoration actions. In addition, it is not just spatial differentiation but the spatial relations of the differentiated zones and the position or location within the whole landscape area or system that are important. The relations and connections or links with adjacent, upslope and downslope areas determine the extent of influence and how influence is transmitted and propagated in the landscape.

Not all the factors summarized above are often considered in the analyzed literature, with most articles and manuals showing a tendency to focus on some aspects more than on others. The complexity of the challenge was instead fully considered by the EU-funded PRACTICE project, which actually developed an integrated assessment framework (Practice, 2012), and by a review paper by Zucca et al. (2013a) that was developed in conjunction with such project.

3.1. Methodological reference

The PRACTICE project appears to be one of the best examples of project on drylands restoration assessment. PRACTICE conceptualized and operationalized a protocol based on (1) key common indicators that represent the overall human-ecological system functioning, (2) site-specific indicators identified by local stakeholders that are relevant to the objectives of the local interventions and to the particular context conditions, and stakeholder perspectives. Each of these sets comprised multidisciplinary indicators, both quantitative (e.g., soil organic carbon) and semi-quantitative (e.g., scores assigned to aesthetic value of the rehabilitated ecosystems). A multi-criteria and multi-stakeholder procedure was then developed to integrate this multi-faceted information into a stakeholder-driven evaluation and ranking of the restoration results.

The integral adoption of the above procedure would shed light on the effectiveness of the achievements obtained in the Badia, as well on the perception that the stakeholder have of them. However, this would be far beyond the possibilities of the limited budget allocated to this research.

For the purposes of this research, only the bio-physical approach identified by PRACTICE will be taken as reference. For the biophysical assessment, PRACTICE developed a suite of ground-based methods and indicators. Among these, the landscape function analysis (LFA) method developed by Tongway and Hindley (2004) was specifically adopted for dryland rangelands. The LFA incorporates both vegetation and soil survey in the evaluation of dryland patchy ecosystems, using functional indicators instead of direct measures of key features. More precisely the LFA uses 13 semi-quantitative field-based indicators (Table 1) to evaluate soil surface conditions at the hillslope scale, targeting surface properties that control soil surface stability, nutrient cycling, and infiltration processes. As an example, the nutrient cycling index informs about the in situ recycling of organic matter and requires, among others, an assessment of the degree of incorporation of the litter to the mineral soil. For every single type of patch or inter-patch, scores are estimated for each of the field indicators contributing to the definition of the relevant indices. The final values of the indices for the sites are calculated by weighing the attained values in all patch and inter-patch types by their representativeness in the working area.

This method was successfully applied to perform a semi-quantitative assessment of the effectiveness of rangeland restoration, as shown by abundant literature, as an example in Northern Iran (Ata Rezaei et al., 2006), South Africa (Parker et al., 2009), Spain (Maestre et al., 2006; Maestre and Puche, 2009; Mayor and Bautista, 2012), Tunisia (Derbel et al., 2009), and Morocco (Zucca et al., 2013b).

Furthermore, thanks to its capacity to perform in patchy, discontinuous systems, it can provide a sound basis to define appropriate sampling strategies to study the spatial distribution of additional quantitative indicators, including soil properties (e.g., Zucca et al., 2016) or vegetation cover and biomass data that can be used to feed RS-based assessment over larger areas (e.g., Zucca et al., 2015).

Table 1. The LFA method uses 13 indicators to calculate three composite indices (stability, SI; nutrient cycling, NC; infiltration/runoff, IR).

Indicator	Aim and unit of measure	Number of classes	SI	IR	NC
Rainsplash protection	Protection offered to soil by perennial vegetation, rocks, and woody material (as overall % cover)	5	X		
Perennial vegetation cover	Contribution of below-ground biomass of perennial vegetation to nutrient cycling and infiltration processes (estimated as % canopy cover of perennial plants)	4		X	X
Litter cover	Contribution of litter material (including ephemeral herbage such as living annual plants) to nutrient availability, as % litter cover plus thickness	10	X	X	X
Litter origin	Contribution of litter material (including ephemeral herbage such as living annual plants) to nutrient availability, with reference to its origin (transported or local)	2		X	X
Litter decomposition	Contribution of litter material (including ephemeral herbage such as living annual plants) to nutrient availability, with reference to its degree of incorporation to soil	4		X	X
Cryptogam cover	Contribution of algae, fungi, lichens, mosses, and liverworts to soil surface stability and nutrient availability, as % cover of cryptogams visible on the soil surface	5	X		X
Crust brokenness	Contribution of soil crust to contain soil loss by erosion and to increase surface stability, assessed as crust condition, or brokenness	5	X		
Erosion type and severity	Evidence of recent/current erosion processes as indicator of local instability conditions, as type (five classes) of process, and its severity (four classes)	20	X		
Deposited materials	Presence of material transported from upslope as indicator of local instability conditions, as % cover plus thickness	4	X		
Surface roughness	Contribution of soil surface roughness to slow outflow rates and increase infiltration, as average relief (mm)	5		X	X
Surface resistance to disturbance	Contribution of soil surface resistance to mechanical disturbance to contain soil loss by erosion, as resistance of dry soil surface to penetration	5	X	X	
Soil slaking	Contribution of soil surface stability under rapid wetting to contain soil loss by erosion, as revealed by slaking test	5	X	X	
Texture	Role of soil surface texture with regard to surface permeability, as texture of the 0–5 cm topsoil manually estimated in the field	4		X	

4. D2. Towards a framework to enhance the impact of land restoration in Badia. Concept note.

Increasing the impact of land restoration, and its effectiveness, requires this to be achieved at scale. A preliminary analysis of evidence and literature suggests that an even stronger (compared to what is discussed about assessment) shift in paradigms is needed both in practice and in research, to enhance the impact of restoration in the Jordanian Badia.

Several frameworks have been proposed to provide guidance to users involved in the practice of scaling (e.g., Linn et al., 2010; MSI, 2012; Reij and Winterbottom, 2015). These considered the success and failure factors, barriers and incentives to scaling up sustainable land management (SLM) and land restoration practices. Several critical factors were identified that would be worth considering to design a research project targeting the challenges and research questions of what is now increasingly defined "science of scaling".

For the purposes of this research, only those closely related to the technical aspects of restoration have been selected. These can be summarized as follows: i) adaptively plan and ii) select SLM "options" for scaling up based on best available evidence. The majority of SLM research to date has been conducted at case study scales (e.g., villages, watersheds). Limited understanding of actual replicability of SLM in ecological and socio-cultural contexts that are different from the local ones where technologies were developed, and of adoption processes at these larger scales makes it difficult to explicitly design scaling. Extrapolations can be biased and lead to failures, so adaptive approaches are needed that have to be supported by specific research. On the other hand, there are many types of evidence that may be used to select the most relevant options for scaling up and out. The economic evidence, which is often neglected, is crucial to both taking the best decision and to convince policy makers and land managers. Surprisingly, also the agro-ecological effectiveness of the options is in many cases poorly documented, or, as discussed in the previous section, supported by short term monitoring conducted under a narrow-angle perspective.

If we consider the body of restoration research conducted in Badia (as in many other regions), we can observe that:

- It was primarily focused on the technical feasibility and performance of few specific options that were dependent on mechanical structures/interventions (notably/mainly: mechanized micro-catchment water harvesting in Benchmark project, and check-dams in WLI). In parallel, research was conducted on adaptability/performance of the drought tolerant shrubs species (e.g., atriplex spp, salsola spp.) that were generally associated with the interventions conducted.

- The experimental trials were conducted in an area relatively small and homogeneous (in terms of climatic and geo-pedologic features, geomorphic dynamics, and topographic conditions), which is expected for experimental research. Conducting assessments in different context would now much contribute to our understanding of the scalability of the available know-how.
- The implementation guidelines reported at the end of the Benchmark project (Karrou et al., 2011) regarding the evaluation of the suitability of land to the tested intervention types were the results of adaptation to the specific project sites, where they were applied. Furthermore those guidelines were almost exclusively related to the technical feasibility and performance, notably the hydrological efficiency (control of runoff and water harvest as a function of rainfall, slope, soil texture), and in suborder the mechanical efficiency of establishment operation.
- The similarity and suitability study published later (Ziadat et al., 2014) followed the same approach (technical feasibility), although this was expected since this study was clearly aimed at a much smaller scale of application (CWANA region).
- Finally, limited or no evidence is available about the potential performance of other options (e.g., ranging from passive restoration to improved community management) that were not subjected to in-depth investigation. Those could be part of the "option basket" proposed to the communities according to the different ecological and social contexts that exist in Badia.

Thus it seems clear that the fundamental important achievements of previous Badia research should be seen as a starting point, and that a new research phase is needed to design scaling pathways moving target from mere feasibility to impact.

It is worth noting that both guideline documents mentioned above do not take into consideration any other "feasibility" aspect, besides technical-operational approached. As an example, in terms of objectives, even though a typical final purpose of the mechanical intervention is the plantation of fodder shrubs, no mention is made to the potential "scalability" of the species that were tested in the field. Even if it is assumed that the Vallerani system can be used wherever in Badia, is it also assumed that the same shrub species can come along? The latter, along with the hydrological efficiency of the structures, may instead be affected by type of bedrock and soil, position in the landscape, climate variability, etc. Not to say about the social aspects of feasibility.

Rightfully, ICARDA's guidelines were used as reference by Jordanian institutional users. They were applied across a range of social and ecological contexts. An assessment of the results obtained could answer an important research question: to what extent the established feasibility criteria need to be updated/diversified to match the requirements of the different contexts?

Furthermore, planning scaling requires going beyond assessing the potential of single options. Complementarity comes in.

As an example, if it is true that the studied mechanical interventions are not advisable on slope angles below 2% or above 12% (as stated by the guidelines), what other option can we recommend in those conditions? Similar questions apply to the other technical factors accounted for by previous studies, or to remote areas where for logistical reasons may suggest different strategies.

An essential gap to be filled is the understanding of impact. This is also relevant to the actual capacity to set goals, and to set a timeframe to achieve those goals. What is the desired restoration trajectory, what the ultimate goal in terms of ecosystem functionality and resilience? Restoration is a slow process. Restoring the quality and health of degraded soils is crucial to restore ecosystem functions and long term ecosystem's productivity and resilience. Incomplete understanding of what is the actual state of target soil and land resources, and what their desirable/achievable "restored" state, would likely lead to biased plans and to unsatisfying results.

Conceptual frameworks need to be developed to help answer these questions and this research will move in this direction.

Literature on restoration assessment

Abdellatif M. Ben, M. Neffati, A. Ouled Belgacem, **2016**. Restoration and rehabilitation of degraded Saharan communal rangelands in southern Tunisia. Journal of new sciences, Agriculture and Biotechnology 25, 1167-1172.

Ahmadpour Amir, Gholam Ali Heshmati, Ramtin Joulaie, **2016**. Rangeland Condition Assessment Based on Economic Criteria. Journal of Landscape Ecology. Volume 9, Issue 2, Pages 83–96.

Akroush S., Dhehibi B., 2015. Predicted Willingness of Farmers to Adopt Water Harvesting Technologies: A Case Study from the Jordanian Badia (Jordan). American-Eurasian J. Agric. & Environ. Sci. 15, 1502-1513.

Chambers, J.C.; Beck, J.L.; Campbell, S.; Carlson, J.; Christiansen, T.J.; Clause, K.J.; Crist, M.R.; Dinkins, J.B.; Doherty, K.E.; Espinosa, S.; Griffin, K.A.; Hanser, S.E.; Havlina, D.W.; Henke, K.F.; Hennig, J.D.; Kurth, L.L.; Maestas, J.D.; Manning, M.; Mayer, K.E.; Mealor, B.A.; McCarthy, C.; Pellant, M.; Perea, M.A.; Pyke, D.A.; Weichman, L.A.; Wuenschel, A., **2016**. Science Framework for the Conservation and Restoration Strategy of the Department of the Interior Secretarial Order 3336. Using Resilience and Resistance Concepts to Assess Threats to Sagebrush Ecosystems and Sage-Grouse, Prioritize Conservation and Restoration Actions, and Inform Management Strategies. Version I. August 5, 2016. Unnumbered Publication. U.S Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Costantini E.A.C., Branquinho C., Nunes A., Schwilch G., Stavi I., Valdecantos A., Zucca C., **2016**. Soil indicators to assess the effectiveness of restoration strategies in dryland ecosystems. Solid Earth 7, 397-414. doi:10.5194/se-7-397-2016.

Davies J., Niamir-Fuller M., Kerven C., Bauer K., **2010**. Extensive livestock production in transition: the future of sustainable pastoralism. In H. Steinfeld, H.A. Mooney, F. Schneider, L.E. Neville, Livestock in a Changing Landscape, Volume 1: Drivers, Consequences, and Responses. Island Press. Washington. Pp. 285-308.

Dreber Niels, Kong Taryn M., Kellner Klaus, Harmse Christiaan J., Van Eeden Albert, Ocampo-Melgar Anahi, **2014**. Towards Improved Decision-Making in Degraded Drylands of Southern Africa: an Indicator Based Assessment for Integrated Evaluation of Restoration and Management Actions in the Kalahari Rangelands. In: Planet@Risk, 2(1), Special Issue on Desertification: 21-28, Davos: Global Risk Forum GRF Davos. https://planet-risk.org/index.php/pr/article/view/40/149.

James Jeremy J., Roger L. Sheley, Todd Erickson, Kim S. Rollins, Michael H. Taylor, Kingsley W. Dixon, **2013**. A systems approach to restoring degraded drylands. Journal of Applied Ecology 50, 730–739.

Karrou, M., Oweis, T., Ziadat, F. and Awawdeh, F. (eds) **2011**. Rehabilitation and integrated management of dry rangelands environments with water harvesting.

Community-based optimization of the management of scarce water resources in agriculture in Central and West Asia and North Africa Report no. 9. ICARDA, Aleppo, Syria. vi + 208 pp. ISBN: 92-9127-258-2.

King Elizabeth G., Richard J. Hobbs, **2006**. Identifying Linkages among Conceptual Models of Ecosystem Degradation and Restoration: Towards an Integrative Framework. Restoration Ecology Vol. 14, No. 3, pp. 369–378.

Louhaichi M., Johnson M.D., Woerz A.L., Jasra A.W., Johnson D.E. **2010**. Digital charting technique for monitoring rangeland vegetation cover at local scale. International Journal of Agriculture and Biology 12: 406-410.

M. Louhaichi, K. Clifton, S. N. Kassam and J. Werner, **2015**. Overlooked benefits and services of grasslands to support policy reform. 15th International meeting of the FAO-CIHEAM subnetwork on Mediterranean forages and forage crops. Orestiada, Greece.

Macleod Neil D., Joel R. Brown, **2014**. Valuing and rewarding ecosystem services from rangelands 36, 12-19.

Marques M J; Schwilch G; Lauterburg N; Crittenden S; Tesfai M; Stolte J; Zdruli P; Zucca C; Petursdottir T; Evelpidou N; Karkani A; Asli-Yilmazgi Y; Panagopoulos T; Yirdaw E; Kanninen M; Rubio J L; Schmiedel U; Doko A, **2016**. Multifaceted Impacts of Sustainable Land Management in Drylands; a Review. Sustainability 8, 177; doi:10.3390/su8020177.

MOE, **2015**. The aligned national action plan to combat desertification in Jordan 2015 – 2020. Ministry of Environment, IUCN, GEF.

Monaco Thomas A., Thomas A. Jones, and Thomas L. Thurow, **2012**. Identifying Rangeland Restoration Targets: An Appraisal of Challenges and Opportunities. Rangeland Ecol Manage 65, 599–605.

Mureithi Stephen M, Ann Verdoodt, Charles Kk Gachene, Jesse T Njoka, Vivian O Wasonga, Stefaan De Neve, Elizabeth Meyerhoff, Eric Van Ranst, **2014**. Impact of enclosure management on soil properties and microbial biomass in a restored semi-arid rangeland, Kenya. J Arid Land 6, 561–570.

Muller K.L. and Schutz A., **2015**. Native Vegetation Council: Rangelands Assessment Manual. Native Vegetation Management Unit, Urrbrae, South Australia.

Myint, M.M., Westerberg, V., **2014**. An economic valuation of a large-scale rangeland restoration project through in Jordan. Report for the ELD Initiative by International Union for Conservation of Nature, Nairobi, Kenya. Available from: www.eld-initiative.org.

PRACTICE, **2012**. Deliverable D2.1 Working papers on Assessment Methods. Alicante. 2012. http://practice-netweb.eu/sites/default/files/root/intranet/participatory_action/deliverables/D2_1_Working_Papers_on_Indicators_261210.pdf

Roger L. Sheley, Jeremy J. James, Edward A. Vasquez, and Tony J. Svejcar, **2011**. Using Rangeland Health Assessment to Inform Successional Management. USDA-Agriculture Research Service, Burns. Invasive Plant Science and Management 4, 356-366.

Stuart P. Hardegree, Jeanne M. Schneider, and Corey A. Moffet, **2012**. Weather Variability and Adaptive Management for Rangeland Restoration. Rangelands 34, 53-56.

Suding Katharine N., Richard J. Hobbs, **2009**. Threshold models in restoration and conservation: a developing framework. Trends in Ecology and Evolution 24, 271-279.

Tongway, D.J. and Hindley, N., **2004**. Landscape Function Analysis: Procedures for Monitoring and Assessing Landscapes. CSIRO, Brisbane, Australia.

Zucca, C., Bautista S., Orr B.J., Previtali F., **2013a**. Desertification: Prevention and Restoration. In: Jorgensen S.E. (Ed.), Encyclopedia of Environmental Management. Taylor & Francis, New York. Vol. I, 594-609. DOI: 10.1081/E-EEM-120046343. ISBN: 978-1-43-982927-1.

The Social-Ecological Resilience of Rangelands.
https://www.nimss.org/projects/view/mrp/outline/14616

Restoration Assessment & Monitoring Program for the Southwest (RAMPS).
https://www.usgs.gov/centers/sbsc/science/restoration-assessment-monitoring-program-southwest-ramps-0?qt-science_center_objects=0#qt-science_center_objects

Rangeland Evaluation. https://globalrangelands.org/inventorymonitoring/evaluation

Literature on LFA

Ata Rezaei, S., Arzani, H., Tongway, D., **2006**. Assessing rangeland capability in Iran using landscape function indices based on soil surface attributes. Journal of Arid Environments 65, 460-473.

Derbel, S., Cortina, J., Chaieb, M., **2009**. Acacia saligna plantation impact on soil surface properties and vascular plant species composition in central Tunisia. Arid Land Research and Management 23, 28-46.

Maestre, F.T., Cortina, J., **2004**. Insights into ecosystem composition and function in a sequence of degraded semiarid steppes. Restoration Ecology 12, 494–502.Maestre, F.T., Cortina, J., Vallejo, R., 2006. Are ecosystem composition, structure, and functional status related to restoration success? A test from semiarid Mediterranean steppes. Restoration Ecology 14, 258-266.

Maestre, F.T., Puche, M.D., **2009**. Indices based on surface indicators predict soil functioning in Mediterranean semi-arid steppes. Applied Soil Ecology 41, 342-350.

Mayor, A.G., Bautista, S., Small, E.E., Dixon, M., Bellot, J., **2008**. Measurement of the connectivity of runoff source areas as determined by vegetation pattern and topography:

A tool for assessing potential water and soil losses in drylands. Water Resources Research 44, W10423.

Mayor, Á.G., Bautista, S., **2012**. Multi-scale evaluation of soil functional indicators for the assessment of water and soil retention in Mediterranean semiarid landscapes. Ecological Indicators 20, 332-336.

Parker, D. M., Bernard, R. T. F., Adendorff, J., **2009**. Do elephants influence the organisation and function of a South African grassland? The Rangeland Journal 31, 395-403.

Zucca C., Pulido-Fernández M., Fava F., Dessena L., Mulas M., **2013b**. Effects of Restoration Actions on Soil and Landscape Functions: Atriplex nummularia L. plantations in Ouled Dlim (Central Morocco). Soil & Tillage Research 133, 101-110. DOI: 10.1016/j.still.2013.04.002.

Zucca C., Wu W., Dessena L., Mulas M., **2015**. Assessing the effectiveness of land restoration interventions in drylands by multitemporal remote sensing – a case study in Ouled Dlim (Marrakech, Morocco). Land Degradation and Development. Land Degradation & Development 26, 80-91. DOI: 10.1002/ldr.2307.

Zucca C., Arrieta Garcia S., Deroma M., Madrau S., **2016**. Organic carbon and alkalinity increase in topsoil after rangeland restoration. A case study on Atriplex nummularia L.. Land Degradation & Development 27, 573–582. DOI: 10.1002/ldr.2378.

Literature on scaling

Karrou, M., Oweis, T., Ziadat, F. and Awawdeh, F. (eds) **2011**. Rehabilitation and integrated management of dry rangelands environments with water harvesting. Community-based optimization of the management of scarce water resources in agriculture in Central and West Asia and North Africa Report no. 9. ICARDA, Aleppo, Syria. vi + 208 pp. ISBN: 92-9127-258-2.

Linn J, Hartmann A, Kharas H, Kohl R, Massler B, **2010**. Scaling up the fight against rural poverty: An institutional review of IFAD's approach. Global Working Paper No. 39, Brookings, Washington DC.

MSI, **2012**. Scaling up – from vision to large-scale change: Tools and techniques for practitioners. Management Systems International, Washington DC.

Reij C and Winterbottom, R., **2015**. Scaling up regreening: Six steps to success. A practical approach to forest and landscape restoration. World Resources Institute.

Ziadat F., S. Mazahreh, M. Haddad, T. Benabdelouahab, S. Attaher, M. Karrou, T. Oweis, and T. Kandakji, **2014**. Similarity and Suitability Analysis to Assist the Out-Scaling of Sustainable Water and Land Management Practices in West Asia and North Africa. Research Report No. 11. ICARDA, Beirut, Lebanon. 79 pp.