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Developing a toolbox for rangeland restoration/rehabilitation in arid environments

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Abstract. Rangelands are recognized for their importance and value in providing society with valuable products and ecosystem services. In such ecosystems, effective management is needed for sustainable plant growth and survival in a context characterized by rainfall unreliability, poor soil nutrient status and high uncontrolled grazing. Therefore, cost-effective techniques/tools for slowing down and eventually reversing this degradation are needed. This paper promotes the identification and association of various tools for degraded arid ecosystems as strategies aimed at rangeland restoration/ rehabilitation. These strategies are founded on science-based evidence and experienced practitioners. For arid rangelands, the preference of applying an isolated rehabilitation technique may not halt degradation since the heterogeneity of the geomorphology, even at micro scale, and the landscape requires very often the use of different tools. For instance, direct seeding in degraded rangelands needs to be combined with soil scarification, when the crust dominates the soil surface, to reactivate the soil water retention and increase seedling emergence and germination possibilities. To achieve this goal, rehabilitation options identified for a specific degraded rangeland need to be holistically integrated with land degradation indicators in a manual-style decision support system for the long-term sustainable production of rangelands in arid environments.

Keywords. Dry areas – Land degradation – Sustainable rangeland management – Restoration.

Développer une boîte à outils pour la restauration / réhabilitation des parcours en milieu aride

Résumé. *Les parcours jouent un rôle écologique et économique très important et fournissent aux sociétés pastorales des produits et des services écosystémiques précieux. Dans de tels écosystèmes, une gestion efficace est nécessaire pour la croissance et la survie durables des plantes dans un contexte caractérisé par une aridité climatique et édaphique très accentué et soumis à une pression de pâturage élevée et non contrôlée. Par conséquent, il devient nécessaire de développer des techniques / outils rentables pour ralentir et éventuellement inverser cette dégradation. Cet article vise l'identification et la combinaison de divers outils pour les écosystèmes arides dégradés en tant que stratégies en vue de restaurer/réhabiliter les parcours naturels. Ces stratégies sont fondées sur des preuves scientifiques et des pratiques validées. Pour les parcours arides, le recours préférentiel à une technologie de réhabilitation isolée ne peut pas arrêter la dégradation car l'hétérogénéité de l'écosystème, même à petite échelle, nécessite très souvent la combinaison de plusieurs outils différents. Par exemple, la plantation d'arbustes fourragers sur des pentes relativement raides doit être associée à une technique de collection des eaux pluviales, pour tenir en compte du caractère torrentiel des en milieu aride. Pour atteindre cet objectif, les options de réhabilitation identifiées pour un parcours dégradé doivent être intégrées de manière holistique aux indicateurs de dégradation des terres dans un système d'aide à la décision sous la forme d'un référentiel technique pour assurer une gestion durable de parcours dans en milieux arides.*

Mots-clés. *Zones arides – Dégradation du sol – Gestion durable des parcours – Restauration.*

I – Introduction

The arid and semi-arid areas are estimated to cover 35% of the earth's land surface and are dominated by rangelands. They are major providers of critical ecosystem goods and services, including food, water, and livelihood sources for many of the world's poor (Milder *et al.,* 2010). Unfortu-

nately, these resources are on steady decline. For many decades national programs and development projects have attempted to reverse the trend of degradation, but in most cases the results were discouraging. Degradation which took place over hundreds of years cannot be reversed using quick fix solutions without considering the underlying causes. In fact, degradation is a result of poor management strategies interacting with other factors, such as climate change, which have continually increased the pressure on natural resources (Ouled Belgacem and Louhaichi, 2013). It is crucial to understand the causes of rangeland degradation and find solutions mobilizing a suite of available tools in a community-based participatory approach.

In this context, this toolbox has been developed to address rangeland rehabilitation at the landscape-level, taking into consideration the biophysical and socioeconomic linkages and trade-offs existing between the different land uses.

II – Sustainable Rangeland Management Practices

There are several sustainable rangeland management practices (SRMPs) that have been developed over the years. These SRMPs combine both indigenous knowledge and science-based interventions. Due to limited space (page number), in this paper we will only focus on key practices and approaches needed to ensure sustainability of rangeland restoration and rehabilitation.

1. Participatory rangeland governance

Sustainable rehabilitation of degraded rangelands that are dominated by collective and/or tribal ownership is a challenging task. The institutional arrangement to tackle this complex issue has been rather sectorial and fragmented. Earlier, the 'top–down' approach, which emphasizes technical solutions and neglects the social context, was the more common form of intervention. Therefore, in response to frequent failures of the top-down approach, efforts were deployed towards 'participatory development' as an alternative approach. National governments have been slow to adopt this participatory approach, but recent experiences suggest that integrated and participatory rangeland governance approaches may lead to more sustainable resource management. Rangeland governance can be defined as "local people's participation in managing the rangeland resources that they themselves use, in a sustainable manner" (Rist *et al.*, 2007). Such arrangement of development aims to organize people on a decentralized basis and to apply participatory tools in order to effectively empower local people (Nefzaoui *et al*., 2014).

2. Water harvesting techniques

Water is an important resource in arid and semi-arid rangelands, but often it is wasted or allowed to erode the landscape. One way to address this is through simple, cost-effective water harvesting techniques (WHT). This practice has been used for thousands of years in arid and semi-arid regions of the world to supplement scarce water resources. In general, the interventions are used to increase soil moisture content, vegetation cover, and productivity. WHT can also control soil erosion and reduce the impact of drought. Experience of the last two decades provides increasing evidence that WHT can mitigate the increasing variability of rainfall. Among the widely used micro catchment WH techniques are contour ridges, semicircular and trapezoidal bunds and small runoff basins. When implementing WHT, field conditions such as slope of the terrain, soil properties, land use and land cover need to be assessed before choosing and constructing water harvesting structures. For large-scale implementation, a special plough can be designed to construct intermittent and continuous contour ridging (Oweis, 2016). In small areas and depending on the land characteristics, different manual constructing bunds can be implanted, includeing semi-circular bunds, stone bunds, earth basins and *Maskat*.

3. Soil surface scarification

Soil surface scarification is a technique that breaks up compacted surface soil to improve water infiltration. The main purposes of this practice are to facilitate germination and emergence of soil seeds and to create a favorable seedbed. This practice is commonly used to ensure a successful regeneration of the natural vegetation, either by sowing or by natural rehabilitation. It is recommended to use a chisel plow or a pitting machine to disturb the top crusty soil (upper 5-10 cm). This intervention should take place 1 to 2 weeks before the expected rainfall events (Gauthier, 2016).

4. Reseeding

Reseeding can be described as the process of introducing seeds of a new or fresh crop to replenish a depleted soil seed bank. Low-productive rangelands, which result in a lack of balance in forage production, must be rehabilitated by inexpensive methods such as reseeding to provide more and better-quality forage to support livestock and protect the soil. Reseeding has a potential of yielding high plant density at low costs and it is a cheap means for providing an adequate feed for livestock and a greater income from the grazing operation. Reseeding is appropriate for moderate to highly-degraded rangelands, where average annual rainfall is above 350 mm. It should be done only as part of a good rangeland management plan to improve both the reseeded area and the native range. Reseeding is necessary to increase nutritional value of forage, fill in bare spots and improve degraded rangelands after poor management. Successful reseeding will depend on; local climate, field characteristics, soil fertility, time of seeding, plant species selection, viability of seeds and the grazing management style.

5. Shrub transplantation

To alleviate the spread of rangeland degradation, planting shrubs provides a large amount of fodder for livestock, combats desertification, and plays a key role in natural resource conservation. The integration of shrubs has the potential to improve both the sustainability and profitability of land, thus improving the livelihoods of smallholder farmers. Shrubs well-adapted to conditions of individual planting sites should be selected. The choice of species will depend on the annual rainfall rate, soil, topography, runoff, and water harvesting potential of the site, and the likelihood of environmental stresses such as drought, salinity, and cold. Species selection is also guided by rangeland development objectives, such as fodder production, wood production, dune fixation, or erosion control. On the other hand, the limits of this rehabilitation method can be translated by the high cost related to the nursery and transplantation; the necessity of protecting the site for more than 2-3 years to ensure plants establishment and survival. The use of exotic shrubs has shown discouraging results in most cases either due to their ecological demands or to the difficulty of their management.

6. Grazing management

Grazing management is a tool to balance the capture of energy by the plants, the harvest of that energy by animals, and its conversion into a product that is marketable. Timing of grazing and growth rate of plants after grazing events are key factors in controlling the frequency, intensity and duration of grazing. These factors enhance soil stability, forage production, efficiency of forage use, and improve livestock production (Abu-Zanat *et al.,* 2005). Grazing is a natural method of land utilization to feed domestic livestock for converting grass and other forage into meat, milk and other products; it is the least expensive way to harvest forage. A proper grazing management should be holistic and using all the available resources with a pre-determined goal focusing on the fundamental ecological concepts/processes (Savory and Butterfield, 2016).

III – How does the toolbox work?

A toolbox is a guide that assists land managers and practitioners making diagnostic and taking proper measures to address causes of degradation. There is no “one size fits all”, as every ecological site has its own specificity. Past disturbances have profound impact on the current degradation status. For instance, direct seeding in degraded rangelands needs to be combined with soil scarification, when the crust dominates the soil surface, to reactivate the soil water retention and increase seedling emergence and germination possibilities (Figure 1).

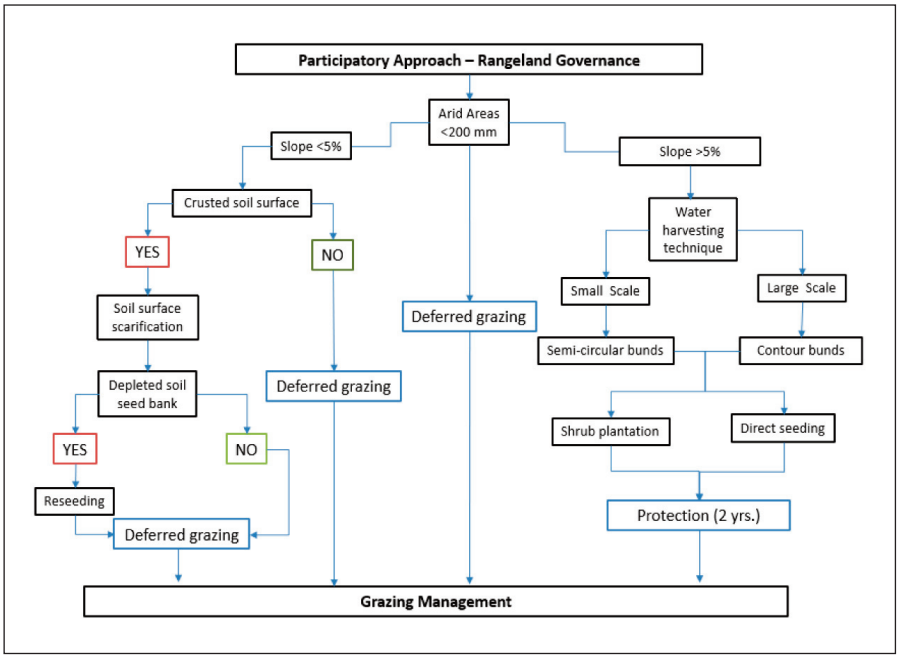

Fig. 1. Case study of the Jordanian Badia.

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