Restoration of Degraded Land for Food Security and Poverty Reduction in East Africa and the Sahel: Taking Successes in Land Restoration to Scale

ICARDA Annual Technical Report (January - December 2017)

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Project Title: Restoration of degraded land for food security and poverty reduction in East Africa and the Sahel: taking successes in land restoration to scale

Funded by: European Union/International Fund for Agricultural Development

ICARDA Focal Person: Aden Aw-Hassan (2016-2017) / Aymen Frija (2018 onward)

Project Team: Aden Aw-Hassan, Enrico Bonaiuti, Quang Bao Le, Aymen Frija

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Progress on Main activities

Activity 6.1.1: Planning & implementation review and Monitoring Strategy

During the period January – June 2017 the project team initiated the drafting of the **M&E strategy** for the project after gathering information from partners. The strategy document was completed and will support the activities of the second funding stream in the remaining period of the project.

The activities related to ICARDA M&E tool (see Annex 1), which is used in the project, focused on (1) developing an API protocol[1] to allow other systems and applications to send and receive information, (2) work with Dataverse Harvard Team[2] to ensure automatic data deployment on multiple Dataverse installations, (3) proofing a survey module (MEL Survey) to allow different users to build and send surveys while retaining encrypted data storage on the server and analyze responses over time for same users, (4) proofing a communication tool to incentivize project partners to write blogs and outcome stories in addition to build campaign using interoperable functions with Mailchimp software[3], and (5) supporting the GeOC tool developed by GIZ and ICARDA in terms of data sharing and protocols in order to optimize functionalities. Development of these functionalities have progressed well and these should be soon operational. The developed features will allow more sustainability of project information upon completion both in terms of evidence and of baseline for future interventions.

During the period July – December 2017 the project team submitted the **M&E strategy** for review of different project partners in the project target countries. The final document will be presented in 2018 during the second phase of the project funded by IFAD (EU funding).

Our next steps will focus on engaging with IFAD-HQ for interoperable functions in order to sustainably support its effort to promote Agricultural Research for Development (AR4D) knowledge. We also aim to test the innovative survey module (MELSurvey) in Niger. A last step will be to link MEL and the GeOC tool in terms of data sharing and concretely use the GeOC for selected case studies based on available project data. This will provide an analysis of baseline and target data for the project indicators in order to prepare relevant summarizes for the different stakeholders.

Activity 3.4.4: Monitoring farmers' adoption and performance of options and enabling interventions (global)

In order to ensure the adoption of project research outputs by farmers and herders at large scale with tangible impact, and in line with IFAD recommendations, the project adopted two strategic out-scaling priorities:

1. The first out-scaling strategic priority is to strengthen the engagement and collaboration with development partners, particularly with IFAD supported national projects. For that purpose, the

[1] https://mel.cgiar.org/console/
[2] https://dataverse.harvard.edu/
[3] https://mailchimp.com/

project conducted self-assessment on how it is engaging development partners, which partners are being engaged, reasons for engagement, process used for engagement and mutual expectations by different partners from each other. The aim of this is to improve the partnership with the development programs for win-win outcomes and for effective out-scaling of research impacts. A detailed description of this self-assessment is summarized below (section 3.4.4.1).

2. The second out-scaling strategic priority is a joint-learning process of applying the outcome mapping tool. Special sessions on outcome mapping were included in three project workshops with the aim of raising the awareness of all partners, and strengthening the interaction between the research teams and development partners. These project workshops are attended by most stakeholders including farmers or famers representatives, research teams, development partners (including national projects and programs working on issues related to land restoration), relevant ministries, and NGOs. Therefore, our special sessions were part of the project effort to build common understanding of the required collaboration, which is a prerequisite for jointly achieving large scale impact. The three project workshops were organized on (1) 5th October, 2017, in Machakos, Kenya by ICRAF, (2) 26th October, in Niamy, Niger attended by all centers and hosted by ICRISAT which jointly organized it with ICRAF, and (3) 25-26 November, 2017, Bahir Dar, Ethiopia organized by ILRI. ICARDA facilitated and provided back ground presentation on outcome mapping in these special sessions.

Results of the outcome mapping exercise are being reported under section 3.4.4.2.

3.4.4.1. Description of the survey on Research Teams' Engagement with Development Partners

a. Rationale and structure of the survey

ICARDA developed a short practical guideline for research engagement with development partners as an effort to ensure that land restoration innovations are scaled out to larger number of users as research outcomes (guideline attached). Along the engagement guidelines, a questionnaire was developed in 2016 and refined in 2017 to establish baseline situation of the project teams in terms of engagement with development partners. The aim of the questionnaire was to raise awareness of research teams about the importance of the engagement with development partners in a proactive manner that ensures establishment of effective collaboration, which is necessary for large scale land restoration outcomes. The questionnaire was then recirculated to the teams in order to assess their actual engagement and interactions with their respective stakeholders. The questionnaire is composed of the following both questions:

Question 1. Who are our Development Partners, how do we interact with them and what outcomes we have achieved so far? This included three points **(1)** name of development partner that the team are engaged with, and **(2)** what engagement activities has the research team conducted with this partner in 2017. The engagement activities were pre-coded for ease of filling the survey, **a**= meetings with partners to initiate research-development cooperation; **b**= delivered presentation of land restoration technologies for awareness; **c**= delivered technical advice upon the request of the partner; **d**= joint field visits; **e**= joint workshop on land restoration; **f=** if the team has regular events (weekly or monthly or quarterly) with the partner; and **g=** others (please specify). The third point is about the **(3)** outcomes that have been achieved with this partner? The Potential outcomes were also pre-coded: **1**= Partner increased interest in research outputs and is now more engaged, requesting information, training, etc; **2**= partner supported, co-funded, contributed to on-farm adaptive research work; **3=** Partner has taken up specific technology (specify:…), included in own program with a target of reaching in hectares of land and number of farmers; **4**= partner produced extension material based on research outputs and has disseminated to farmers; **5=** partner took action on supporting policy changes that would facilitate adoption of land restoration technologies by the resource-poor farmers.

Question 2: What were expectations of the two parties from each other in this engagement? This is important because, often research expects assistance from develop partners to disseminate research outputs and bring about the needed behavioral changes that will realize large scale uptake of innovations and impacts. However, without clear and effective communication, research and development may have wrong expectations form each other.

b. Results of the project's development engagement survey

i. Who are our development partners?

The project has implemented a process of engaging the IFAD supported development projects by having continuous dialogues on ways to collaborate on the applied research for development so that research outputs will be most relevant to development goals. Overall the project has quite significant outreach with development community and is actively collaborating with very large development programs, particularly IFAD funded projects in the target countries. ICRAF is working with World Vision, Reseau MARP, KCEP-CRAL in Kenya, World Vision- Ethiopia, Drylands Development Program (DRYDEV), ILRI and ICRAF are also collaborating with Community-Based Natural Resource Management Project (CBINReMP). In addition, ILRI is collaborating with Amhara Bureau of Agriculture (Amhara BoA) in Ethiopia. The project in Ethiopia is also collaborating with RESET and BRACED projects; and consortia of international and local NGOs: CARE, Farm Africa, SOS Sahel, OSHO, GPDI. ILRI is also engaging with the Southern Rangelands Land Owners Association (SORALO) in SORALO has brought together the communities in the group ranch to put in place strategies for managing the rangelands better. Based on the research done by one of the SORALO researchers, the Olkiramatian and Shompole communities were identified as potential areas for improved rangeland management that would enhance biodiversity conservation and improve the livelihoods of the pastoral communities.

ii. Mode of engagement

Choice of development partners**.** The partners were mainly selected because of their national lead in coordinating and implementing land restoration activities in the target countries, for example the DRYDEV program in Mali, Burkina Faso and Kenya. These programs are generally implementing land restoration activities across the target country. Another example is CBINReMP in Ethiopia which is implementing a similar program in the country's highlands, and the Sustainable Land Management Program and the Participatory Small-scale Irrigation Development Project (PASIDP), both of which are also IFAD-supported. Another example is the Participatory Rangeland Management (PRM) in Ethiopia, which follows similar approaches in pastoral areas, which includes widely applied restoration activities such as bush-clearing, in different pastoral areas with different institutions and management approaches (sufficient range of institutional context). Another important factor is that the selected national programs and projects provide a wide range of contexts for the research that are representative of other parts of the country or the whole East African region. The selected programs and projects have the capacity for large scale restoration capacity.

How do you engage with partners and partner's role in the research activity? At the administration level, a MOU is signed between the Center leading the project in each country and the national agency implementing the development project. However, at the operational level, the engagement with development projects begins with research needs assessment conducted on land restoration issues including soil, water, agroforestry, rangelands, and forage crops which involves experts in these fields, project implementers, community participants and related government institutions, including both formal (government) and informal (traditional) institutions in the project target areas. This allows that research and development projects construct common understanding of the problem and jointly contribute to the proposed land restoration solutions and process of maintaining field experiments, monitoring and evaluating them. This way the development partners provide feedback and contribute to research concepts and design; and also lead the identification of locations, communities and pastoralists; and contribute to the evaluation of outcomes and impacts. The development partner assists with community engagement and liaison community members' participation in the planned comparison experiments. During the land user surveys, the development partner provides facilitation support including organizing meetings, field guides and translation services, and obtaining any permissions required to conduct surveys in the community. The partners are then engaged in designing and implementing the research activities. These include Participatory Tailoring of Options-by-Context (OxC), development and implementation of participatory action learning activities with farmers, working along with the participating smallholder farmers to customize intervention options for their specific circumstances. The discussions with partners could at times result in significant modifications to the research focus and design. The roles of the partners include providing feedback and contributing to research concepts and design; leading identification of locations and target land users; and contributing to evaluation of outcomes and impacts.

How does research engage with development? First researchers were asked an open question to describe the process they use to engage development partners. Most research teams mentioned problem analysis as the entry point. However, the strongest explanation provided by ICRAF was the team initiated the design and implementation of well-structured process to engage the appropriate country-level partners that can play an important role in achieving the intended outcomes and impacts. These included stakeholder analyses with outputs of stakeholder maps showing social networks of stakeholder relationships, power/interest grids for stakeholders, plan for engaging, managing and communicating with key stakeholders for both program implementation and scaling; baseline of stakeholder networks in the project sites for future comparisons. Country level Joint Quality Monitoring which entails co-reflection on what is going well and not so well operationally, followed by the development of corrective action plans to address the latter.

The engagement process that the research teams reported also included a process of integrating local and expert knowledge through review and refinement by farmers and experts; joint participatory processes to select, refine, and review the contextual appropriateness and performance of various options; and jointly designing planned comparisons /action learning activities.
Later in a revised version and pre-coded, researchers were asked what engagement activities the research team conducted with its partner in 2017. Only few teams replied to this question in the last quarter of 2017, and this question needs further follow up. However, the main responses included: meetings with partners to initiate research-development cooperation, joint field visits, validation workshop for activities being implemented, training workshop on data collection, and participation in program's annual planning meeting.

Interaction platforms. Researchers were also asked about the process used to coordinate the development partnership and if there is some kind of multi-stakeholder platform for that purpose. In some cases, a country support team is established to better coordinate activities being carried out in the field. The support team is composed of all relevant development partners and research. In other cases, the research project has created some structures and conducted some activities that will be built upon. Future follow up should clarify this much more with the research teams, and the process through which the partnership is managed should be more systematic and clearer.

Communicating and managing expectations. Often research expects support from development partners to disseminate research outputs and bring about the needed behavioral changes that will realize large scale uptake of innovations and impacts. However, without clear and effective communication, research and development partners may have wrong expectations from each other. To address this, research teams were asked what they expect from development partners and what they think development partners expect from them.

Expectations from development partners. The research project team expects from development partners to translate its scientific insights in combination with local knowledge into interventions that can have a meaningful impact in the drylands and at scale. In essence the project expects that development partners facilitate and promote the widespread adoption of context-specific technologies, processes and practices. Likewise, development partners are expected to collaborate and support the implementation of the planned comparisons activities in multiple sites, sharing of research findings from the best fit practices for Climate Smart Agriculture and identifying areas of collaboration between partners. Collaboration and support in monitoring the trees planting in planned comparisons is also expected. Some teams indicated that they expect some budget allocation for staff assigned, mainly for labor in the operations, and for research implementation and assistance in maintaining community relationships and ensuring farmer participation. The stated expectations from the development projects also include a strategy to successfully convince farmers to maintain treatments, for example sustaining improved grazing enclosure successes, identifying "*practical ways*" to out-scale the adoption of land restoration options, especially to achieve 'win-win' solutions for public environment goods together with enhanced local livelihoods, identify how land restoration successes vary across contexts, to support ongoing scaling across the highlands nationally.

Partner expectations from research. The expectations from research by development partners included technical backstopping and capacity development that could directly enhance the performance of development programs and increase the impacts on a large number of beneficiaries. Others mentioned collaboration and support in implementing the planned comparison activities, and sharing of research findings leading to identification of areas of collaboration. Researchers also explicitly acknowledged that research is expected to show results that bring tangible benefits to farmers and pastoralists, and thus convince these land users to adopt and sustain land restoration technologies. Research is also expected to identify practical ways to improve land restoration, especially to achieve 'win-win' solutions for public environment goods together with enhanced local livelihoods under different contexts. The development partners also expressed expectations in capacity development for local community members, and access to data and reports and participation in peer reviewed publications.

iii. Performance of the project engagement with development partners

Any assessment of an activity requires indicators to monitor performance. To raise research teams' awareness on the need for assessing the performance of the engagement, they were asked to identify indicators that can be used to track the engagement and can best capture the performance of the engagement. The research teams proposed the following indicators: number of water management plans updated, number of hectares under on-farm water & soil management, number of hectares under afforestation and farmer managed natural regeneration, number of capacity building events for Rain Water Harvesting held, number of stakeholders engaged and interacting with each other.

The indicators listed above are quantitative and can be realized in the medium to long term. In addition, others identified much shorter term and qualitative indicators. These include buy-in or interest in joint collaborative agreements, assignment of staff in project sites or administrative levels, commitment on resource sharing, expansion of adaptive research to additional areas, implementation of research outputs at scales larger than those for experimentation.

Overall, these indicators are quite robust set and this shows that the research teams are fully aware of how the performance of development engagement can quantitatively and qualitatively be measured and evaluated in the short and long term. Future works should include further monitoring of these indicators and all the teams in all project sites should fill these surveys in the last quarter of every year.

Observed outcomes. The research teams reported observed intermediate outcomes of the engagement with development partners as follows;

1. Number of times the partners consulted the research team for direct advice in the last 12 months: ICRAF reported 6 requests by Sahel, and 8 requests by Reseau MARP, and ILRI reported 4 requests by CBINReMP, and 4 requests by RESET and BRACED projects as well as 2 requests by SLMP/GiZ.
2. Number of times that research gathered partners for consultation on inputs in research: 12 (at least).
3. Number of events co-funded by development partners and research partners in the last 12 months: 5.
4. Number of partners who increased their interest in research outputs and who are now more engaged, requesting information, training, etc.: 3.
5. In addition, development partners solicit research support for land restoration issues, involved consultations that included the design of planned comparisons related to: comparing earth bunds and stone lines, with or without vegetation; comparing the survival rate and growth of plants as a function of pits size, soil type, period of pits preparation and watering regime and comparing different grafting techniques on the growth of *Balanites aegyptiaca; also intrest by NGOs i*n Ethiopian pastoral areas, in improving participatory rangeland management,

These indicators show positive signs that the project has initiated the process of out-scaling land restoration technologies in collaboration with development programs. Further follow up is needed to further materialize these indications. *Follow up actions are need to translate these intermediate behavioral changes to outcomes at the beneficiaries' level (see the outcome mapping framework).*

3.4.4.2 Synthesis of Outcome Mapping Sessions in the Three Project Workshops

a. Defining outcome mapping

Outcome mapping is an analytical framework which expresses how a research project can achieve its outcomes and impacts ((Jones and Hearn, 2009; Earl, et al., 2001; Smutylo, 2001). The framework consists of four main concepts that are analyzed starting from the mission/goal and going backwards (**Figure 2).**

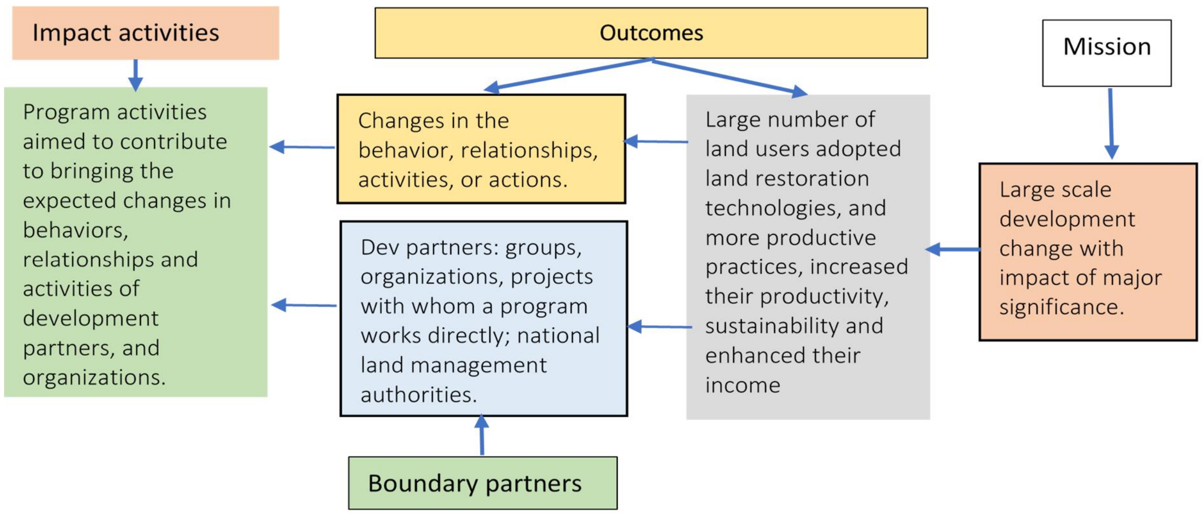

Figure 2. Outcome mapping framework

The first concept is the project mission which is the project's ultimate development goal on the welfare of the poor rural populations and their supporting natural environment that sustain them, including soil, crops, livestock, agroforestry and range. The second concept is the outcomes which can be structured in to two elements. The first element is the intermediate outcomes which is defined as changes in knowledge, attitudes, skills and/or relationships, manifested as a change in behavior, activities, or actions of individuals, groups and/or organizations that result in whole or in part from application of research outputs. Policy changes or changes on land restoration programs at national or local levels are examples of these outcomes. The second element is the large-scale adoption and use of the research outputs by the target beneficiaries. Examples of that are large scale adoption and adaptation of land restoration practices by land users. These two elements are interlinked and the second cannot be achieved without the first. The third concept of outcome mapping covers the partners that are essential to support and promote the changes needed to achieve the project outcomes and goal. These are individuals, groups and organizations with whom the research program works directly who have influence over the expected outcomes. These agents of change are called development partners or boundary partners and they hold the key to achieving the expected large-scale outcomes and the ultimate mission of the project. Finally, the fourth concept is the project activities; not research activities, but activities that are termed as impact activities. These are activities that are targeted to influence key partners with the aim of bringing about behavioral change that deliver large-scale outcomes ultimately the project mission. The engagement activities that and the outcome mapping sessions as part of these impact activities.

b. Participatory exercise on outcome mapping

After the outcome mapping framework is presented and discussed, participants are divided into organizational categories and questions related to the outcome mapping described above were posed. The groups were asked to brainstorm on the questions and present their responses to the panel**.** *In Machakos, (Kenya)* all the groups were given the same questions. The questions given were: What changes in the behavior, relationships, activities, or actions do we need to make to achieve the project goal? And who needs to be involved to achieve the change? What activities should the program and partners do to facilitate the behavioral changes described above? Give positive change as a result of the program? *In Niamey (Niger)*, the research group was asked how the development partners can be more helpful in scaling out the adoption of land restoration interventions. Provide experience of actions that generated success? What should research do more to ensure the buy-in and fruitful collaboration from development partners? What specific land restoration innovations can give development partners to scale out? The development community and donors were asked what they expect from research to ensure that research outputs can be included in their development agenda. *In Bahir Dar (Ethiopia),* the questions were more specific to pasture ex-closures. The suggested questions were: What are the major constraints facing the large-scale adoption of pasture ex-closures? And what are the solutions and actors who can help bring about that solution?

c. Summary of the participants' responses

The first main changes or actions needed to achieve project goals proposed by the participants *in Machakos, Kenya,* were related to policies. These included changes in land use and environment policies, changes in land tenure system to discourage land fragmentation, changes in policy to ensure more participatory land management by government and stakeholders, and overall enforcement of these policies. The second main proposed changes focused on *technology adoption*. These included disseminations of machinery for conservation agriculture, adoption of water resources conserving technologies- such as installation of rainwater harvesting from greenhouse (RWHG) and considering quality as well as quantity of water and advocating climate smart production for livestock and crops. The third main area for actions was *strengthening knowledge transfer process.* Participants suggested more agricultural training can be ensured by building technical institutions and vocational training centers, increase in the number of extension officers to reach out to more farmers, and increase the efforts of sensitizing communities on land restoration and sustainable tree harvesting using different mediums. Additional proposals included introducing collective marketing as opposed to individual marketing that can raise the bargaining power of smallholders, and the increase smallholder farmers' access to finance. Changes in school curriculum was also proposed which could have fundamental but longer-term effects on future generations. This suggestion on change in elementary school curriculum could build knowledge on the importance of protecting the environment and planting trees for the health of the environment and improving rural livelihoods.

The participants *in Machakos workshop (Kenya)* also identified specific actions that the project can take and can lead to achieving outcomes. The main suggested project actions were again related to policy area. The participants proposed that policy gaps in land restoration should be identified, forums for policy discussion be established, training on the role of policy on land management be conducted, and material on policy impacts made available. These actions are expected to influence policy formation and implementation. The second set of proposed actions were more facilitation and motivation of farmers and stakeholders' involvement that increase their awareness, knowledge and skills in land restoration. The project is already doing a great deal of that; however, this shows the demand for more such efforts.

In the Niamey, Niger, workshop participants were divided into two groups: the research team and the donors (some researchers were added to the donor group and asked to role-play as donors). The responses of the research group are presented in Table 1. The first and the second questions were related to what actions should research and development partners take to advance land restoration outcomes. These responses show the complexity and multidimensional nature of the problem at hand. Over all, research is expected to show commitment, build trust with community and partners, link scientific and local knowledges, and transform knowledge to practical guidelines. On the other hand, development partners are expected to support long term programs, fund technology dissemination, and be willing to accept feedback. The third question was related to experience in success and the key point here was that programs funded for a long term are more likely to succeed. The final question was related to ready technologies and the group provided a list of readily available land restoration options.

Table 1. Responses of the research group to questions raised in the outcome mapping session in Niamey, Niger

Question	*Response*
Question 1: What should research do more to ensure buy-in and fruitful collaboration with Development Partners?	• Commitment with stakeholders • Engaging with cross-learning, pick up knowledge and technology • Building and cultivating trust with all partners • Transforming present research results to communicable messages • Timely delivery so research results can be incorporated into the development cycle
Question 2: What should development partners do more to ensure buy-in of their research questions and fruitful collaboration with research organizations?	• Finance long-term land restoration innovations, including long-term fallow up, observatories and monitoring • Finance dissemination of research • Support more resource allocation for field work • Finance Land Restoration interventions that is connected to local knowledge • Encourage developing shared awareness and appreciation of both worlds; this includes to be open to each other to facilitate learning • Willingness to receive feedback • Build and cultivate trust
Question3: Mention experiences that generated success.	• In Niger there was a good collaboration with KEITA- Research+ Development; IRAN, made suggestions on technologies. The reason for the success was that the amount of resources was sufficient and it was long term (1984-1997) • Another example in Niger was the wide-scale observatory of Land Degradation • Collaborating with Development Partners on proposals.

Question 4: Which Land Restoration Innovations are currently ready for scaling?	• Agroforestry • Soil fertility improvement • Increasing native grass species • FMNR (farmer managed natural resources) • Soil and water conservation • High value and multipurpose trees/ agroforestry practices • Value added innovation on hillsides and mountains, tree-crop-livestock interactions

Participants in the donor group were asked only one question: *What do donors/development community expect from research to ensure that research outputs can be included in your development programming*? In this context, one member of this group posed a hypothetical question to the rest of the group:

"I am a Development Agency with substantial funding available to invest tomorrow in Niger and I would like a list of land restoration options with clear information on where these interventions can be implemented at scale. I need a clear return on investment of the interventions, cost per farmer/family of implementing, potential for adoption, methodology for implementation and M&E. I need this information urgently packaged for a big investment in the next 2 weeks".

This question was based on practical experiences that research teams regularly face when discussing research-development linkage with donors and shows the challenges that research faces in coming with such a detailed information in short time. In essence the response to such question is nothing less than a detailed feasibility study of research outputs (technologies, recommendations) in a large-scale development context. Such information is not readily available within research organizations unless ex ante impact studies are conducted. Therefore, the lesson from this question is that (1) research should *do ex ante* impact assessment of its outputs to cover that demand (this will be a major focus for this project in the remaining period which ICARDA will lead), and (2) development partners should involve research in the feasibility studies of large investments so that the research-development linkages can be built into the program from the start.

However, in response to the question, the group listed what research should do to address the donor / development partners' requirements. Some of these suggestions are as follows:

1. ability to quantify the impact on the ground (ref. SDGs),
2. showing short term results,
3. providing actionable interventions at farm level,
4. packaging final research products into simple, adaptable, and accessible solutions,
5. outcomes should be attractive to donors,
6. outputs should be able to leverage other funds (National, etc),
7. needs assessment should include development partners before defining outputs,
8. outputs should support the promotion of the partner development agenda

In Bahir Dar, Ethiopia, the questions asked to workshop participants were: (1) what are the major constraints facing the large-scale adoption of pasture exclosures which the project is promoting? (2.a)

What solutions/ actions can address these constraints? And (2.b.) which organizations and development partners can help to bring about those solutions? In response to the first question the group listed constraints in three major areas including social and policy issues, production system and technology issues and integration issues. The detailed list of constraints is given below:

Social and policy:

- lack of awareness among the community;
- some members of the community refuse to accept the community by-laws approved by themselves and similarly lack of commitment to enforce the by-law on the part of some institutions;
- border conflict and encroachment on the communal grazing land;
- weak enforcement or lack of regulations on land use planning;
- Absence of pasture management policy.

Farming system and technology issues:

- farmers with large number of cattle refuse to keep their animals outside the enclosure and keep it around their backyard;
- lack of inputs such as improved varieties of forage crops ;
- High cattle population;
- Use of improved practices, which may increase productivity, on pasture land
- Failure to document and up-scale best practices;

Integrations issues:

- Integration between development partners involved is below the required level.

During the workshop it was noted that the property rights of the exclosures and how the exclosures will affect pre-existing rights to graze these lands has not been fully clarified, and that may be one of the reasons that some livestock owners refuse to keep their animals out of the exclosures and others do not follow the by-laws. Further work is needed to understand the social dimensions of the exclosures and how that may affect the use rights over these resources.

In responding to the first part of the second question "*What are the solutions and actions to these constraints*", the group gave the following solutions:

1. using GIS and GPS technologies, clearly delineate and demarcate communal grazing lands to avoid encroachment and conflicts which have been widely occurring around these areas;
2. continuous awareness creation program for the beneficiaries and supporting institutions;
3. introduction of modern technologies related to forage and livestock production;
4. develop appropriate pasture land policy;
5. minimize per capita cattle population;
6. establish a system which induce all stakeholder institutions involved in the sector to work together in an integrated manner to elicit synergy;
7. facilitating experience sharing platforms within the region and outside;
8. provision of associated inputs such as improved and high breeds of animals and subsequently reduce the number of local breeds; provide high quality & improved varieties of forage seed to enrich grazing lands; motivate private organizations to provide the required inputs;
9. involve the community during development, implementation and monitoring of the community by-laws and enforce its practical application;
10. identify and document best practices and facilitate experience sharing platforms therein for ultimate out-scaling;

The response to the second part of question 2, “Organizations, development partners that can help to bring about those solutions”, the participants indicate that the Bureau of agriculture and its affiliates (including livestock agency); the community at large, community watershed committees and Kebele (the lowest political administrative unit) administrative bodies; justice and judiciary bodies (to enforce community by-laws); and nongovernmental organizations and micro-financial institutions are key players. Overall, the Bureau of Agriculture and its affiliates should lead the effort.

Activity 5.2.5: Impact assessment and modeling

a. Framework for Benefit-Cost assessment

The overall objective of the project is to provide an effective and generic restoration approach of degraded lands in the drylands of Niger, Mali, Ethiopia and Kenya through the scaling of different on-farm restoration innovations in collaboration with development programs and IFAD country investments[4]. Within this framework, a set of restoration options have been and are being tested with farmers and herders in selected sites of these countries. Monitoring the adoption, costs, benefits, and impacts of these interventions is essential to measure the progress of the project. Currently comprehensive datasets about these different experiments are being generated in the target countries, with detailed individual data about contextual factors, and their respective performance. The objective of this activity is to provide a comprehensive framework for the economic analysis of datasets collected during this project. Particularly, we aim to generally discuss and enumerate the different economic and financial costs and benefits of land restoration options, and to provide an adapted framework for the use of the project based on available data items. While this framework has been developed in 2017, its implementation for the different case studies, is expected for 2018. The framework considers three main factors which will determine the different costs and benefits that can be considered for the evaluation of a given land restoration option. These are (1) technical characteristics of the option, including the technical itinerary used by farmers to implement it in their fields, (2) data items available concerning costs and benefits that can be used in the economic/investment analysis. The type of available data will help us defining assumptions regarding the costs and benefits items which we have to consider and/or reject; and finally (3) the influence of contextual factors on the costs and benefits of the different options.

The project team elaborated a technical economic valuation (considering environmental costs/externalities and benefits) which can be called as “extended costs/benefit valuation”. Methodological details for the extended costs/benefit valuation framework is shown in Annex 2. Food prices and other ecosystem services are more likely to negatively affect the poorest households when their food expenses constitute a large share of their household expenditures. The increase in food prices, reducing people’s disposable income, would have the effect of lowering their willingness-to-pay for non-provisioning Ecosystem Services (ESS), which are primary global public goods, thus limiting the funds available to protect the land. A more comprehensive assessment of these aspect will be implemented in 2018 using the methodological framework presented in annex 2.

[4] See http://www.worldagroforestry.org/news/icraf-presents-land-restoration-activities-ifad-regional-implementation-workshop-riw-kampala

b. Comparative evaluation of efficiencies of restoration options

To compare the application of SLM/restoration practices in terms of their impact on crop production efficiency, the project team has fully elaborated an economic methodology to evaluate (1) farm production efficiency and (2) farm production frontier (i.e. production potential under different contexts) induced by the application of given SLM/restoration technologies. Through this methodology, we are able to measures farm production efficiency with respect to major farming inputs such as water (m^3), fertilizers (cost), pesticides (cost), seeds/gemplasms (cost), machinery and energy (costs), and labor (working days). To measure impacts of applied restoration practices on farm production efficiencies, we will compute and compare efficiency estimates and production frontiers across households who adopted SLM/restoration measures and these who did not adopt. Methodological details for the developed evaluation framework are shown in Annex 3. This framework will be applied in 2018 using the primary data collected in the different action sites of the project.

c. Analysis of adoption based on collected primary data

Despite a large number of published analyses of farmers' adoption of sustainable land management (SLM) practices – including land restoration measures, coping with social and ecological contextual diversity which are constraining such adoption is still under investigated. In 2017, we also developed an improved method that stratifies the studied community/landscape according to social-ecological contextual variables, then conduct multi-variate adoption analysis for each strata to additionally infer adoption drivers in relation to the contextual types. In this way, adoption analysis would require the identification of plausible contextual typologies beforehand. Econometric models for identifying determinants of households' adoption of land restoration measures were elaborated. The set of considered affecting factors combine both household's livelihood attributes and relevant field's characteristics. Main categories of household livelihood attributes include key assets of household livelihood: human asset (e.g. labor, health, education and capabilities), natural asset (e.g. farmland quantity and quality, livestock and water resources), financial assets (incomes and savings from different sources), physical assets (e.g. housing conditions, access to infrastructure and equipment for agricultural production), and social assets (e.g. supports and advantages from social network, positions and projects/programs). Relevant attributes of field/land parcel to be considered include field's proximities (distance) to road and water supplier, land topography or hydrological status, plot size, Soil fertility and tenure status.

The adoption analyses will also consider the diversity in livelihood contexts. It is recommended to conduct both types of adoption analyses: analyses in specific to contextual groups and analysis for combined/whole sample. The benefits for this approach would be (1) understand the added values of livelihood type-specific adoption analysis, and (2) reveal common determinants of adoption across different contexts. Methodological details for context-specific adoption analysis shown in Annex 4. This methodological will again be implemented in 2018.

d. Linking Benefit-Cost to geo-referenced option by context

The contribution of EU-IFAD project to this development was through Quang Bao Le and Enrico Bonaiuti during the supervision of a group of junior researchers and consultants funded by a GIZ/BMZ project focusing on the GeOC tool development. The 3rd version of the off-line Excel template for "Standardized Description of Sustainable Land Management (SLM) Technologies with a Focus on Field-Landscape Level" was produced in that framework. This was the continued development of the earlier versions that were developed in 2016 and supported by CRP Dryland Systems. Figure 3 illustrates some screenshots of the off-line template. The main improvements of the 3rd version of the off-line Excel template, made during 2017 in the framework of the current project, are:

- Field-to-field matching the web-based SLM input form that allows for uploading the off-line data to the web-based GeOC.
- The creditability of the template was improved by the acknowledgement of information fields that are either inherited or modified from WOCAT (World Overview of Conservation Approaches and Technologies - https://www.wocat.net/), or newly developed by the project team.

On-line standardized and integrated data template. The project team with a group of junior researchers and consultants co-funded by a GIZ/BMZ project improved the current version of the web-based SLM inputs (https://mel.cgiar.org/slm), as a part of the GeOC tool, in terms of (1) Its compatibility with the off-line Excel form (field-to-field match) for uploading offline data filled by users (see Figure 3 below), (2) the online workflow were properly partitioned into short sections with more user-friendly interface, (3) functions for data submitters' management (e.g. online saving or viewing of their on-progress products, uploading off-line data, and submission) and administrator's management (e.g. viewing of on-progress or submitted work by users, functions for admin's decisions– reject/accept/revision, and feedbacks to data submitters) is in finalization, (4) functional links to the WebGIS, a sub-tool of the GeOC, containing data on the drivers (providing socio-ecological contexts) of land use/management and the indicators of baseline land degradation/improvement and impacts (see Figure 4), and (5) land use/management and the indicators of baseline land degradation/ improvement and impacts. Table 2 summaries the main features of our online and off-line SLM templates that may be complementary to the current status of WOCAT.

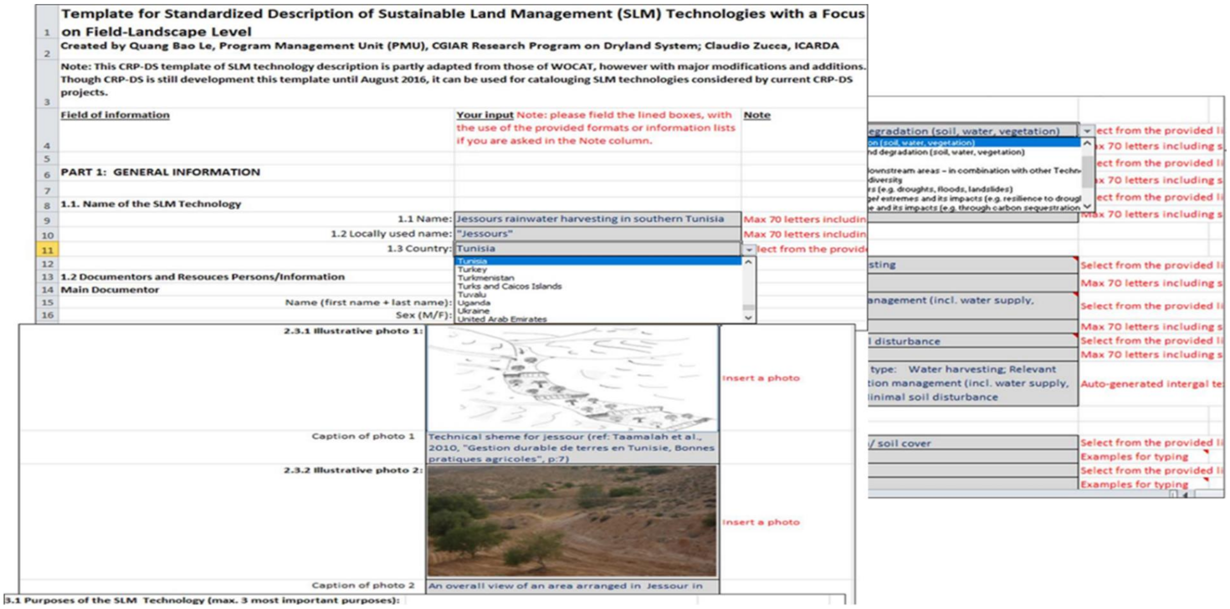

Figure 3. Screenshots of the standardized Excel template filled by a SLM option locally called as 'Jessours', and technology for harvesting rainwater in the context of southern Tunisia. Note: SLM/restoration data in this template/form in the countries targeted by this EU-IFAD project are being imported and reviewed.

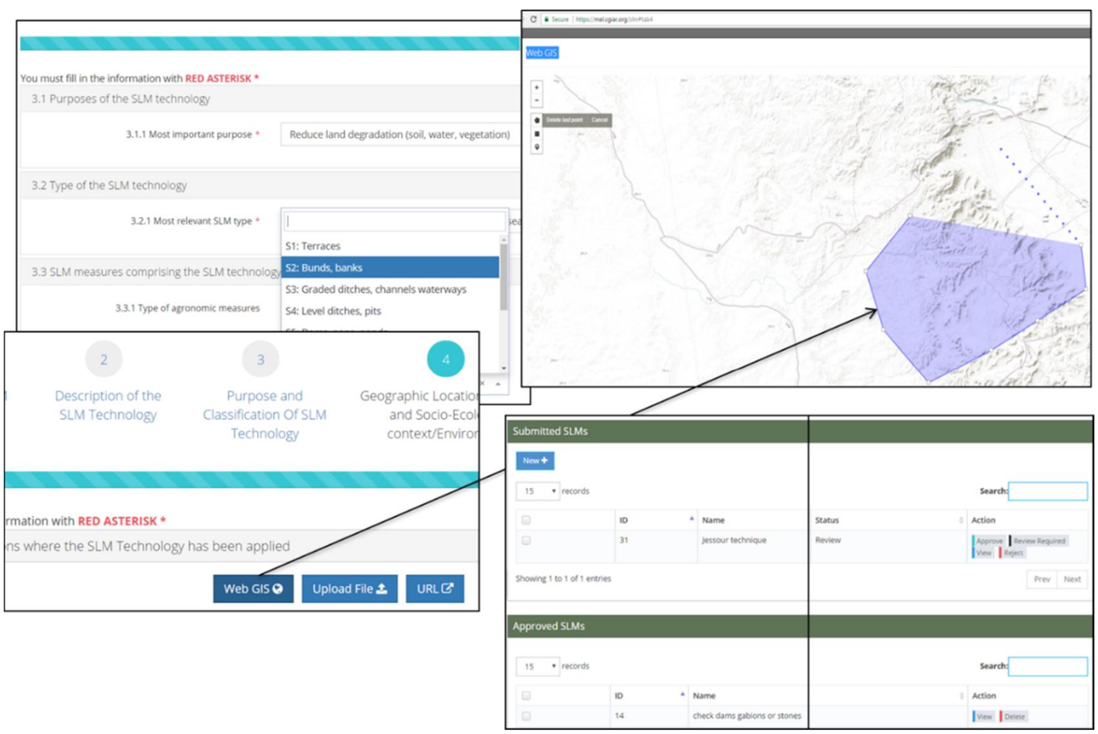

Figure 4. Screenshots of the web-based SLM form with standardized information fields and functional links to WebGIS containing data on the drivers (providing socio-ecological contexts) of SLM/restoration options, as well as land use's outcomes (e.g. productivity, productivity trend, NPP gap, affected population). Note: Further details can be found in https://mel.cgiar.org/slm

Table 2. Features of the GeOC's off-line and online templates being possibly complimentary to current WOCAT (its status in 2017)

Feature	
The data exposing to users are multi-variate database rather than static factsheet (PDF or document file)	Allow user-defined queries in response to SLM's attributes selected (e.g. type, environmental and socio-economic characteristics), or exportation to spread-sheet formats for further multi-variate analyses
Synchronized with the GIS database and tool (WebGIS) to retrieve - hence relate with – spatial data on contextual /driver and impact variables over larger scales	Allow spatially explicit analysis/assessment in comparison with baseline data in land degradation/improvement to define best SLM practices given a context. If trade-offs among aspects of impacts are too complex to measure and/or cope with, the tool will inform stakeholders a portfolio of SLM options with quantified *pros* and *cons* for inform the multi-stakeholder discourses toward social consensus.
Data entry forms both off-line and web-based form for standardized description of SLM (adapted from WOCAT)	Allow either on- or off-line inputs and aligning each other (online with off-line) Relatively match with WOCAT questionnaire, thus creating opportunities to communication and automatic contribution to the WOCAT global database once technological links between the two are done. Owners of SLM data in GeOC also have a high chance to submit and publish their data in the well-known WOCAT global database (with some minimal adaptation to the current WOCAT standard).

e. The customization of WebGIS sub-tool in the Global Geoinformatic Options by Context (GeOC) tool and exploring complementary links with ICRAF's Landscapeportal.org.

The project team worked with a group of consultants on the development of the WebGIS sub-tool in the GeOC (https://mel.cgiar.org/slm/visualization). This work was co-funded by the EU-IFAD project and another GIZ/BMZ project. Figure 5 shows a screenshot of the WebGIS interface with notes on its functions. Per initial exchange with the project lead team in ICRAF, we intended to explore chance for having complementary links between the ICARDA's WebGIS and ICRAF's Landscape Portal (http://landscapeportal.org/). The ICARDA-ICRAF exchanging process on this would include:

- Sharing some basic information of the platforms and meta data structure.
- Sharing operational requirements for data entry in each platform.
- Identify what data from the LandscapePortal should and can complement to the database of the GeOC's WebGIS (as the GeOC will be used for comparative analysis/synthesis).

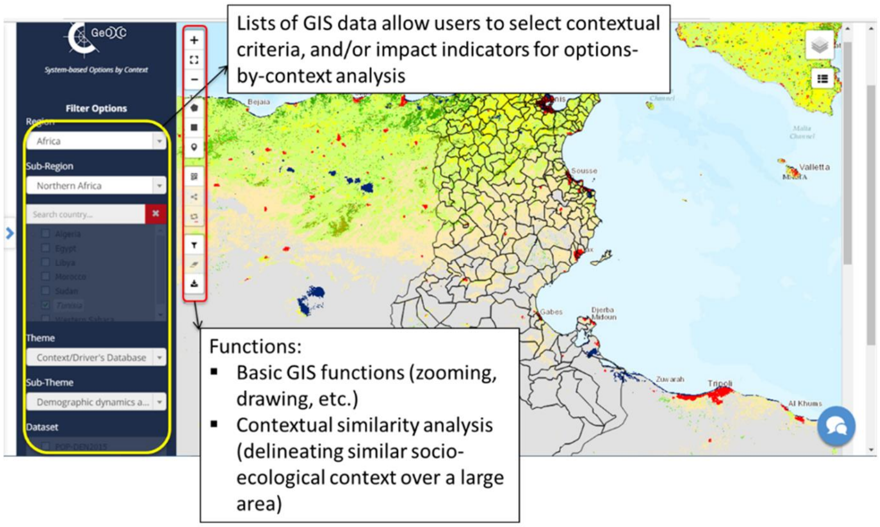

Figure 5. The GeOC's WebGIS interface and its functions. Note: Further details can be found in https://mel.cgiar.org/slm/visualization/, and tutorial Youtube videos: https://www.youtube.com/watch?v=NLpd9vY21CA&list=PLRIsJ0x4IVjn1NUkaWPcIVswWv5jKtEVH

Opportunities and options for creating inter-operability between the two (ICARDA and ICRAF) platforms, based on earlier discussions will be explored in the plan of work of 2018. Harmonization of the SLM sub-tool (web-based and off-line form) in GeOC with WOCAT will be one of our objectives in 2018. This is mainly because this tool could provide the SLM R&D community (including WOCAT's consortium partners) consort without-scaling capacity that WOCAT does not have. We are also discussing this as a goal to have interoperability of peer systems under the new project proposal if there are interests from peer groups/organizations (within and outside CGIAR).

f. Identification and characterization of land restoration options.

The ICARDA team is on a pilot process of reviewing, cataloguing and importing the SLM/restoration options data provided by national teams. Through reading and reflecting of previous countries' reports, we recognize the differences/variation between the approaches used by these reports and the standardized protocol proposed by ICARDA team who are responsible for data standardization for comparative analysis and synthesis. In the national reports, land restoration options were described as rather:

- single technological measures,
- largely separated from (or without in many cases) the social and ecological contexts or the consider landscapes and regions,
- not in a standardized frame.

These issues cause difficulties for data fusion and quantitative comparative analyses. While the GeOC/WOCAT description is rather following an integrative system approach:

- As the interactions of technological/management options with social-ecological contextual factors (drivers) determines land use/management performances/impacts, thus all three parts (context, option, and performances/impacts) need to be considered.
- In most case of SLM options, the combination of different measures (agronomic, vegetative, structural, and economic) in space and time are practiced to provide a basis for achieving/improving the sustainability of land management. In another word, the restoration option is seen as a technical-management package.
- The GeOC/WOCAT uses standardized form for acquiring information to allow better comparison and synthesis.

Keeping this in mind, it is impractical for ICARDA team alone to catalogue and analyze data based on the country reports provided. Therefore, we propose that researchers and partners in the project countries would use our GeOC's SLM templates to generate land restoration options-by-context data; thus creating a project database for interesting analyses that help achieving the project objectives. More concretely, the following steps would be implemented:

- The filling of GeOC's SLM template would be rather based on data available underlying the national reports (some extra expert-based inputs and/or field observations may be needed)
- The extensive mapping of case areas where the restoration practices were implemented is critically needed. This would help proving not only the visibility and credibility of the project, but also utilize the WebGIS/GIS database of the GeOC for filling out many contextual data with no cost, and perform analysis to support out-scaling.
- ICARDA team would provide needed training about the tool, do pretests together with the national project teams and partners, reviewing data collected by partners using the template and do comparative analysis/synthesis based on sizable data in due format. This process would be done for the next 6-7 months.

Related publications

CRP Dryland Systems

Richard Thomas, Tana Lala-Pritchard, Enrico Bonaiuti, Quang Bao Le, Marah Al Malalha, Valerio Graziano. (2017). Dryland Systems Annual Performance Report 2016. Amman, Jordan: CRP on Dryland Systems (DS). http://hdl.handle.net/20.500.11766/6847

Thomas, R.J., Reed, M., Clifton, K., Appadurai, A.N., Mills, A.J., Zucca, C., Kodsi, E., Sircely, J., Haddad, F., Hagen, C., Mapedza, E., Wolderegay, K., Shalander, K., Bellon, M., **Le, Q.B.**, Mabikke, S., Alexander, S., Leu, S., Schlingloff, S., Lala-Pritchard, T., Mares, V., Quiroz, R. (2017). Modalities for Scaling up Sustainable Land Management and Restoration of Degraded Land. Global Land Outlook (GLO) Working Paper, United Nations Convention to Combat Desertification (UNCCD), Bonn, Germany, p. 25. URL

MEL Tool:

Enrico Bonaiuti, Claudio Proietti, Bastian Mueller, Richard Thomas, Jalal Omari, Moayad Al-Najdawi, Leigh Ann Winowiecki, Quang Bao Le, Patricia Victoria Bravo Sosa, Valerio Graziano, Percy Cabello, Belal Mazlom, Mohammad Opada Al Bosh, Bashar Ayyash, Mustafa Kaatuah, Mohammad Salem, Omar Alsoudani, Mohammad Wadi, Satish Nagaraji. (2017). A Web-based Platform for Enhancing Monitoring, Evaluation and Learning (MEL) in Research for Development - Toward Achieving Development Outcomes. http://hdl.handle.net/20.500.11766/7349

Claudio Proietti, Holly Anne Holmes, Enrico Bonaiuti, Valerio Graziano, Megi Cullhaj. (2017). MEL Survey - Feedback on reporting 2016 "What we Learned". http://hdl.handle.net/20.500.11766/7033

GeOC approach and Tool:

Quang Bao Le, Enrico Bonaiuti, Richard Thomas (2017). Global Geo-informatics Options by Context (GeOC) Tool for Supporting Better Targeting and Scaling-out of Sustainable Land Management: Designing the System and Use Cases. CGIAR Research Program on Dryland Systems (CRP-DS) and International Center for Agricultural Research in Dry Areas (ICARDA). Amman, Jordan. 24 p. URL

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Fajr Fradi, Jim Jaspe, Bashar Ayyash, Quang Bao Le, Enrico Bonaiuti, Megi Cullhaj, Federico Lettieri, Valerio Graziano. (2017). GeOC User Guide. Amman, Jordan: The International Center for Agriculture Research in the Dry Areas (ICARDA). http://hdl.handle.net/20.500.11766/7065

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Nkonya, E., von Braun, J., Mirzabaev, A., Le, Q.B., Kwon, H.-Y., Kirui, O., 2016. Concepts and Methods of Global Assessment of the Economics of Land Degradation and Improvement. In: Nkonya, E., Mirzabaev, A., von Braun, J. (Eds.), Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development. Springer International Publishing, pp. 15-32.

Smutylo, Terry. 2001. Outcome mapping: A method for tracking behavioural changes in development programs. ILAC (The Institutional Learning and Change) Brief 7. CGIAR.

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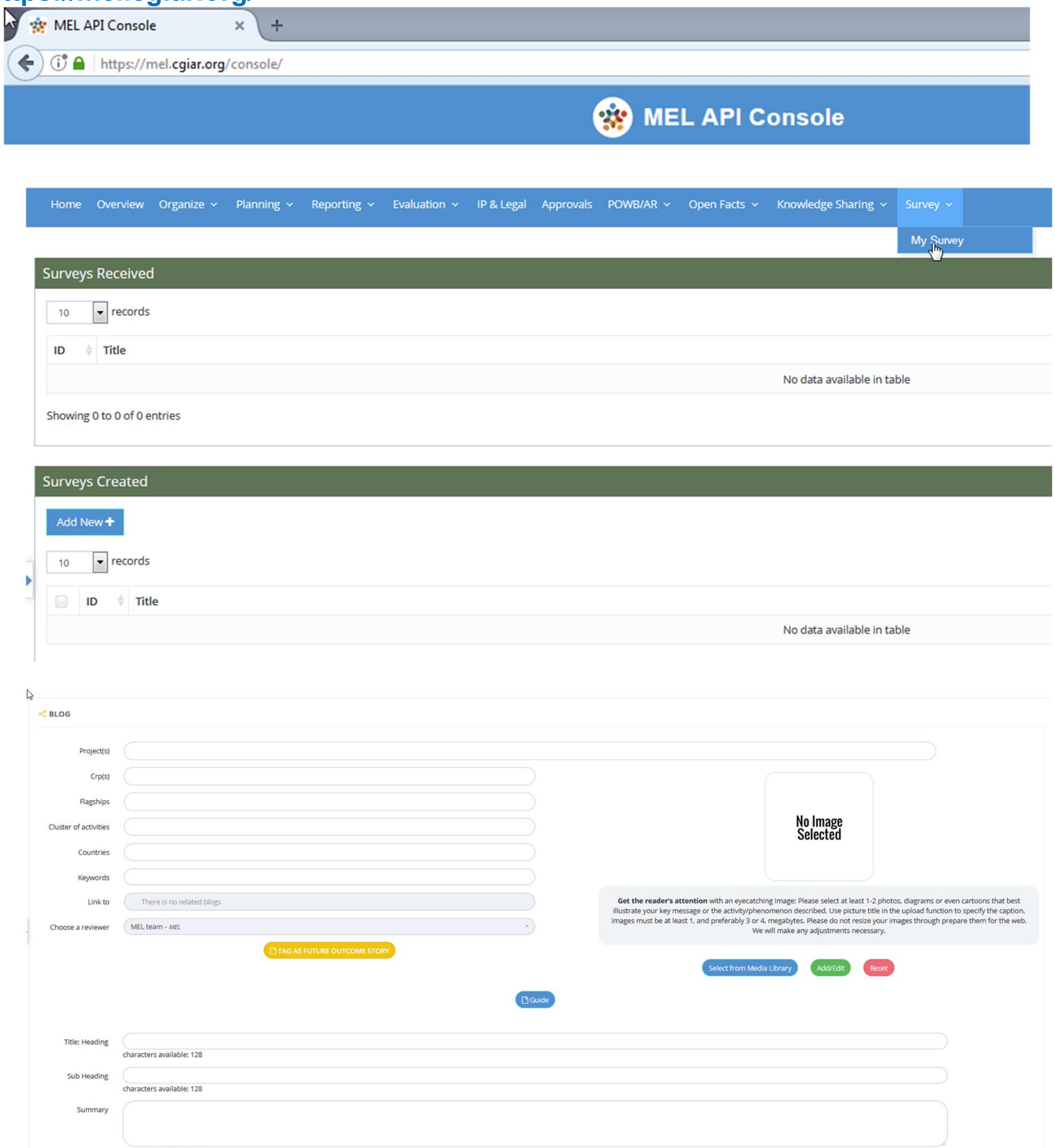
Thiombiano, A.B., Le, Q.B., 2016b. Maize and Livestock Production Efficiencies and Their Drivers in Heterogeneous Smallholder Systems in Southwestern Burkina Faso. CGIAR Research Program on Dryland Systems (CRP-DS), International Center for Agricultural Research in Dry Areas (ICARDA), Amman, Jordan, p. 31.

Thiombiano, B.A., Le, Q.B., 2015. Soil nutrient balance, economic performance and scenarios for closing nutrient gaps in heterogeneous smallholder farm systems in south-western Burkina Faso. In: Gritti, E.S., Wery, J. (Eds.), Proceedings of the 5th International Symposium for Farming Systems Design (FSD5) - Multi-functional Farming Systems in a Changing World. European Society of Economy (ESA) and Agropolis International, Montpellier, France, pp. 467 - 468.

Annexes

Annex 1. MEL platform as monitoring and evaluation tool. URL Source: https://mel.cgiar.org/



Annex 2. Methodological Framework for Benefit-Cost Assessment

The underlying central hypothesis of the framework is that land restoration measures improve the production of both food and other ecosystem services of land (Y_{deg} shifting up to Y_{res} in Figure 6), while also reducing prices/costs of both food and other ecosystem services (shifting C_{deg} down to C_{res}).

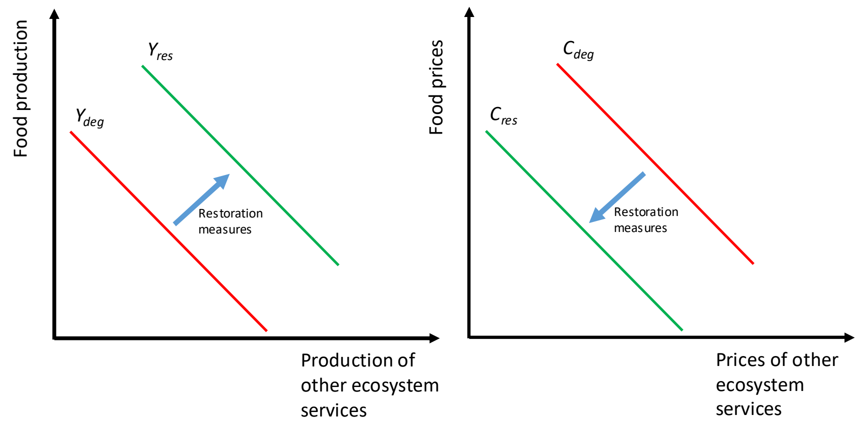


Figure 1.2. Hypothesized positive impacts of land restoration on the production and the prices of food and other ecosystem services. Source: Modified from Le et al. (2017).

The economic model for the extended costs/benefit evaluation is adapted from the model proposed by Nkonya et al. (2016). The extended cost and benefit of land restoration measures (action state *c*) - against the background of land degradation and inaction - is given by the net present value (NPV) for taking action against land degradation in year *t* for the land users planning horizon *T*:

$$\pi_t^c = \frac{1}{\rho^t}\sum_{t=0}^{T}\left(PY_t^c + IV_t + NU_t + b_t^c - lm_t^c - c_t^c - \tau_t^c\right) \tag{1.2}$$

where π_t^c = net present value (NPV) for taking restoration measures (state *c*) - against land degradation - in year *t* for the planning horizon *T*; Y_t^c = direct use value of production services when using restoration practices; *P* = unit price of Y_t^c; IV_t = indirect use value; NU_t= on-site non-use value; b_t^c = off-site positive benefit of restoration practices; $\rho_t = 1 + r$, *r* = land user's discount rate; lm_t^c = cost of restoration practices; c_t^c = direct costs of production other than land management; τ_t^c = off-site costs induced by restoration measures (i.e. externalities). If land user does not take restoration measure, the corresponding NPV (π_t^d) is given by

$$\pi_t^d = \frac{1}{\rho^t}\sum_{t=0}^{T}\left(PY_t^d + IV_t + NU_t + b_t^d - lm_t^d - c_t^d - \tau_t^d\right) \tag{2.2}$$

where the meanings of the equation elements are similar to those of equation (2); *d* donates the inaction state of the degraded land. The difference (π_t^c - π_t^d) is the economic basis for land users' rational decision making during their planning horizon T. This economic model will be applied for case study sites in the target countries in 2018-2019.

Annex 3. Methodology for comparative evaluation of efficiencies of restoration options

To compare how well the application of MRBT brings about efficient crop production, the efficiency evaluation should be referenced to the *production frontier* that presents the maximum output attainable from each input level given the potentials of the considered technological regime and bio-physical condition of the site. **Figure 1.3** describes the production process of one input ***x*** (e.g. water, seeds, or fertilizer, or labor/energy) into output ***y*** (e.g. crop yield) of a farm (Coelli, 1996a; Nguyen *et al.*, 2014). Curve ***F*** represents the production frontier being the production potential determined by the current land management/technical regime and biophysical potential of the site. As ***F*** is of production potential, it is impossible to have any farm operating at a point above curve ***F***. If farms operate on curve ***F***, they will be efficient. For example, farms B and C are technically efficient at two different levels of inputs. If a farm operates below the frontier, if it will be technically inefficient. For instance, farm A is an inefficient compared to either farm B (having a higher yield given the same input), or farm C (having the same year but with a lower input).

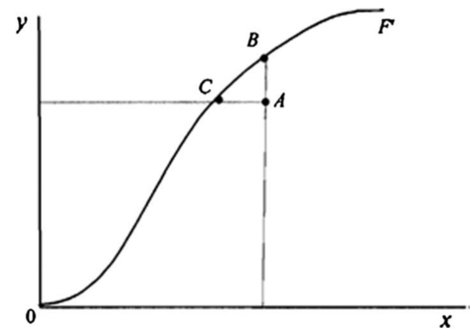


Figure 1.3. Production frontier (curve ***F***) as a reference for evaluating technical efficiency (*TE*). Notes: ***y***: output (e.g. crop yield), ***x***: input (e.g. water, or fertilizer, or labor). ***F*:** production frontier curve reflecting the production potential of the considered technology; A: inefficient farm, B and C: efficient farms. Source: Nguyen et al. (2014).

The curve/function of production frontier (***F***) can be used as a reference to calculate input-orientated *TE* in the way that addresses the question of the proportional reduction of input quantities while producing a given level of output quantities. *TE* is defined as:

$$TE = \frac{xTE}{x} \quad (1.3)$$

where *xTE* is the vector of inputs at the technically efficient point (on the production frontier *F* in Figure 1.3) and *x* is the vector of currently used inputs (Nguyen et al. 2014). In evaluation of restoration option's efficiency, the input vector would include major farming inputs such as:

- water (m^3),
- fertilizers (cost),
- pesticides (cost),
- seeds/gemplasms (cost)
- machinery and energy (costs), and
- labor (working days).

Obviously, the approach in equation (1.3) requires the estimation of the production frontier function. There are two principal methods for this task (Coelli, 1996a), which are Data Envelopment Analysis (DEA) or Stochastic Frontiers (FRONTIER). The former method involves mathematical programming, while the latter is based on econometric analyses. The methodological details and computer software for DEA can be found in Coelli (1996a) (http://www.uq.edu.au/economics/cepa/deap.php), while those for FRONTIER is described by Coelli (1996b) (http://www.uq.edu.au/economics/cepa/frontier.php).

Given TE calculated for every sampled farm/household, comparisons about TE between the group of households who adopted SLM/restoration measures and the non-adopted group are recommended. There will be two main comparisons with the following testing hypotheses:

Hypothesis 1: TE of farms with SLM/restoration practices is higher than TE of farms without SLM/restoration action.

To control the variation of social-ecological context, the comparison should be done within each contextual group/cluster identified from the use of GeOC tool, or any valid pre-studies. The layout for TE comparison is showed in Table 1.3, in which the comparison will be done between rows of the same column. *T-test* will be used to test this hypothesis.

Table 1.3. Comparison of TE between farms with and without SLM/restoration practices in different each contextual group/cluster. Hypothesis: $TE_{action,\, k} > TE_{inaction,\, k}$ where k = contextual type

	Livelihood context			
	Livelihood group 1	Livelihood group 2	…	Livelihood group k
With SLM/restoration measures	$TE_{action,\, 1}$	$TE_{action,\, 2}$	…	$TE_{action,\, k}$
Without SLM/restoration measures	$TE_{inaction,\, 1}$	$TE_{inaction,\, 2}$	…	$TE_{inaction,\, k}$

Hypothesis 2: The efficiency frontier of farms with SLM/restoration practices is higher than those of farms without SLM/restoration practices.

This hypothesis refers to qualitative improvement (new and higher equilibrium) induced by SLM/restoration practices. Graphics comparison will be used to test this hypothesis. The upper ceiling of the SLM/restoration farms cloud (i.e. curve F_{action} in Figure 2.3) is hypothesized to be above the ceiling of non-SLM/restoration farm clouds (i.e. curve $F_{inaction}$).

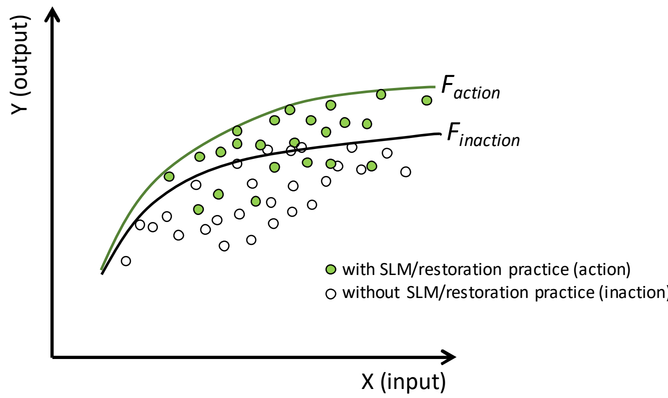


Figure 2.3. Hypotheses that SLM/restoration improves farms' production efficiency and production frontier (production potential).

Annex 4. Methodology for analysis of adoption based on collected primary data

Despite a large number of published analyses of farmers' adoption of sustainable land management (SLM) practices – including land restoration measures, how to cope with social and ecological context diversity remains a problem. As in many other adoption analyses, the drivers of SLM/restoration measures' adoption were inferred from the analysis of one household/farm sample selected for the study area, hence the revealed cause-effect relationships are also applied uniformly over the study area. Indeed, the causal relationships defined in that way (one sample for the study area) is only valid when applying for an 'average household/farm' of the area (located in the centroid of the multi-variate sample). The more diversity in livelihood context/setting in the area would lead to the less representativeness of this average household/farm, thus weakening the plausibility of applying the causal relationship over the whole area. An improved method would be the stratification the studied population in according to social-ecological contextual types, then conduct multi-variate adoption analysis for each strata to additionally infer adoption drivers in specific to the livelihood context type (Thiombiano and Le, 2016a). Adoption analysis in this way requires the identification of plausible contextual typologies beforehand. The social-ecological contextual typology is also important as it can shape the efficiency assessment of the considered restoration action/intervention (Thiombiano and Le, 2015; Thiombiano and Le, 2016b).

Inferential statistical model. As the dependent variable (adoption variable) is in dummy scale (1 if the household/farm adopts a SLM/restoration practice, 0 otherwise), binary logistic regression (bi-logit) is proposed to be used to identify factors determining SLM/restoration adoption. As constraints and potentials for restoration outcome are essentially shaped by site condition, the unit of SLM/restoration adoption analysis is recommended to be a field/land parcel rather than household. The vector of explanatory variables (i.e. hypothesized adoption drivers/determinants) are from the indicators of livelihood assets of the household who own or operate the land. The set of these variables should combine both household's livelihood attributes and relevant field's characteristics.

Main categories of household livelihood attributes:

- human assets: labor, health, education and capabilities
- natural assets: lands (amount and quality), livestock and water resources,
- financial assets: incomes and savings from different sources,
- physical assets: housing conditions, access to infrastructure and equipment for agricultural production, and
- social assets: supports and advantages from social network, positions and projects/programs

Relevant attributes of field/land parcel to be considered:

- Field's proximities (distance) to road and water supplier
- Land form or hydrological status
- Field size
- Soil fertility
- Tenure status

Contextual type-specific and combining adoption analyses: It is recommended to conduct both type of adoption analyses: analyses in specific to contextual groups and analysis for combined/whole sample. The benefits for this strategy can be:

- Understand the added values of livelihood type-specific adoption analysis. E.g. The type-specific analyses reveal more informative determining roles of 'Age', 'Education' and 'Distance to road', and number of cattle (see related rows in Table 1.4)
- Reveal common determinants of adoption. E.g. The common positive effect of 'Field size' across livelihood types (Table 1.4)
- Limitation of data deficit in livelihood type-specific adoption analysis. For example, in Table 1.4, for the case of 'Tenure security', it seems there are not enough variations in this variable within livelihood groups (resulting non-significant effects), but it is not the case with the combined sample, i.e. still significant likely due to enough variation in data. Thus, the adaption analysis for the whole sample complimentarily helps not to ignore the effect of the tenure factor.

Table 1.4. Example synthesis table shows bi-logit results for contextual groups and whole sample of households/farms

Explanatory variable (X_i)	*Effect on adoption of organic fertilizer use* (Note: + and – indicate significantly positive and negative effects, respectively; ns = non-significant)			
	Livelihood type A	*Livelihood type B*	*Livelihood type C*	*Whole population*
Age	+	*ns*	-	*ns*
Education	+	+	-	ns
Field size	+	+	+	+
Distance to main road	ns	+	-	ns
Number of cattle	+	-	+	+
Tenure security	ns	ns	ns	+
Etc.	Etc.	Etc.	Etc.	Etc.