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Trans-disciplinary approach as a decision support tool for sustainable land management

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Abstract

This paper presents an integrated and a trans-disciplinary analysis from a case study in Northwest of Tunisia in order to release a decision for upscaling sustainable land management practices in the national level. The integrated, trans-disciplinary approach aims at initiating a process of co-production of knowledge and joint learning between relevant stakeholders from the local to the (sub-) national level. Thus, a range of different stakeholders – from land users, civil society organisations, and local authorities to industry and government representatives - must actively be engaged in this process. This study is conducted using a range of workshops, which are a cornerstone of stakeholder participation and aim at enabling transdisciplinary-learning processes, between scientific and non-scientific actors. Thus, the workshops provide opportunities to initiate, promote and deepen a mutual learning process between the researchers and a range of relevant stakeholders (e.g. land managers, food producers, developers, industry, regulators, advisory services, authorities, experts) that have some kind of interest in the topic of land threats in the case study site. Each of the stakeholders - from science, practice or policymaking – has his/her own perspective and contribute to process of knowledge; exchange and learning with his/her own expertise and experience. Given that, the knowledge contributed by scientific and non-scientific actors is valued equally in this process, and that local and scientific knowledge is integrated to some extent, which seems, that more suitable sustainable solutions can be identified and implemented concerning the prevailing land threats in the case studies. This approach was successfully efficient to engage appropriate stakeholders in a dialogue by sharing their knowledge and experience concerning the land degradation threats, and by contributing to a joint reflection, decision-making and evaluation process about mitigation and remediation practices. Results of this study were used in favor of an international project called Decision Support for Mainstreaming and Scaling out of Sustainable Land Management (DS-SLM), which aims to mainstream sustainable land management best practices into national and/or sub-national agricultural and environmental plans and investment frameworks, policies and programs to address combating desertification, land degradation and drought (DLDD) in 15 countries, which Tunisia is a member.

Introduction

The context of the research is the Tunisian Northwest. This region, mainly rural, is dominated by the agricultural sector, which is still precarious and exposed to climatic change and hazards (floods, drought.). The forest occupies 327,520 ha of the region (20% of its area) and it plays an important role ecologically, socially and economically (Elamri, 2013) at both national and local levels. The hydrographical network of the region provides 82% of the surface water resources of the country. This is explained by rainfall levels exceeding 1,000 m3 / year in some places in addition to snowfall in mountainous areas.

Despite this potential, the northwest region poses the biggest Tunisian regional paradox: this agricultural area deemed one of the most privileged and the richest of Tunisia in term of propitious natural resources, is also the poorest human region relative to other regions of Tunisia due to the cumulative effects of inappropriate land management.

From this context, the criteria of development sustainability in the region is approached under different aspects notably by looking for an adequacy between the population needs (work, income, energy, pasture, life standards and education) and resource mobilization (inside the local district or territory, or in rich areas nearby) in order to ensure a sustainable management of the productive capital and the protection of the environment (Khlidi. 2003).

At the basis of the transdisciplinary approach are a series of participatory stakeholder workshops to be carried out in the study area in order to select the most suitable Sustainable Land Management (SLM) to be implemented and extended in the national level.

The selection is based on a process of evaluating and scoring different SLM practices, which meet the specific conditions of the given local context.

The overall aim is to select promising (existing and potential) practices for soil conservation to be test-implemented in the selected study site as part of DS-SLM project (FAO/GEF/WOCAT).

This process aim to jointly provide good decision and select 1-2 SLM practices to be implemented / field-tested in the study site; and to strengthen trust and collaboration among concerned stakeholders as well.

Materials and Methods

Materials:

The methodology applied in this research, is based on participatory principles. The group was monitored and was guided through a series of consecutive steps that assist the stakeholders and exchange their ideas on which SLM practices should be implemented in Northwest of Tunisia.

Two major categories of stakeholders are being distinguished:

1. Local stakeholders (land users, representatives of local authorities, local NGOs, etc.) with site-specific knowledge and experience who live in the specific rural environment; local stakeholders know best the characteristics of their land and the way to work it.

Therefore, in order to achieve this study, some experts (socio-economist, botanist and water and soil conservation and forest expert) were selected and invited, to be involved in this trans-disciplinary process. Some land users and the omda (the lowest rank of interior ministry official) of the region were invited also to be part in the workshop study.

2. External stakeholders, i.e. soil scientist and geographer working in the Ministry of agriculture, also two PhD student working in the same regions with 2 university professors (external participants), with different degrees of professional expertise on natural resources-related issues, and able to suggest alternative techniques and evaluate their results.

In order to ensure interaction and exchange between the different stakeholders. This research is structured as follow:

- Stakeholder workshop 1: Identification of current / potential Sustainable Land Management (SLM) practices.
- Stakeholder workshop 2: Selection of SLM practices to be tested.
- Stakeholder workshop 3: Valuation of ecosystem services.
- Stakeholder workshop 4: Evaluation of SLM practices.

Field data and data from the previous World Overview Conservation Approach and Technologies (WOCAT) studies are used. (WOCAT 2003, 2007, 2008a,b, 2008)

The duration of stakeholder workshops is 4 days, which the field day was included. This means that this task was performed in 1 stakeholder group including both internal and external stakeholders as well.

Methods:

The contents of the workshop can be summarized as:

- Identification of SLM practices (from the WOCAT database) for the local context.
- Identification of relevant criteria to evaluate those practices, and creating a hierarchy among these criteria (“ranking”)
- Assessment of each SLM practice, to which extent it fulfils the different criteria identified (“scoring”).
- Focusing on an assessment of best practices for different types of landscapes.
- Analysis and prioritizing of SLM practices. Decision on 1-2 practices to be test-implemented.
- Optional: Embedding the practices into the overall strategy and the objective of DS-SLM project.

Step 1: Review of SLM objectives

This part aims to anticipate the main SLM objectives through recalling and refreshing main discussions and results from stakeholders. In addition, we need to decide on which objectives to focus on for the selection of SLM practices that will be test-implemented.

Moreover, the objective(s) defined in this task should be on an overall strategy for the case study site. What came up as the most relevant land threat, and the most important objective!

This task seems to be quite a 'heavy' but important exercise, which is divided into two steps. Its objective is to understand the various problems and indicators of land degradation at the study site. As we may know that landscape is more sensitive to pressure in steep and south facing terrain than in flat and north-facing areas. The analysis will address the assessment of the different aspects across the different types of landscapes.

At the same time, already applied conservation practices (solutions) and 'entry points' for changes towards a more sustainable land management will be identified.

By means of a site visit: - allowed everyone to make a personal connection to the study site - observe, discuss, and document the land degradation at the site with particular focus on how it impairs the various functions. - observe, discuss, and document locally applied SLM solutions that mitigate the land degradation and act towards a balanced functional approach at the site.

By means of group discussion: - identify local indicators for land degradation, and SLM mitigation - identify already applied and potential SLM interventions and prioritize the SLM objectives.

In order to assess all these aspects, we decided to follow the transect procedure and observe, discuss and document the different aspects throughout the different landscapes.

The identified aspects were generally: the landscape type (slope, soil type and land use system), vegetation type, problems and constraints such as steep slopes, fine texture of soil, overgrazing, fires, inappropriate management etc…, and degradation type, current and potential management and water resources.

Step 2: Identification of SLM practices

The aim of this part is to identify with the help of the WOCAT database a range of SLM practices (technologies and approaches) that fit the selected objectives and to visualise the potential practices. Firstly, in order to avoid suspicion and mistrust, the purpose and the use of the WOCAT database was transparent and well explained to the participants. Then, presentation of SLM practices: according to the selected objective at the field study site, including their benefits in the economic/socio-cultural/ecological categories was carried out. Finally, the election 5-7 priorities SLM practices was made.

Step 3: Criteria for evaluation, and their hierarchy ("ranking")

The objective of this part is firstly to identify and agree on a set of criteria relevant for the local context, along which the different SLM practices can be evaluated. Then, to assign a hierarchy to the criteria identified ("ranking"). In order to identify the relevant criteria, the three dimensions of sustainability shall be considered. Firstly, criteria should be feasible; practices must fit into the specific biophysical, economic and socio-cultural context of the respective study site. A practice can only be considered sustainable if its evaluation is (more or less) positive concerning 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 by local actors, i.e. it has to fit into the socio-cultural context and practices.

Step 4: Assessing the SLM practices against the criteria ("scoring")

The aim of this part is just to reply for the following question: "How good is a particular SLM practice towards achieving the selected criterion?" By the mean of discussion and assessment made by the working group. Scores from 1 to 5 are given to assess each SLM practices against the selected criteria, which means as follow: 1 (very bad), 2 (bad), 3 (acceptable). 4 (good), 5 (very good).

The expected results of all SLM practices are assessed against all criteria.

Step 5: Data analysis and visualisation of results

This step aim the calculation of the performance of SLM practices based on ranking and scoring (step 2 to 4) and visualisation of the relative merits of different practices as a basis for discussion. Then interpretation of obtained results.

Step 6: Prioritising of SLM practices - negotiation & decision-making

The objective of this final step is to find a final agreement on which practice(s) should be selected for test implementation at the study site. As the negotiation of obtained results remains crucial for good decision-making.

Results and discussions

Assessing SLM objectives (Step 1)

In order to assess and review the main SLM objectives, the different landscape types, problems / existing degradation, the current potential management and water resources were identified and discussed with the participants. Through the different main land use system in the study site, we can recognize different types of landscapes. Therefore, it is crucial to assess each situation of landscape separately, as the problems and land degradation types/causes, differ from one to another. Consequently, solutions and potential management will certainly be different.

Generally, an accelerated soil degradation and fertility decline caused by the fine texture which most are clay- limestone soils.

The majority of lands are distributed over hilly terrains; this is why the slope plays an important role in the accentuation of the problem of run-off and water erosion.

Therefore, the first main objective is the prevention against water erosion and trying to consolidate the land in order to prevent deflation, leaching and sediments transport. This objective concerns all the land use systems and its importance was confirmed from all the participants as a first and major objective for sustainable land management.

As it is also confirmed that the problem of monoculture clearly and directly depletes soils, through the decline of soil fertility, invasion of the weeds... An improvement of the soil quality and prevention against more biological degradation (species impoverishment) seems urgent and crucial to focus on it and recommending the possible options for sustainable land management.

The field crops land use system is the dominant LUS and it represents more than 70% of the study area. We confirmed that we should prioritize the monoculture problem and deal with it and consequently prioritize the objective of combating against soil biological degradation.

Others constraints and problems were discussed also, such the fragmentation of land tenure, hiring lands, conflicts in the forests, overgrazing…

According to all the stakeholders, water erosion and biological degradation represents the most relevant land threat, and dealing with them remains the most important objective.

The selected objectives were confirmed and defined for this task, as they should be on an overall strategy.

Appropriate SLM practices (Step 2)

In the second step, a range of SLM practices were listed, that fit with the selected objectives.

In order to face the water erosion and biological soil degradation, many conservation measures were selected, which some can applied separate or in combined ways. Many conservation measures such as plantation, agronomic, structural and management measures were identified.

Planting measures involve the use of perennial grasses, shrubs or trees (olives trees, almond…) that lead to a change in slope profile. They are often zoned on the contour or at right angles to wind direction they are often spaced according to slope. Vegetative strips / cover are implemented as grass strips, hedge barriers, windbreaks, etc. Planting olives trees, is an efficient technology, promotes increasing ground cover, improving soil structure, and infiltration, as well as decreasing erosion by water and wind.

The grass strips along the contour and the vegetation strips along riverbanks remain the dominant best practices.

Regarding agronomic measures, such as mixed cropping, contour cultivation, mulching, etc. are usually associated with annual crops and repeated routinely each season or in a rotational sequence. They are of short duration and not permanent and they do not lead to changes in slope profile.

Vegetation/soil cover, fertilization, soil surface and subsurface treatment, seed management and improved varieties are some of applied agronomic measures. For example, we can see mixing cropping, intercropping, relay cropping, cover cropping, some conservation agriculture cases, many cases of application of manure/mulching, crop rotations, breaking compacted subsoil, deep ripping, seed selection and production of improved varieties.

Structural measures are normally of long duration or permanent and they require substantial inputs of labor or money in the installation. The structural measures are often carried out to control runoff, erosion and wind velocity, and to harvest rainwater…and often they lead to a change in slope profile and they are aligned along the contour/against prevailing wind direction.

In the study site, we can see bench terraces, bunds, fences and low walls. These measures are efficient in sloping terraces against tillage, runoff and water erosion – the downslope movement of soil during cultivation. Rotational grazing using fences and area closure are efficient against overgrazing and soil deterioration. Some water harvesting/supply/irrigation equipment exist also in order to ensure and improve water harvesting. Shelters for plants and animal are considered as a best practice as well.

Management measures involve a fundamental change in land use and usually do not involve agronomic and structural measures. It seems often a reduction of the intensity of use such as land use change, or change of management/intensity level such as the fallow, area closure/resting, protection, change from cropland to grazing land, from forest to agroforestry, afforestation.

Change from grazing to cutting (for stall feeding), farm enterprise selection (degree of mechanization, inputs, commercialization), vegetable production in greenhouses, irrigation; from mono-cropping to rotational cropping; from continuous cropping to managed fallow; from open access to controlled access (grazing land, forests); from herding to fencing, adjusting stocking rates, rotational grazing. Other management measures can be considered such as exclusion of natural waterways and hazardous areas, separation of grazing types, distribution of water points, salt licks, livestock pens, dips (grazing land); increase of landscape diversity, forest aisle, land preparation, planting and cutting of vegetation.

Table 1 The different criteria classified in the different categories

Economic category	Socio-cultural category	Ecological category
Low costs	Increased recreational opportunities	Improved water quantity
Increased crop yield	improved community institution strengthening	improved water harvesting / collection of surface runoff
Decreased risk of production failure	Improved soil conservation / erosion knowledge	Increased soil moisture
Increased irrigation water availability / quality	Improved food security / self-sufficiency (reduced dependence on ext. support)	Increase evaporation
Increased off-site water availability (groundwater, springs)	Improved suitability for small holders / large-scale land users	Decreased surface runoff
Decreased expenses for inputs	suitability for local socio-cultural conditions	Improved excess water drainage
Increased diversification of income sources	Less damage on neighbours' fields	Decreased waterlogging
Increased land availability: decreased loss of land (decreased production area) or increased production area (new land under cultivation / use)	Less socio-cultural conflicts / conflict mitigation	Heightened groundwater table/aquifer
Increased water availability / quality for livestock		Improved resilience towards adverse events (drought, floods, storms, …)
Increased product diversification		Decreased downstream flooding
Improved suitability for local socio-economic conditions (e.g. cropping system, market orientation, etc.)		decreased off-site stream / river flow
Increased fodder production		Decreased downstream siltation /sediment yields
		Decreased off-site buffering / filtering capacity (by soil, vegetation, wetlands)
		Improved soil cover
		Increased biomass / above ground C
		Increased soil organic matter / Improved C sequestration
		Decreased soil loss
		Decreased soil crusting / sealing
		Decreased soil compaction
		Increased plant diversity (incl. crop diversity)
		Improved suitability for local ecological conditions: slope, soil, climate, etc.

The rotational system / shifting cultivation / fallow, is characterized though the rotation of rather different land management such a few years of intensive crop production followed or by a period of low intensity use allowing natural regrowth (fallow) or replanting of grasses, legumes, trees etc. and then followed by intensive use and clearing of the vegetation. Shifting cultivation is an agricultural system in which plots of land are cultivated temporarily, and then abandoned. This system often involves clearing of a piece of land followed by several years of wood harvesting or farming until the soil loses fertility. Once the land becomes inadequate for crop production, it is left to be reclaimed by natural vegetation, or sometimes converted to a different long-term cyclical farming practice. Slash and burn refers to the cutting and burning of forests or woodlands to create fields for agriculture or pasture for livestock, or for a variety of other purposes. Reduction of invasive species, selective clearing, encouragement of desired/ introduction of new species, controlled burning (e.g. prescribed fires in forests/ on grazing land)/ residue burning are also recommended. Other measures such as beekeeping, small stock farming (e.g. poultry, rabbits), fishponds; food storage and processing (including post-harvest loss reduction) are considered as best practices as well.

As we already mentioned, all these measures can occur separately or in combinations where different measures complement each other and thus enhance each other's effectiveness, as they may comprise any two or more of the above measures.

After listing all the existing practices and the possible practices that can fit with the selected objectives, a decision on the selection of practices to be assessed was made. This decision is made according to select the SLM practices, which are important to reach the target objective, seem feasible and appear interesting enough for the context of the study site to be more thoroughly assessed in this task.

The selected SLM practices across the different landscapes are as follow:

- Agroforestry (landscape: common).
- Conservation agriculture and minimum till (landscape: the steep slopes areas mainly).
- Rotational system / shifting cultivation / fallow (landscape: field crops land use system mainly).
- Vegetation strips along riverbanks (landscape: borders of rivers).
- Manuring / composting / nutrient management are intended to improve soil fertility, and simultaneously enhance soil structure (against compaction and crusting) and improve water infiltration and percolation (landscape: in the clayey heavy soil).

Table 2 The selected criteria classified in different categories

Economic category	Socio-cultural category	Ecological category
Low costs (1)	Increased recreational opportunities (6)	Improved suitability for local ecological conditions: slope, soil, climate, etc. (11)
Increased crop yield (2)	Improved soil conservation / erosion knowledge (7)	Improved water harvesting / collection of surface runoff (12)
Increased diversification of income sources (3)	Improved food security / self-sufficiency (reduced dependence on ext. support) (8)	Decreased surface runoff and downstream siltation/sediment yields (13)
Increased irrigation water availability / quality (4)	Less damage on neighbours' fields (9)	Increased soil organic matter / improved C sequestration (14)
Increased land availability: decreased loss of land (decreased production area) or increased production area (new land under cultivation / use) (5)	Improved suitability for small holders / large-scale land users (10)	Improved soil cover (15)

Table 3 Scoring SLM practices against crieteria based on stakeholders votes

Base criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Agroforestry	3	4	4	4	4	4	4	4	4	4	4	3	4	3	4
Conservation Agriculture	1	4	3	4	4	1	4	3	4	3	3	4	4	5	5
Rotational sys/Shifting cultivation/fallow	4	4	5	4	3	3	4	4	2	3	4	2	2	3	4
Vegetation strips along riverbanks	3	2	2	4	4	3	4	2	3	2	3	3	3	1	2
Manuring/composting/nutriment management	2	4	3	3	4	3	4	3	2	4	2	2	2	5	3

Appropriate crieteria (Step 3)

After discussion and coming up with criteria that fit with the dimensions of sustainability. Criteria were written by category (economic/ecological/sociocultural), on a flipchart in order to select the more precise and better relevant for the local context.

"Low costs" criterion is selected by default.

Table 1 shows the different criteria classified in the different categories (economic, socio-cultural and ecological category).

After selecting the criteria to be applied, the next step is creating a hierarchy of importance among them ("ranking"). By the mean that the participants have a common understanding and satisfaction of selecting the priorities criteria by making a vote for a maximum of 5 criteria. Ranking gives a chance to point out what is important. Participants have voted for the criteria that they want to have included. The ranking can now be performed.

After placing the results, the Table 2 shows the priorities criteria.

SLM practices against criteria (Step 4)

In this part, all SLM practices are assessed against all criteria following the ranking procedure.

The Table 3 summarizes the results.

After proceeding all the data, a visual representation of the relative merits of each SLM practice across the different criteria is produced.

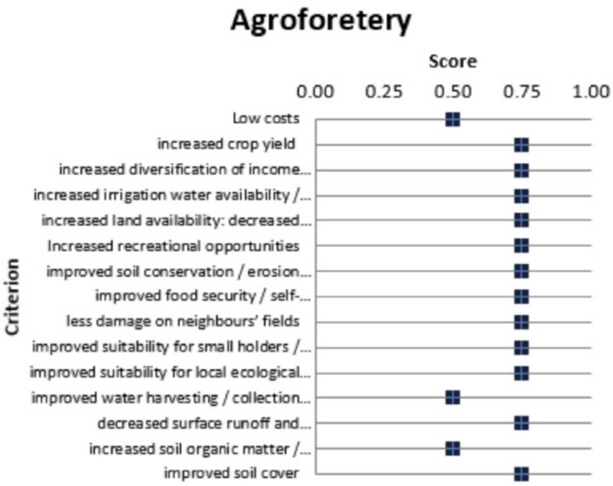
Visualization and interpretation of results (step5)

In order to interpret the graphs, the further the small squares are in the right, the better is the result.

As we can see, the agroforestry's performance remains good towards most of the criteria.

In addition to that, the performance of rotational system/shifting cultivation/fallow practice is very good toward the increased diversification of income and it remains good for the most of the relevant criteria (7 criteria). See Figure 1.

The performance of the conservation agriculture is very good toward increasing soil organic matter and



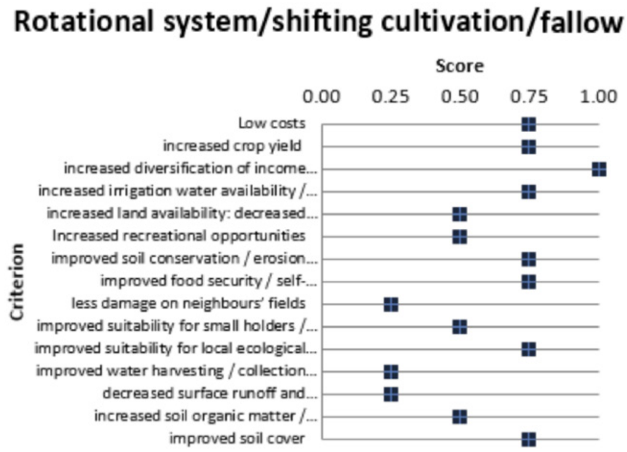
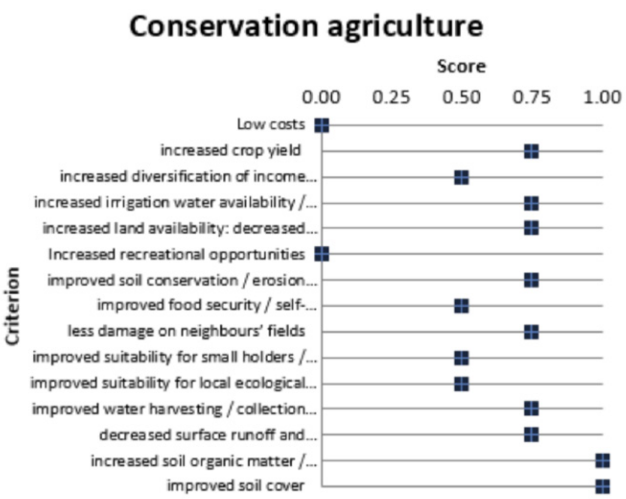


Figure 1 - Graph of Agroforestry (left) and rotational system's performance (right) scored against the various selected criteria



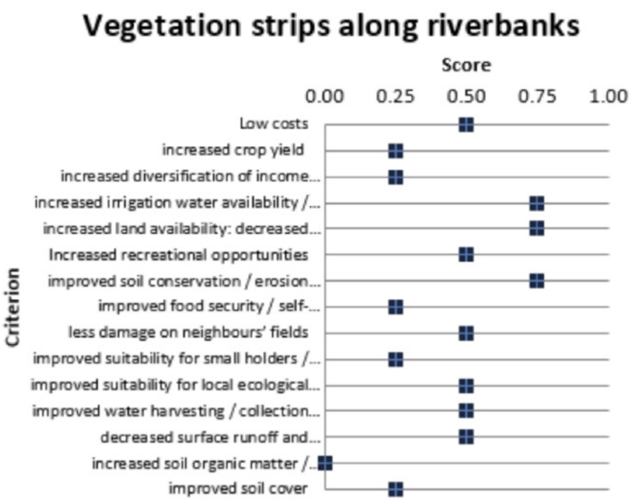


Figure 2 - Graph of Conservation agriculture (left) and vegetation strips along riverbanks system's performances (right) scored against various selected criteria

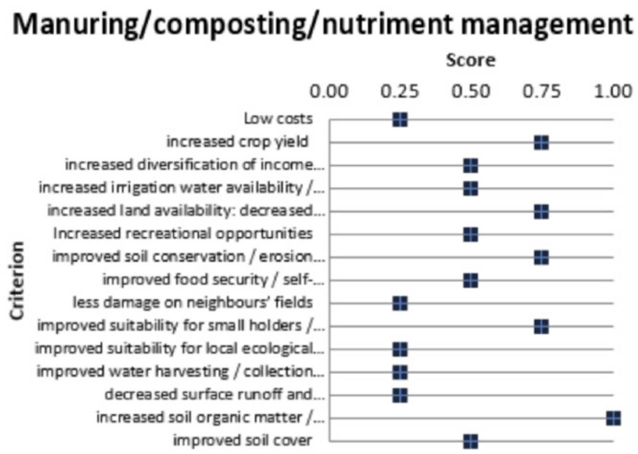


Figure 3 Graph of Manuring / Composting / Nutriment management's performance scored against various selected criteria

improving the soil cover as well. However, according to the graph, its performance toward the low cost is poor because of the high cost of the seeding equipment.

The performance of vegetation strips along riverbanks system is good just toward increased irrigation water availability / quality, increased land availability: decreased loss of land (decreased production area) or increased production area (new land under cultivation / use) and improved soil conservation / erosion knowledge. See Figure 2.

The performance of this management measure is very good toward increasing soil organic matter and relatively good toward increasing crop yield, increased land availability: decreased loss of land (decreased production area) or increased production area (new land under cultivation / use), improved soil conservation / erosion knowledge and improved suitability for small holders / large-scale land users as well. See Figure 3.

After the assessment of the performance of the SLM practices, the assessment of the different relevant criteria toward the SLM practices seems crucial. Herewith we may also look into how stakeholders evaluated each practice's performance towards one particular criterion.

The overall results per criterion are as follow (Figure 4).

The overall results for all SLM practices in all categories" graphs show a comprehensive bar chart displaying the combined performance of each SLM practice on a scale from 0 (very poor) to 1 (very good). This process allows for direct comparison of the practices, which is the main outcome of this study. Regarding the low cost criterion, the rotational system/shifting cultivation/ fallow is the most suitable, as it is less costly comparing with the remaining SLM practices. The agroforestry, conservation agriculture, Rotational system and manuring and nutriment management has the same good performance in regard of increasing crop yield. Concerning increasing diversification of income sources, the rotational and shifting system has the best performance. The agroforestry, conservation agriculture, rotational/shifting system and the vegetation trips practices has the best performance regarding increasing irrigation water availability and quality.

Regarding the increase land availability, it is just the rotational and shifting system practice that remain having the lowest performance.

The conservation agriculture shows the lowest or the insignificant performance toward increasing recreational opportunities. Contrariwise, it shows the best performance toward improved water harvesting / collection of surface runoff and improving soil cover.

Moreover, the vegetation trips along riverbanks shows the lowest performance as well regarding improving food security and self-sufficiency (reduced dependence on ext. support) and improving suitability for small holders / large-scale land users.

The agroforestry and the rotational system show the best performance comparing to the remaining SLM practices especially for the local ecological conditions: slope, soil, climate, etc... Toward improving soil conservation / erosion knowledge, all the SLM practices has the same good performance. The agroforestry, conservation agriculture show the best performance on ensuring less damage on neighbours field and decreasing surface runoff and downstream siltation/ sediment yields.

Finally and definitely, the conservation agriculture and manuring/composting/nutriment management have the best performance regarding increasing soil organic matter and improving C sequestration. Last but not least we can also analyse how the SLM practices performed in each of the 3 categories - economic vs. socio-cultural vs. ecological. It is very likely that we will find practices that perform well ecologically, but not economically, or vice versa. See Figure 5.

In order to interpret results: A bar represents each practice showing the range of overall scores for that practice (integrating criteria for all 3 categories). The further to the right in the graph, the better (promising) the practice. The overall results (numeric values from 0 to 1) mean, e.g. 0 = very poor; 0.25 = poor; 0.5 = acceptable; 0.75 = good; 1 = very good.

The smaller the bar, the clearer the valuation through the participants, i.e. the lower the variability of valuations. A practice is clearly better than another, if there is no overlap between the bars.

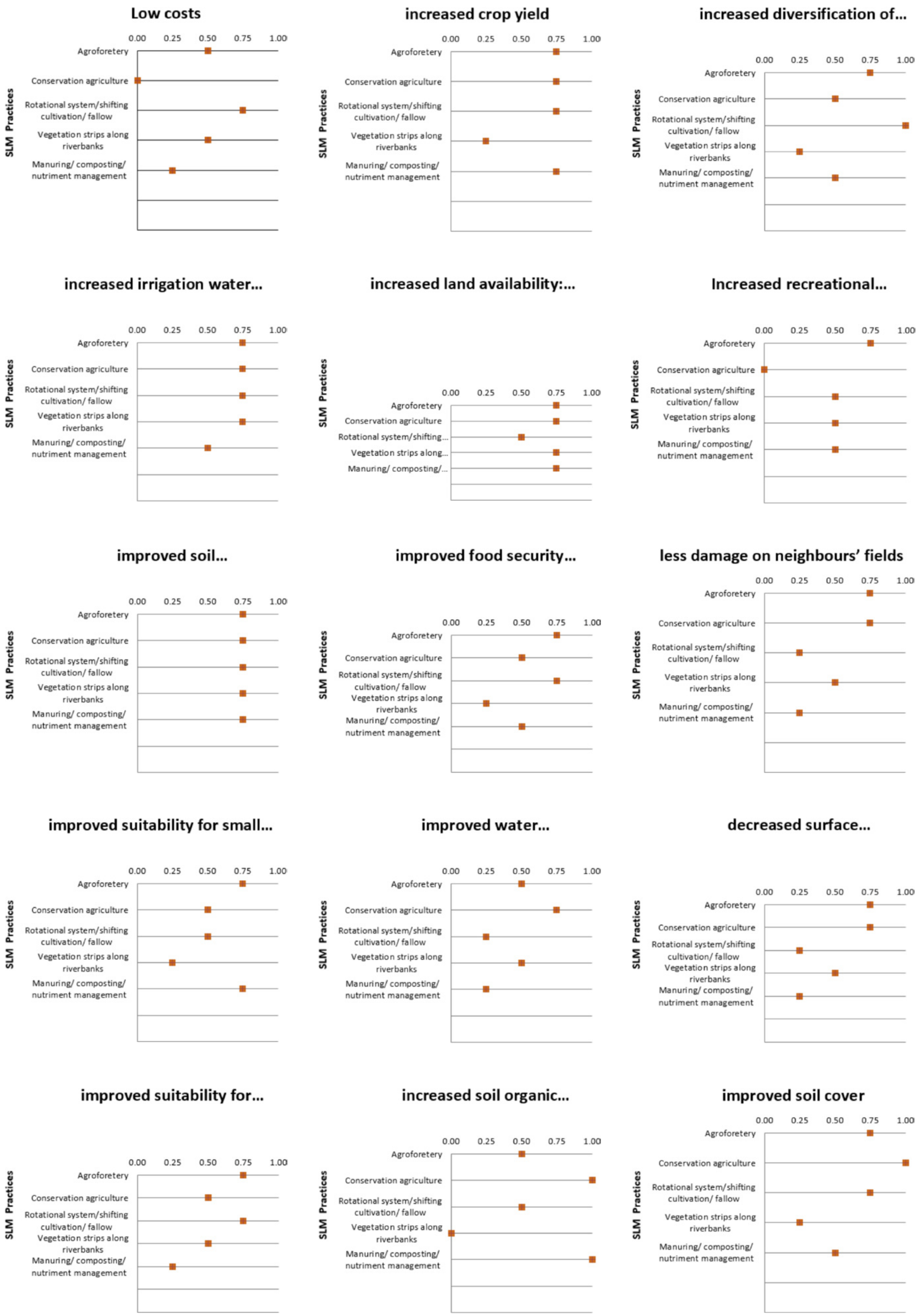


Figure 4 Graphs showing the overall results of the performance of SLM practices selected against the criterion

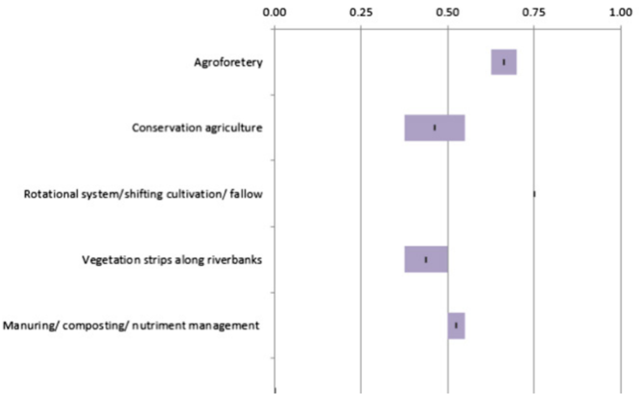


Figure 5 Graph showing the overall results for all SLM practices performance in the economic category

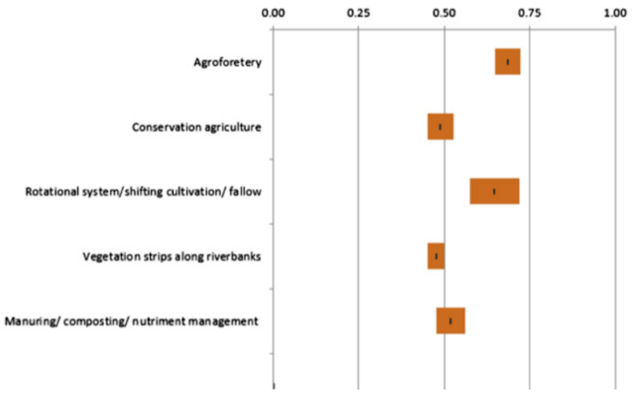


Figure 6 Graph showing the overall results for all SLM practices performances in the socio- cultural category

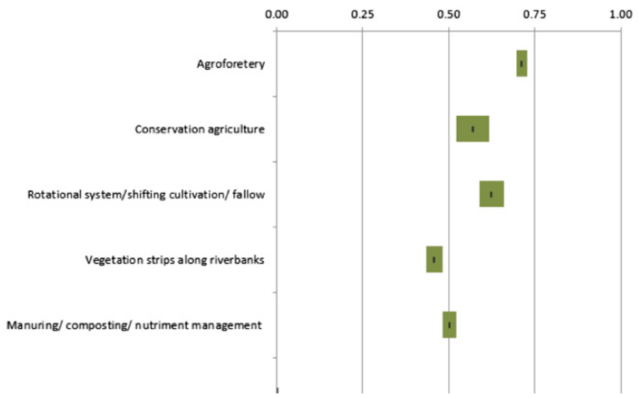


Figure 7 Graph showing the overall results for all SLM practices performance in the ecological category

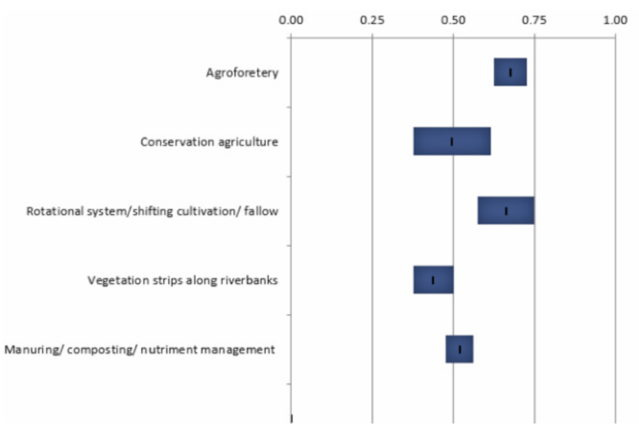


Figure 8 Graph showing the overall results for all SLM practices performance in all categories

As a result, it is clear from all the graphs (Figure 5. Figure 6, Figure 7) that the agroforestry perform well economically, socio-culturally and ecologically as well, with the clearer valuation through the participants. However, the rotational system/shifting cultivation /fallow perform much better economically with a very clear valuation through the participants.

In conclusion, we can deduct from the overall results for all SLM practices performance in all categories that generally the rotational system/shifting cultivation /fallow perform well, and then comes the agroforestry with good performance as well and more clearer data valuation (Figure *8*).

Once we are running the analysis and looking at the results, we start to get a feeling that we have included all the important factors. Does the analysis produce the sort of results that people who are familiar with the situation would expect, or that appeal to them? If not, the question should be; what is missing? Are there criteria that should have been included but were missed out? Are there problems with the hierarchy or the rankings? Do we need to collect additional information to refine the scores? Have additional practices emerged, which need to be added and assessed?

The process is iterative – the first runs provide useful information on how to refine the matrix to come up with a decision that people involved with confidence.

We might expect to have to revisit practices, criteria and their ranking, and/or scores, and considering the different landscape aspect several times before feeling confident that we really have chosen the best practice(s).

Using this tool, the relative merits of different practices become clear, and stakeholder get aware of the pros and cons depending on the view of different stakeholders. Stakeholders understand which practices are most promising in the local context.

Negotiation of the obtained decisions (Step 6)

Finally, referring to the interpretation performed in previous steps, and pointing out the agroforestry as the practices score well in all three categories. Also, the option of the study that we have a larger case study site where several – more than 2 – practices might be considered for implementation and up-scaling in parallel, thus addressing the specific challenges in various parts of the site at the same time. In addition keeping in mind that, the rotational system/shifting cultivation /fallow is very suitable economically to be implemented.

The negotiation of these practices is the aim of this transdisciplinary study. Also explain that before a technology will be implemented in the field, a more detailed assessment of necessary adaptations to make it fit to local conditions will be necessary and will be made by the study site researchers in collaboration with local and external stakeholders.

Conclusions

This transdisciplinary study was made for the benefit of Decision Support for Mainstreaming and Scaling up of Sustainable Land Management (DS-SLM) project, in order to select, scaling up, and promising SLM practices in the study site and expanding them to the national scale.

The transdisciplinary process was suitable to successfully find a consensus among the different level of stakeholders concerning which SLM practice shall be test-implemented in the next step of DS-SLM project.

To reach this consensus the final best practice(s) need to be negotiated among the stakeholder groups. For example, if two practices generally score well, but one scores better ecologically, and the other better economically, the stakeholders have to negotiate which aspect is more important to them. Sometimes the group has two fractions, the conservationists and the developers. The conservationists are most concerned about ecological criteria and the developers over economic criteria, which will show in their different ranking of the criteria. The discussion about this divergence can promote collaboration and the recognition of each other's contribution to the solution. For this reason, it is very important to moderate this negotiation process well.

It will be important that the test-implementation is broadly accepted and supported, and that local stakeholders really have an interest in it. Therefore, it is important that everybody can speak out his / her concerns and give local stakeholders enough space to reason.

The whole selection and decision process is iterative, i.e. the discussion during Step 6 may conclude that it would be necessary to revise criteria, practices, scores and rankings and landscapes types before everybody will agree with the decision.

If we suppose that no consensus can be found, participants vote (openly or secretly). Each person has 1 vote and the SLM practice which receives the highest number of votes is selected. However, a selection by voting bears a higher risk that some people will not accept the result, and therefore it should be avoided if possible.

The technology of Agroforestry and the approach of framing the rotational system/shifting cultivation/ fallow were selected for expanding implementation with agreement from stakeholders under the support of DS-SLM project. In addition, stakeholders were satisfied and they specified how they are going to support the implementation process and commit themselves.

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