REPORT

On-Job-Training in Rangeland Survey and Restoration

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CGIAR INITIATIVE ON Livestock and Climate

Table of Contents

Introduction

Rangelands are among the most crucial natural resources in Tunisia, covering an area of approximately 5.5 million hectares. Of this total, 87% is located in arid and desert regions, with 45% in the south and 42% in the desert areas. These rangelands contribute to at least 30% of the livestock feed requirements. Unfortunately, in recent decades, overexploitation, including overgrazing, early grazing, and wood cutting, has led to their deterioration and reduced productivity. All stakeholders are now aware of this alarming situation and are focused on rehabilitating, developing, and managing grazing.

The process of conducting vegetation cover surveys and determining carrying capacity is crucial for understanding the condition and trends of rangelands. This information is essential for developing strategies and programs aimed at rehabilitation and rational management. In this context, research and development institutions aim to enhance the capacities of their staff, ensuring their active participation in various activities.

Within the framework of implementing the Livestock and Climate Initiative of the OneCGIAR, on-the-job training related to the restoration and sustainable management of communal rangelands was held in the Dhahar of Beni Khedache and Douz rangelands on November 1-2, 2023.

Objective

The objective of this on-the-job training is to enhance and build the capacity of the Engineers and technical staff involved in rangeland survey, management, and development from institutional partners and stakeholders.

Beneficiaries

The beneficiaries of this training course were the staff of the Commissariat Régional au Développement Agricole (CRDA – Medenine and Kebili), the Office of Livestock and Pastures (OEP), Institut des Régions Arides (IRA – Medenine), and the community-based organizations (both Agricultural Development Groups:GDAs of Dhahar Beni Khedache and Dhahar Douz).

Participants may have limited or no prior experience or training in vegetation cover survey and management skills. The course follows a general approach and is designed for participants with diverse educational backgrounds. A total of 13 participants attended both training sessions, including 4 from the CRDA of Medenine and Kebili, 1 from the OEP Kebili, 3 from IRA, and 5 from the GDAs of Dhahar Beni Khedache (2) and Douz (3). Among the trainees, 4 ladies attended the training. The attendance sheet is attached as an annex for reference.

Training Methodology:

Upon request of the stakeholders and within the framework of the baseline study, two main themes were considered in this on-the-job training:

- Rangeland condition survey: quantitative methods of determining the vegetation cover attributes, (cover, species composition, plant density, biomass production, …) using modern technology and IT application (Land-Potential Knowledge System) as well the well-common classic techniques;
- Restoration of degraded rangeland ecosystems using native species with a focus on those showing better resilience towards climate change and well adapted to harsh environment of southern Tunisia.

Vegetation cover attributes and soil surface states survey

Participants were trained on vegetation cover parameter measurements and field data collection, using the following methods:

1. Land-Potential Knowledge System (LandPKS) application

Within this training program, participants explored the LandPKS application and its role in surveying rangeland vegetation cover and soil characteristics(Figure 1). They installed the application on their mobile phones and began collecting and filling data on soils, climate, topography, and vegetation. The application facilitates the identification of land cover types, including tree cover, shrublands, and grasslands, enabling the development of customized land management strategies. It also helps distinguish between grazed and non-grazed land uses, assisting in the assessment of land degradation risks associated with various animal species.

Furthermore, the app offers slope and slope shape analysis to assess susceptibility to soil erosion, highlighting soil conditions like deep cracks and salt accumulation that indicate potential growth constraints for plant species. Additionally, the assessment of soil layers, including texture and rock content, informs decisions related to water infiltration, holding capacity, and erosion risk. Collectively, these functions empower land managers to make informed, sustainable choices, ultimately enhancing land health.

The staff of CRDA and OEP particularly appreciated the tool, as it will help them make more sustainable land management decisions.

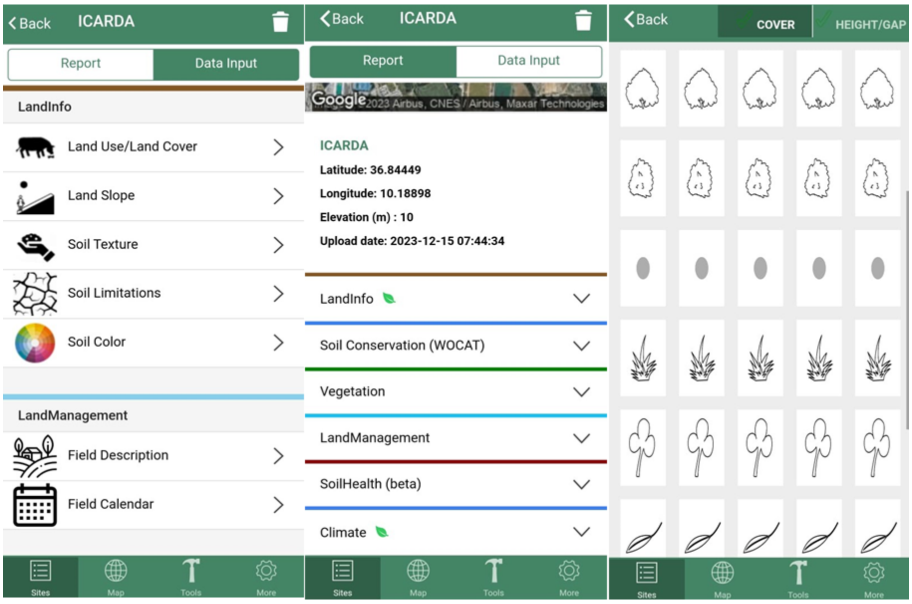


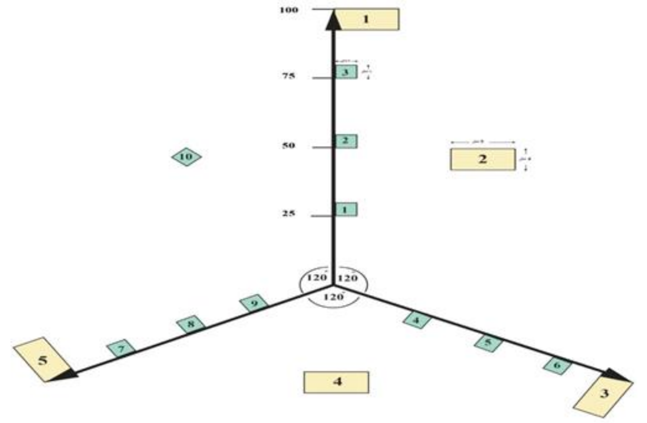
Figure 1. Landpkd Application.

The training focused on vegetation cover, including aspects such as cover, structure, and utilization. Trainees learned to use the LandPKS Vegetation Module, which allows for rapid data collection and monitoring of various vegetation attributes, including composition, cover, height, basal/canopy gaps, and species density (Figure 2). The module simplifies vegetation cover assessment using a 1-meter stick and a point-intercept method, providing cover trend graphs over time for user-friendly interpretation.

Figure 2. Participants Utilizing the LandPKS Application.

2. Line point intercept and quadrats methods

The design we used in the traing is summarized in Figure 3.



In each sampling area, the design comprises: i) 3 lines of 100 m each serving for measuring the total vegetation cover, species composition and soil surface states; ii) 5 quadrats of 20 m² each for determining the density of perennial plants and iii) 10 quadrats of 1 m² each for determining the density of annual plants.

Figure 3. Design for Measuring Plant Cover and Species Composition Using the Line-Point Intercept Method and Quadrats for Plant Density.

2.1. Line-Point Intercept

The Line Point Intercept (LPI) method was utilized to determine total vegetation cover, species composition, and soil surface states (bare soil, litter, rocks, sand, crust, etc.). In other words, the procedure involves lowering a sampling pin or rod through the vegetation at regular intervals along a set of transects in each plot. The first plant species intercepted vertically in its path or the type of ground cover, if not intercepted by plants, is recorded.

Initially, the different tools required for the measurements were introduced to the participants: two 50-meter length tapes, thin gauged pins, a hammer, stakes, LPI data forms, clipboard, etc. The number of replications of the transects to be considered was also presented and discussed. It was agreed that, for a given measurement and regardless of the state of the vegetation cover, the transects should be replicated until reaching 100 points of vegetation contacted by the thin gauged pin.

In the training, At each line, two participants (1 reader, and 1 recorder) made the survey. At each observation point, the reader follows the needle-sighting line into the vegetation and announces the observation point and the list of elements found there. This involves either plant species, of which at least one organ should touch the needle, or elements on the ground (litter, bare soil, rough elements, basal vegetation, etc.) touched by the point of the needle as it arrives on the ground. The second observer records the information on a pre-established record form. Note that the measurements are more precise on days when there is no wind, Additionally, participants collected soil samples at depths of 10 cm, 20 cm, and 30 cm, and combined them to create composite samples for each depth (Figure 4).

Figure 4. Participants Collecting Data Using the Line Point Intercept (LPI) Method Along with Soil Sampling.

2.2. The quadrats

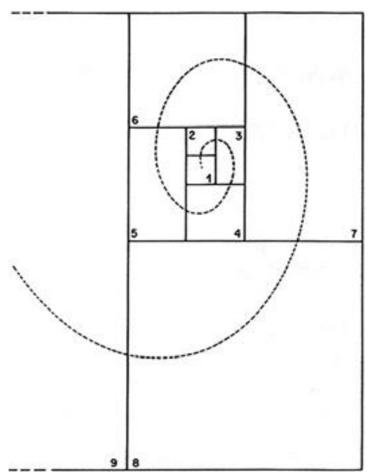
2.2.1. Minimal area

If the size of the quadrat used to count the number or cut the biomass of annual vegetation is generally small, sometimes even less than 1 m^2, the concept of minimal area becomes crucial for estimating species richness, plant density, and biomass production in arid areas. This is particularly important in determining quadrat size, especially for perennial species.

The distribution of plant and soil elements is usually very irregular in arid and desert zones, rendering the notion of homogeneity difficult to address. Among these difficulties is the determination of the number of measurements to take for each site based on the calculation of the confidence interval applied to acquired data. In arid zones, one must accept relative reliability for the averages obtained, for example, with standing plant density and biomass measurement values. These are among the data showing the greatest spatial heterogeneity and for which the number of measurement plots rapidly attains a size incompatible with what is possible at the level of observation.

The concept of area-species relations allows for control of vegetation representativeness. It is based on the probability that a species will be present in a portion of the space studied. Consequently, the surface considered to be representative serves as a model adapted to the type of vegetation, considering the frequency of each recorded species. The representative minimal area of the vegetation present is a major characteristic of each type of environmental unit.

Within a unit considered homogeneous and sufficiently spread out, a certain number of stations where the surveys will be made are randomly chosen. The mechanism is implemented gradually. The survey involves establishing the floristic list on progressively larger plots, with the surface area doubling at each stage, e.g., 1, 2, 4, 8, 16, 32, 64 m^2, etc. Practically, doubling the area is stopped when about 80% of the site species are recorded (Figure 5).



The principle consists of the following steps:
1: list the species present in the first 1m^2
2: double the area (2 m^2) and list the new species (absent in the first square)
3: double the area (4 m^2) and list the new species (absent in the previous squares)
4: double the area (8 m^2) and list the new species (absent in the previous squares)
5: double the area (16 m^2) and list the new species (absent in the previous squares)
6: double the area (32 m^2) and list the new species (absent in the previous squares)
7 double the area (64 m^2) and list the new species (absent in the previous squares)
8: double the area (128 m^2) and list the new species (absent in the previous squares)
9: double the area (256 m^2) and list the new species (absent in the previous squares)
Minimum area = 256 m^2 if no new species is recorded when doubling the area

Figure 5. Mechanism for increasing surface areas to determine the minimal area

The sum of species found at each stage permits to establishment the species-area curve. If the environment is homogeneous, the number of species being added to the list progressively falls to zero. From this graph, the point of inflection of the curve of new taxa acquisition should determine the minimal area (the surface measured in m^2) for this survey. In practice, it is often necessary to take measurements on surface areas that are double the minimal area established. The minimal area will be very important to determine the number of quadrats used to estimate species density and above-ground biomass. For example, if the minimal area is equal to 32 m^2, the number of quadrats per sampling area will be at least 4, with each having an area of 8 m^2.

2.2.2. Plant density

Plant density is the number of individuals or stems of each species per unit area. The number of individuals of each perennial species were counted in each of the 5 quadrats of 20 m^2 each. However, the annual species were accounted in ten 1 m^2 quadrats (Figure 3).

2.2.3. Biomass Estimation

The total dry weight equivalent of plant matter per unit area is known as the plant biomass. Not all the plant biomass is available as feed for animals. Plant biomass varies greatly between seasons and years even in the absence of grazing or other forms of use. There are two methods for estimating above-ground biomass - the destructive which consists of direct clipping or the semi-destructive method which does not involve clipping.

For our training case, we used the destructive method which is the most accurate although it is hard and time-consuming. Range biomass production was estimated by harvesting the vegetation inside five quadrats of 10 m^2 each for annual species, and by clipping half of the potentially grazeable biomass (according to the rule take half and leave half) of ten tufts of each species for perennial vegetation. The total biomass of perennial species was estimated by multiplying the mean available biomass per individual by the density of the species. The clipped plants were weighed immediately (after that samples were oven-dried for 48 h at 65°C in the laboratory for estimation of dry matter content (DM).

Restoration of degraded rangeland ecosystems

During the last decades, complex political, social, and environmental factors and management practices have degraded large areas of rangeland, this calls into question rangelands' long-term sustainability under current usage practices. The major causes of rangeland degradation, habitat change, and biodiversity loss are the conversion of natural ecosystems to farmland, exploitation through selective grazing, fuel wood removal, charcoal production, and livestock overgrazing. Disturbances caused by these activities and, by climate change, influence ecosystem dynamics, structure, and composition. On the other hand, rangelands rehabilitation and management are facing several challenges and constraints, the main are:

- The protection can be efficient only if the vegetation cover keeps its resilience and the key range species are rarefied and do not disappear. Long-term protection may lead to the aging of the plants and the extension of the crust. Short-term protection (rest) is acceptable by the pastoral communities.
- Most of the plant species used in the rehabilitation operations have low palatability. This may be attributed to the lack of seeds from high-palatability rangeland species. The establishment of a seed production system by the newly created National Center for Vegetation Cover and Combating Desertification will address this problem.
- Some of the reasons for the ongoing deterioration of rangelands and the lack of progress in their rehabilitation and sustainable management are attributed to the ineffective application

of rangeland and forestry laws and their regulations. To address this, there is a need for an integrated monitoring system that can enhance the application of these laws, reduce abuses, and halt offending activities aimed at protecting and developing rangelands. The creation of an Environmental Police force may help overcome this problem.

- Communication and coordination among the various institutions serving and supporting grasslands in rangeland regions have been weak, with pastoral communities rarely being consulted when projects are first formulated. Consequently, most past efforts aimed at the development of these spaces have been predominantly technical, lacking consideration for social aspects such as tribal rules and land tenure. In the present era, with decentralization and local empowerment gaining momentum, community participation can no longer be ignored.

- Rangeland ecosystems in dry areas, including southern Tunisia, are sensitive to climate changes. Climate change intensifies the negative impacts of drought on rangeland vegetation, leading to low levels of emergence of annual species, changes in phenology and reproduction timing, reduced biodiversity, low plant cover, and a decline in the productive capacity of pastoral systems. Climatic changes may also contribute to water resource shortages, widespread land degradation, and increased desertification. These threats have the potential to negatively impact rangeland biodiversity, the life cycle of plants, and crop/livestock productivity. Overall, climate change poses a significant risk to the resilience of rangeland ecosystems.

During this ongoing on-the-job training, we engaged with various stakeholders, including the GDAs and community representatives, discussing concepts and main techniques of restoration and rehabilitation that can be adopted to enhance pastoral productivity in the selected rangeland sites.

In this present on-the-job training, we engaged with all stakeholders, including the GDAs and community representatives, discussing concepts and the main techniques of restoration and rehabilitation that can be adopted to improve pastoral productivity in the selected rangeland sites.

Depending on the stage of degradation reached, several techniques have been developed and practiced in different countries of the MENA region to enhance the ecosystem resilience of rangeland in the face of disturbance and stress factors and improve its productivity. Figure 6 presents the general model describing the ecosystem degradation process to help decide when restoration, rehabilitation, or reallocation should be the preferred response. The latter two pathways are suggested when one or more 'thresholds of irreversibility' have been crossed in the course of ecosystem degradation and when 'passive' restoration to a presumed pre-disturbing condition is deemed impossible.

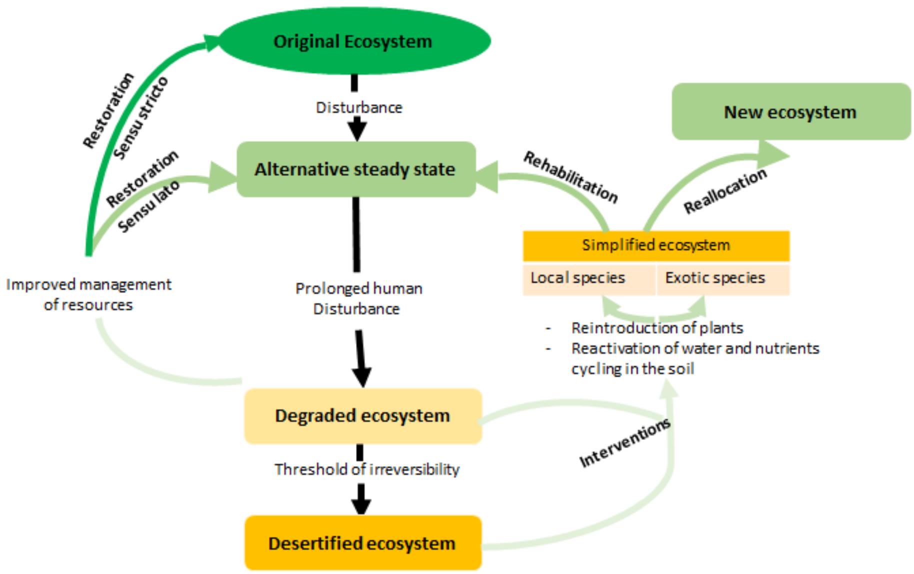


Figure 6. A schematic representation of the general model depicting rangeland ecosystem degradation and three potential development options (adapted from Aronson et al., 1993).

In our case and within the experimental site we visited with the trainees, the rangeland degradation reaches the threshold of irreversibility and we presented some indicators such as lack of seeds in the soil and the reconstitution of the ecosystem by a simple restoration is no longer possible, the rehabilitation by reintroduction of the native range species having disappeared and/or improving the soil conditions (scarification, water harvesting techniques, etc.) become the only alternative to improve the productivity of the rangeland ecosystem to be comparable to the initially existing one.

Since the site of the training was severely degraded and invaded by sand mobile dunes, we have largely selected the most suitable native range species that can first stabilize the dunes and secondly constitute a source of feed for the community livestock grazing.


Figure 7. Retam raetam (left) and *Calligonum comosum* (right), Exemplifying Two Native Rangeland Species Well-Adapted to the Dynamic Environment of Mobile Dunes.

Conclusion

Tunisia's rangelands, essential for sustaining livestock and biodiversity, have faced the detrimental effects of overexploitation, signaling an urgent need for rehabilitation and sustainable management. The recently conducted on-the-job training emerged as a pivotal initiative, fostering collaboration, knowledge exchange, and practical insights into the intricacies of effective rangeland management.

This training, centered on crucial themes such as quantitative rangeland surveys and ecosystem restoration, harnessed a blend of modern technology, exemplified by the Land-Potential Knowledge System (LandPKS) application, and time-tested traditional methods. Participants, drawn from diverse institutions, gained proficiency in conducting vegetation cover surveys, soil surface assessments, and biomass estimations. The laudable integration of the LandPKS application garnered praise for its potential to revolutionize sustainable land management decisions, showcasing the power of technological innovation in environmental stewardship.

The emphasis on vegetation cover, spanning aspects of cover, structure, and utilization, was reinforced by the practical application of techniques like the Line Point Intercept (LPI) method and quadrats. The incorporation of the minimal area concept within the quadrats method underscored the training's commitment to obtaining accurate estimates of species richness, plant density, and biomass production, particularly vital in arid environments.

The collaborative pledge to implement sustainable practices, fortify protective measures, and amplify community engagement is pivotal for fortifying the resilience and vitality of Tunisia's rangelands. This training represents a significant stride towards a future where these vital ecosystems not only endure but thrive harmoniously with the needs of communities and the broader ecosystem.

Annex: List of participants

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Rangeland rehabilitation in Mthinine, Southern Tunisia: On the job training
31 October 2023
List of participants

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☒			مجمع التنمية الفلاحية	محمد كرداوي	3
☒			مجمع التنمية الفلاحية	عمر القاسمي	4
☒			المندوبية الجهوية للتنمية الفلاحية	أنيس الغزال	5
☒			دائرة الغابات	مختار كراب	6
☒			معهد المناطق القاحلة	محمد وسار	7
☒			معهد المناطق القاحلة	أماني حتالي	8
☐					9
☐					10
☐					11
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Rangeland rehabilitation in Dhahar Douz, Southern Tunisia

2 – 3 November 2023

List of participants

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