USE OF CONSERVATION AGRICULTURE IN CROP-LIVESTOCK SYSTEMS (CLCA) IN THE DRYLANDS

FOR ENHANCED WATER USE EFFICIENCY, SOIL FERTILITY AND PRODUCTIVITY IN NEN AND LAC COUNTRIES

IFAD Investing in rural people
ICARDA Science for resilient livelihoods in dry areas
CIMMYT International Maize and Wheat Improvement Center

Progress Report:
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With contributions from:

CIMMYT
INRAT – IRESA (Tunisia)
ITGC (Algeria)
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UAM-X (Mexico)

Cover page figure caption. Photos from different CLCA sites in LAC and NA Countries (Credit: ICARDA & CIMMYT)
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ACRONYMS AND ABBREVIATIONS

AIS: Agricultural Innovation System
AWPB: Annual Work Plan and Budget
BBN: Bayesian Belief Network
CA: Conservation Agriculture
CGIAR: Consortium of International Agricultural Research Centers
CIDES-UMSA: Postgraduate School of Development of the Universidad Mayor de San Andres
CIMMYT: International Maize and Wheat Improvement Center
CLCA: Crop Livestock Conservation Agriculture
COTUGRAIN: Compagnie Grainière Tunisienne
CT: Conventional Tillage
DZD: Algerian Dinar
GDA: Groupements de Développement Agricole (GDA)
HH: Household
ICARDA: International Center for Agricultural Research in the Dry Areas
ICT: Information and Communications Technology
IFAD: International Fund for Agricultural Development
INGC: Institut National des Grandes Cultures (Tunisie)
INIFAP: Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias
INRAT: Institut National de Recherche Agronomique de Tunisie
IRESA: Institution de la Recherche et de l'Enseignement Supérieur Agricoles (Tunisie)
ITELV: Institut Technique des Elevages (Algérie)
ITGC: Institut Technique des Grandes Cultures (Algérie)
KM: Knowledge Management
LAC: Latin America and Caribbean Countries
M&E: Monitoring and Evaluation
NA: North Africa
NARES: National Agricultural Research and Extension Services
NARS: National Agricultural Research Services
NEN: Near East and North Africa
NGO: Non-Governmental Organization
NT: No Tillage
O4S: Organization for Scaling
ODK: Open Data Kit
OEP: Office de l'Elevage et des Pâturages (Tunisie)
OM: Organic Matters
PMAT: Entreprise Nationale de Production de Matériels Agricoles Trading (Algérie)
PROINPA: Fundación para la Promoción e Investigación de Productos Andinos
R&D: Research and Development
SCT: Simplified Cultivation Techniques
SME: Small and Medium Enterprises
SMSA: Mutual Association of Agricultural Services
SOLA: Maquinaria Agrícola Solà company
SOM: Soil Organic Matter
TND: Tunisian Dinar
UAM-X: Universidad Autonoma Metropolotana-Xochimilco
US$: United States Dollar
WUE: Water Use Efficiency
ZT: Zero Tillage

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ACKNOWLEDGMENT

ICARDA and CIMMYT would like to acknowledge the following partner institutions for their valuable contributions to the project activities design and implementation:

Bolivia

- ✓ Fundación para la Promoción e Investigación de Productos Andinos I PROINPA

Mexico

- ✓ Universidad Autonoma Metropolotana-Xochimilco I UAM-X

Algeria

- ✓ Technical Institute of Field Crops I ITGC
- ✓ Technical Institute of Livestock I ITELV
- ✓ National Institute of Soils, Irrigation and Drainage I INSID
- ✓ "Trait d'Union" Association for Modern Agriculture I ATU-PAM
- ✓ Directorate of Agricultural Services (Setif, Oum El Bouaghi, M'Sila) I DSA
- ✓ National Company of Agricultural Equipment Production & Trading I PMAT
- ✓ Setif - "Farhat Abbes" University

Tunisia

- ✓ Institution of Agricultural Research and Higher Education I IRESA
- ✓ National Institute of Agronomic Research of Tunisia I INRAT
- ✓ National Institute of Field Crops I INGC
- ✓ Agency of Livestock & Pasture I OEP
- ✓ Regional Office for Agricultural Development (Zaghouan, Seliana, Beja, Jendouba) I CRDA

Background

The project goal is to sustainably increase production and enhance climate resilience of small farmers' communities and their crop-livestock production systems in drylands. To develop in participation with smallholder crop-livestock producers contextually relevant and gender sensitive processes for enhancing the broad uptake of Conservation Agriculture (CA) within integrated crop-livestock systems in drylands in LAC (Andean drylands, Central American dry corridor and the northern South American savannah) and NEN (Near East and North Africa) regions. The expected outcomes are: i) 3,000 smallholder farmers reached (at least 40% women and 20% youth below 35 years) and 2,100 have directly adopted CLCA farming systems [in four (4) target countries] with increased production and improved cost-benefits optimized by filling research and development gaps; ii) At least six (6) NARES, in addition to decision makers, NGOs and IFAD loan project partners in the four (4) target countries have adopted tools and methodologies for reliable decision making and guide investments on contextually appropriate CLCA system; and iii) At least four (4) effective agricultural innovation systems – one (1) in each implementation area of the four (4) target countries - are coalesced in order to foster broad uptake of CA practices within integrated dryland crop-livestock production systems.

Countries initially selected for the implementation of the project are Bolivia and Nicaragua in LAC and Algeria and Tunisia in North Africa. For force majeure reasons, the target countries in LAC were changed to be Bolivia and Mexico. Through the IFAD investment projects and project partners it is estimated that the training and adoption of technologies and practices for CLCA systems will reach an additional 10,000 small crop-livestock farmers. Other beneficiaries will be NARES (National Agricultural Research and Extension Services) and R&D partners and policy makers who will have access to innovative technologies and practices and knowledge on proven benefits of CLCA systems for climate resilience and sustainable intensification of production for crop-livestock farmers in drylands.

The project consists of two (2) main components (Figure 1). The first component is further divided into two subcomponents:

Component 1. Participatory adaptive research with integrated capacity development of farmers and other key partners to fully implement and evaluate CLCA systems

a. *Subcomponent 1.1*: CLCA system optimization [filling research gaps and the full implementation and integration of technologies developed supported by both centres for the two (2) regions];
b. *Subcomponent 1.2*: Appropriate system development methodology to support wider adoption and decision-making.

Component 2. Accelerate adoption through the development of delivery systems/participatory farmer-led extension systems and inform the development of contextually relevant CLCA technologies and practices.

The overall cost of the project is estimated at US$ 3 million, over four (4) years (2018-2021), of which IFAD will finance US$ 2,5 million, governed by performance-based tranches. IFAD funding is supplemented by a contribution of US$ 0,5 million from NARES in the form of in-kind contributions. The official starting date is 13 April 2018, the project completion date is 30 June 2022 and the effective closing date is 31 December 2022.

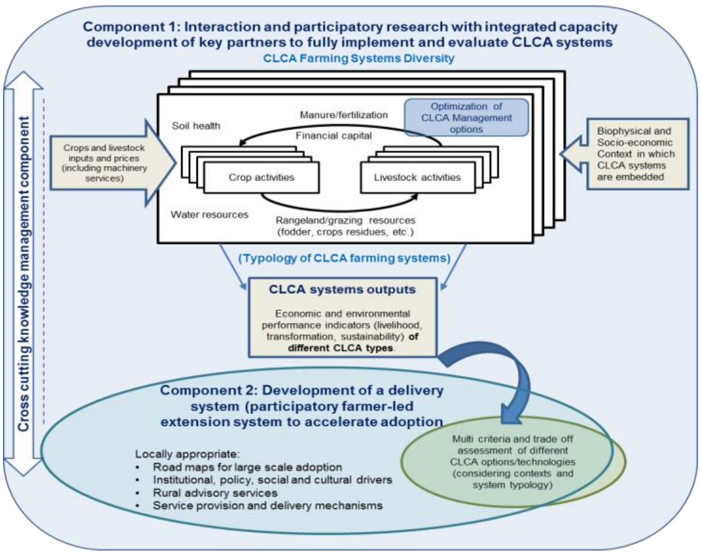


Figure 1. Conceptual framework for CLCA systems

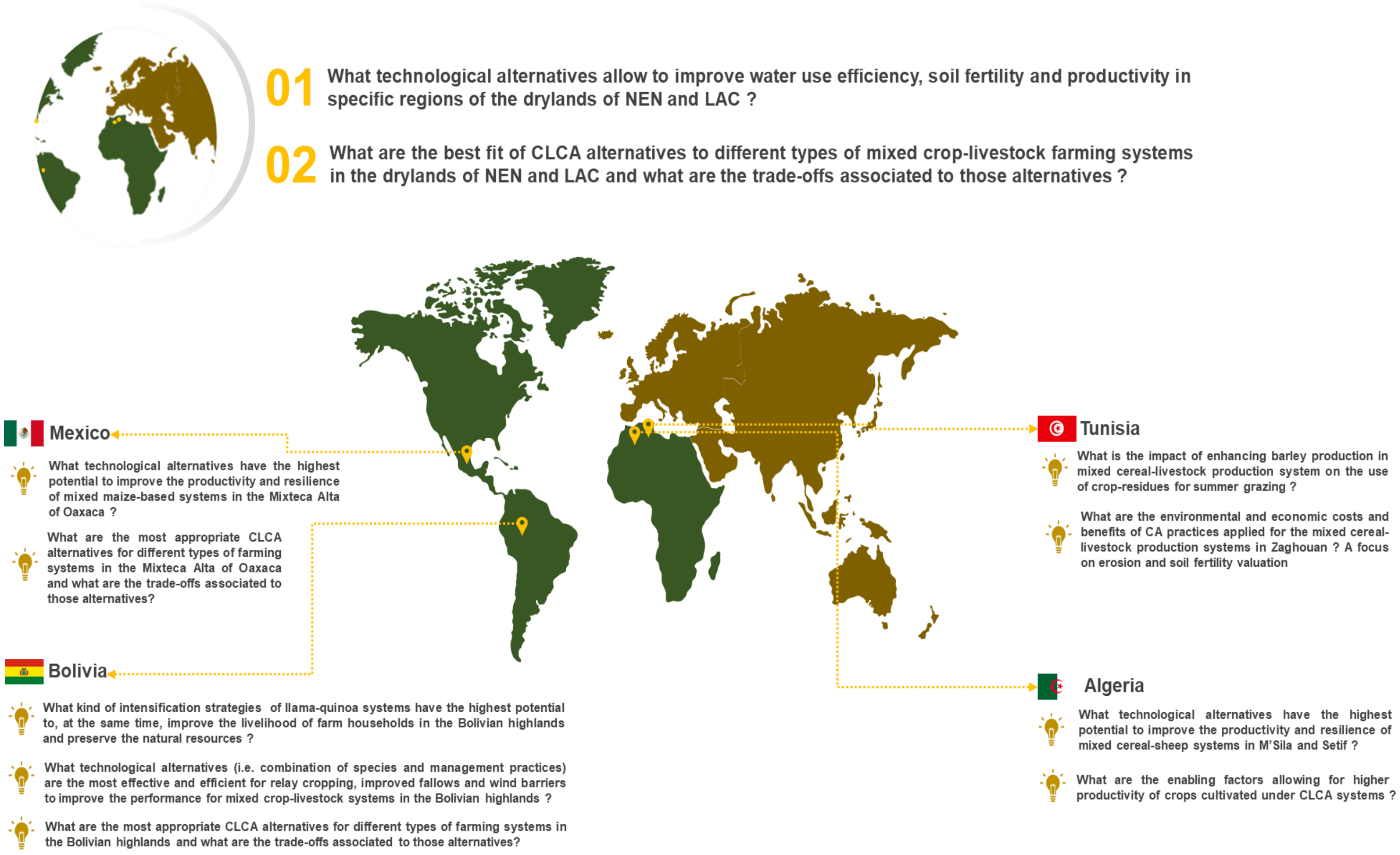
Review of progress and performance by project component

In LAC the development of the project has been slower due to the change in site from Nicaragua to Mexico and the recent political disruptions in Bolivia. However, through partnership with the different collaborators in Mexico and Bolivia, activities were carried out somehow normally and the road map for the whole project was co-developed.

In North Africa, Year-II of the CLCA Project was marked by the rapid implementation of the scaling road maps for Tunisia and Algeria. These road maps were co-developed with national partners at the end of Year-I. Sections of this report will reflect on the progress made from this perspective.

In what follows, we report the progress of the grant by project component. The grant performance can be assessed by comparing what was achieved against what was supposed to be achieved as described in the approved AWPB (Annex 1) and by attempting to show the level of progress by country using the logical framework matrix (Annex 2). To keep the integrated focus of the project, three (3) activities under component (1) are reported together. These are “fine-tuning of agronomic practices” together with “reduction of erosion” and “improvement of water use efficiency”. For several examples, activities falling under components (1) or (2) are mapped to the cross-cutting components of the project namely “Knowledge Sharing and Management”, “Gender Focus” and “Monitoring and Evaluation (M&E)”. In such cases, and to avoid redundancies, the progress is reported under the relevant headings of this reporting template.

For Year-II of the project, a number of research questions were deduced from the technical coordination meetings that took place in LAC and NA between CIMMYT, ICARDA and their respective partners and which underline the activities that are listed in the AWPB. In the following graph, we have selected the main research questions specific to each of the four (4) countries and also the overarching questions which bring all the project components and all geographies under the same sphere and give the project its integrated dimension. These questions were partially or totally answered during the implementation of the project activities in Year-II.



Component 1. Participatory adaptive research with integrated capacity development of farmers and other key partners to fully implement and evaluate CLCA systems

Sub-component 1.1. CLCA system optimization (filling research gaps and the full implementation and integration of technologies developed supported by both centres for the two regions)

Stakeholder engagement and rapid appraisal

In LAC countries, stakeholder engagement and collaborations have been successfully maintained and increased. In **Bolivia**, PROINPA foundation (main CLCA Partner in Bolivia) has been engaged in deploying actions on the ground and ensuring that different stakeholders (including NGOs and farmers organizations) participate in the project activities. A new collaboration is being built up with the Postgraduate School of Development of the Universidad Mayor de San Andres (CIDES-UMSA) (http://www.cides.edu.bo/webcides2/) one of the most prestigious universities in Bolivia in relation to rural development and agriculture. Initial activities with CIDES-UMSA is the organization of a systems analysis course open to a wide range of participants (postponed due to the COVID-19 crisis) and the application of systems analysis tools by students in the Altiplano Sur and Centro of Bolivia.

In **Mexico**, collaborations have been formalized with the Department of Crop and Animal Production of the Universidad Autonoma Metropolotana-Xochimilco (UAM-X) (http://www2.xoc.uam.mx/oferta-educativa/divisiones/cbs/departamentos/paa/) to test and assess the performance of the current and alternative crop and livestock management systems for improved sustainability of mixed crop systems. Collaborations with the National Institute of Forestry, Agriculture, Fisheries and Livestock Research (INIFAP) have been defined as well as with four (4) local NGO's in order to test, implement and share alternatives for improved CLCA systems. Through semi-structured interviews, a stakeholder mapping was done (Annex 3) for the Mixteca Alta in Oaxaca and a multi-stakeholder workshop was held, mainly focused on the analysis of innovation capacity for scaling solutions in the CLCA system and the structural conditions around it. Sixty (60) participants in the workshop, from a wide range of organizations including farmers, NGO's, academic institutions, among others recognized that soil degradation and water scarcity in the Mixteca Alta are major threats to smallholder livelihoods of maize based mixed crop-livestock systems. There is expressed willingness and promising opportunities from a range of stakeholders to move to a more sustainable CLCA systems in the region. Actions in year-III of the project will focus on harnessing the strengths from these different actors to develop and scale a specific CLCA alternative in the region.

In NA Countries, the 2nd year of CLCA project was successful in further engaging with national public and private partners. In **Algeria**, the Technical Institute of Field Crops – ITGC (CLCA project coordinating institution) signed an agreement with the National Company of Agricultural Equipment Production & Trading – PMAT http://pmat.dz/entreprise which is one of the largest companies in Algeria for machinery market. The agreement stipulates that ITGC (in the framework of the CLCA project), provides technical assistance to PMAT for further promoting zero-tillage seeder. The seeder, called Boudour, is now included as part of the commercial strategy of the company and ITGC continues to provide assistance to farmers who are willing to acquire it. This will give a strong push to CLCA in the coming two (2) years, especially in terms of expansion of No-till areas.

In **Tunisia**, the National Institute of Agronomic Research of Tunisia – INRAT (CLCA Project coordinating institution) continues to successfully cooperate and engage with COTUGRAIN, a private seeds' production and commercialization company https://www.cotugrain.com/en/. The partnership is set around the commercialization of some forage crop seeds, in addition to some forage mixtures (Vetch-Oat, Vetch-Triticale, Meslin[1]), tested and recommended by the CLCA research team. The expansion of the collaboration this year refers to the significant of seeds produced by COTUGRAIN company based on the recommendation of the CLCA team (oat 100 tons, fenugreek 150 tons, faba beans 30 tons) in addition to the inclusion of new types of forage mixtures (more than 30 tons of forage mixture seeds were launched in the market). It also refers to higher number of farmers engaged by COTUGRAIN

[1] Combination of four (4) forage species (Vetch, Triticale, Oat, Fenugreek).

company and technically supported by CLCA team members, to successfully produce these seeds for the company. More than twenty (20) multiplication contracts (Forage seeds multiplicator farmers) were established with an area of 300 ha in the different target sites of CLCA Project.

Both **Tunisia and Algeria** CLCA coordination units also expanded their partnerships towards inclusion of farmers groups and additional public extension institutions. In **Tunisia**, successful discussions have been undertaken with the National Extension Agency - AVFA, to cooperate around integrating some CLCA trainings in their relevant "training centers/regions". Other workshops were also organized in Tunisia for a number of cooperatives (SMSA) and farmers' groups (GDA) that were interested to engage in integrated crop-livestock agricultural systems; the objective of these workshops is to set a working framework with farmers' organizations for a more effective scaling up of CLCA technologies [Organization for scaling (O4S) approach]. Compared to the first year of the project, five (5) SMSA-s farmers' organizations have been recruited in testing the CLCA packages and collaborate with the project. The Tunisia CLCA team is currently working to support farmers in Gboullat Site, new site of CLCA Project in North West of Tunisia towards the creation of Farmers' Organization specializing in CLCA practices.

An extended partnership in **Algeria** has been established by including new farmers associations such as the Cereal and Seed Producers Association – Prodec, the Irrigators association and the Common interest groups – GIC and additional public/development partners (Agricultural Service and Supply Cooperative of Setif – CASAP, Interprofessional Council of Agricultural Sector- CWIF, Cereals/Legumes Interprofessional Council – CIC & CIL). It is also important to mention that CLCA teams in Tunisia and Algeria are now coordinating and synergizing their ongoing activities in full partnership with other ICARDA projects in the same sites such as Food Security Project, ICT2scale, Consortium Research Program (CRP) on Livestock (Feed and Forage and Animal Health Flagships), and/or national programs operating in the same project areas (INGC & OEP/Tunisia, ITELV/Algeria).

In both countries, many meetings, workshops and field days were organized during this second year to secure stakeholder engagement whether at the national or regional levels in the districts where Year-I was implemented and in potential new areas which could represent the scaling domain. Stakeholder meetings, field days, workshops and training events (Table 1) were held in an intensive pace to pave the road towards exposing all stakeholders to the concept of CLCA systems and to expose policy makers to the concepts of sustainable, integrated crop-livestock systems.

Table 1. Second year events for stakeholder engagement in Algeria and Tunisia

Country	Type of event	Target population	Partners	Location	Objective/topic	#attending
Algeria	Information Day (1)	All stakeholders involved in CLCA project in the new site of Bordj Bou Arreridj (BBA)	ITGC/ITELV/DSA CAW/ATU	BBA Chamber of Agriculture	Introduction of the Project activities to the main local stakeholders and Establishment of the project work plan in the region.	80 (F: 20, Y: 24)
	Local Workshop (1)	CLCA Leader Farmers and Breeders	ITGC/ITELV/HCDS/ITMAS	ITMAS – Setif	Stubble management under CLCA system	30 (F: 8, Y: 12)
	Regional Workshop (1)	All stakeholders in the district of M'Sila	ITGC/ITELV/DSA/COOPSSEL/M'Sila University	M'Sila Province	Forage crop and feed production	60 (F:15, Y: 20)
	Regional Workshop (1)	Rural actors of 6 districts (M'Sila, Oum El Bouaghi, Setif, Batna, Bordj Bouareridj and M'Sila)	ITGC/ITELV/DSA/CAW/ATU	BBA Chamber of Agriculture	Scaling CLCA system in the eastern high plateaus of Algeria	80 (F: 21, Y: 30)
	Focus Group (1)	Women farmers	ITGC/ITEL/DSA/CAW	BBA Chamber of Agriculture	Gender roles and needs in integrated livestock-crop production	25 (F: 7, Y: 15)
	Field days (11)	Potential CLCA farmers in the different districts of the project target areas (Ain Mlila, M'Sila, Setif, Bordj Bouareridj, Batna, Constantine)	ITGC/ITELV/DSA/CAW/Requable/CCLS/GIC/ITMAS/CASAP/CWIF/Irregators/Prodec/ATU/CNCC/CMA-PMAT	Various locations	CA principles, Soil fertility, Crop diversification, and soil management, Water Use Efficiency, Land-degradation, Direct seed Drill/ZT machinery, stubble management	420 (F: 105, Y: 130)
Tunisia	Information Days	All local stakeholders in the project target areas of Zaghouan, Beja, Kef, Siliana, Kasserine, Jendouba	INRAT/ITGC/OEP/RCDA/SMSAs/GFDA	Various location	Introduction of the project activities to the main local stakeholders and establishment of the project work plan in the different project target areas	190 (F: 25, Y: 80)
	Coordination meetings (4)	All stakeholders involved in CLCA Project	COTUGRAIN/INGC/OEP/INRAT/SMSAs/GFDA	Various location	Establishment of the plan of work for Year-II and way of collaboration	145 (F:32, Y:60)
	Local Workshop	All stakeholders in the District of Gboullat, Beja Site.	INRAT/INGC/OEP/RCDA/SMSA	Private Farm in Beja Site	O4S approach: Engaging with Farmers' Organizations for more effective of Scaling up CLCA Technologies in Tunisia _ Pushing toward the creation of Farmers' Organization specializing in CLCA practices	39 (F:7, Y:25)
	National Workshop – Expert Panel Meeting	All stakeholders involved in CLCA Project: Director generals from MAWRF, from research institutes, extension institutes and representatives of farmers' unions and NGOs	IRESA/INRAT/INAT/INGC/OEP/ATAE/APAD	INRAT	Characterisation and scope of agroecological practices in the agricultural production systems of Tunisia	35 (F: 11, Y: 12)
	Trainings (5)	Potential CLCA Farmers and Women Farmers in the different districts of the project targets areas (Zaghouan, Beja, Jendouba)	INRAT, INGC, OEP, ENMV, RCDA-s, SMSA-s, GFDA	Various locations	- Animal health for profitable crop livestock integration (3) - Enhancing seeds quality and forage production through entrepreneurship and farmers associations (1) - Adoption of Mixtures by Women Farmers to increase forage production, diversify rotation systems and enhance soil fertility (1)	174 (F:82, Y:95)
	Meetings with platforms, learning alliances, community of practices (1)	CLCA Leaders Farmers and Breeders in the districts of Saouef, El Fahs, El Krib, Laaroussa	INRAT, INGC, OEP, ENMV	Zaghouan & Siliana sites	Assessment of the animal health situation in the different CLCA sites in Tunisia for profitable crop livestock integration.	24 (F: 21, Y: 12)
	Field days (5)	Potential CLCA Farmers	INRAT, INGC, OEP, RCDA, SMSA-s, GFDA	Various location	Best Agricultural Practices under CLCA Technologies	143 (F:32, Y: 90)

M: Male participants; F: Female participants; Y: Participants below 35 years of age

Developing integrated improved crop management systems including reduction of erosion and improvement of water use efficiency

We briefly recall here that the trials and field work described in this section of the report contribute to the optimization of the main CLCA systems in the target countries/regions. Based on the work undertaken during Phase I and the orientations for Phase II, the main CLCA system in North Africa revolves around the introduction of CA in cereal field crops, intensification of forage inclusion in the rotations in particular legume forages and legume/cereal mixtures and the application of an integrated package to improve the integration of livestock mainly composed of small ruminants. One critical issue is to address the summer feeding patterns of livestock and to find alternatives for stubble grazing. By CLCA systems in North Africa, we also include smart agronomic practices like minimum tillage (very popular in Algeria) as an entry point to other practices advocated by the project like cultivation of the fallows, practice of rotations and integration of promising forage mixtures.

Implementing CLCA systems in LAC countries

In Latin America, the project is being implemented in rainfed, mixed crop livestock production system of **Bolivia and Mexico** in the Mixteca region of Oaxaca state. In **Bolivia** and in order to align with the existing IFAD projects, current project targeted the quinoa-llama system. Intensive cultivation of quinoa led to unsustainable production systems, resulting in inconsistent crop yield, price volatility and poor profits to the growers. Interventions such as improved pastures for llama feeding, windbreaks and appropriate use of cover crop and llama manure can make quinoa-llama system sustainable and profitable.

in the new site of **Mexico** case study, a biophysical characterization of the region was carried out and the main CLCA alternatives to be tested and adjusted for further scaling were identified. Due to previous work in the region with several partners, including the National Institute for Agricultural Research (INIFAP) and the Autonomous Metropolitan University (UAM) some insights on different aspects of CA in the region were acquired and, together with these partners, a set of main issues specific to mixed crop-livestock systems and potential alternatives were identified and the protocols for further field testing were developed. The Mixteca region occupies some 15,671 square kilometers of very diverse geographic and climatic regions. It lies between the intersection of the Sierra Madre del Sur and Sierra Madre de Oaxaca mountain ranges. The Mixteca is a predominantly mountainous region of valleys, hills and coastal area, soil erosion being very common in almost all land scape. This region is characterized by being made up of a multi-ethnic panorama and a morphological landscape that presents heterogeneity in its terrestrial geoforms, characterized by severe soil erosion, as well as a rainfall deficit in its large semi-desert extension. Agriculture is characterized by subsistence and mixed crop livestock type with presence of small ruminants. The project operations are limited to highlands of Mixteca, popularly known as Mixteca alta (The Mixtec highlands). This region has an altitude between 1700-2300 masl with eroded soils and extended maize fields mosaiced with pastures and forest ecologies. About 90% of agriculture in Mixteca alta is rainfed with an average maize yield of 1.1 ton/ha. The project activities will be implemented in eight (8) municipalities of Oaxaca including Heroica Ciudad de Tlaxiaco, San Andrés Sinaxtla, San Bartolo Soyaltepec, San Francisco Chindúa, San Juan Sayultepec, Santa Catarina Tayata, Santo Domingo Yanhuitlán, and Villa Chilapa de Díaz (Figure 2).

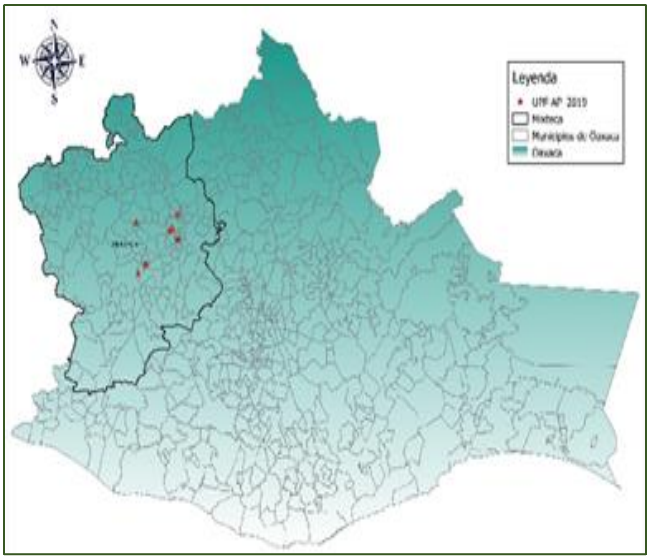


Figure 2. Map of Oaxaca, Mixteca and selected municipalities for project operations

Main technical constrains for CLCA systems in the region are related to erratic rainfall and prolonged dry spells, affecting crop production in poor fertility soils that cannot hold water and nutrients and are highly susceptible to erosion. Monocrop of maize dominates, and the residues are used for fodder or sold to local market as in some years, crop residues have a good price in the market. Another constraint for intensifying crop production is the high costs of inputs (e.g. fertilizers, mechanization services, labor, pesticides). Additional constraints are the lack of technical know how to manage crop-livestock system in an integrated way and the unavailability of fair markets for crop and livestock products that allow farmers to generate income and invest for further intensification. Main technical alternatives for CLCA systems in the Mixteca Alta are conservation agriculture-based maize and fodder production systems, introduction of improved and appropriate varieties of diversified fodder mixes in intercropping (rainy cycle) and relay cropping (winter cycle), multi species barriers to reduce erosion and to strengthen food and feed production, the use of crop residues, cover crops and animal manure for improving soil health, integrated pest management and controlled grazing of crop residue and cover crops. Collaborations with local INIFAP and UAM as well local NGO's have been agreed and aim at establishing and assessing some of these alternatives in eighty (80) fields of thirty (30) farmers in the region.

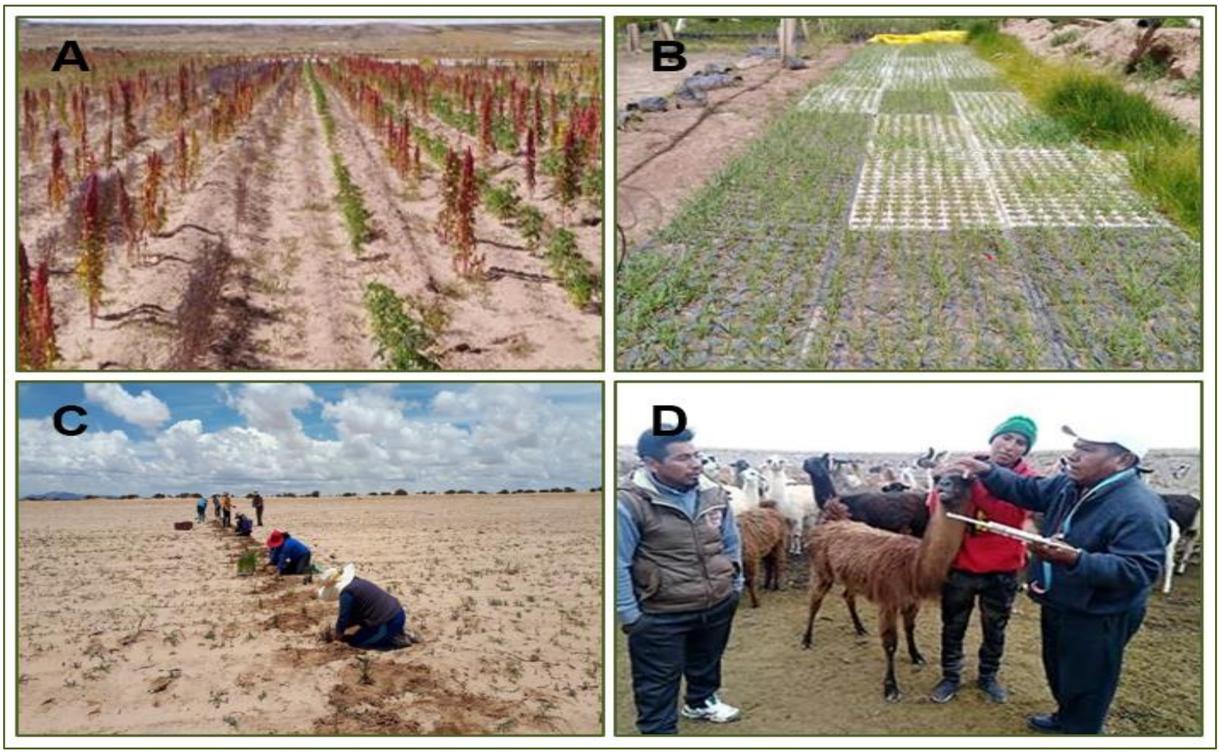


Figure 3. Lupinus established in relay cropping with Quinoa (A), seedling production of fodder shrubs for wind barriers (B), establishing of wind barriers (C), training of farmers on llama nutrition (D)

In **Bolivia**, technical alternatives identified in the first year were established in a broader network of fields and farmers to assess their performance and serve as a vehicle for discussion with farmers and further adaptations.

In this second year, twenty-three (23) demonstrative plots were setup in Chacala and Chita communities covering different CLCA technologies including improved fallows and pastures, wind barriers, manure application and pest control in quinoa and wind barriers (including the production of seedlings) as well as improving nutrition of llama. A total of twenty-eight (28) hectares were implemented with CLCA technologies as well as 5,100 meters of wind barriers with fodder bushes. Seventy-three farmers (23 of them women) participated in the implementation of CLCA alternatives. Some promising results have been collected as well as local material inputs for further rolling out of these alternatives; for example, 9,400 seedlings of fodder shrubs for windbreaks have been produced as well as twenty (20) additional kilograms of Lupinus seeds. Notably, ten (10) farmers [six (6) of them women] have been trained in seed collection and reproduction of local wild leguminous and fodder species ensuring the long-term sustainability of the project by leaving the knowledge generated by our project partner (PROINPA) in the hands of local farmers. In order to improve the nutritional management of the llamas, training was given on use of quinoa residue to feed llamas and the use of probiotics for improving feed use efficiency of llamas. The trials have been initiated with twenty (20) farmers, and they were supplied with sufficient quantity of probiotics to feed at least two llamas in their herd.

- ✓ **Manuring in quinoa**

Since most of quinoa in the Bolivian highlands is grown organic, quinoa crop was manured in two ways; incorporating compost and green manures. Manuring was conducted to improve crop nutrition and water holding capacity while reducing erosion of the soil. Wild lupin locally known as *Qila qila* (*Lupinus* spp) was planted as relay cropped green manure with quinoa. Six (6) demonstrative and validation plots were established In Chacala, Sevaruyo and Chita communities. These validation trials have been set up based of the results of previous adaptive trial, where relay cropping of wild lupin showed potential to improve yield (Table 2) and reduce erosion.

Table 2. Effect of different crops in system on Quinoa yield (Bolivia)

Previous Crop in system	Quinoa yield (q/ ha)
Tulas (*Parastrephia lepidophylla*)	1.84
Pasto llorón (*Eragrostis cuvula*)	2.20
Wild lupin Q'ila q'ila (*Lupinus* sp.):	6.13
Edible Lupin (*Lupinus mutabilis*)	5.87
Control	1.25

We have noted that bringing lupin as relay or sequential crop helped in significant improvement of quinoa yield. The biggest advantage of wild lupin is its seed dispersion and perpetuation over cycles. A single wild lupin plant can disperse seeds up to 6 m, which means planting once wild lupins can bring in sustainable intensification of quinoa crop for many cycles.

Another validation plot has been established on 1.5 ha land, with several legumes such as edible lupin (*Lupinus mutabilis, Lupinus angustifolius*) and vetches (*Vicia sativa*). This validation trial will give us an idea on biomass production of cover crops, erosion control and its subsequent effect on quinoa yield.

Field trials were also setup on incorporation of improved compost in two (2) demonstrative and validation plots. Our previous result indicated that incorporation of composts can improve quinoa yield up to thirty (30) percent in first crop cycle.

- ✓ **Pest management in quinoa**

Pests mainly "Ticona" (*Helicoverpa quinoa*) and polillas (*Eurysacca quinoae*) are major limiting factor. In order to manage these insects, an organic insecticide Bio Max (plant extract of *Sophora flavescens*) was used to control insect pests. Thirty-three farmers participated in this activity in Chacala and Chita communities of Southern altiplano. Application of BioMax has resulted 84.4 to 93.3 % control of Ticonas and 73.9 to 80.5% of Polillas.

Implementing CLCA systems in NA Countries

Results of cropping season-I (September 2018 – July 2019)

The results presented here correspond to the cropping trials that were set up during the first cropping season and the protocols as well as the entry CLCA options are reported in detail in the first technical report. In **Algeria**, the target areas are situated in the high plateaus of eastern Algeria covering three (3) districts (Wilayas), namely M'Sila,

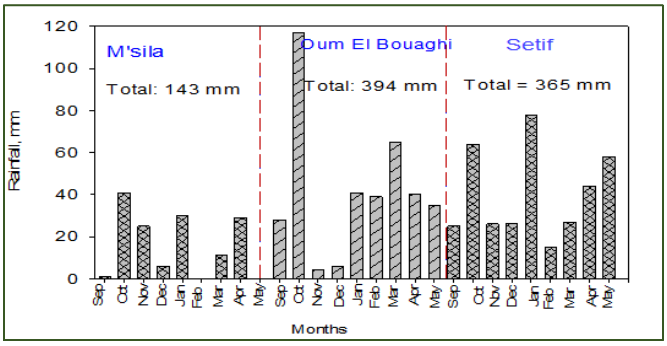


Figure 4. Rainfall pattern during crop growing season (September to May) in 2018/19 in three regions, i.e., M'Sila, Oum El Bouaghi, and Setif – Algeria

Oum El Bouaghi, and Setif, with edaphic and climate diversity. The long-term average seasonal rainfall is 350, 200, and 300 mm, respectively, in Setif, M'Sila, and Oum El Bouaghi (Figure 4). In the 2018/19 cropping season, participatory on-farm evaluation of different agronomic interventions was set up in thirty-six (36) sites in three agro-ecological areas, which covered 316.5 ha areas with six (6) different major food and forage crops, i.e., wheat, barley, triticale, lentil, pea, vetch.

In **Tunisia**, the 2018/19 cropping season was characterized by a relatively favorable annual rainfall for cereal and forage crops in most project sites. The annual rainfall during this cropping season (from November to May) was variable from one region to another. As an indication, the rainfall recorded in Saouef (233 mm), Zaghouan (250 mm) and Chouarnia (346 mm) are considered insufficient for good growth of cereals, that require an annual rainfall between 450 and 500 mm well distributed during the growing season (Table 3). In Beja district, rainfall quantities were considered as sufficient and favorable for cereal and forage growths. Indeed, the annual rainfall in Beja district was variable between 427 mm and 550 mm, which is close to the Crop Evapotranspiration (ETC) of cereals (crop water requirement) in those regions.

Table 3. Monthly rainfall (mm) during the growing season 2018-2019 in different project sites (Tunisia)

District	Month							
	Project sites	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total
Zaghouan	Saouef	2	4	5	21	145	19	37	233
	Zaghouan	10	17	43	31	85	36	28	250
	Fahs	36	45	84	30	179	38	40	452
Beja	Teborsouk	45	66	136	63	134	36	70	550
	Gboullat	63	50	66	33	148	25	42	427
	Medjez El Bab	61	61	75	33	114	30	57	431
	Beja-South	69	51	71	37	153	27	50	458
Siliana	Chouarnia	38	29	42	33	55	80	69	346
	El Krib	43	84	224	105	113	35	83	687

✓ ***Assessment on the impact of CLCA practices on soil fertility, yield performance and water use efficiency (WUE)***

In order to asses soil fertility of plots under CA for new adopter farmers in Siliana district – Chouarnia site North West of **Tunisia**, thirty (30) soil samples from soil surface layer (0-15 cm) were collected during the first year. Physical and chemical soil proprieties, soil organic matter and soil microbial activity were determined during the second year and will be determined at the end of the project.

Results of the intial soil characterization showed that all soils samples collected are unsalted soils (avg = 275 ± 14 µS / cm), slightly alkaline (avg pH = 7.46 ± 0.15), moderately poor in organic matter (SOC avg = 0.99 ± 0.05%) and in organic nitrogen (Avg Ntot = 0.64 ± 0.16 ‰). Soils are moderately rich in assimilable phosphorus (P_2O_5 avg = 41.7 ± 3.4 ppm), rich in exchangeable potassium (K_2O avg = 540.4 ± 80.8 ppm) with N mineral av = 454.0 ± 109.5% mg N / kg soil.

In **Tunisia**, most of the trials established were barley and durum wheat. Results recorded showed that grain yields (q ha^{-1}) for cereal crops (wheat and barley) under both systems (CA vs CT) varied considerably by regions and depended on the annual rainfall and its monthly distribution during the cropping season. The grain yields for durum wheat under CA are more correlated to the annual rainfall during growing season (from November to May) than under CT, with correlation coefficients of 0.305 and 0.104, respectively (Figure 5). Same results were observed for barley, with correlation coefficient of 0.174 and 0.071 under CA and CT, respectively (Figure 5). Those results indicate that under similar annual rainfall, agriculture practices under CA allow to provide more stable cereal grain yield than CT.

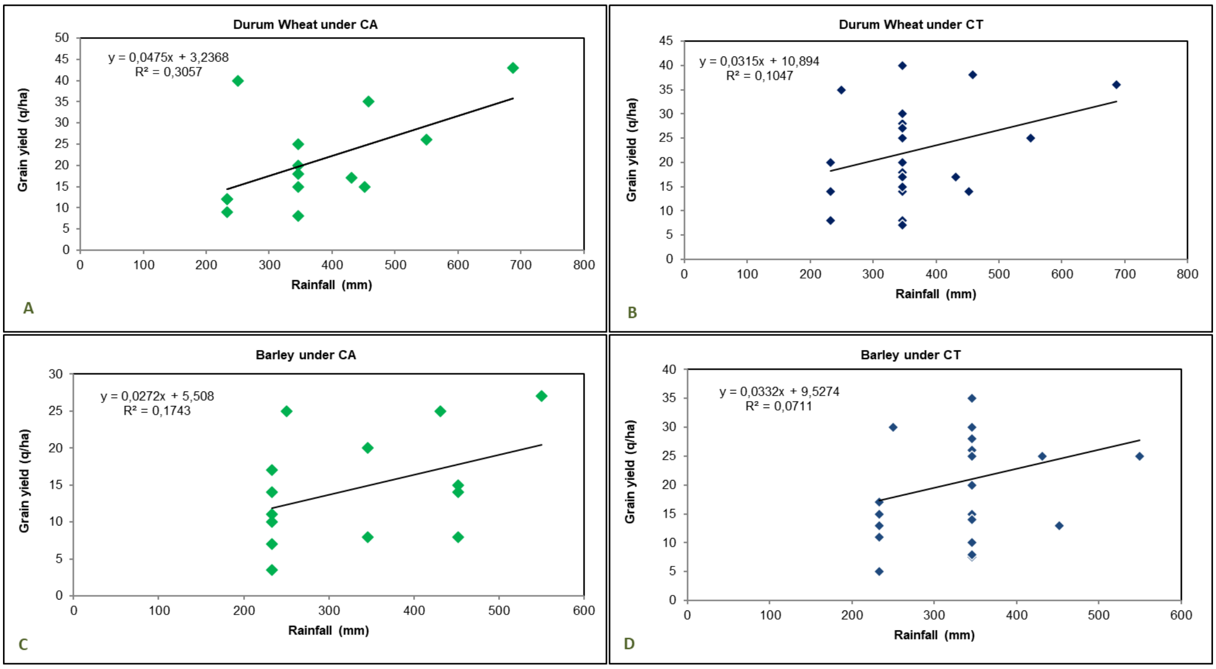


Figure 5. Relationship between grain yield (q ha^{-1}) and annual rainfall (mm) for durum wheat and barley under conservation agriculture (A, C) and Conventional tillage (B, D) – Cropping season: 2018/19

Crops yields were collected from most of on-farm CA plots implemented in the project sites. For this, several samplings were done by the CLCA project team and additional information was obtained from the participating farmers using a survey related to the agricultural practices applied for each plot under CA and also under CT. Results related to the grain yields (q ha^{-1}) for durum wheat and barley showed no significant difference between CA and CT. The average grain yield (q ha^{-1}) recorded varied from region to region and was between 17 q ha^{-1} and 26 q ha^{-1} for durum wheat and between 13 q ha^{-1} and 26 q ha^{-1} for barley (Figure 6). Beja region recorded the highest grain yields for both systems (CA and CT) and both crops (durum wheat and barley). However, most recorded yields were below expectations given that annual rainfall and its monthly distribution were favorable for cereal crops. According to the survey conducted related to the technical package implemented by farmers, it revealed the poor management of nitrogen supply in terms of quantity and optimum stage of application, as well as a lack of weeds management, despite the advice and the monitoring that was carried out by the project CLCA team.

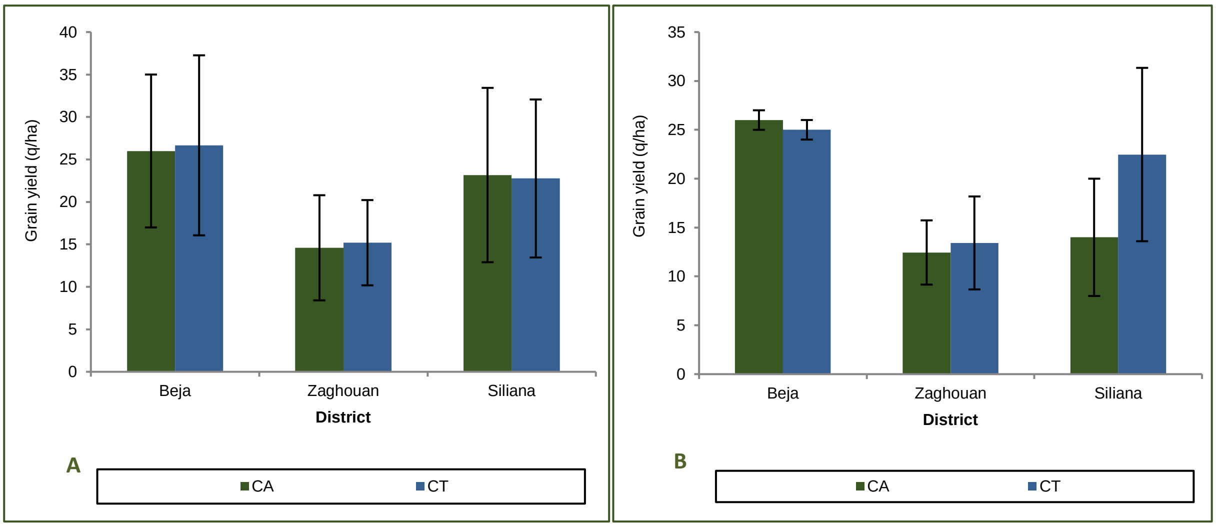


Figure 6. Grain yield (q ha^{-1}) of durum wheat (A) and barley (B) under CA and CT

In **Algeria**, the average grain yield of cereal crops grown under CA and conventional practices for wheat and barley in all three regions (Figure 7) produced similar yields. CA practice avoids soil tillage before seeding, which constitutes about 12 % (Table 17 in economic analysis) of the total cultivation cost.

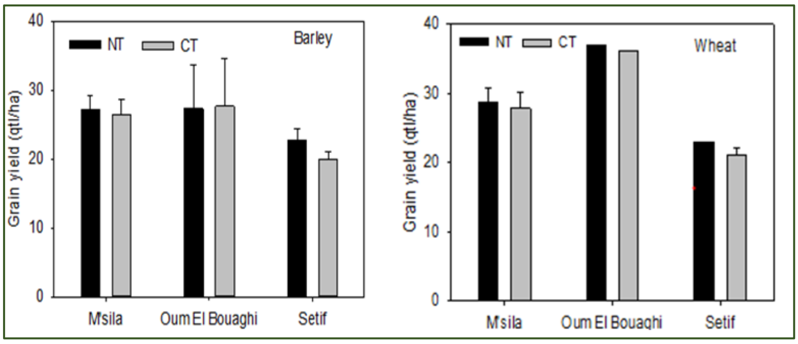


Figure 7. Grain yield of wheat and barley under conservation (NT) and conventional (CA) tillage practices in three regions, i.e., M'Sila, Oum el Bouaghi, and Setif during 2018/19 cropping season

The agronomic evaluation also focused on Water Use Efficiency (WUE) of cereal crops (durum wheat and barley). In this context, WUE was determined as: [WUE (kg ha^{-1}mm^{-1}) = grain yield (kg ha^{-1}) / annual rainfall from sowing to harvest (mm)], and is calculated for all plots under CA and CT implemented in the framework of the project in all project sites (Beja, Siliana, Zaghouan) in **Tunisia**.

Results of the first year showed that WUE are very low under both systems (CA vs CT) for durum wheat (between 4.7 kg ha^{-1} mm^{-1} and 7 kg ha^{-1} mm^{-1}) and for barley (between 2.6 kg ha^{-1} mm^{-1} and 6 kg ha^{-1} mm^{-1}). Moreover, no significant differences were found for wheat between CA and CT for WUE (Figure 8). However, it is evident that longer term observations are needed to detect differences in WUE.

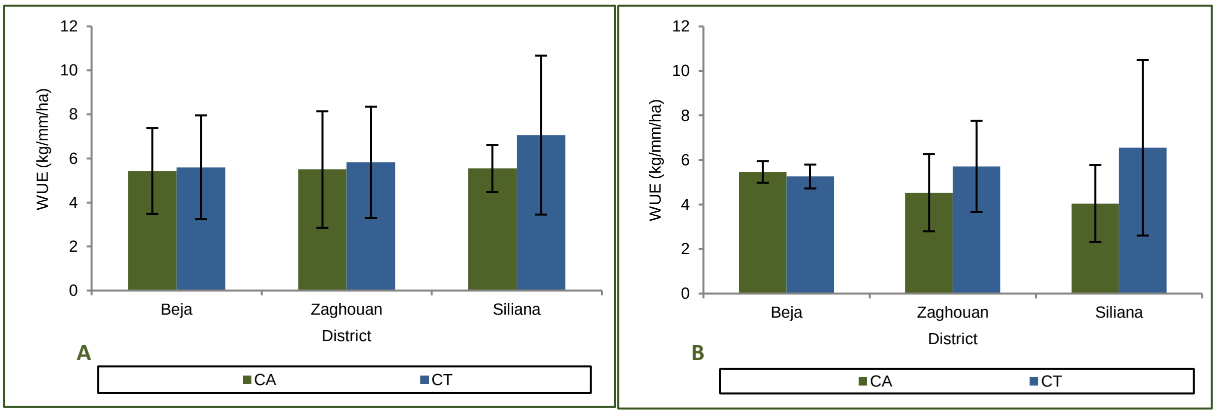


Figure 8. Water Use Efficiency (Kg mm^{-1} ha^{-1}) of durum wheat (a) and barley (b) under CA and CT in different project sites of Tunisia

Differences between CA and conventional cropping practices in WUE are presented in the section "Environment and climate focus" with data from long-term trials.

In M'Sila region, **Algeria**, seasonal rainfall is less than 200 mm, crop production is possible only with supplementary irrigation. Flood irrigation with poor water management leading to low WUE, is the common practice in the region. Previous work in the framework of the CLCA (I) project has shown that CA reduces irrigation water loss in flood irrigation, but sprinkler irrigation can further increase its water use efficiency. For efficient water management and an increased efficiency of irrigation, CLCA-II project initiated to evaluate CA practice combined with

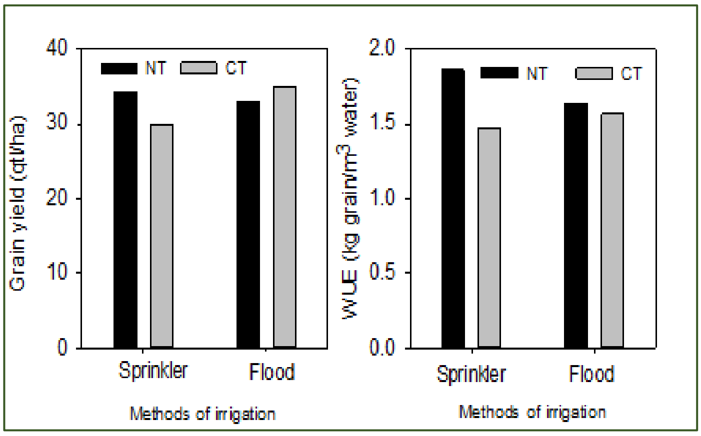


Figure 9. Grain yield (Qt /ha) and water use efficiency (WUE) as affected by tillage and irrigation methods (Algeria)

sprinkler irrigation to increase WUE in the region. Participatory on-farm evaluation comparing tillage practices, i.e., conservation and conventional tillage and irrigation management, i.e., flooding *vs.* sprinkler irrigation was conducted in the flat plains of M'Sila. The results showed that 18% of irrigation water can be saved using sprinklers compared to flood irrigation (1830 vs. 2240 m^3/ha). Adoption of CA practice with sprinkler irrigation increased grain yield of wheat by 1.2 t ha^{-1} and with 26% higher water use efficiency (Figure 9) compared to the CT with sprinkler irrigation. This result indicates the importance of the combination CA and sprinkler irrigation as a strategy to enhance WUE. Irrigation water was applied based on the farmers' visual observation; the quantities can be further reduced if irrigation is applied based on soil moisture.

- ✓ **Effort to reduce the Glyphosate application rate without compromising yield under conservation agriculture practice**

Weed management is one of the major challenges for the wider adoption of conservation agriculture practice in the region. As conservation agriculture practice avoids soil tillage, mainly practiced for eliminating weeds in the field before planting, it is recommended to apply glyphosate, a non-selective herbicide, to make the field free of weed before seeding. The overuse of glyphosate pollutes the environment and increases production cost, which sometimes masks the economic benefit of soil tillage. The glyphosate application rate varied with weed density, stage of weed growth, quality of water used for the tank mixture, and climatic condition. In this response, in **Algeria**, the project has evaluated four (3) different doses of glyphosate, as presented in table 4, and combined with three (3) different water quality for tank-mixture as presented in table 5 on yield performance of barley in 2019/20 crop season. Twelve (12) different combinations derived from four different glyphosate concentration and three (3) different water qualities were applied in the field 5-7 days before seeding. No other weed management practice was applied during the entire cropping season.

Table 4. Four different application rates of glyphosate used with active ingredient (g/ha)

Application rates	Quantity (lit/ha)	Active ingredient (g/ha)
D1	3.0	1080
D2	2.5	900
D3	2.0	720
D4	1.5	540

Table 5. Chemical characteristics of the water used for tank-mixture for glyphosate application

Water quality	pH	CE ($dS.m^{-1}$)	Ca^{+2} ($meq.l^{-1}$)	Mg^{+2} ($meq.l^{-1}$)	Na^{+} ($meq.l^{-1}$)	TH (meq/l)	SAR
W1	7.94	0.144	2.360	2.610	3.76	4.97	2.724
W2	7.7	0.194	3.750	2.790	3.60	6.54	2.702
W3	8.1	0.270	4.150	3.130	2.90	7.28	2.208

TH: Hydrotimetric degree (water hardness), SAR: Sodium Adsorption Ratio

The preliminary result showed that the quality of the water used had a significant effect on yield performance in all rates of glyphosate application (Figure 10). The yield is higher using water with a lower hydrotimetric degree (TH = 4.97 meq/lit), even at low herbicide concentrations. It is found that grain yield of barley was consistently higher under the treatment W1 compared to W2 and W3 for all application rates of glyphosate (Figure 10). W1 is characterized by low concentrations of Ca^{+2} and Mg^{+2} compared to W2 and W3. This variation could affect glyphosate effectiveness, knowing that this herbicide and all its main metabolites can form a complex with Ca^{+2} and Mg^{+2}.

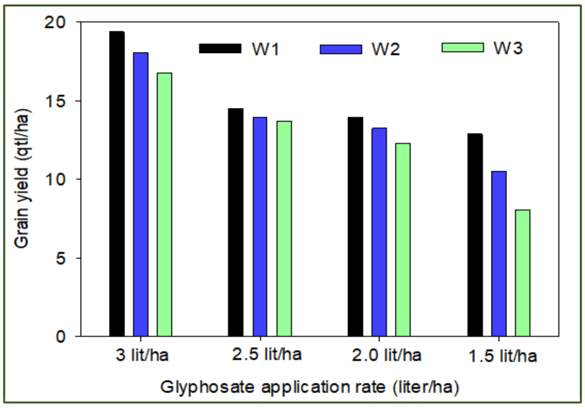


Figure 10. Grain yield of barley under four different glyphosate application rates (lit./ha) with combination of three different water qualities, i.e., W1, W2 and W3 (details in table 5)

This preliminary result indicates that water quality can reduce the glyphosate application rate on glyphosate-based weed management practices in conservation agriculture without compromising yield.

- ✓ **Performance of legume and cereal-legume mixture in the cereal mono-cropping rotation under CA**

Oat and triticale are the commonly grown cereal forages across the semi-arid sheep and cereal belt in **Algeria and Tunisia**. The nutritional quality of these cereal forages is low and is often exacerbated by poor agronomic practices and deplorable harvesting and storage conditions when hay is produced. Livestock owners have to rely on other feed resources such as wheat bran, cereal stubbles along with an overuse of cereal grains and commercial concentrates, hence making livestock enterprise very costly and unsustainable. From another angle, one of the main pillars for successful adoption of CA in mixed crop-livestock systems is the enhancement of crop diversification/crop rotations. Intercropping cereal to forage legume is one of the recommended practices. The benefit of forage crops mixture is to better valorize the ecological, nutritional and agronomic differences of mixed species in terms of production, quality and environmental benefits. Their main advantages are higher forage production and quality compared to monoculture, reduced nitrogen inputs and functional traits involved in weed competitiveness and cycle disease breakdown. To increase the quality of forage production and enhance soil quality and diversify the crop rotation system, the project tested, evaluated and validated several crops mixtures combinations under CA practice in the first year. For the second year of the project, CLCA team started the scaling of some validated forage mixtures and new forage varieties and also continued testing/validating other crops mixtures options.

Three (03) hay forage mixtures in four (4) locations from **Tunisia** (Safsafa/Beja-North, Ksar El Cheik/Beja-South, Fernana/Jendouba, Z'hir/Mateur-South, Bizerte) were evaluated: i) Vetch 70% - Oat 15% - Triticale 15% (V70-O15-T15), ii) Vetch 60% - Oat 7% - Triticale 33% (V70-O7-T23), and iii) Vetch 70% - Oat 30% (V70-O30). Measurements and analysis were assessed on six (6) harvested samples of one square meter in each plot at hay stage. The results revealed that the Land Equivalent Ratio [LER, defined as the relative land area required as a sole crop to produce the same yields as intercropping (Mead and Willey, 1980)] values were more advantageous for the mixtures over pure stands for all studied forage mixtures. Regarding CRc [Competitive Ratio of the Cereal, is a measure of intercrop competition, to indicate the number of times by which one component crop is more competitive than the other (Willey and Rao, 1980)], triticale and oats together (T-A) in the same mixture are less aggressive towards vetch crop than oat alone and T-A may offer better tutor ability towards common vetch. The legume represents respectively 51%, 25% and 27% of the final biomass of V70-O15-T15, V70-O7-T23 and V70-O30 mixtures, respectively. Weeds percentage was consistently high (20%) for the mixtures V70-O7-T23 and V70-O30 and was very low (4%) for the mixture V70 -O15 -T15. The three (3) studied mixtures produced respectively 12, 11.6 and 11.1 t DM ha^{-1}, which is indicative of a very high forage potential. The V70-O30 mixture showed the highest average crude protein (CP) content (16.7%). Crude protein content is by far higher than for oat alone for which values seldom exceed 9%. The combination of the high yield and high protein content of the tested forage mixtures represent a valuable alternative for stubble grazing of the flocks early in the summer period.

Results of Vetch-Oat mixture in the proportions 70% (Vetch) and 30% (Oat) tested in other regions of Zaghouan, Siliana and Beja districts showed that V-O mixture produced significantly more hay yield under CT (6.72 t ha^{-1}) than under CA (4.6 t ha^{-1}). However, most CA trials were sown with the no-till seeder for the first time, and likely on bare soil, which may explain the lower yield obtained compared to conventional seeding. Tutor ability of oat was low because most farmers did not provide nitrogen fertilizer as advised by CLCA team; they assumed that the presence of vetch in the mixture would compensate for nitrogen fertilization. Overall and across all the studied sites, we were able to document a strong enthusiasm of the farmers introducing the vetch-oat mixture both under CA and conventional tilling systems.

In **Algeria**, oat and triticale are the commonly grown cereal forages in the region. In this context, to increase the quality of grown forages and enhance soil quality and diversify the crop rotation system (critical for a CLCA system), the project has evaluated the following mixture combinations under CA practice: i) Pea (65%) + Triticale (35%), ii) Vetch (65%) + Oat (35%), iii) Vetch (70%) + Barley (30%) and, iv) Sole oats (100%).

All the cereal and legume mixtures grew well under CA and produced higher biomass than the sole cereal (oat) (Figure 11). Vetch + barley (10.2 t ha-1) produced higher biomass followed by pea + triticale (9.2 t ha-1) and vetch + oats (7.9 t ha-1), while lowest biomass was observed with sole oat (6.3 t ha-1). This indicates that alternative forage crops (a mixture of cereal and legume) can be grown under CA practice with increased biomass and quality forage than the current forage crop in Algeria.

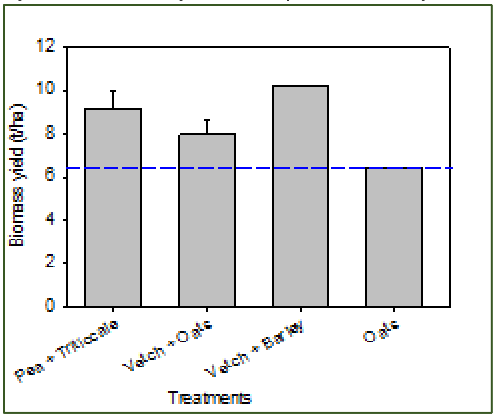


Figure 11. Performance of different forage crops (sole and mixture) under conservation agriculture practices

Establishment of agronomic trials for cropping season-II (September 2019 – March 2020) in North African Countries

During this second year, experimental work on agronomy trials including forage trials, weeding management and soil health measurements (SOM, erosion, water retention, WUE) continued and expanded in **Algeria and Tunisia** as planned in the annual workplan. In **Tunisia**, CLCA directly implemented agronomic and forage trials under CLCA system with ninety-two (92) farmers over a total area of 1,450 ha between October and December 2019 in the different sites of the project (Figure 12).

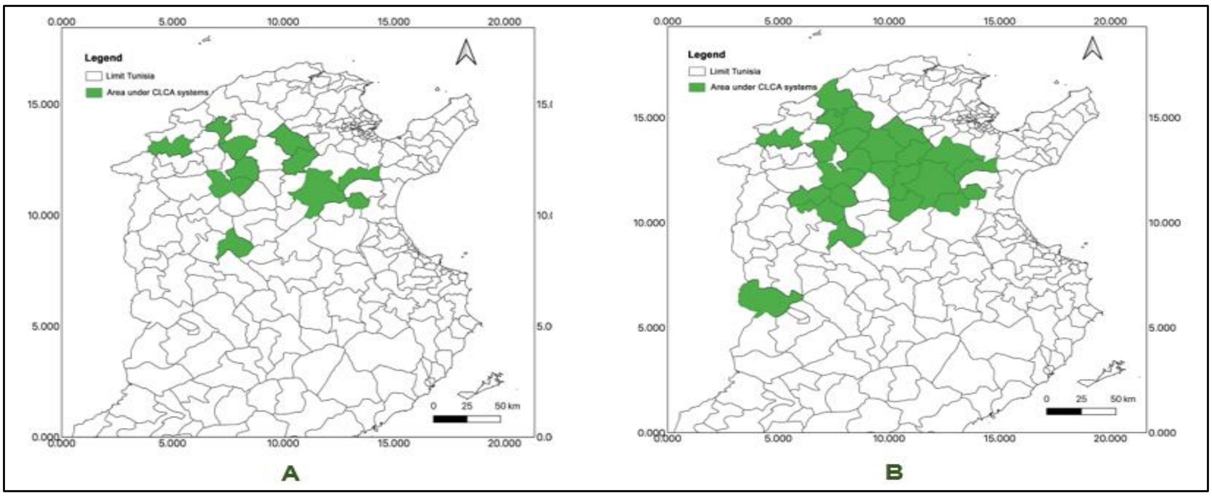


Figure 12. Map of the project intervention sites in Tunisia: (A) Cropping season 2018/19, (B) Cropping season 2019/20

Twenty-two (22) women farmers (pioneers) have been involved in on-farm trials and demonstration plots under CLCA systems. In addition to the districts of Siliana, Beja, Zaghouan (focus of Year-I), the project activities were extended to the districts of Jendouba, Kef, and Kasserine. This is almost a 3.5-fold increase compared to what has been directly achieved in the first year of the project (440 ha by 70 farmers).

- ✓ Beja: 406 ha implemented by 23 farmers;
- ✓ Zaghouan: 435 ha implemented by 31 farmers;
- ✓ Siliana: 486 ha implemented by 20 farmers;
- ✓ Kef: 75 ha implemented by 11 farmers;
- ✓ Jendouba: 42 ha implemented by 06 farmers;
- ✓ Kasserine: 6 ha implemented by 03 farmers.

In **Algeria** and similarly to Tunisia, the project activities expanded from the target districts of M'Sila, Setif and Oum El Bouaghi in the first year to new districts mainly Constantine, Batna and Bordj Bou Arreridj (Figure 13).

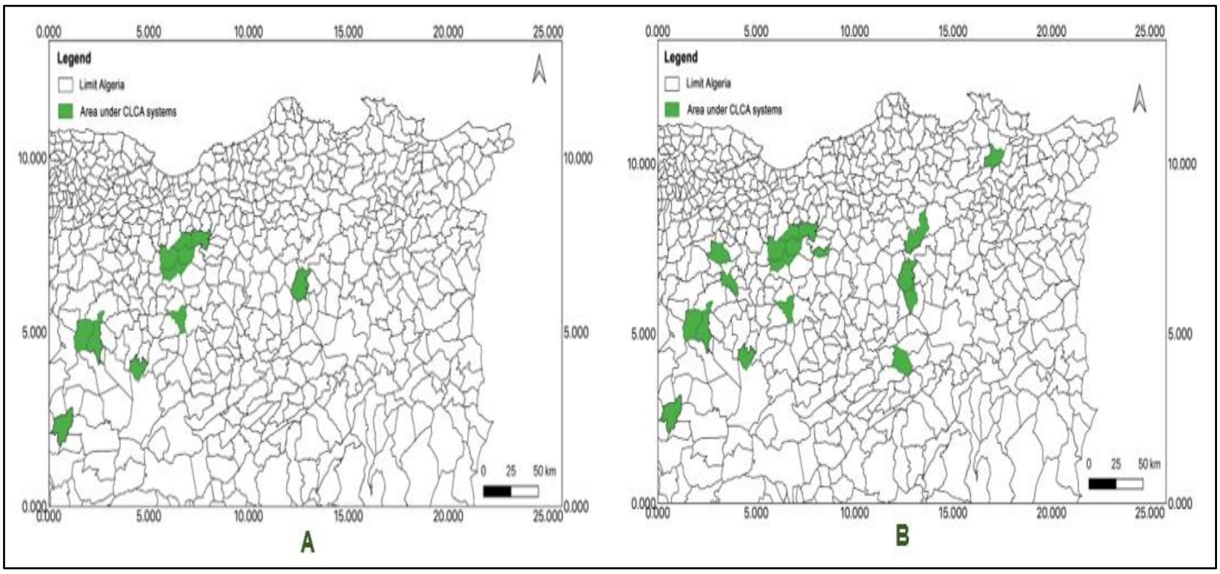


Figure 13. Extension of the project intervention area in Algeria: (A) Cropping season 2018/19, (B) Cropping season 2019/20

During the second cropping season in **Algeria**, the CLCA project directly facilitated establishment of 982 ha by almost 241 smallholder farmers (compared to only 316.5 ha and 35 farmers in Year-I).

For both countries, assessment of the trials is underway, and both the protocols and the results will be consigned in the next-year technical report.

Fine-tuning crop residue use in different geographies and socioeconomic environments

Optimizing stubble use in mixed small farms to meet the livestock feeding needs in summer and to comply with CA package requirements in **North Africa** is a key work package throughout phases (I) and (II) of the project. Trade-offs between the use of stubbles for livestock feeding or to cover the soil have to be resolved, particularly in drylands where fodder availabilities are low and the options to produce summer feed are scarce.

For this second round of monitoring stubble grazing in **Algeria** and **Tunisia** and as per the recommendations of the traveling workshop held in Tunisia from 1st to 4th July 2019, it was decided to expand the monitoring to a larger number of farmers adopting CA, reach out to new districts recruited in the project and simplify the protocol of measurement focusing on the key data to assess stubble use and residuals in a CLCA system. In this context, it was decided to harmonize the data collection protocol to initial biomass, final biomass, actual stocking rate, number of grazing days, type of stubble, type and breed of grazing animals, variation in body condition score (BCS) when the grazing period allows to depict changes in this trait.

For the second year of the project, stubble grazing was monitored with fourteen (14) farmers in three (3) of the districts (Siliana, Jendouba and Beja)/**Tunisia** where agronomic trials were established. In all trials, ewes of the Queue Fine de l'Ouest breed were the dominant sheep (79% of farmers), other flocks were of the Noire de Thibar breed. Ewes were in the earliest stage of pregnancy. The experimental ewes were treated against gastrointestinal parasites and were vaccinated against enterotoxaemia before being grazed on stubble. Such health preventive treatments are recommended as part of the good practices in the field before the animals move to stubble grazing.

The stocking rates and grazing durations varied between farmers (Table 6). Results showed that the initial biomass ranged between 540 Kg DM ha^{-1} and 3268 kg DM ha^{-1} and at the end of the grazing period, the residual biomass varied between 205 and 2603 kg DM ha^{-1}, representing 18 to 91 % of the initial biomass (average 58%).

Table 6. Variation of stubble biomass in CA plots before and after grazing (Tunisia)

Farmers	Grazing period (Day)	Stocking rate/ha	Initial Biomass (Kg DM/ha)	Final Biomass (Kg DM/ha)	% of residual biomass
Farmer 1	35	7	1350	1130	83
Farmer 2	59	7	540	453.6	84
Farmer 3	27	6	2977.2	2602.8	87
Farmer 4	60	10	594	421.9	71
Farmer 5	60	25	2138.4	1314	61
Farmer 6	59	10	612	507.6	83
Farmer 7	26	7	1734	1578	91
Farmer 8	60	50	1346.4	572.4	42
Farmer 9	59	50	1144.8	205.2	18
Farmer 10	63	15	1364.4	1004.4	74
Farmer 11	63	15	1299.6	759.6	58
Farmer 12	37	62	3268.8	716.4	22
Farmer 13	60	16	1932	1470	76
Farmer 14	63	25	1728	432	25
Average	52	22	1557.8	905.2	58

Table 7 presents stubble biomass variation by plant species. The results show that proportions of residual biomass are important for all the species and ranged between 48.4 and 87.4 % for wheat and Faba bean stubbles, respectively (average 68.7%). When adjusted to 30/30 criteria, residual biomass proportions ranged between 30.1 for Faba bean and 72.5 % for oat (averaged 58.4%).

Table 7. Residual biomass by plant species (Tunisia)

Plant species	Average grazing period (days)	Average stocking rate (Ewes/ha)	Initial Biomass (Kg DM/ha)	Final Biomass (Kg DM/ha)	Residual biomass (% of initial)
Wheat	53	24.6	1816.07±875.2	879.4±385.1	48.4
Faba bean	27	6	2977.2± 375.3	2602.8± 269.8	87.4
Barley	60	10	594±104.2	421.2± 72.7	71
Oat	51	33	1575± 569.3	844± 654.6	53.6
Vetch/oat	59	8,5	576± 164.5	480.6± 137.6	83.4
Mean	52	16,5	1507.6 ±417.7	1045.6± 303.9	68.7

** Residual biomass corrected using extrapolation, as if we had 30 animals per hectare grazing for 30 days*

It is noted that for all on-farm trials, animals maintained their BCS and sometimes a significant slight increase was obtained (data not shown). However, we estimated that from a nutritional point of view, showing changes in BCS is more informative when related to the type of stubble. It is interesting to note that under all types of stubble, pregnant ewes were able to maintain and even increase their body condition and this is critical for the progress of pregnancy, fetal growth and for avoiding metabolic-incurred disorders. The highest increases of BCS were obtained with wheat and faba bean stubble.

In **Algeria**, monitoring stubble use and residuals was performed with ten (10) different CLCA beneficiaries in the three (3) main districts where the project is operating (M'Sila, Setif and Oum El Bouaghi) out of twenty (20) selected farmers (Table 8). In M'Sila, most of the stubble is not grazed because the farmers have large sheep flocks and during the summer period, the flocks are herded in vast communal pastures in the south. In Setif, the absence of data on stubble use is related to the commitment of farmers who have been collaborating with the project since Phase (I) and they are now more enrolled into the practice of CA leaving all the stubble as mulch. For this last category of farmers, flocks are systematically kept in feedlots. Wheat, barley and triticale stubble were considered, and biomass was shown to vary considerably between districts, crop species and agronomic practices (supplemental irrigation, intensive use of fertilizers, infestation by weeds). Compared to Tunisia, stocking rates are much higher in Algeria as the flock size is typically larger and therefore grazing periods are much shorter.

Table 8. Variation of stubble biomass in CA plots before and after grazing (Algeria)

District	Farmers	Grazing period (Day)	Stocking rate /ha	Initial Biomass (Kg DM/ha)	Final Biomass (Kg DM/ha)	% of residual biomass
Oum El Bouaghi	Farmer 1	16	40	4240	1950	46
	Farmer 2	16	20	2830	960	34
	Farmer 3	16	30	1880	1260	67
	Farmer 4	14	12	1020	810	79
	Farmer 5	17	25	1844	879	47
	Farmer 6	15	25	1686	1546	91
	Farmer 7			1860		
M'Sila	Farmer 1	11	28	3410	2660	78
	Farmer 2			1590		
	Farmer 3			2260		
	Farmer 4			370		
	Farmer 5			2270		
	Farmer 6			2210		
Setif	Farmer 1			2290		
	Farmer 2	9	17	1940	1790	92
	Farmer 3	9	17	1771	1530	86
	Farmer 4			800		
	Farmer 5	9	70	1050	240	23
	Farmer 6			1390		
	Farmer 7			3350		
	Average	12.9	28.4	2003.05	1362.5	68

Comparisons of the available initial biomass per site between summer 2018 (Year-I) and summer 2019 (Year-II) is shown in table 9. Comparatively to last year, dry matter biomass at Oum El Bouaghi was higher in year-II while it was much lower in M'Sila and Setif. These differences can be explained by the higher number of farmers included in the trials in year-II, the environmental conditions having characterized the cropping season and the harvesting conditions. Such a variability is a main characteristic of dryland systems and requires that farmers should fine tune the stocking rate and grazing duration to optimize stubble use for animal feeding and mulching.

Table 9. Comparison of initial stubble biomass between years 1 and 2 of the project (Algeria)

District	Stubble biomass DM t/ha	
	2018	2019*
Oum El Bouaghi	1.78±0.37	2.63±0,86
Setif	2.98±0.26	2±1.00
M'Sila	3.01±0.48	1.79 ± 1.45

** means of 3 to 7 repetitions depending on the homogeneity of the plot*

The stubble is composed as 49 % leaves, 40 % stems and 11 % spikes (Figure 14). The quantities of spikes are very variable due to the adjustment of the combine harvesters and for this cropping season, two (2) farmers did not harvest their crops because of the low yields and the invasion of the plots by bromine. These plots have been converted to grazing.

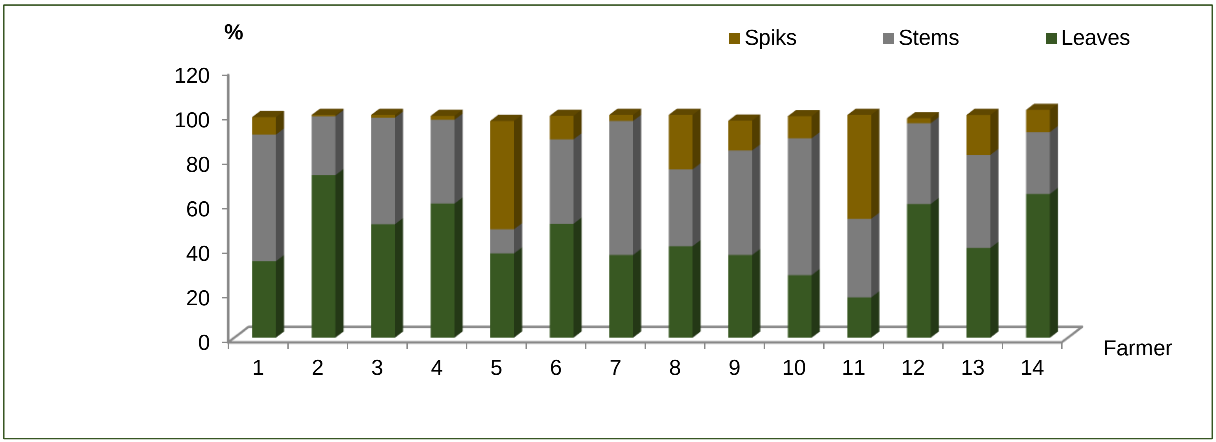


Figure 14. Stubble composition in terms of spikes, leaves and stems in Algeria

Advocating alternative feeding systems and livestock enterprises

The main findings that characterize stubble availability and use in **Algeria** are the relatively moderate stubble availability after harvest in most of the project sites which can sustain sheep feeding for only a short period of time because of the large sheep flocks and the resulting high stocking rates. Comparatively to Tunisia and this is supported by data from Phase (I) and the first year of the second phase, stubble can only be used for a maximum period of twenty (20) days if sufficient quantities are to be left as mulch. This has prompted the Algerian team to work on the formulation of summer diets and to build a communication strategy based on the organization of field days and the elaboration of extension material. According to the farms' management mode in the project area, stubble biomass and its characteristics in each district, a contextualized approach to formulate rations for sheep during the summer gap was carried out by ITELV technical team. The proposed rations are based on partial and limited grazing of stubble, limited integration of alfalfa hay in irrigated areas or a combination of cereal/legume hay with a supplementation with barley grains and olive pomace (widely available in the project area). The rations were formulated according to the type of sheep and the physiological stage. A summary of the proposed summer feeding diets is presented in figure 15.

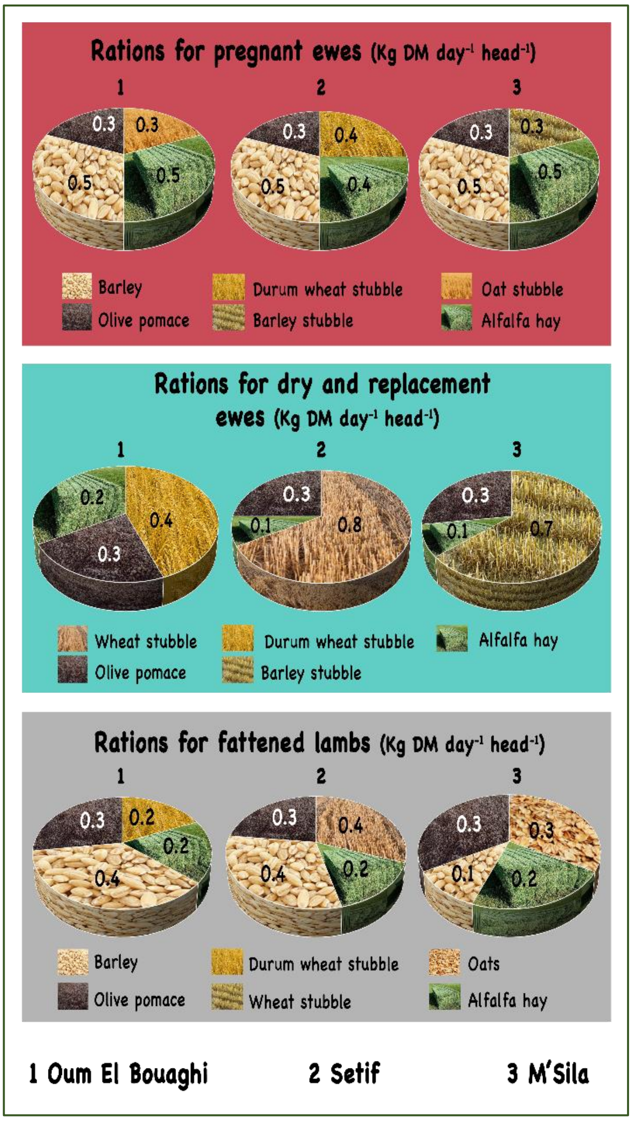


Figure 15. Proposed summer sheep feeding rations in the different CLCA districts of Algeria

Alternative diets for the summer feeding of flocks in **Tunisia** were also elaborated in the framework of the CRP livestock (feed and forage flagship) and feeding solutions will be reported later.

In the project target area in **Bolivia**, practically all farmers manage mixed crop-livestock systems. The major livestock species are llamas, cattle and sheep. In southern highlands, llamas are common, while, in central and northern highlands cows and sheep are dominant. Animals are an important source of milk, meat and manure products. Open grazing in cultivated and rangeland is common. Overgrazing by domestic and wild animals (Vicuña, alpaca) causes degradation of rangelands. Most of rangelands in the project domain are degraded. This second year, activities which are initiated during the first year on setting-up trials to improve feed availability for llamas continued as planned in the annual work plan:

- Pasture development: Six (6) validation pasture plots developed in the communities of Chacala, Chita and Sevaruyo. Fodder grasses Eragrostis curvula, Nasseella neesiana and Agropirun elongatum were planted. So far, the growth and development of fodder grasses is satisfactory.
- Use of quinoa residue (Jipi and Bronza) and probiotics for llama nutrition: Trials have been initiated on use of quinoa residues for llama nutrition in Chacala and Chita community, seventeen farmers were involved in feeding quinoa residue and on the use of probiotics for improving feed digestion efficiency by llamas. Results of both the trails are awaited.
- Improved fallow: Twenty-three (23) demonstrative plots were setup in Chacala and Chita communities. Wind breaks of 5,100 m were established using fodder bushes such as Sup-u-tula (Parastrephea lepidophilla) Nak-u-tula (Baccharis incarum), Uma tula (Parastraphia luceda). The survival rate of these saplings was 95%.

Financially viable business models for No-Till and other agricultural machinery service provision enterprises

While the work on unlocking the constraint of Zero-till machines continues in North African countries (training, advocacy with policy makers and scaling), the CLCA team also engaged in generating business models for livestock-based small machinery. This was mainly in the areas of forage seeds treatment and cleaning machines as well as the feed grinders and the project team had to respond to this demand from the farmers and to convert it to the benefit of the project as an entry point to CLCA system.

- ✓ **Forage seed and feed Production business development at farmer group level**

The conventional national seed system in **Tunisia** is not providing enough quality forage seeds. Forage seed production like vetch, oat, barley, faba beans or Alfalfa is mainly done by large seed producing cooperatives who are subcontracting with individual farmers. One private seed enterprise COTUGRAIN and the national forage agency OEP are equally engaged in forage seed production.

Due to insufficient forage seed supply, but also to save costs, many small-scale farmers prefer using their own farm seeds. The quality of these farm seeds is generally low as they are normally cleaned manually, so the final product still contains some unproductive seeds (broken seeds or small sized seeds). In addition, these untreated seeds are sometimes attacked by pests and diseases. The results of using these poor-quality farm seeds are low forage yields and low income.

Traditional and manual seed cleaning by woman farmer

To tackle this constraint the CLCA-II project, in collaboration with other ongoing ICARDA projects – the Feed and Forage flagship (CRP Livestock), promoted the use of innovative locally produced seed cleaning and treatment units to develop business for lead farmers and Small and Medium Enterprises (SME) around forage seed production. After discussing with national partners (INRAT, OEP, INGC), the business idea was found more suitable for small or medium SMSA (Mutual Association of Agricultural Services/Societé Mutuelle des Services Agricoles) as the machine would benefit more farmers. SMSA are a kind of farmer cooperatives providing services to their members. The cooperatives can provide seed cleaning and treatment services for their members. The business can help to provide additional income for the cooperative and forage seed production of their members. The seeds are used by the members themselves.

ICARDA and its national partners in **Tunisia** designed and developed a prototype of a "mobile seed cleaning and treatment unit" which has been locally manufactured at low cost. One-unit costs 12,500 TND (about 4,350 US$) and has a capacity of about 800 kg / hour depending on the kind of seeds treated. Four (4) mobile seed cleaning and treatment units were delivered and distributed to farmers' associations having between 150 and 350 members each and are located in different CLCA target areas (North Western and Central regions of Tunisia) – globally, over 1,000 small-scale farmers will benefit directly from these units during the upcoming years https://hdl.handle.net/20.500.11766/11103. Young farmers and women were considered among the beneficiaries and accurate sex as well as age-disaggregated data will be provided in year-III.

With the help of the mobile seed cleaning and treatment unit, members of these farmer cooperatives can significantly increase their seed quality and consequently their barley fodder production. In addition, the unit can serve as an income generating activity for the cooperative as farmers have to pay renting fees to use the machine. The project monitors and coaches these associations to see how the units are managed in an economically sustainable way. Beneficiaries, who have been carefully selected based on their interest and need for the machine, contributed with 10 % of the total price of the machine (1,250 TND/435 US$), which is used to train them on the machines and on other good practices for seeds production and cleaning in general. The 10 % contribution was also considered as a proof of farmers motivation and engagement for getting the machine and using it in its operations. Financial contribution of beneficiaries is considered essential to create ownership.

The distribution of the machines served to enhance small businesses of the recipient farmers' cooperatives. During this second year, Cooperatives started to rent them at a negotiated cost to their member farmers and generated additional income for the cooperatives.

Training day to demonstrate the mobile seed cleaning and treatment unit

The major seed cleaning and treatment season in Tunisia is between September and December, right before or at the beginning of the cropping season. As the machines reached the beneficiaries only at the end of October some farmers had already started cleaning seeds in the traditional way.

The potential of this technology and the engagement of all four cooperatives in using the units is displayed in table 10. The treated seeds were to a large extent cereal like barley and wheat. Legume forage seeds have not been cleaned and treated yet, as suitable sieves with different sized holes were not available. The project will support and co-finance the purchase of adapted sieves in 2020.

During this short period of use, already a total of 66 tons of seeds were cleaned and 173.6 t cleaned and treated. A total of 138 farmers benefited from the four (4) units. The total benefit for these four (4) cooperatives with about 2,000 TND (682 US$) is not significant as the intention of some cooperatives during this first experience was rather to attract members using this service than making a benefit. This explains the different service prices varying between 10 TND and 35 TND for cleaning 1 t of seeds and 50 – 80 TND for treating seeds. Service prices will be adjusted once the demand and market are created.

All four (4) cooperatives employed one person on a temporary basis to operate the unit. Some cooperatives let the unit be stationed at the cooperatives' base, others allowed the farmers to take it and use it at the farmers' site. In any case it was the employee who was responsible for manipulating the unit. The SMSA Ettaouen which used the machine for almost 150 t of seeds is already considering the purchase of a second machine as the demand is high and treating period limited. One unit will be placed permanently at the cooperatives site and the other will be allowed to move from farmer to farmer.

Table 10. Use of seed cleaning and treatment unit by four (4) farmer cooperatives (SMSA) in November and December 2019

SMSA	Qtt seeds cleaned (t)	Qtt seeds treated (t)	Cleaning price (TND/t)	Treatment price (TND/t)	Return	Total benefit (TND)	Number of users (farmers)	Number of potential SMSA users
El Amen	24.2	0	35	N/A	847	315	12	320
El Felah	4.7	42.6	10	80	3,455	-13	20	200
Ettaouen	14.6	131.1	20	70	9,469	1467	95	350
Melyen	22.5	0	20	50	450	225	11	150
Total	66	173.6	N/R	N/R	14,221	1,994	138	1,020

Besides the seed cleaning units, in **Tunisia** six (6) mobile grinders were placed with young entrepreneurs and farmers associations engaged directly with CLCA project (Link).

The grinders can chop and grind material like cactus cladodes and fruits, small olive branches and leaves, straw, hay, date kernels, cereals, faba beans etc. which are ingredients of the small ruminant diets. Low-cost feed supply is a major constraint for small scale livestock farmers during summer. Through grinding of locally available feed, the intake will be increased, and productivity gained. Almost 1,080 beneficiaries (members of farmers associations) including young farmers and women are now benefiting from this equipment & related training. Recipient farmers associations were carefully selected based on their interest and need for the use of the machine to develop their feed and / or compost business. They either produce and sell the final product or they provide grinding services to farmers. These grinders can lead to reducing costs and thus increasing income. It is an ideal tool for smallholder farmers to improve their incomes which represents an opportunity for improved livelihoods in traditional small-scale farming. The use of these tools reduces the labor time spent on feed-farming operations especially for women farmers. Protocols to monitor how women labour is freed off are being developed together with gender specialists. The project is also closely monitoring and coaching the associations to see how these small feed grinding machines are managed in an economically sustainable way.

Small-scale feed grinder to improve the quality of roughage feed (Tunisia)

- ✓ ***Assessment of profitability threshold of no till (NT) Boudour seeder***

An important output in **Algeria** is the commercial launch of the Zero-till seeder "Boudour" which is newly manufactured by the Agricultural Machinery Construction - Sidi Bel Abbes (CMA) in collaboration with ITGC and the National Company of Agricultural Equipment Production & Trading (PMAT) and the Spanish company SOLA (Link). PMAT has deployed twenty (20) units of ZT seeder in different parts of the country through its different sales points along the cereal-production belt spreading from Northern East to Northern west Algeria (Algiers, Constantine, M'Sila, Sidi Bel Abbes, Setif). During this cropping

Zero-Till "Boudour Seeder" (Algeria)

season, 982 ha area was seeded under zero tillage with the “Boudour” ZT seeder. Together, ITGC and PMAT were able to convince the Algerian government about the relevance of the technology for small field crop farmers in Algeria and to include the seeder into the national nomenclature of subsidized agricultural machines. With this effort, the “Boudour” ZT seeder is now subsidized at 30% when the seeder is purchased individually and 40% when it is purchased by a farmer association on its original price of US$13,000. Through the guidance of ITGC field technicians and regional stations, farmers and local companies providing agricultural machinery services started also to acquire such seeders and renting them to farmers in their respective regions. This process was all induced through the agreement between CLCA national coordinator (ITGC) and the PMAT signed in June 2018 immediately after the official start of the CLCA-II Project, thus providing strong evidence and argument for the ministry to include this zero-till seeder in the subsidy nomenclatures. The agreement signed between both parties stipulates that ITGC (in the framework of the CLCA Project), provides technical assistance to PMAT for further promoting zero-tillage seeder https://www.youtube.com/watch?v=iF4g-NkeBUs.

The subsidy that is granted by the government to make the seeder affordable to small-scale farmers, can benefit individual farmers or a group of farmers when they are part of a producers’ association or a cooperative. Therefore, in order to convince farmers or cooperatives of farmers to invest in NT “*Boudour*” seeders, we calculated the true economic cost of direct seeding for an individual investor (individual farmer) and for a collective group of farmers (cooperative or association of farmers), and to evaluate the financial feasibility of investing in this seeder under both scenarios. The empirical findings of this analysis are outlined in table 11.

Table 11. Estimated cost for NT seeder use in Algeria (DZD/ha)

Operations	Boudour Seeder with 30% subsidy	Boudour Seeder with 40% subsidy	Tractor
Resale value	1467000	1467000	4095000
Purchase cost DZD (Without subsidy)	1630000	1630000	4550000
Purchase cost DZD	1141000	978000	3185000
Estimated life	15	15	20
Estimated salvage value	74328	69682,5	207480
Interest rate	0,057	0,057	0,057
Labour Setif and M’Sila	2000 DZD/day	2000 DZD/day	2500
Time of labour per ha	1 hour	1 hour	1 hour
Renting Seeder Cost	4500 DZD /ha	4500 DZD /ha	4500 DZD /ha
Ownership cost	**Amount (DZD)**	**Amount (DZD)**	**Amount (DZD)**
Depreciation	104320	104320	
Opportunity capital cost	74328	69682,5	207480
Shedding	24000	24000	24000
Insurance	8000	8000	10000
Total fixed costs	106328	101682,5	241480
Operational Costs	**Amount (DZD)**	**Amount (DZD)**	**Amount (DZD)**
Fuel	0	0	1152
Reparations	5000	5000	10000
Labour	100000	100000	100000
Total variables costs	105000	105000	111152
Total costs (fixed + variables)	211328	206682,5	352632
Estimated annual usage per hour	400	400	400
Estimated annual usage per hectare	400	400	400
Total operating cost per hectare	528,32	516,70625	881,58
Total Variable Cost (DZD/hrs)	262,5	262,5	277,88
Total variable cost of seeding per hrs	1144,08	1144,08	1159,46
Breakeven point (ha)	**31.68**	**30.29**	

1 US$ = 119,71 DZD

These results suggest that the Break-Even Point (BEP) for the two scenarios is quite similar. This indicates the following: If an individual farmer wants to make profit with the investment in “Boudour” seeder, the annual usage must exceed 31.68 hectares per year. In the case of a collective investment, the annual use of the seeder should go beyond 30.29 hectares. Finally, it is indicated that the calculation of BEP in the different areas of the project is the same because there is no difference in the cost of renting of machinery and in the labor wage.

Agricultural machinery hiring is a very useful method of having access to agricultural machinery especially by small and medium size farms. Therefore, efforts are made through this study, and for the first time, to calculate the true economic cost of investing in the NT "Boudour" for an individual farmer or for farmers' association. These calculations will help to determine the reasonable hiring cost of this seeder in Algeria. Financial analysis shows that the investment in "Boudour" seeder is a profitable option when smallholder farmers are investing collectively (through a farmers group or cooperative) to acquire it.

Sub-component 1.2. Appropriate system development methodology to support wider adoption and decision-making

Developing comprehensive trade-off models

Farm level modelling and protocols for the assessment of indicators in LAC countries

In order to explore the diversity of farming systems in both LAC sites (**Bolivia**, **Mexico**) and asses the possibilities for optimization of current and alternative crop-livestock systems through a farm level modelling approach and based on the farming systems typology developed with the ProCamelidos baseline survey in **Bolivia** and, for **Mexico**, on previous work from UAM, three (3) representative farms with different levels of crop livestock integration were selected in each Mixteca Alta (**Mexico**) and Altiplano Sur (**Bolivia**) to collect detailed data on their farming practices and parametrize the FarmDESIGN model for multicriteria assessment and trade off analysis. The FarmDESIGN model is a multi-objective model that allows assessing current performance of farming systems through several indicators and, by optimizing systems with a genetic algorithm, explores and assesses alternative farm configurations.

Farming system diversity assessment

- ✓ **Mixteca Alta farms**

The region studied in Mixteca Alta in Oaxaca Mexico comprehends the municipality of Santa Catarina Tayata. It is a mountainous region at on average 2200 meters above sea level (masl) with soil pH > 8.2, low soil organic matter (SOM), moderate but extensive erosion, and precipitations between 650 - 750 mm.

The farms diversity was characterized by agricultural production for self-consumption (human and animal food), based on basic crops including corn, beans, squash and some agricultural products such as vegetables, amaranth grain (Amaranthus) and beans, marketed locally. Monetary income comes mainly from livestock activity, activities outside the production system at the regional level, remittances and subsidies. Also, some farms depend on agro-forestry spaces for grazing activities, obtaining firewood and wood for the construction sector, water use for domestic consumption and micro-irrigation. A typology analysis of these farms derived five types: i) crop-livestock farms, ii) dependent on external agricultural labors and low monetary income, iii) dependent on government programs, iv) with high non-agricultural income, and v) medium external income.

- ✓ **Altiplano Sur Farms**

Given the great intrinsic diversity of agricultural-livestock systems, CLCA team in LAC countries proceeded to build farm typologies for each municipality, using data from the pro-camélidos 2017 Base Line of 298 farmers in the municipalities of Uyuni and Challapata. Given that farms can be considered as open systems, it is desirable to know the outputs and inputs of the system, for this, 47 variables were chosen that inform us about: the available land, the use given to the land, diversity of crops and livestock, income and its sources, the family structure, the destination of livestock and agricultural production. This information was used to construct typologies based on statistical analyzes that include the reduction of dimensions through principal component analysis (PCA) and hierarchical clustering (cluster analysis). For each municipality, previous to PCA, variable selection procedures were followed to avoid either redundant information or incorporating variables that do not provide variation to the analysis.

Through a comparative analysis it was found that in Challapata, farms are larger than in Uyuni. Also, in both municipalities, agriculture is practiced but with different objectives. Income generation is based on what they produce in the farm, but in Challapata there is a greater generation of income from activities outside the farm, even though, the income generated is higher in Uyuni. In Challapata, income coming from agriculture is almost zero, but crops self-consumption is more common. In Uyuni, crop production is more common and is intended mainly for marketing. In Uyuni llama herds are slightly larger but in Challapata there exists a greater diversity of animal handling including a few alpacas or sheep. Although different types were found in each municipality, some convergences could be found in production strategies.

- Uyuni Typology: The following types are proposed: i) Livestock farms with crops self-consumption, low income with off-farm activities, ii) Livestock and agricultural farms with large land holdings and high incomes with off-farm activities, iii) Crop farms with livestock and income based on on-farm activities;
- Challapata Typology: i) Low income farms of diversified livestock, large land holdings and off-farm activities, ii) Commercial farms based on llama trading with intermediate incomes and smaller land holdings, with significant income generated off-farm, and iii) High off-farm income farms, with livestock and crops for self-consumption.

Farms' selection

After farms diversity has been assessed a few farms of interest can be selected from certain types to be modelled through FarmDESIGN tool.

In Mixteca Alta the crop-livestock type comprehends 23 % of the sample of farms, three (3) farms of this type were selected for FarmDESIGN analyses for several reasons, these farms presented the largest landholdings, high bovine and ovine livestock production, 80% of their nutrition was fulfilled with their own products and their on-farm income was 40% from total, which was the highest compared to the other types. From the typology analysis also four (4) areas of improvement were thought to be of interest for optimizing the systems productivity of farms: crop-livestock sub-systems integration, livestock production, nutritive efficiency of crops and intensification through poly-cropping.

In Bolivia, farms were chosen following a participatory approach working with local collaborators. After the numerical exercise based on ProCamelidos data base, the typologies of each municipality were presented to local staff and the participants were asked to recall farms that were alike those presented, emphasizing on its principal characteristics. Farm-I in Challapata is completely dependent on crop-livestock agriculture on a medium land area extension (16 ha) it produces three (3) species of crops, quinoa, barley and potato, and three (3) species of livestock, grazing in pasture lands outside the farm production unit is practiced. In farm-II in Uyuni the crops area is bigger (60 ha) and is under quinua production for commercial purposes, also a small piece of lands is under potato cultivation for self-consumption. This farm has a high intensity of off-farm work and much of its income comes from renting machinery and its labor. Lastly, farm-III in Challapata is a smaller farm (5.5 ha) but it is more diversified in its income sources, their crops and livestock species. An important time is dedicated to migration and off-farm work, they grow an important amount of their pastures (Lucerne and Barley) as their main products are dairy milk and cheese from cows, they have some sheep and llamas that are used for self-consumption, sales, and also some products are produced and commercialized. They grow quinoa for commercialization and a small amount is saved for food.

Data collection for Models parametrization

In both LAC countries, the input data for modelling is extensive and came from different sources as: information derived from field measurements, interviews with farmers for detailed information on inputs used and outputs produced of the different farm activities and databases/bibliography.

Model Indicators

Ten (10) indicators that can be calculated with the FarmDESIGN model are, among others, the operating profit of the farm, its self-sufficiency in terms of food and feed, labor productivity as well as a suit of environmental indicators related to organic matter and nutrient balances as well as pesticide use and GHG emissions:

- *Indicator-1/* Operating profit: ability of a farm to generate monetary income from agricultural activities. This considering the gross margin of crop production in agricultural activities, the gross margin of livestock husbandry, cost of manures, regular contracted and casual labor costs, costs of land, assets costs and general costs;
- *Indicator-2/* Income from farm activities: is the income generated from farm activities represented as the percentage of the total income generated on (Operating profit) and off-farm;
- *Indicator-3/* Free time available: is the time available after all crop, herd and farm maintenance work is fulfilled is its obtained subtracting the time needed for all those activities from the time available as labor of the whole family;
- *Indicator-4/* Labour in agricultural activities (%);
- *Indicator-5/* Food self-sufficiency: is the number of persons that one Ha of land satisfies their kcal needs per year;
- *Indicator-6/* Soil Organic Matter balance: The organic matter balance is calculated as the difference between organic matter (OM) accumulation and OM loss. The accumulation originates from roots and stubble that remain on the field after harvest, green manures that are grown as a source of OM and ploughed under before growing a next crop, feed losses that are dependent on the feeding system and type of feed supplied, and manure either produced on-farm due to excretion by the animals or imported from an external source. Part of the manure is degraded in the year of excretion and other losses of OM occur through breakdown of active organic matter in the soil and erosion of soil. All this depends on soil moisture, temperature and soil texture;
- *Indicator-7/ Nitrogen balance*: was calculated from nitrogen inputs, considering crop products or food of plant origin, imported animal products, imported fertilizer, symbiotic fixation, non-symbiotic, deposition, and nitrogen outputs are exported crops, exported animal products, animal manure, and exported human manure, in the end it divided by the number of farm hectares;
- *Indicator-8/* Pesticide: is the sum of the active ingredients (ai) of the pesticides used in each crop within the farm, and is divided by the number of hectares in the unit resulting in kg ai ha -1 per year;
- *Indicator-9/* Greenhouse Gas Emissions or CO_2 eq (GH): were determined by adding the emissions calculated for the unit regarding: application of green manures, symbiotic nitrogen fixation and atmospheric nitrogen deposition, animal activity UPF daily total (enteric fermentation, animal manure dynamics, application of mineral fertilizers, is divided by the number of hectares of the farm, with unit Mg ha^{-1} per year;
- *Indicator-10/* Forage self-sufficiency: the forage produced within the unit was considered, over the total forage necessary for the animals, including the purchased or obtained outside, indicated as a percentage.

For each of these indicators an objective was also chosen, either as maximization (e.g. Economic profit) or minimization (e.g. GHG Emissions) (Table 12).

Table 12. Performance of three different crop-livestock farms in Mixteca Alta (Oax. Mexico) based indicators obtained in the Describe phase of FarmDESIGN analysis (▲Maximize; ▼ Minimize)

Indicator	Mixteca Alta (Oax. Mexico)				Altiplano Sur (Bolivia)			
	Farm-I	Farm-II	Farm-III	Objective	Farm-I	Farm-II	Farm-III	Objective
Ind-1 (US$ / BS)	2977	254	1090	▲	27600	98785	7314	▲
Ind-2 (%)	91	17	66	▲	100	60	40.4	▲
Ind-3 (hours $Year^{-1}$)	5297	1671	6429	▲	7762	- 427	4206	▲
Ind-4 (%)	62	73	54	▼	100	82.2	62.8	▼
Ind-5 (persons fed ha^{-1} $Year^{-1}$)	3.3	1.8	3.9	▲	2.3	0.9	3.9	▲
Ind-6 (kg ha^{-1} $Year^{-1}$)	63	275	-53	▲	462	426	826	▲
Ind-7 (kg ha^{-1} $Year^{-1}$)	52	44	58	▲	50	50	200	▲
Ind-8 (kg ha^{-1} $Year^{-1}$)	0.01	0.01	0.23	▼	-	-	-	▼
Ind-9 (Mg CO_2 eq ha^{-1} $Year^{-1}$)	5.5	4.4	2.5	▼	-	-	-	▼
Ind-10 (%)	51	39	24	▲	0.0	0.0	28.8	▲

In the preliminary results for both sites in LAC a large variability on the performance of different farms can be seen and potential tradeoffs between environmental and economic indicators are being revealed (Figure 16). With the optimization capabilities of the model, further assessment can be done to quantify the performance and the trade-off among indicators under different scenarios of adoption of CLCA activities enlarging the window of opportunities for improved performance of farming systems by adding a set of alternative crop and livestock management practices in the optimization routine.

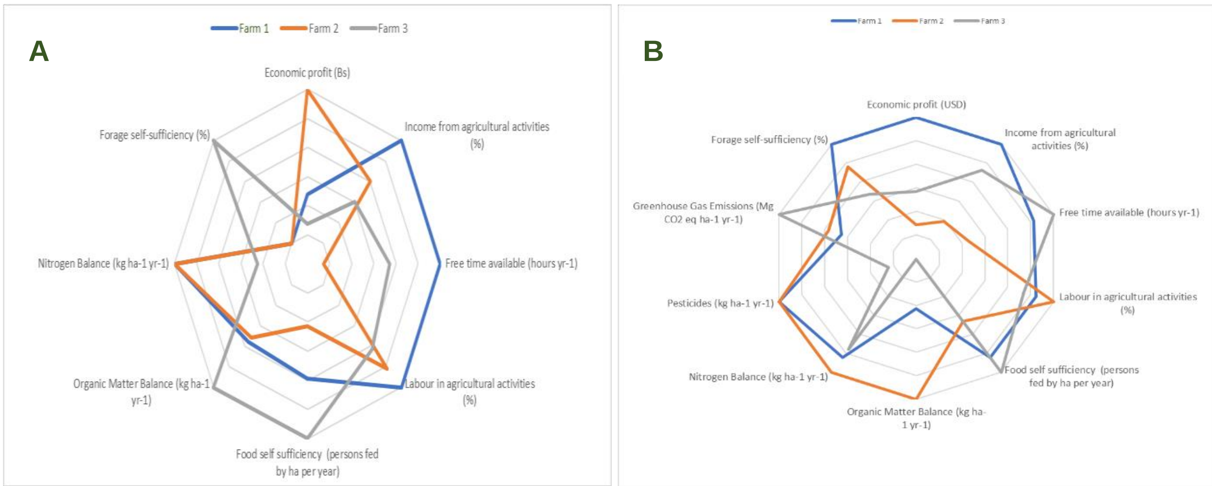


Figure 16. A radar graph to compare the performance of eight indicators obtained in the Describe phase of FarmDESIGN analysis for three farms in Altiplano Sur, Bolivia (A) and Mixteca Alta, Oax. Mexico (B)

Modelling of trade-offs due to the adoption of CLCA systems in North Africa Countries

The objectives of the socioeconomic activities of CLCA in North Africa is to co-create and share knowledge on the applicability of CA to support food security, enhance food production and to prevent land degradation in the agroecosystems selected by the CLCA project in both **Tunisia and Algeria**. During this second year, many background and prospective studies were undertaken in this regard to help and guide the scaling efforts of the project members in both countries.

Identification and assessment of the main drivers of crops residues patterns in the cereal-sheep production systems

The objective of this activity is to characterize trade-offs related to the use of crop residues in the small cereal-sheep farms of North West **Tunisia**. For doing so, we firstly quantify the quantity of cereal biomass residues left on the soil in addition to the quantity harvest and the one grazed in the summer. This was done for a set of farmers based on survey data (150 farmers in Seliana-**Tunisia**) and the Harvest Index of the cereal crops cultivated in the study areas. Secondly, a Bayesian Belief Network (BBN) model is used to analyse the complex relationships (causality linkages) of factors influencing farmer's choices regarding crop residues allocation (across mulch and feed). This BBN analysis is so far conducted only for **Tunisia** (a regression model to explain residues management patterns was applied for **Algeria** – see results

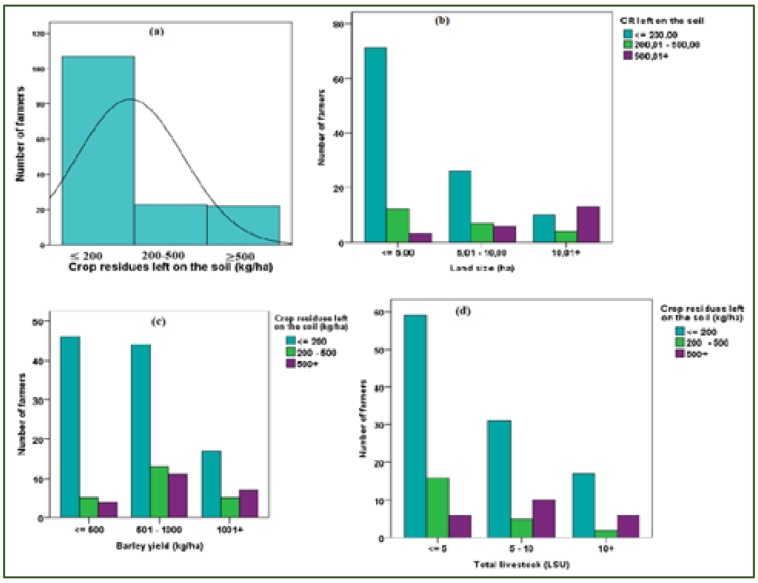


Figure 17. Distribution of the quantity of crop residues left on the soil (a), Quantity of crop residues left on the soil as function of the total number of land size (b), barley yield(c), number of livestock (expressed on LSU) (d) - Tunisia

below). It is important to note that even for the case of Tunisia, this quantification and causality assessment was based on data from CLCA I project (in Seliana). We prepared relevant surveys to collect similar data and conduct similar analysis in the newly selected sites of CLCA II, but data collection was delayed due to the COVID-19 crisis and related confinement in North Africa countries.

Results of this analysis from Seliana, **Tunisia** (Figure 17) show that, 74% of farmers are keeping less than 200 kg/ha, of crop residue as mulch. This is especially relevant for the smallest farms with limited grazing opportunities and financial capacities to complement their animals with concentrate feed. The residue management is especially influenced by the share of livestock income, livestock herds, cost of livestock feed, barley area, and available grazing areas.

The same type of analysis was conducted for the region of M'Sila, **Algeria** (350 farmers). Results of crop residues quantification and management patterns in M'Sila (Figure 18) shows that more than 50% of farmers in the study area retain more than 500 kg/ha of cereal residues on the soil. About 25% of farmers maintain between 200 and 500 kg/ha and around 25% do retain less than 200 kg/ha. It is thus clear that farmers in **Algeria** as keeping more residues on the soil compared to their Tunisian counterparts. It is however important to relate these results to another major structural characteristics of farmers in M'Sila, where about 55.5% of farms are larger than ten (10) hectares.

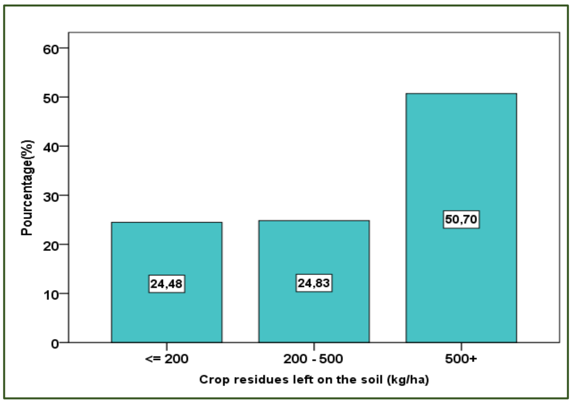


Figure 18. Distribution of the quantity of crop residues left on the soil (kg/ha) – Algeria

On contrast, in Seliana/**Tunisia** more than 48% of farms have a small size lower than five (5) hectares (Figure 19). More than 70% of farmers in our sample have low to medium cost of livestock feed while only 29.1% of farmers have high feed cost for their livestock. Most farmers have more than 60% as a share of livestock income. Moreover, about 72% of farmers have less than one livestock unit per hectare (LSU/ ha). Concerning the quantity of concentrate consumed by livestock 37.5% of farmers use less than 200 kg/LSU. On the other hand, 48% of farmers have less than two ha of barley whilst, only 15.8% have more than 5 hectares cultivated with this feed commodity. The majority of farmers (48%) have access to a grazed area smaller than fifteen hectares while 30% have access to more than 30 ha.

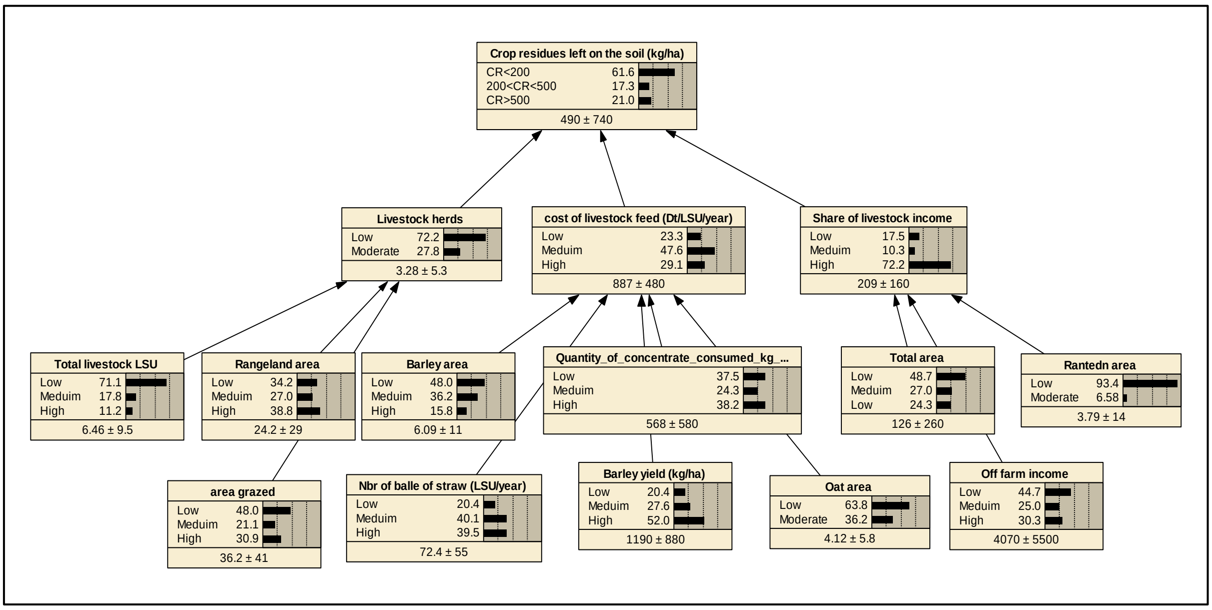


Figure 19. BBN Network (causality) results explaining factors driving different residue management patterns – Numbers in the network are explaining probability distributions

BBN results showed that increasing the quantity of the crop residues left on the soil in the study area is highly related to the share of livestock income, livestock herds, and cost of livestock feed. “Share of livestock income” has the highest significant effect on the decision of farmers keeping more than 500 kg of residues per ha. Results provide evidence that enhancing crop residue management can only happen when we reduce the probability of having farms with high share of livestock in the farm income (more than 30%), in addition to farms with low overall cost of feed (farmers trying to minimize feeding costs are the ones who overgraze the most).

For the case of **Algeria**, it has been demonstrated, through a logit econometric regression, that a level of residues left on the soil (after summer grazing) higher than 500 kg/ha is significantly and positively correlated with number of bales of barley straw produced by the farmer, the level of barley yield, the level of durum wheat yield, and the share of livestock in the total income. This means that farmers having higher values of these variables are also keeping higher quantities of residues on their soil. The dependent variable is however negatively and significantly correlated to the rangeland area grazed by the farmer, and number of bales of wheat (Table 13).

Table 13. Explanatory variables of crop residues management in M’Sila (Algeria)

<table>
<tr><th colspan="2" rowspan="2">Variable</th><th rowspan="2">Signification</th><th colspan="2">CR>500 Kg/ha</th></tr>
<tr><th>A</th><th>Exp (A)</th></tr>
<tr><td colspan="2">Area of crop residue grazed (ha)</td><td>0,01</td><td>-0.037</td><td>0.964</td></tr>
<tr><td colspan="2">Rangeland area (ha)</td><td>0.350</td><td>-0.005**</td><td>0.995</td></tr>
<tr><td colspan="2">Number of bales of durum wheat</td><td>0.000</td><td>-0.34***</td><td>0.966</td></tr>
<tr><td colspan="2">Number of bales of barley</td><td>0.003</td><td>0.001***</td><td>1.001</td></tr>
<tr><td colspan="2">Barley yield (kg/ha)</td><td>0.000</td><td>0.008***</td><td>1.008</td></tr>
<tr><td colspan="2">Durum wheat yield (kg/ha)</td><td>0.000</td><td>0.004***</td><td>1.004</td></tr>
<tr><td colspan="2">Share of barley straw in the total straw</td><td>0.115</td><td>-1.504</td><td>0.222</td></tr>
<tr><td colspan="2">Livestock herds</td><td>0.458</td><td>0.148</td><td>1.159</td></tr>
<tr><td colspan="2">Share of livestock income</td><td>0,002</td><td>0.031***</td><td>0.969</td></tr>
<tr><td colspan="2">-2 Log Likelihood</td><td colspan="3">254.520</td></tr>
<tr><td colspan="2">Cox & Snell R Square</td><td colspan="3">0.391</td></tr>
<tr><td colspan="2">Nagelkerke R Square</td><td colspan="3">0.522</td></tr>
<tr><td rowspan="2">Hosmer and Lemeshow Test</td><td>Chi-square</td><td colspan="3">10.752</td></tr>
<tr><td>Signification</td><td colspan="3">0.216</td></tr>
<tr><td colspan="2">Overall percentage (%)</td><td colspan="3">79</td></tr>
</table>

Farm Design modelling

In North African countries, the main objective of this activity was to build a bioeconomic model using the FarmDESIGN model to explore current state and future possibilities of Crop-Livestock integration in sheep-cereal farm types for each site (Zaghouan – **Tunisia**, and Setif & Oum Bouaghi – **Algeria**). This activity aims to simulate CLCA management practices for finding compromises related to the biomass trade-offs being investigated and build a model for each of the farm types identified in the first typology step.

The diversity of sheep-cereal farming systems in Zaghouan, North East of **Tunisia**, were characterized using a typology. The data used for the typology was collected in 2018, in the context of the ‘Mind the Gap’ project funded by GIZ and implemented by ICARDA in the same project area. For the typology construction, the framework of Alvarez, Paas, Descheemaeker, Tittonell, and Groot (2014); Alvarez et al. (2018) is being used. This framework aims to use both expert knowledge, participatory approach and multivariate statistical methods. Steps performed were: i) pre-screening of the data, ii) selection of the key variables, iii) data reduction by using Principal Component Analysis (PCA), iv) clustering the farms by using Hierarchical Clustering (HC), v) testing the significance of the formed types using both Kruskall-wallice as Post-Hoc test of Bonneferoni, and vi) describing the formed types.

Six (6) farm types were formed (Figure 20), which can be shortly described as follow:

- ✓ Relatively small average farm size of two (2) hectares, having low livestock counts (10 sheep) and cultivating small plots of barley and olives;
- ✓ Relatively small average farm size of 1.5 hectares, having a slightly larger herd (20 sheep) and cultivating small plots of barley and olives;

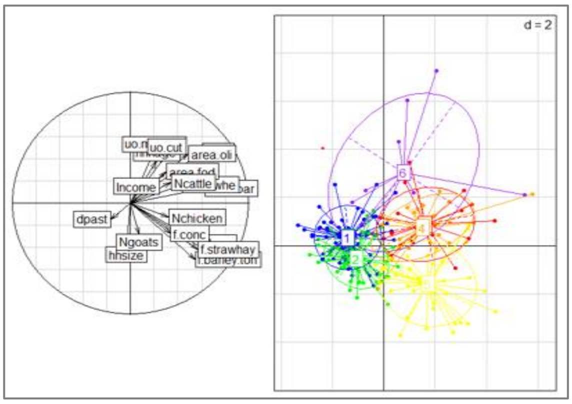


Figure 20. Farm types – Zaghouan Site, North East Tunisia

- ✓ Relatively larger farms (8.7 ha), having relatively large plots of olives (4.7 ha). Herd consists of 30 sheep and barley is also cultivated;
- ✓ Relatively larger farms (5.2 ha), with more diversification in cropland. Besides olives and barley, wheat and fodder are also cultivated. In this farm types farmers also may have some cows;
- ✓ Average farm size (3.6 ha) with more livestock (39 sheep). Feed inputs are relatively high. In this farm types farmers also may have some cows;
- ✓ Small group of farms which not necessarily show similar configuration, but does show higher counts of integration, using own crop residues and manure.

To measure current integration and performance in addition to future improvement scenarios of these attributes, a farm level modelling with FarmDESIGN is being performed. Four (4) farm visits, including a farm tour and detailed household-survey, were done in Zaghouan in order to be able to fill the farm types 1-5 in FarmDESIGN. The survey focussed on general livestock and crop management and yields with detailed real data collected from each. Furthermore, during the survey attention was payed to current management concerning Crop-Livestock integration, for example management of residues, manure and feed. The four (4) farms visited did not resemble the types well enough to serve as real case study farm highly representative of the identified farm types. Therefore, the information obtained from the visits was combined to deduce general management practices of farming systems in Zaghouan. The types were then formed in FarmDESIGN using both the information of the farm visits (costs, management, yields, residue management etc.), as well as the general configurations (structural characteristics) of each type based on the typology (LU, grazing management, cropland hectares). The objective of this modelling exercise is to explore the effect of crop-livestock integration on the economic and environmental (soil fertility) performances of the farm. Once filled of data and calibrated for each farm type, the farm design model allows to choose an optimization “objective” (direction) among a list of possible objectives, and then provides all possible crop and livestock management options (hypothetic farms) which could help reaching these specific objectives. The objectives, allowed to be optimized by Farm Design, and which will be considered in the current study are as follows:

- ✓ Maximizing OM balance, which refers to the accumulation of organic matter in the soil thus improving soil life, resilience, and long-term productivity;
- ✓ Maximizing farm operating profit to guarantee (improved) income;
- ✓ Maximizing area of fodder crops provided to farmers in Zaghouan in context of the CLCA project. On-farm fodder production may improve integration and also contributes to soil building. Furthermore, it serves diversification in rotations, adding to CA as well. Fodder crop seeds are also distributed among farmers Zaghouan which makes it interesting option to look at;

- ✓ Maximizing self-sufficiency of feed supply at the farm level, given the promoted species by the CLCA project in the region;
- ✓ Either maximizing soil N balance up until 15 kg/ha to avoid mining; or minimizing N soil losses.

From the set of management practices suggested/resulting for each of the previous farm design runs and types, the management options, which are closest to the current real farms configurations and to the project scope of intervention, will be further promoted.

The same analysis was planned to be conducted for the new sites in Algeria, and data collection started early February/March. However, this was interrupted due to the COVID19 crisis. CLCA team of ICARDA and national programs in Tunisia and Algeria are now planning a webinar – Online training on FarmDESIGN model (will be provided by Wageningen University and CIMMYT scientists), which will help to continue the implementation of this modelling approach in both North Africa countries.

Generating suitability map for sustainable CA adoption in Zaghouan (Watershed level modeling)

The aim of this activity is to generate suitability map for sustainable CA adoption at watershed level, integrating both biophysical and socioeconomic suitability indicators and acceptance. Such a map generation is based on a participatory generic framework, simple to use by stakeholders that combine Geographic Information System (GIS) and the "Simple Multi-Attribute Rating Technique" (SMART).

A participatory SMART method is used to calculate a composite sustainability indicator (SCI) for a CA adoption in terms of economic viability, environmental protection and social equity. The SCI, calculated from the perspective of stakeholder groups will be integrated into the biophysical suitability maps. The framework (Figure 21) will be tested in Oued Rmal watershed, Zaghouan site. The adopted approach can be useful to support decision making and potential investments in CA in the dry areas of Tunisia.

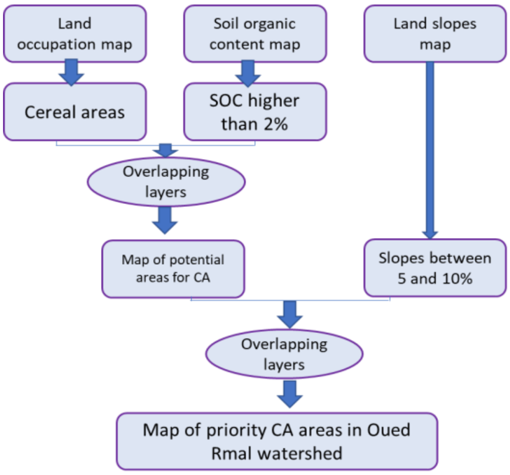


Figure 21. Conceptual approach for mapping CA suitability map in Oued Rmal watershed, Zaghouan, North East Tunisia

While the biophysical suitability map has been already generated (Figure 22), the inclusion of socioeconomic indicators (CSI) is however still pending due to the lack of data (constrained by the COVID 19 pandemic).

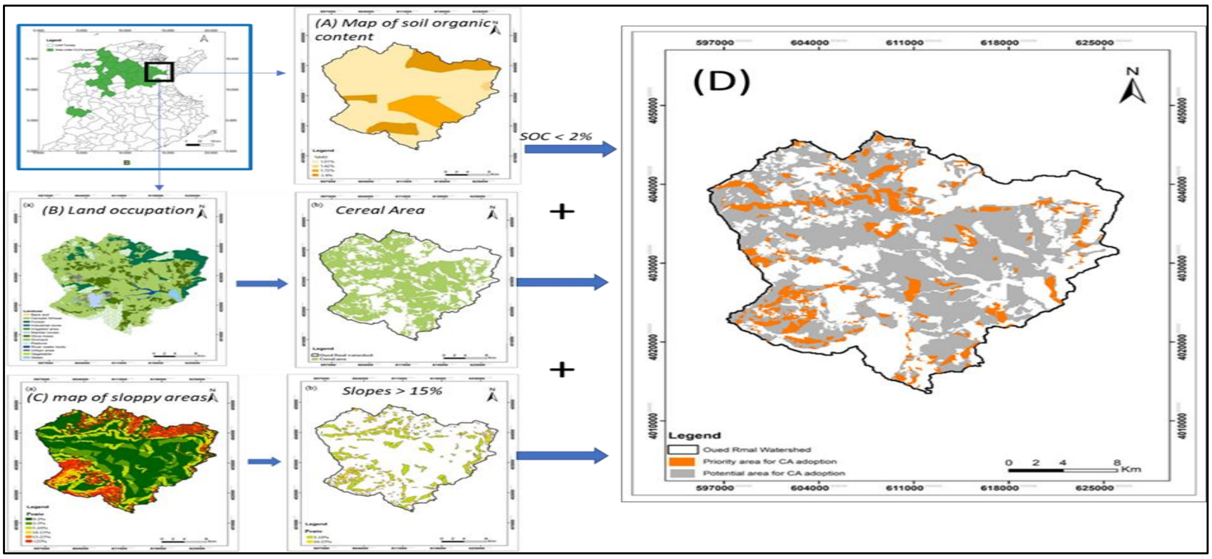


Figure 22. (A) Land occupation in Oued Rmal watershed (Cereal areas); (B) Map of soil organic content (> 2%); (C) Map of sloppy area (> 15%); and (D) Resulting potential priority areas with low fertility level (MO < 2%) cereal occupation, and sloppy areas, where CA adoption can be encouraged for environmental objectives

Preliminary assessments of mapping sloppy agricultural land on cereal crops and on low fertility maps shows that the potential areas for adopting CA in Zaghouan-Oued Rmal watershed are about 38,000 ha, with high priority areas reaching 9,047 ha (24% of total cereal area in the watershed).

Spatially explicit cost benefit analysis of CA adoption

The aim of this activities is to provide a spatially explicit Extended Cost Benefit Analysis (ECBA) of CA adoption in Zaghouan in **Tunisia**. Firstly, the ECBA framework will internalize environmental and social impacts of CA adoption at large watershed scale. Conventional CBA is a decision-support tool for assessing the social and economic costs and benefits associated with an existing or proposed project, programme, or policy over a given period. CBA compares the present value of a stream of benefits (positive effects) with the present value of all investments and recurrent costs (negatives). ECBA extends CBA by including the environmental impacts of a proposed project, programme, or policy, thus, incorporating indirect effects of CA adoption on environmental rehabilitation (particularly reducing of erosion and enhancing soil fertility). Secondly, attention will be paid to the spatial variation in the costs and benefits involved (as a function of environmental conditions and distance to markets). All economic and environmental costs and benefits will be added to a cash flow and a discount rate will be applied. It is assumed that land users will only potentially implement technologies if they are financially viable over reasonable (acceptable) time range. Final output of this study will be a high-resolution map describing the distribution of (environmental) cost and benefit of CA adoption on each grid cell.

The investment costs of CA implementation encompass soil preparation and Seeder purchase and maintenance. Only one type of off-site impact was considered so far, i.e., preventing soil erosion as a positive consequence of CA (we will try to include soil fertility next year).

Preliminary results (Table 14) suggest that CA investment increases the Internal Rate of Return (IRR) and the Net Present the Value (NPV), respectively, from 16.2 % and 347 TND/ha to 20.4% and 746 TND/ha. The ECBA shows that with positive environmental externalities in the form of reducing land degradation, CA did benefit the local population at both the household and societal levels.

Table 14. Extended Cost Benefit Analysis of CA adoption: Case of Zaghouan site - Tunisia

	Financial CBA (12%)	Extended CBA (8%)
NPV/ha (TND)	374	746
IRR (%)	16.5	20.40

Economic valuation and adoption assessment of CLCA related technologies

- ✓ **Economic evaluation of the practice of conservation agriculture in comparison with the conventional system under the crop-livestock system**

The activity aims to provide a quantitative analysis in order to guide farmers towards future decisions to adopt these innovations. Thus, cost calculation represents an economic justification for the choice of innovations by the farmers. The cost-benefit analysis was conducted according to a comparative approach of conservation agriculture regrouping two (2) variants: Zero-till (ZT) and Simplified Cultivation Technique (SCT) with the conventional system, to highlight the economic effects of conservation agriculture under crop-livestock system. Simplified cultivation technique which is expanding rapidly in **Algeria** is considered as a smart agronomic practice that may eventually lead to the full package of CA and it consists in minimum ploughing of the soil surface prior to the sowing season. To this end, the costs generated by the various farming operations and the incomes were quantified using a data sheet valued on the technical itinerary practiced by the farmers in conservation agriculture [direct seeding (ZT) and simplified cultivation techniques (SCT)] and farmers in conventional tillage (CT), in rainfed mode (Setif) and under irrigation system (M'Sila).

To integrate livestock in our assessment we calculated the expenses generated by the maintenance of the livestock (Vaccination, Shepherd expenses) and supplemental feeding (Concentrate). The feeding ration is calculated according to a conventional feeding plan practiced and a feeding plan under CA (Table 15).

Table 15. Practiced feeding plan under CT and CA systems

Under CT System				
September - February	**March/Flushing**	**April – May**	**June – July –August**	
Natural grazing + Straw + Barley grain	Natural grazing + Straw + Barley grain	Natural grazing (fallow)	Stubble grazing	
Under CA System (ZT and SCT)				
September - February	**March/Flushing**	**April – May**	**June – July**	**August**
Natural grazing + Straw + Barley grain	Natural grazing + Straw + Barley grain	Natural grazing + Straw + Barley grain	Stubble grazing	Straw + Barley grain

Under Irrigated System: M'Sila Site – Algeria

The data analysis of the Cost benefit (CB) per hectare of the three (3) techniques shows that the net return (NR) is slightly different for SCT and ZT (Table 16). The NR obtained by using SCT and ZT are respectively 64621,06 DZD, 65382,62 DZD but it is smaller for CA 60905,98 DZD (-7%) compared to ZT. The highest CB ratio is obtained by ZT and it represents 2.036. This ratio remains almost the same as the last cropping season (2017/18) with a value for about 2.019. The same trend is noted for CA (a ratio of 1.936 in the 2017/18 cropping season and 1.960 in the cropping season 2018/19). During this year we noted that SCT-CBR is slightly more profitable than the last year (2.036 in year-II and 1,744 in year-I).

Table 16. Cost benefit (CB) analysis and comparison between three farming systems modes (SCT, ZT, CT) under irrigated system – M'Sila

Operations	SCT	ZT	CT
Tillage (DZD/ha)			5168,96
Simplified Techniques [2 cover-crops] (DZD/ha)	6137,92		3461,2
Weeding (DZD/ha)	1724,12	11300	1724,12
Sowing (DZD/ha)	4378,36	4378,36	4378,36
Fertilization (DZD/ha)	21069,18	21069,18	21069,18
Fuel (DZD/ha)	1291,36	322,84	1614,2
Irrigation (DZD/ha)	13780	9187	13780
Harvesting (DZD/ha)	11500	12000	11500
Transportation (DZD/ha)	1000	1000	800
Agricultural inputs (DZD/ha)	60880,94	59257,38	63496,02
Vaccination (DZD/ha)	168	100	168
livestock grazing (DZD/ha)	490	400	490
livestock feeding (DZD/ha)	840	2000	940
Livestock inputs (DZD/ha)	1498	2500	1598
Total inputs (DZD/ha)	62378,94	61757,38	65094,02
Revenues			
Agricultural revenues (DZD/ha)	112000	109640	111000
Livestock revenues (DZD/ha)	15000	17500	15000
Total revenue (DZD/ha)	127000	127140	126000
Indicators			
Net returns (DZD/ha)	64621,06	65382,62	60905,98
% Change in Net Return (NR)		0,012	0,387
% Change in Total Cost (TC)		-0,010	-0,344
Internal Rate of Return (IRR)		-1,183	-1,123
Benefit-cost ratio 2018/19	2,036	2,059	1,936
Benefit-cost ratio 2017/18	1.774	2.019	1.960

1 US$ = 119,71 DZD

Under Rainfed System: Setif Site

The results related to the rainfed system are displayed in table 17. These findings show that the total costs are higher on conventional agriculture compared to no-till and SCT. The difference per hectare between the two (2) techniques shows that it is evaluated to 12 % comparatively to ZT and 11% to SCT.

Regarding to net returns, the highest CBR was obtained among farmers who practiced ZT with slight difference between the two (2) last cropping seasons (2017/18 and 2018/19).

Table 17. Cost benefit (CB) analysis and comparison between three (3) farming systems modes (SCT, ZT, CT) under rainfed system – Setif

Operations	SCT	ZT	CT
Tillage (DZD/ha)			5 168,96
Simplified farming techniques (DZD/ha)	3 161,20		4 153,44
Weeding (DZD/ha)	5 909,72	9 378,90	5 909,12
Sowing (DZD/ha)	5 218,36	5 218,36	5 218,36
Fertilization (DZD/ha)	30 039,18	30 039,18	30 039,18
Fuel (DZD/ha)	1 291,20	322,84	1 614,20
Harvesting (DZD/ha)	10 000,00	10 000,00	10 000,00
Transportation (DZD/ha)	800,00	800,00	800,00
Agricultural inputs (DZD/ha)	56 419,66	55 759,28	62 903,26
Vaccination (DZD/ha)	163,64	100,00	163,64
Livestock feeding (DZD/ha)	745,00	1 320,00	745,00
Livestock inputs (DZD/ha)	908,64	1 420,00	908,64
Total inputs (DZD/ha)	57 328,30	57 179,28	63 811,90
Revenues			
Agricultural revenues (DZD/ha)	120 600,00	182 700,00	174 100,00
Livestock revenues (DZD/ha)	15 000,00	20 125,00	33 333,33
Total revenue (DZD/ha)	135 600,00	202 825,00	207 433,33
Indicators			
Net returns (DZD/ha)	78 271,70	145 645,72	143 621,44
% Change in NR		0,86	- 0,10
% Change in TC		- 0,00	- 0,10
Internal Rate of Return (IRR)		-331,15	1,00
Benefit-cost ratio 2018/19	2.37	3.55	3.25
Benefit-cost ratio 2017/18	2.42	3.29	3.32

1 US$ = 119,71 DZD

✓ **Economic valuation of the conservation agriculture technical package under crop-livestock system**

The absence of tillage makes it essential to extend rotations to control weeds that are no longer destroyed by ploughing. The cultural succession and the development of diversified cultures make it possible to answer the dual challenge: agro-ecological and agro-economic. Thus, this activity will focus on the economic evaluation of the different rotations practiced in the two (2) regions. The evaluation of CA technologies will focus on the evaluation of the rotations recommended by the project in comparison with those practiced by the farmer in direct seeding under both rainfed agriculture (Setif) and irrigation systems (M'Sila). The different types of rotation practiced in the two (2) regions are presented in table 18.

Table 18. Rotation practiced by farmers *vs* CLCA recommendations

Region	Common farmers rotations	Rotations recommended by CLCA project	Some rotations newly practiced by farmers
Rainfed System (Setif)	Wheat / Wheat Barley / Barley	Wheat / Lentil Wheat / Vetch-Oat **Barley / Feed-pea** **Barley /Vetch**	**Wheat / Lentil** **Wheat / Vetch-Oat** **Wheat / Feed-Pea** **Wheat / Barely**
Irrigated System (M'Sila)	Barley / Barley	Barley / Triticale-Pea Barley / Vetch-Oat	**Barley / Barley** **Wheat / Barley**

Note: Bold rotations are the ones for which cost benefit assessment has been conducted

Under Irrigated System: M'Sila Site

M'Sila is situated in a steppe area, dominated by the cereal-livestock production system, where the cultivation of cereals especially barley is the most important speculation to feed their livestock. Farmers in the area frequently practice Barley/Barley rotation. The review of the CBR of the rotations practiced at M'Sila site shows that the rotation Wheat/Barley is the most profitable (with a CBR for about 0.5) comparing to Barley/Barley rotation (0.11). Though the profitability is low for the two (2) rotations (Table 19)

Table 19. Economic valuation of rotations (practiced by farmers) under irrigated CA system in M'Sila site

Operations/Type of rotation	Barley/Barley (1)	Wheat/Barley (2)
Charges (DZD/ha)	58836,36	65133,19
Revenue (DZD/ha)	63913,64	96346,81
Revenue Net (DZD/ha)	5077,28	31213,62
Indicators		
% Change in NR	-	5,15
% Change in TC	-	0,11
Internal Rate of Return (IRR)	-	48,10
Benefit Cost Ratio (BCR)	0.1	0.5

1 US$ = 119,71 DZD

Under Rainfed System: Setif Site

Under the rainfed system, the findings show that net income from Wheat/Vetch-Oats rotation is higher than the net income of the Wheat/Wheat rotation, with a value of 65,474 DZD ha^{-1} and 23,154 DZD ha^{-1}, respectively (Table 20).

The economic valuation of wheat rotations under CA and comparison between the two (2) cropping seasons under the rainfed system are also displayed in Table 22. The empirical results show that CBR of Wheat/Feed-pea rotation is higher than Wheat/Lentil and Vetch/Oat rotations. The comparison between the two (2) cropping seasons 2017/18 and 2018/19 shows that the profitability decreased between year-I and year-II, Indeed the revenues obtained from Wheat/Feed-pea decreased from 141,926 DZD in year-I to 118,320 DZD in year-II (- 17%) and the CBR indicators of Wheat/Feed-pea, Wheat/Vetch-Oat, and Wheat/Lentil decreased respectively from 3.1 to 1.5, 2.2 to 0.6, and 3.1 to 1.4. This was mainly due the increase of inputs prices (forage seeds, fertilizers, fuel, herbicides, labour) during the 2018/19 cropping season.

Table 20. Economic valuation of Wheat rotations (practiced by farmers) under CA and comparison between the two (2) cropping seasons 2017/18 (Year-I) and 2018/19 (Year-II) – Rotations newly practiced by farmers

Operations/Type of rotations	Wheat/Barely	Wheat/Feed-pea		Wheat/Vetch-Oat		Wheat/Lentil	
	Year-II (2018/19)	Year-I (2017/18)	Year-II (2018/19)	Year-I (2017/18)	Year-II (2018/19)	Year-I (2017/18)	Year-II (2018/19)
Total Charge (DZD /ha)	46536,44	45674,02	47619,64	45834,02	46279,64	45974,02	47919,64
Total Revenue (DZD /ha)	65883,56	141925,98	118320,36	99665,98	75040,36	142125,98	117380,36
Net Returns (DZD /ha)	19347,12	96251,96	70700,72	53831,96	28760,72	96151,96	69460,72
Indicators							
% Change in NR	-	2.1	2.65	0.8	-	2.1	2.59
% Change in TC	-	-0.11	0.02	-0.11	-	-0.1	0.03
Benefit Cost Ratio	0.4	3.1	1.5	2.2	0.6	3.1	1.4

1 US$ = 119,71 DZD

When we analysed the barely rotations options, we noted a decrease of Barely/Feed-pea rotation profitability (Table 21). The revenues declined from 133826 DZD in year-I to 90510 DZD in year-II (-32%) but surprisingly it's not the case for the Barely/Vetch rotation, even though there was an increase of the costs by 20 %. This was due probably to the high yields recorded during the last cropping season (2018/19) and the increase of the selling price of vetch in the local market. It is also noted that the best profitability for wheat and barley rotations under CA in the rainfed area, during this crop season, is respectively Wheat/Feed-pea and Barley/Vetch.

Table 21. Economic valuation of barley rotations (recommended by the CLCA project) under conservation agriculture and comparison between the two (2) cropping seasons 2017/18 (Year-II) and 2018/19 (Year-II) in Setif site

Operations/ Type of rotations	Barley/ Feed Pea		Barley / Vetch	
Cropping season	Year-I (2017/18)	Year-II (2018/19)	Year-I (2017/18)	Year-II (2018/19)
Total Charge (DZD /ha)	33924,02	40349,64	32524,02	38949,64
Total Revenue (DZD /ha)	133825,98	90510,36	131476	219710,36
Net Returns (DZD /ha)	99901,96	50160,72	98951,96	180760,72
Indicators				
% change in NR	2,3	-	2,3	-
% change in TC	0,05	-	0,01	-
Internal Rate of Return (IRR)	46,0	-	230	-
Benefit Cost Ratio	2.9	1.2	3.0	4.6

1 US$ = 119,71 DZD

Establishing appropriate monitoring and evaluation frameworks

Progress for this activity is reported under the section "Monitoring and evaluation".

Component 2. Accelerate adoption through the development of delivery systems/participatory farmer-led extension systems and inform the development of contextually relevant CLCA technologies and practices

Develop a road map – based on previous CLCA initiatives by ICARDA and CIMMYT - for large-scale adoption of CA within dryland crop livestock environments + Integrate scaling partners with the network of on-field, multiscale innovation and validation sites + Develop of network of on-field, multiscale innovation and validation sites

Enabling environment for scaling in the Mixteca Alta/Oaxaca, Mexico – an application of the scaling scan tool

CLCA project in Oaxaca, **Mexico** sets a lot of emphasis on stakeholder participation as part of the research process, to ensure the constructive engagement with the strategic actors throughout the project life cycle and beyond. In February 2020, a multi-stakeholder workshop was held, mainly focused on the insider analysis of innovation capacity for scaling solutions in the CLCA system, and the structural conditions around it. During this participatory workshop, sixty (60) participants attendants from different organizations and institutions, including NGO's, farmer organizations (crop and livestock focused), extension agents, government and academia representatives.

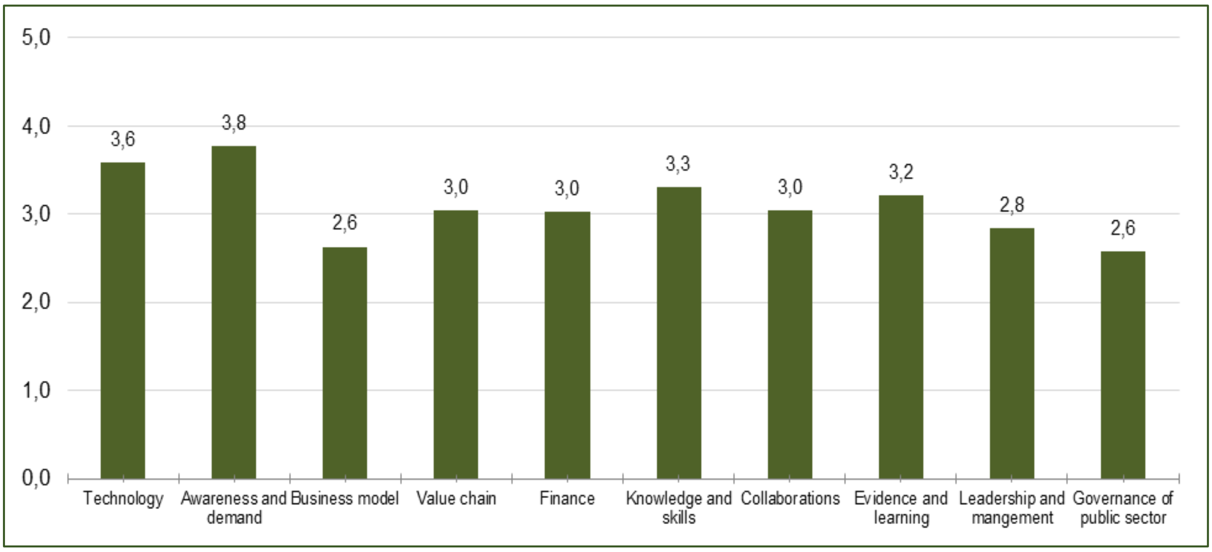


Figure 23. Results of a rapid scan to quantify the status of the enabling environment for scaling CLCA in Oaxaca, Mexico

Most notably the Oaxaca's secretary of Agriculture participated in the workshop, and a group of sixteen (16) agronomy students from the municipality participated. The tool used was the Scaling Scan to identify and analyze challenges and opportunities for the crop livestock system. The above figure 23 shows that the lowest ingredients are business model, governance of public sector, and leadership and management. While the top ingredients are technology, and awareness and demand.

Water scarcity and soil degradation in the Mixteca Alta were recognized as major threats to smallholder livelihoods. Some of the perceived root causes of the soil erosion and degradation are showed in Figure 24.

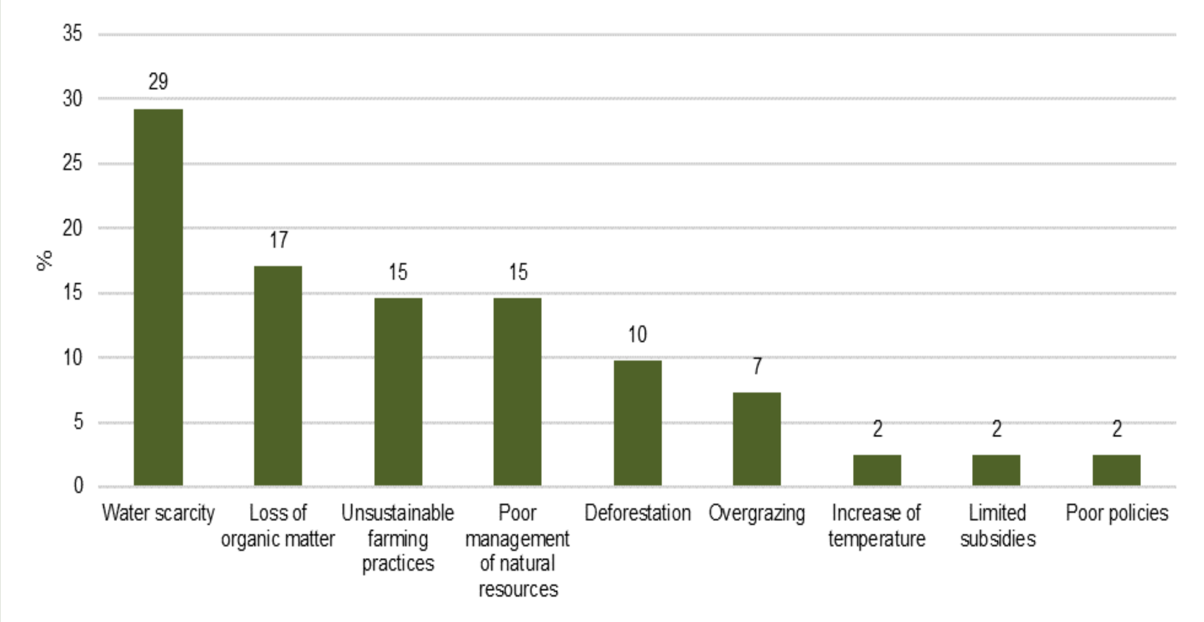


Figure 24. Root causes of the soil erosion in the Mixteca Alta, Oaxaca, by participants of scaling workshop February 2020

According to the participants, the major causes were the ones categorized as water scarcity, loss of organic matter, unsustainable farming practices, and poor management of natural resources.

Water management and soil health in the Mixteca Alta can be improved by the use CLCA practices with the support of local stakeholders and networks. Hence, the recognition of the willingness and promising opportunities existing from a range of sectors and stakeholders to move to a more sustainable production system provides us a positive sign. Noticeable, there are previous experiences in the region related with CA principles and different organizations expressed need to address land degradation and soil erosion of the region. From the farmers' perspective, they recognized that good practices of CA in crop-livestock systems could help them to free time to other activities. This could be positive to increase on/off farm activities that generate an extra income.

Identification of scaling partners to assist with the implementation of the scaling road map

Innovation systems are social systems as they deal with a multiplicity of actors coming together to prioritize challenges, and to jointly uncover opportunities for mutually beneficial outcomes through resolution of these challenges.

For the case of Mixteca Alta, Oaxaca/**Mexico**, all the stakeholders are influenced by informal institutions, practices, behaviors, and attitudes, as well as, formal policies and institutions. This landscape of actors supports or hinders the scaling process.

The hub model is a key component of the Agricultural Innovation System (AIS) in the Mixteca Alta. This model includes testing plots in farmers' fields (called 'innovation modules') and experimental plots (called 'experimental platforms'). As well as the recognition of farmers' fields adapt learned innovations (called 'extension area'). Here, researches, technical advisers, farmers, policy makers, and private companies play a key role in the innovation process to scale sustainable and responsible impact. Table 22 describes these roles per actor.

Table 22. Roles of CLCA AIS actors in the Mixteca Alta, Oaxaca

Name	Role(s) in CLCA
Rural Production Units	Innovate, adapt and diffuse innovations. Responsible of innovation modules and extension areas. Advocates for CA principles.
International Maize and Wheat Improvement Center (CIMMYT)	Lead CLCA-Oaxaca Project. Identify recommendation domains of optimal CLCA management options. Design and use tools and frameworks to capture, analyze and improve agricultural systems. Offer development of capacities and agronomic advice through MasAgro collaborators. Provide initial access to seeds and (new) varieties to assess feasibility.
Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP)	Raise awareness with extension agents and public sector. Support research and innovation by leading an experimental platform in the region.
Secretaria de Desarrollo Agropecuario, Pesca y Acuacultura (SEDAPA)	Support the scaling of CLCA for enhanced water use efficiency, soil fertility and productivity via advocacy, coordinating leadership and alignment of resources. Policy formulation and implementation. Funding.
Local authorities (ex. municipalities)	Support coordination of efforts across the region. Policy formulation and implementation. Funding.
Universidad Autónoma Metropolitana (UAM) – Unidad Xochimilco	Research and development implementation partner. Experts on livestock management.
Fondo para la Paz	Broker of innovation, technical support in the implementation (crop and livestock) and advocates for CA principles.
Sociedad de Producción Rural "Ñuu Kuini Pueblo de Tigre"	Broker of innovation, technical support in the implementation (crop and livestock) and advocates for CA principles
Agricultura Familiar y Agronegocios (AFA)	Broker of innovation, technical support in the implementation (crop and livestock) and advocates for CA principles
Centro de Bachillerato Tecnológico Agropecuario (CBTA)	Reference point to put demonstration plots. Social services are important to support follow trials, and to data collection. Spaces to develop future leaders, farmers, extension agents, etc.
Unión de Ejidos y Comunidades del Valle de Nochixtlán	Lobbyist, articulator and engaged in the implementation process.
Comité Estatal del Sistema Producto Maíz-Frijol de Oaxaca, A.C.	Advocacy leaders, negotiators with other stakeholders, and advisors.
Comité Estatal Del Sistema Producto Caprino de Oaxaca, A.C.	Advocacy leaders, negotiators with other stakeholders, and advisors.
Proyecto Mixteca Sustentable, A.C.	Broker of innovation, technical support in the implementation (crop and livestock) and advocator of CA principles
Instituto de Investigaciones en Ecosistemas y Sustentabilidad, Universidad Autónoma Nacional de México (IIES-UNAM)	Research and development implementation partner. Experts on sustainable rural development. Mediators.

To conclude, promoting innovations in agriculture requires coordination and leadership from agricultural research, extension and education to policy, management and trade, by fostering innovation partnerships and linkages along and beyond agricultural value chains, and creating an enabling environment for sustainable and responsible impact at scale. Further steps to be taken are: i) review and adapt roles and responsibilities with stakeholders, ii) development and iterative feedback of the scaling road map, and iii) development and follow-up of critical scaling ingredients. Finally, during the course of the project most interested and best suited stakeholders have to be determined to take the leadership on scaling CA principles in the Mixteca Alta.

In **North Africa**, and to further aggregate the project scaling activities under the scaling hubs planned to be consolidated in Year-III, the project teams started identifying a list of potential scaling partners who can be directly or indirectly involved in the scaling activities in the remaining project duration. Some of these will be supported to serve as scaling vehicles even after the end of the project. The identified scaling partners in **Tunisia** and **Algeria** are listed in table 23.

Table 23. CLCA extended partnership in Tunisia and Algeria

Country	Acronym		Name	Type of Organization
Tunisia	IRESA		Institution of Agricultural Research and Higher Education	National Agricultural Research System
	IRESA	INRAT	Institut National de Recherche Agronomique de Tunisie	
		INRGREF	Institut National de la Recherche en Génie Rural, Eaux et Forêts	
		INAT	Institut National Agronomique de Tunisie	Academic Institution
		ESAM	Ecole supérieure de l'agriculture de Mograne	
		ESAK	Ecole Supérieure d'Agriculture du Kef	
	INGC		Institut National des Grandes Cultures	Development institutions and agencies
	OEP		Office de l'Elevage et des Pâturages	
	AVFA		Agence de la Vulgarisation et de la Formation Agricoles	
	CRDAs		Commissariats Régionaux de Développement Agricole	
	ATAE		Association Tunisienne d'Agriculture Environnementale	NGO
	APAD		Association Pour l'Agriculture Durable	
	GDAs		Groupements de développement Agricole	Farmers associations
	GFDAs		Groupements Féminin pour le Développement Agricole	Community Based Organization (CBO) – Women Farmers
	SMSAs		Sociétés Mutuelles des Services Agricoles	Farmers Cooperatives
	COTUGRAIN		Compagnie Grainière Tunisienne	Private Sector
	ICT2scale Project			ICARDA ongoing project
	Food Security Project			ICARDA ongoing project
	CRP-Livestock			ICARDA ongoing project
Algeria	ITGC		Institut Technique des Grandes Cultures	National Agricultural Research and Extension Services
	ITELV		Institut Technique des Elevages	
	DSA		Direction Des Services Agricoles	
	INSID		National Institute of Soils, Irrigation and Drainage	
	ITMAS		Institut De Technologie Moyen Agricole Spécialisé	
	HCDS		Haut-Commissariat au Développement de la Steppe	
	PMAT		National Company of Agricultural Equipment Production & Trading	Private Sector
	CCLS		Coopérative de Céréales & de Légumes Secs	Government – Farmers Cooperative
	CAW		Chambre d'Agriculture de la Wilaya	
	CNCC		Centre National de Contrôle et de Certification des semences et plants	National Agricultural Research and Extension Services
	CWIF		Conseil national interprofessionnel de la filière	Farmers Cooperatives
	COOPSSEL		Coopérative de services spécialisée en élevage	
	CASAP		Coopérative Agricole de Services et des Approvisionnement	
	GIC		Groupement d'Intérêt Commun	Farmers association
	CIC		Conseil Interprofessionnel de Céréales	Farmers Cooperatives
	CIL		Conseil Interprofessionnel des Légumineuses	
	REQUAblé		Réseau qualité de blé	Farmers association
	Prodec		Association des producteurs de céréales et de semences	NGO
	irregators		Association des Irrigateurs	
	ATU		"Trait d'Union" Association for Modern Agriculture	
	Setif - "Farhat Abbes" University			Academic Institutions
	University Mohamed Boudiaf - M'Sila			
	Université M'Hamed BOUGARA de Boumerdès			
	Université - Mouloud - Mammeri -de Tizi Ouzou			
	École nationale supérieure agronomique d'Alger (ENSA)			
	Université Mohamed El Bachir El Ibrahimi de Bordj Bou Arreridj			
	Université de Batna			

Identify women's (both women-headed households and women in male headed households) decision-making constraints and develop opportunities to effective CLCA adoption

In this section, we are reporting the CIMMYT household study in **Bolivia** and **Mexico**, while in the section related to "gender focus", we will report the project achievements in the field in terms of gender inclusiveness.

Within the CLCA project, considering social inclusion determinants, is an essential part of the multidisciplinary integrated process of research and intervention that seeks the sustainability of food production.

Targeting alternatives and implementation of interventions at a larger scale, need to consider that farm assets, farm functions and household dynamics are heterogeneous, and that more than one characteristic of the farms would determine which interventions or alternatives suit best the farmers objectives. Among these heterogeneous characteristics considering social determinants is helpful. Having a map of the possible obstacles a farm might face towards accepting or practicing new technical alternatives, because of its social identity is crucial to enhance social inclusion.

With the aim of examining the implications of different CLCA alternatives in women's involvement and empowerment, a wider approach to farm typologies was adopted and a novel typology of farming system was developed for the regions of Mixteca Alta in **Mexico** and Altiplano Sur in **Bolivia** taking into account social inclusion determinants.

A quantitative approach was followed to characterize the diversity of farming systems exploiting the ProCamelidos baseline survey for Bolivia and the ProAgro survey carried out by CIMMYT in 2019 for Mexico. A Principal Component Analysis (PCA) followed by Hierarchical Clustering (HC) was employed to define relatively homogeneous and distinguishable farm-household types. The variables included in the analysis comprised structural and functional features of the farm household (i.e. resources available and use) as well as social variables such as ethnicity, age, education and gender of the household head and/or its members.

Six (6) types (T) of farm households were identified in **Bolivia**: i) High production crop-livestock households (T1), ii) Livestock households with limited resources (T2), iii) Households with diversified incomes (T3), iv) Young family households (T4), v) Elder farm households (T5), and vi) Households with extensive livestock management (T6) _ it was observed that the livestock sub-system (especially llamas) is an element that is always present, and that sometimes there is a division of labor in which women are more related to livestock husbandry and men to crops production. Another finding is that the use of land is more intensive as the area is smaller, although in general, all farms have large herds and big areas. For the **Mexico** case study, five (5) types of farm households where determined: i) Elder farm households (T1), ii) Crop-livestock households using animal traction (T2), iii) Crop-livestock households with limited resources (T3), iv) Female-headed households (T4), and v) Households focus on crops and off-farm activities (T5) _ In Mixteca Alta, women participate heavily in agriculture but are less empowered as they do not take decisions. For both regions, the types and their characteristics are summarized in table 24.

Table 24. Farming systems diversity in Altiplano Sur (Bolivia) & Mixteca Alta (Mexico)

Altiplano Sur (Bolivia)			
T	**Type**	**Structural-Functional Characteristics**	**Social Characteristics**
T1	(n: 55 / 9.6%) High production crop-livestock households	Small land areas (67.5 ha) for grazing (78.5%). Income, $ 3,000 USD, produced on farm (95%), from agriculture (65.7%) and livestock (30.1%). They produce up to 3.2 Mg ha-1 of quinoa with the highest yield (0.3 Mg ha-1) and 0.3 Mg ha-1 of potato; higher self-consumption of crops (63.3%). They have herds of 68.4 llamas in high density (1.42 llamas /ha).	Populated families (4.3 persons) all working their land (96.3%) and being residents (72.8%). Young people (34.1 years) of secondary education (2.7). Women working in livestock (80.0%) and men in agriculture (85.5%). Unlikely to be found in Challapata or Turco, but likely to be found in Uyuni. They have little probability to be found in Santiago de Machaca.
T2	(n: 29 / 5.1%) Livestock households with limited resources	Farms with the smallest area (45.2 ha) with 81.5% for grazing. Income of $ 1000 USD from livestock (87.8%). They produce 0.05 Mg ha^{-1} of quinoa and consume 1/3 of the production. They have herds of 64 llamas in high density (1.47).	Families of 3.7 people, the majority working their own land (59.4%), residents (62.4%). Young people (35.9 years), with the highest proportion of females as household heads (27.6%). Women work in livestock (89.7%) and men in agriculture (55.2%). With an unemployed population (10.3% women, 27.6% men). Unlikely to be found in Challapata or Turco, but highly probable in Uyuni.
T3	(n: 103 / 18.1%) Households with diversified incomes	Area of 87.7 ha, for grazing 81.1%. Income of $ 3.6 thousand USD generated off farm (74.0%). They produce 0.2 Mg ha^{-1} of quinoa and consume 1/3. They have herds of 59 llamas.	High population (4.4 members) working on farm (87.7%), residents (66.4%). 7.8% of female household heads, with the highest education (2.8). Women work in livestock (53.4%) and men in agriculture (63.1%). 11.7% of unemployed people. High probability of being found in Challapata.
T4	(n: 184 / 32.3%) Young family households	Area of 87.8 ha, 84.9% for grazing. Income of $ 1.1 thousand USD produced on farm (88.3%) by livestock (88.3%). They produce 0.2 Mg ha-1 of potato and consume 1/3. They have herds of 78.9 llamas with a density of 1.01.	Large families (4.5 members) all working on their farm (90.1%), residents (71.6%). Young people (32 years), moderate education (2.7). Women as household heads 1/5. Women working in livestock (55.4%) and 1/3 in agriculture, while men in agriculture (70.1%). Less likely to find them in Santiago de Machacha.
T5	(n: 123 / 21.6%) Elder farm households	Area of 118 ha, 80.1% for grazing. Income of $ 1.8 thousand USD produced on farm (64.2%) from livestock (62.4%). They produce 0.1 Mg ha^{-1} of potatoes, of which they consume 10.3%. They have herds of 80 llamas with low density (0.8).	Smaller family population (1.7 members), working on their farm 96.2%, few residents (30.1%). Members of older age (59.4) and less education (1.7). Large female household heads (26.8%). Likely to find them in Santiago de Machaca, less likely in Uyuni.
T6	(n: 76 / 13.3%) Households with extensive livestock management	Larger areas (278 ha). Income of $ 3.6 thousand USD from livestock (77.0%). They produce 0.2 Mg ha^{-1} of quinoa and consume 1/10. They have herds of 215 llamas in low density (0.8).	Families of four (4) persons, working on their farms (94.3%). Average age (41.8). 10% of female household heads. Women are related livestock rearing (46.1%) and agriculture (43.4%) and men to agriculture (84.4%) Less likely to be found in Uyuni and Challapata, and more likely in Turco.

Table 24. Cont'd

Mixteca Alta (Mexico)			
T	**Type**	**Structural-Functional Characteristics**	**Social Characteristics**
T1	(n: 7 / 7.6%) Elder farm households	At an altitude of 1,178 m in zones with high-value of wage ($ 5.3 UDS), little participation of women and youth in local agriculture (0.6). 2.1 ha areas, with land in fallow (2.7 ha). Plots in hilly regions (1.4) without irrigation (0.3); production in two cycles (1.6). Low mechanization (22.1%) with own machinery (2.7) and hired machinery ($ 84 USD ha^{-1}). Big cattle (1.6). They work little outside the farm (7.6%) and contract 1/3 of the agricultural work on the farm. They consume 37.1% of their production. Annual income of $ 1,176 USD, from social transfers (47.9%), other sources (20.0%) and remittances (17.1%). Yield in corn of 1.2 Mg ha^{-1}, and self-consumption of maize 58.0%.	Oldest family's average age (62.9 years) and lowest education (0.7). Higher degree of economic dependency (67.6%). Greater participation of women in agriculture (35.7%), without decision-making (14.3%). They are not considered indigenous, with a lower probability of being poor (62.6%).
T2	(n: 10 / 10.9%) Crop-livestock households using animal traction	At an altitude of 2,345 m in zones with high-value of wage ($ 6.2 UDS), with youth and women participating in local agriculture (1). Surfaces of 0.9 ha. Plots in terrain with slopes (1.9) without irrigation (0.1). Little mechanization (17.5%), with manual and animal tools. Big cattle (1.7). They work outside the farm (97.5%), they do not hire labor (18.5%). They consume 1/3 of their production. The highest income ($ 2520 USD), from agriculture (62.7%). Yield in corn of 2.5 Mg ha^{-1}, and self-consumption of 76.5%.	Average age 47 years, with higher education (1.2). Low economic dependency (17.5%). Women work in agriculture (90.0%), without low decisions-making levels (4.0%). Some households with female household heads (3.2). They are considered indigenous (1.0). probability of being poor 75.9%.
T3	(n: 26 / 28.2%) Crop-livestock households with limited resources	At an altitude of 2,124 m in high-value wage zones ($ 6 USD). Surface of 2.1 ha, with 0.3 ha in fallow. Hilly plots (1.7) without irrigation (0.2). Low mechanization (15.2%). Few major (1.3) and minor (1) cattle, with poultry (0.3). Low work off farm (9.8%), and low labor hiring (19.2%). High self-consumption (54.2%). Income of $ 840 USD, from agriculture (45.0%) and livestock (15.0%). Yield in corn of 0.9 Mg ha^{-1}, and self-consumption of 97.1%.	Youngest families (46.8), with low education levels. Low economic dependency (30.9%). Women related to agriculture (86.2%). probability of being poor 75.9%.
T4	(n: 17 / 18.5%) Female-headed households	At an altitude of 2,243 m in low-value wage zones ($ 5 UDS). Area of 1.5 ha, 0.3 ha for livestock and 0.3 ha at rest. HIlly plots (1.7) without irrigation (1.1). Mechanized tasks (35.5%), with own equipment (2.9). They hire the largest workforce (58.5%). Little cattle (0.8) and pigs (0.2). Income of $ 642 USD, from other sources (55.9%). Yield in corn of 1 Mg ha-1, and self-consumption of 99.3%.	Mature families (51.7), of low education level (0.8), with more female household heads (3.0). Economic dependency of 54.6%. Greater number of women (62.6%), who are related to agriculture (98.0%). probability of being poor 73.8%.
T5	(n: 32 / 34.8%) Households focus on crops and off-farm activities	At an altitude of 2,250 m in high-value wage areas ($ 6.2 UDS). Surface of 1.8 ha, with 0.6 ha under fallow. Plots with high slopes (1.9) without irrigation (0.1). Without mechanization (2.2%), with expenses in mechanization ($ 1,200 ha^{-1}). There are big sized livestock animal (1.1). They work outside the farm (55.6%), they contract almost no labor (18.8%), with the least self-consumption (24.2%). Income of $ 462 USD, from social transfers (27.1%), wages (14.6%) and remittances (9.5%). Yield in corn of 1 Mg ha^{-1}, and self-consumption of 91.4%.	Families in middle age (48.2), with low education (0.7). High economic dependency (51.5%). Women related to agriculture (84.4%). Probability of being poor 78.7%.

A large heterogeneity in the diversity of farming systems was found in both regions (Figures 25 & 26). The main difference found, is the resource endowment of the farms. In **Bolivia**, another trend found was that livestock rearing is related to women and agriculture to men, farms exist with aging families and a strong degree of economic diversification; the high participation of women is present in all types of farms. In Mixteca Alta (**Mexico**), of the five (5) identified units, two (2) are related to livestock rearing, some are aging, others are based on agriculture and others have an important income coming from selling their work force. Women participate in agriculture but have a low degree of participation in decision making in farming.

This shows the need to implement mechanisms to promote gender equality as part of the efforts to include women in the project. Although some families could be classified as "young", no evidence was found of an active participation of young people in agricultural activities. The typologies show complex social problems linked to the availability of resources and their limitations to improve their production system.

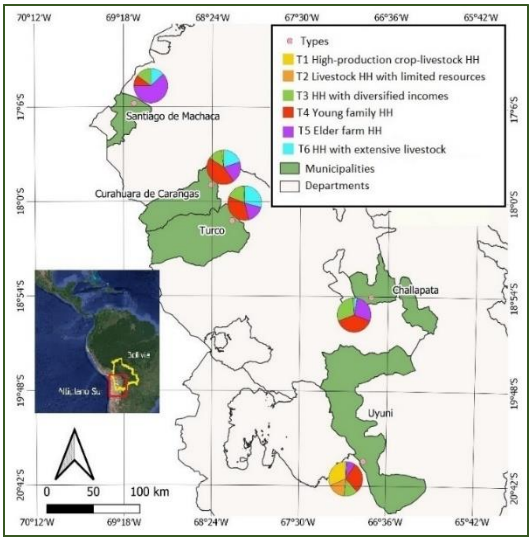


Figure 25. Diversity of farming systems in relation to social inclusion determinants in the Southern Highlands of Bolivia

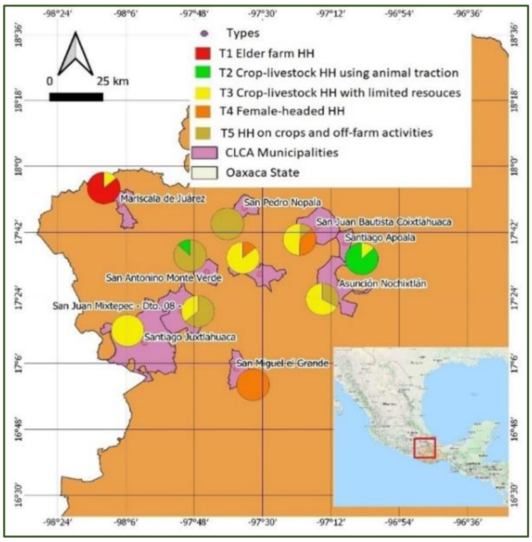


Figure 26. Farming system types distribution in the Mixteca Oaxaqueña of Mexico

Both in the case of **Bolivia** and **Mexico**, the defined types show that there are units that have a large endowment of resources, with a higher income or with a lower degree of poverty. On the other hand, there are units with highly restricted resources. The role of considering social variables in the analyses, provides a broader picture of the effects of the degree of marginalization. Although women clearly work on farms, most units are not headed by women (although it stands out somewhat in Bolivia), so men are the owners of most of the land. The definition of these types will play crucial to target different CLCA alternatives, as well as advisory and service provision systems for their wider implementation, and direct specific alternatives and actions for the most marginalized types of farm-households.

In the third year, the project will guarantee that women are included in the innovation processes, regardless of land ownership, since in both regions they show an active and relevant role. In Mixteca Alta, this implies awareness on gender equality. In both regions, the farms with the highest number of women tend to be the units with the most limited resources. This could be explained as a strategy of these farms in which men migrate and women who stay, manage the farm or become the household's head but with limited rights to decide on farm affairs. On the other hand, in this analysis the role of young people is less evident. This is due to limitations of the databases around the youth and its roles, but also due to the difficulty of this social group to access productive resources and services. All farms have very particular productive and social characteristics that make them vulnerable and deserve a focused effort by the project to meet the objective and goal of developing gender-sensitive technologies that sustainably increase climate resilience and production of small farmers in arid areas.

In the context of family farming, the roles and responsibilities of different family members play a crucial position on the functioning of the systems as a whole. Some activities and decisions are carried out by different family members while others are done together as family. In the development of technical alternatives for improved mixed-crop livestock systems, it is important to understand these different roles and responsibilities that different family members play. Knowing these could allow to, among others, i) identify who will be the most importantly affected (positively or negatively) within the family by the adoption of an specific innovation, ii) identify potential bottlenecks and opportunities for alternatives generated for empowerment of women and other non-empowered groups, and iii) provide specific recommendations to local partners and other projects on how to target such vulnerable groups in the development of alternatives.

Developing a framework for effective services delivery, including rural advisory, extension systems and service provision for machinery, agronomic and livestock services

Adoption and impact assessment in North Africa Countries

Identification of the perceived risk factors in CLCA technologies adoption in Tunisia

The adoption of the composite technical CLCA package involves in-depth understanding of the specific constraints in the adoption process. In this sub-activity, we tried to highlight the perception of the main implicated stakeholders which are researchers/extensionists and farmers involved actively in the implementation of the project. The main objective was to identify their perceived risk factors linked to the adoption of CLCA improved technologies and consequently, to show if there is any agreement and/or disagreement on the perceptions between the different concerned actors.

To emphasize perceptions of researchers/extensionists and farmers regarding the CA adoption constraints in crops-livestock systems, in the methodological framework we opted for a matrix presentation of main constraints that are proper to the Tunisian context and which are synthesized from socioeconomic studies done since the first phase of the CLCA project. The perception was presented as five (5) levels scoring Likert-scale scoring varying from the strong disagreement (1) to the strong agreement (5) regarding the eight main risk factors in CLCA improved technologies adoption constraints.

The main constraints are relating to the: i) lack of CA specific equipment, ii) risk of yield declining during the first years of the technical package implementation, iii) incapacity to integrate CA and livestock, which can lead to reducing livestock output, iv) risk of the income decrease, v) lack in term of qualifications/skills of extension officers, vi) absence of adapted extension packages to address the needs of farms with a mixed cropping system, vii) difficulty to access to credit, and viii) deficiency of support to farmers in term of training on CA and /or CLCA package.

The data collection was done through focus groups for implicated farmers and via a survey sheet for the researchers/extensionists staff. The participating sample on this assessment consists of sixteen (16) researchers/extensionists member of the CLCA-II Project and forty-two (42) farmers from three (3) dissemination sites in **Tunisia** (Saouef/Zaghouan, Chouarnia/Siliana, and Medjez El Bab/Beja).

The main results show that there is a divergence between farmers and researchers/extensionists' perceptions on the risk factors concerning the CLCA adoption of improved technologies (Figure 27).

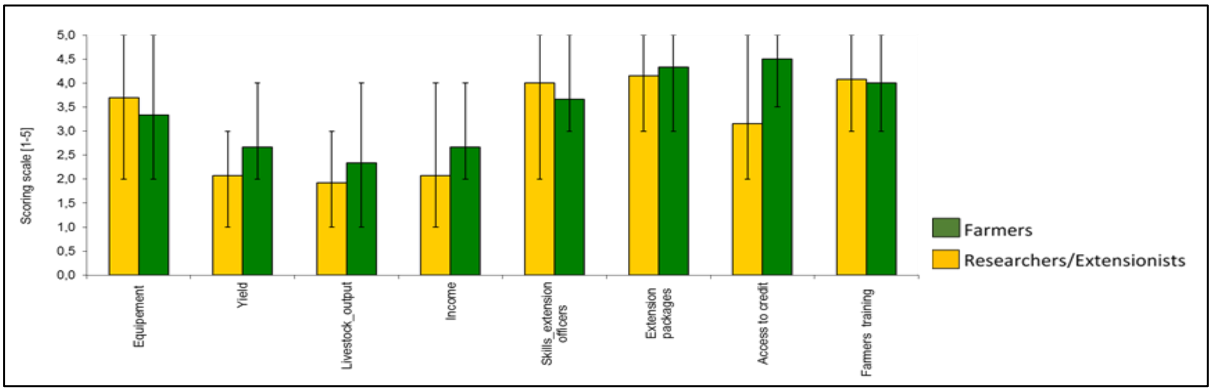


Figure 27. Farmers and Researchers/Extensionists scoring results (Tunisia)

The main perceived constraints from the research and extension staff are about the lack of equipment, the deficiency of extension skills on CLCA technical package, and the shortcoming in terms of CLCA targeted training. These results highlight the awareness of implicated researchers and extensionists about the importance of extension toward technology upscaling. From the farmers' side, it seems that the main adoption constraints are the difficulty of access to credit and the non-adequation of the CLCA technical package. Both results could be explained by the kind of farms targeted by the project, which are almost a small-scales farms with mixed farming systems. According to scoring results regarding economic constraints (risk of yield, income, and livestock output decreasing), we can also see that farmers always have the worries of CLCA technology profitability.

The findings on the risk perception of CLCA adoption reveals that knowledge (awareness) is not a barrier to adoption of CLCA improved technologies. Thus, intention to adopt CLCA seems to be constrained by negative perceptions towards CLCA (i.e. profitability on adopting these improved technologies).

Assessment of the perceived effectiveness of agricultural technology transfer methods for CLCA improved technologies

The purpose of agricultural extension is to spread information about new technologies from research to farmers by upgrading farmers knowledge and accelerating best management practices adoption as well as helping farmers become better managers (Anderson and Feder 2007). Such process targets the improvement of farmer decisions and increases productivity, potentially contributing to agricultural development and higher incomes (Anderson and Feder 2004, 2007). Such a role makes agricultural extension services one of the main determinants of new technologies diffusion.

The agricultural extension techniques have changed significantly to be adapted on the new social and economic contexts. The characterization of this new context can be shown from to levels; (i) the upstream level with new types of agricultural technologies, constraints on public budget, privatization and developing of information and communication technologies and (ii) the downstream level with basic changes of agricultural production systems and emerging of farmers groups (new organizational forms).

Thus, referring to the above noted aspects, the objective of this sub-task is to assess the perceived effectiveness of the technology transfer methods used to diffuse the CLCA improved innovations with the final goal to come up with a cost-effective transfer method to enhance the adoption of CLCA project technical packages.

With the aim to record the perceptions of farmers regarding the use and effectiveness of sources and approaches to technology transfer as used by agricultural extension/research; and to record the opinions of farmers regarding the technology transfer process of CLCA improved packages in **Tunisia**, this research used primary data collected from 20 adopters' farmers. The data collected in 2019/20 containing the opinion of these farmers from a list containing nine (9) potential and used technology transfer methods. The methodology consists on the use of Likert scale to score the evaluation of farmers' perception of three (3) main aspects relating to extension services: i) the effectiveness of extension methods, ii) factors influencing the effectiveness of extension methods, and iii) Potential impacts of extension activities on the livelihood of CLCA adopters. The respondents were asked to give their perception scores regarding the three (3) CLCA technical packages (agronomic practices, livestock activity, soil and water conservation practices) https://hdl.handle.net/20.500.11766/10446.

For **Algeria**, the effectiveness of various agricultural technology transfer methods for CLCA related technologies was examined by using primary data collected from 115 crop-livestock farmers in the three (3) areas of the project: M'Sila, Setif, and Oum El Bouaghi. In addition, we determine the key factors affecting the effectiveness of these extension methods in agriculture information transmission for CLCA improved technologies and we identified the potential impacts of extension activities on the livelihood of adopters/ planners of CLCA related technologies in these project areas. We employed descriptive statistics supported by Kendall's W-test to identify and assess various agricultural technology transfer methods and their perceived effectiveness.

✓ ***<u>Perceived effectiveness of the agricultural technology transfer methods for CLCA improved technologies</u>***

According to the reported scoring results (Figure 28), it seems clear that the low effectiveness scores are attributed to the "farmer to farmer" and "documentation" extension techniques. This result could be explained by the fact that in both extension techniques there is less and less involvement of extensionists in the extension process. Such inference highlights the significant part the extensionist must play in the process of dissemination of the different technical packages of the CLCA project. We also could deduce that the nonsignificant scoring difference between agronomic, livestock, and soil and water conservation packages lead us to conclude that involved farmers are seeking, regardless of the technical package, to be supported by extension services on their adoption process in **Tunisia**.

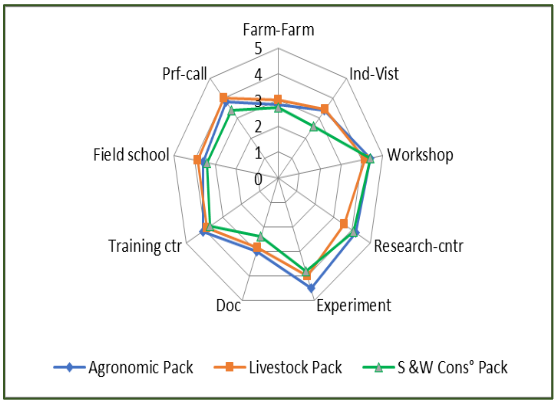


Figure 28. Farmers' perception of the effectiveness of extension methods (Tunisia)

In **Algeria**, the analysis of farmers perception on the effectiveness of the extension system delivery show that about 45.2 % of the respondents are satisfied with the ability of the current extension system and extension organizations to transfer technology and disseminate knowledge on improved agricultural/ livestock technologies. The findings reveal also that about 20% of farmers are completely unsatisfied with the extension systems delivery and its effectiveness. Finally, about 15.7% of the respondent consider the extension delivery system not very efficient.

The study findings of the potential options and priorities to strength the agricultural extension and advisory systems are displaced in table 25. The computed mean values shown in this table indicate the weight of the perception by the farmers about a particular option and/or priority towards strengthening the extension delivery system. The option and priority that was most suggested by farmers to enhance the extension delivery system was increasing the capacity of extensions agents (with mean value of 8.04). Increasing the number of experts and subject matter specialist was also perceived to have very high impact on improving the efficiency of the extension delivery system (mean of 8.13). Enhancing the capacity of extension program managers and agents on participatory and new extension approaches come third in terms of priority (with mean value of 8.21). Such results reveal the importance that should be given to the expertise and specialization of extension officers.

Table 25. Rank of the variables and priorities to strengthening agricultural extension and advisory systems in CLCA farming systems (By order of priority) – Algeria

Variables	Mean Rank	Rank	Min Score	Max Score	Mean
Increase technical capacity of extensions agents	8.04	1st	1	5	4.51
Increase number of experts and subject matter specialists	8.13	2nd	1	5	4.16
Enhance capacity of extension program managers and agents on participatory and new extension approaches	8.21	3rd	2	5	3.96
Increase capacity of extension personnel on marketing value chain and post-harvest	8.23	4th	2	5	4.10
Enhance capacity of extension program managers and agents on inclusion of woman as direct beneficiaries	8.37	5th	2	5	3.96
Organize farmers into farmers associations/organizations /community	8.63	6th	1	5	3.86
Increase number of extension services	8.80	7th	2	5	3.95
Strengthen information and communication technology for farmers - (SMS expert systems; online discussions)	8.80	8th	2	5	3.99
Change the extension policy toward more decentralization	8.87	9th	1	5	3.86
Change the extension policy toward more market-oriented approaches	8.92	10th	1	5	3.95
Develop model farms and conduct on farm research and demonstration activities	8.94	11th	1	5	3.85
Establish / enhance connections with universities; research and development institutions and organizations	8.96	12th	1	5	3.87
Develop improve training facilities and equipment at the regional and sub regional offices	9.13	13th	1	5	3.85

Table 25. Cont'd

Variables	Mean Rank	Rank	Min Score	Max Score	Mean
Increase number of vehicles available for extension activities	9.22	14th	1	5	3.98
Strengthen the involvement of agricultural inputs companies in extension services	9.59	15th	2	5	3.91
Develop or enhance private advisory services to serve medium to large farmers or farmers associations against direct payment	9.91	16th	2	5	4.04
Involve private companies in delivering services to serve medium to large farmers or farmers associations against direct payment	12.25	17th	2	5	4.04

Regarding the perceived effectiveness of crop-livestock farmers about the various technology transfer methods in terms of influencing the adoption of CLCA related technologies, the perception of the farmers in **Algeria** was measured on the five (5) point Likert scale, 5 being most effective and 1 being the least effective. The computed mean values shown in table 26 indicate the weight of the perception by the farmers about a particular technology transfer method.

Table 26. Effectiveness of agricultural technology transfer methods for CLCA improved technologies (By order of priority) – Algeria

Technology Transfer Methods	Mean Rank	Rank	Min Score	Max Score	Mean
Extension staff visits	4.91	1st	1	5	3.27
Farmers field school (FFS)	4.92	2nd	1	5	3.04
Study groups/ traveling workshops/ training	5.19	3rd	1	5	3.03
School lecture	5.29	4th	1	5	3.14
Individual farm visit	5.44	5th	1	5	3.14
Research center (demonstration center trials)	5.48	6th	1	5	3.14
Households / Neighbouring	5.80	7th	1	5	3.25
Farmers to farmers	5.90	8th	1	5	3.22
Mass media - radio	5.98	9th	1	5	3.28
Field days	6.09	10th	1	5	3.30

The empirical findings indicate that the extension methods in Algeria had more than a high perception index of influencing farmers to adopt CLCA improved production techniques. The extension method that was most perceived by farmers to influence adoption was extension staff visits (with mean value of 4.91). It appears also that farmers field schools (FFS) was also perceived to have very high impact on adoption of CLCA related technologies (mean of 4.91). The Study groups/ traveling workshops/ training, school lecture, individual farm visit, demonstration trials, come third, fourth, fifth, and sixth with mean values of 5.19, 5.29, 5.44, and 4.48, respectively. Finally, it is worth to indicate that there is a significantly low patronage of the mass media and ICT tools such as video, mobile phone, for communicating information to farmers in the study area.

- ✓ ***Factors affecting effectiveness of the extension methods in agriculture information transmission for CLCA improved technologies***

The main results regarding the perceived factors influencing the effectiveness of extension services in **Tunisia** infer that the main factors are relating to structural issues such as "logistic resources availability", "extensionists availability", and "extensionists experience" (Figure 29). Such results crave to reconsider the agricultural extension services relating to CA diffusion and to look for alternative road maps of upscaling. Regarding the perception of farmers to the influence of the type of technology on the extension effectiveness and as stated by Anderson and Feder (2007), the type of technology requires an adaptation of extension techniques to answer farmers' needs in terms of new knowledge and support.

As in the previous sections for **Algeria**, the perception of the farmers was measured on the five (5) point Likert scale. The computed mean values shown in table 27 indicate the weight of the perception by the farmers about a particular factor influencing the effectiveness of the extension methods towards a large adoption of the CLCA related technologies.

The three (3) potentials factors revealed by the respondents and affecting the effectiveness of the extension methods are the type of the farmer being targeted (with a mean for about 5.17), the cost of extension method (mean of 5.21), and the age of extension officer (mean of 7.43). These findings suggest the need to think on using technology-led approaches (ICT and mass media such as video, mobile phones, and radio) since these methods have been found to be cost effective with significant impact on CLCA related technologies adoption decisions of farmers. The use of cost-effective technologies allows to reach large numbers of farmers within a short time and at minimal cost.

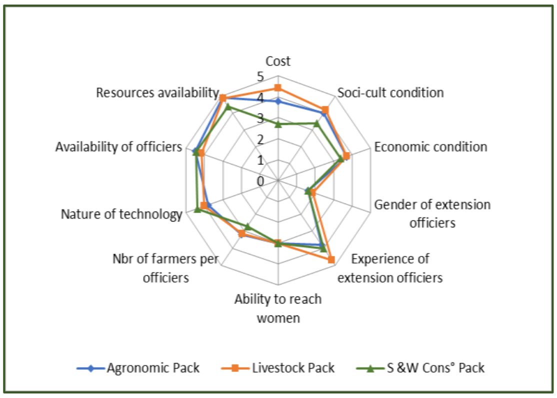


Figure 29. Farmers' perception of factors influencing the effectiveness of extension methods (Tunisia)

Table 27. Factors affecting the effectiveness of the extension methods in agriculture information transmission (By order of priority) – Algeria

Factors affecting the effectiveness of the extension methods	Mean Rank	Rank	Mean	Min Score	Max Score
Type of farmer being targeted	5.17	1st	1.81	1	5
Cost of the extension method	5.21	2nd	1.81	1	5
Age of extension officers	7.43	3rd	3.05	1	5
Sex of extension officers	7.44	4th	2.92	1	5
Ability to reach women beneficiaries	7.49	5th	2.98	1	5
Sociocultural conditions of the farmer	7.62	6th	3.05	1	5
Number of farmers per extension officer and categories of farmers	7.65	7th	2.98	1	5
Qualifications/ skills of extension officers	7.77	8th	3.053	1	5
Location and availability of extension offices	7.84	9th	2.98	1	5
Years of experience of extension services	7.92	10th	2.98	1	5
Availability of resources (transport for extension officers; information technology and equipment)	7.99	11th	3.02	1	5
Economic conditions of the farmer	8.00	12th	3.05	1	5
Nature of the technology transferred (elements of the technology)	8.40	13th	3.14	1	5
Geographic location of the farmer	9.07	14th	3.36	1	5

Finally, it is worth to mention that the ability to reach women beneficiaries is listed in the five (5) top options. During the implemented focus groups discussion (FGD's) with women farmers in Algeria, a complaint was raised regarding their non participation and/or invited to the demonstrations or field days organized by the extension service of the department.

✓ ***Potential impacts of extension activities on the livelihood of adopters / planners of CLCA technologies***

The results from farmers' perception on potential impacts of extension on the livelihood of CLCA adopters in **Tunisia** are presented in the figure below (Figure 30). The main expected impacts of extension services are about "yield and productivity", "the farm management", "food security", and "new technology adoption". Such results highlighted the awareness of farmers about the causality link between all these aspects, which are determinants of their livelihood resources sustainability, and the effectiveness of extension services.

In the case of **Algeria**, the perception of the farmers was measured on a 3-point Likert scale, 3 being high impact of the technology on their livelihood and 1 being the low impact. The results are displayed in table 28. From this table, it appears that the high impact of extension activities on adopters of CLCA related technologies is related to improve the nutrition quality of their households (with a mean of about 301). The improvement of the farmer ability to identify the farmers needs and problems and help addressing them come second with a mean of 3.67. The third perceived impact was the increase of the adoption rate of the new CLCA technologies. These findings argue how the food security of the household is the most important factor for the adopters of these CLCA related technologies.

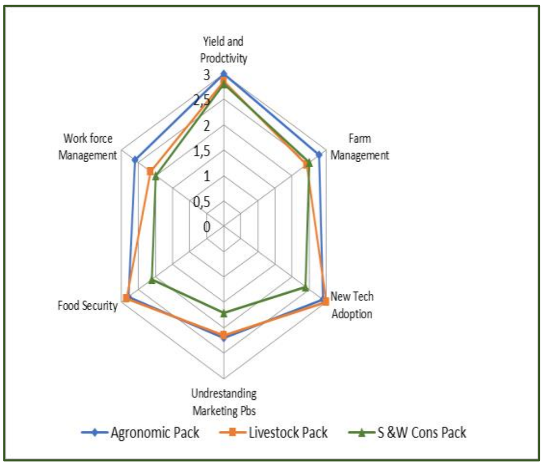


Figure 30. Farmers' perception on potential impacts of extension on the livelihood of CLCA adopters

Table 28. Potential impacts of extension activities on the livelihood of adopters /planners of CLCA technologies (By order of priority)

Potential Impacts Factors on Livelihoods	Mean Rank	Rank	Mean	Min Score	Max Score
Improved the nutrition quality of your household (HH)	3.01	1st	1.54	1	3
Improved your ability to identify your own needs and problems and to solve them	3.67	2nd	1.93	1	3
Increased your rate of adoption of new CLCA technologies	3.86	3rd	1.89	1	3
Improved your abilities to effectively understand marketing issues	3.90	4th	1.95	1	3
Improved your management practices	4.23	5th	2.83	1	3
Improved the food security of your HH	4.84	6th	2.13	1	3
Decreased the farming work burden	5.64	7th	2.41	1	3
Improved your farm production yield and profitability	6.97	8th	2.80	1	3

Innovation systems diagnostic document for Oaxaca, Mexico

This activity aims at characterizing agricultural innovation systems in Oaxaca, **Mexico**. While Mexico has available natural and human resources, the diagnosis of agricultural innovation systems shows some organizational and structural gaps on strategic innovation areas that are limited by weak linkages among stakeholders and between sectors. The public sector, through its different instances at national, state and local level, executes extension services programs and projects as well as some financing mechanism to the agricultural and livestock production sector, but it exits a dispersion of efforts and little coordination between them. Moreover, it does not exist a current coordination between small ruminants and maize based systems. Similarly, the international cooperation agencies, foundations and NGOs, not necessarily coordinate their actions among them.

There is high scientific capacity and is based on human resources, infrastructure and equipment located mainly in universities, research centers and private sector, but the efforts to scale the benefits of the generated innovations have a limited capacity at scale. These capacities constitute the main potential to generate dynamics within the system based on research, generation of knowledge and agricultural technologies, especially from the perspective of primary production. Moreover, mechanisms to allow the flow and transmission and exchange of knowledge have to be improved, including enough resource mobilization. On the positive side, a legal framework exists that aims to foster the potential of agricultural sector.

It is therefore necessary to focus efforts to overcome these obstacles and create the conditions for leveraging the impacts of scientific and technological development to accompany the sustainable development of the rural areas. The scaling pathway to achieve this can be strengthening the small ruminants-maize systems. In this process, the participation and coordination of the government with the public, private and academic sectors of the country and at regional level is transcendental, including active participation of indigenous communities and local authorities.

Global indicators on economy, doing business and innovation show that there is great potential for Mexico to come to par with other countries but, although agricultural and rural development are critical for sustainable development in the country, the sector is under-invested, and the leadership scattered. Currently, in Mexico there is no specific agricultural extension service as such. Farmers have technical assistance by accessing the various support programs of the Ministry of Agriculture (SADER), or other institutions, NGOs or private companies. Extension methodologies used in this part of Mexico are mainly participatory.

In **Mexico** as in **Bolivia**, and many other countries, research, extension and development on livestock (small ruminants) and on crop production (maize) exist independently from each other. Also, most development interventions are often implemented in isolation leading to unsustainable and short-lived piecemeal innovations. Some local NGO's have started to implement integral projects considering both crop and livestock components and there is big potential for improved communication and collaboration between development and research actors, the government and the private sector.

Adapted conservation agriculture principles have a high potential for the production systems of the Mixteca Alta, particularly to i) improve natural resource management, ii) maintain soil quality from pasture and forage management, use of manure and crop residues, iii) sustainably intensify the production of both agricultural and livestock components, iv) make better use of available resources and improve their efficiency, and v) balance household incomes and manage risks to changes in climate and markets.

Comparing **Mexico** with other countries one will easily conclude that it is a country very conducive to processes towards innovation, transformation and scaling. The CLCA project makes an important contribution by providing credible evidence that small ruminants-maize based systems indeed can be improved and that rural agri-food systems can benefit from that in the short and long term. It is therefore important that the project partners invest in building a constituency of local stakeholders that are interested, capable and willing to promote and adopt innovative solutions and scale them beyond the project boundaries.

Application of the Best-Fit Framework to set appropriate rural advisory and services provision for crop-livestock systems in Oaxaca, Mexico

The Best-Fit framework (developed by Birner et al., 2009) focuses on the elements of a system of advisory and service provision. According to Birner and colleagues (2009), these elements are frame conditions (i.e. policy environment, general capacity of potential service providers and partners, and farming systems and socioeconomic conditions), characteristics of the systems of agricultural advisory services (i.e. governance structures, capacity and management, and advisory techniques), performance (i.e. quality management in the provision of agricultural advisory services), farm households outcomes, and impact assessment with regard to multiple goals. The framework provides a tool for designing, analyzing, and evaluating agricultural advisory services. It depends on local context and acknowledges services form the wider view of agricultural knowledge and innovation systems.

Interactions among all previous components must be considered. Especially, the interactions and operation within the components and with other systems such as research, academia, knowledge management, etc. This focus could support the general understanding of diversity and complexity of rural advisory and service providers. Furthermore, the framework can be applied as a feedback loop, whereby the impacts modify the frame conditions (Figure 31). This type of loop illustrates evidence of systems change over time. The framework has been adapted theoretically to CLCA systems and it is currently applied for each case study to adjust and validate the framework according to each innovation system.

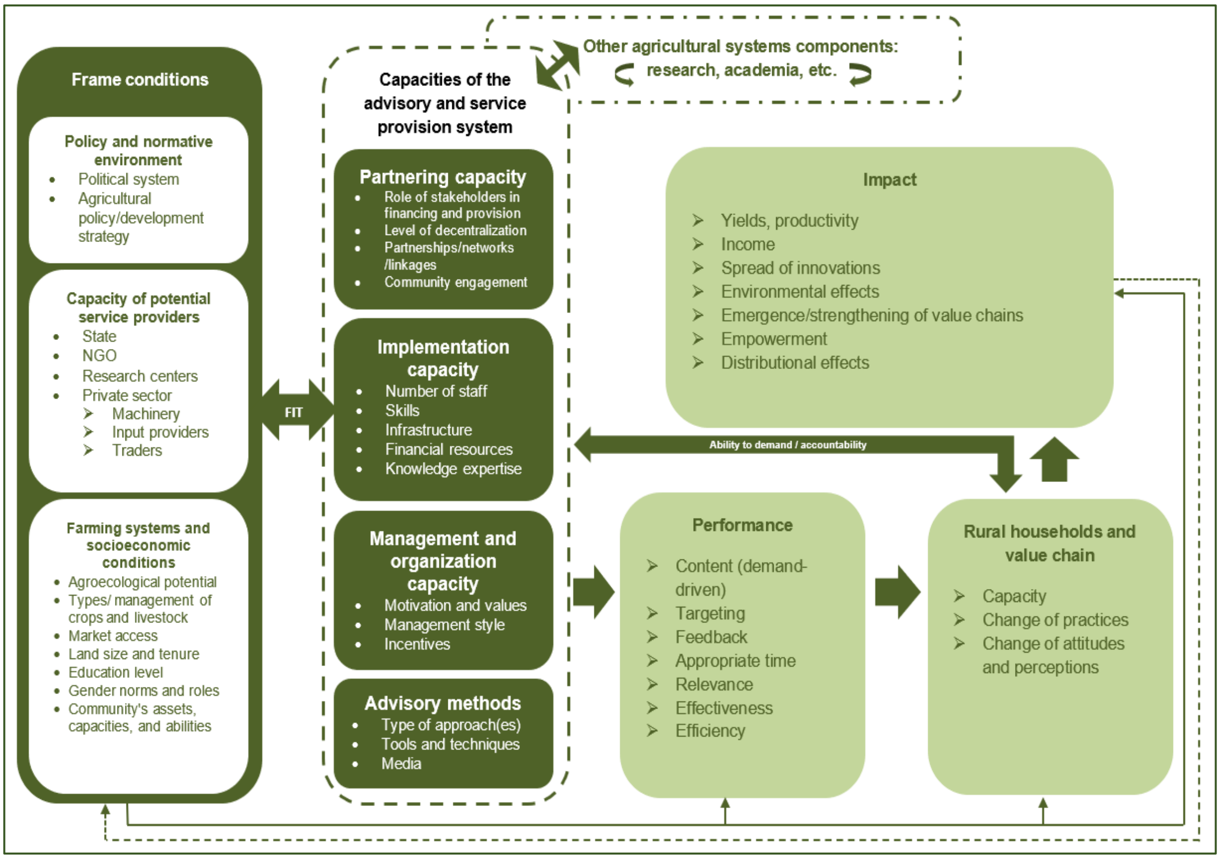


Figure 31. Adapted framework for rural advisory and service provision for crop-livestock systems

- Frame conditions: The purpose is understanding contextual factors that allow researchers and practitioners to better tailor any advice or service to a particular situation. This component includes three (3) key elements: i) The policy and normative environment outline agricultural development priorities at the national, regional and local level, as well as the budget (public or otherwise), ii) the capacity of potential service providers acknowledges the inventory and gap analysis of actors. According to Faure et al. (2016), this analysis should include (a) who defines the rules for what and for whom, (b) who funds whom and how, and (c) who provides service to whom under which conditions, and iii) farming systems and socioeconomic conditions provided based on the crop-livestock production systems and socioeconomic aspects.
- Capacities of the advisory and service provision system: Partnering capacity depends on the governance structures and interactions. Implementation capacity refers to human, financial, and physical assets of service providers. While, management and organizational capacity reflects on management style, including planning, monitoring, evaluation and learning processes. Additionally, the advisory methods collected approach(es), tools and techniques that are applied in the field. All these capacities are interrelated and are relevant to individual and organizational effectiveness.
- Performance: The performance measurement and quality management in the provision of agricultural advisory services depends on different factors. Faure et al. (2016) recognize some of them: achievement of objectives, return of investment, quality of services provided, equity of access and benefit to services, sustainability, and autonomy of actors. This block can be considered as intermediate outcomes (Davis & Spielman, 2017);
- Farm households and value chain: This component is the result of decision-making process of rural households and value chain stakeholders. It refers to the primary outcomes of rural advice and provision of services with different stakeholders of the crop-livestock systems. Actors engage

in new practices and knowledge which generate changes at various levels of a farm, household, community, or territory;

- Impact: It unpackages economic and social impacts, as well as, direct and indirect ones. From the scaling approach, we suggest including the assessment of undesired consequences too, that might be positive or negative.

Preliminary findings in a best-fit framework for Oaxaca, Mexico

For **Mexico**, a preliminary matrix of findings of capacities of the advisory and service provision system is described in table 29. In Mexico, farmers have technical assistance by accessing the various support programs of the Ministry of Agriculture, or other governmental institutions. Also, by engaging in initiatives with NGOs or private sector.

Table 29. Preliminary findings for Mexico (Oaxaca) by Framework Characteristics

Characteristics	Preliminary findings
Partnering capacity	✓ Agricultural innovation and extension services are a mixed of public and private efforts. Universities, research centers, and some public institutions are the organizations for research and technological development, while NGO's and governmental programs (through professional service providers) deliver advisory and extension services; however, coordination can be improved. ✓ Knowledge management and linkages between research, extension, education, and other actors in the innovation system remains weak; however, initiatives and alliances such as MasAgro and Geopark Mixteca provide local spaces for cooperation.
Implementation capacity	✓ There are limited operational funds in government programs. Hence, national, state and municipal extension services have a limited number of staff and resources. ✓ Donor-funded projects often focus on specific value chain or thematic. Usually, advisory and extension services is often a complementary underfunded component. ✓ Lack of access (especially by indigenous and female farmers) to finance, extension service, and inputs constrains innovation uptake. ✓ The focus is on technical training. ✓ Infrastructure: MasAgro's experimental platforms, modules and extension areas, as well as demonstration plots of NGO's and another research center such as INIFAP and UAM.
Management and organization capacity	✓ Gender sensitization, climate-smart agriculture, and nutrition topics are found mainly in special programs (i.e. MasAgro) and projects (i.e. local NGOs).
Advisory methods	✓ Participatory approaches are common, as well as, farmer-to-farmer approach. Additionally, there is an increasing interest on market linkage approach. ✓ On farm trainings, specific courses, demonstration plots, field visits, exchange experiences. ✓ Conferences/forums. ✓ WhatsApp groups, radio and social media campaigns.

Identification of performance incentives and ICTs role in monitoring extension performance can be also an interesting approach to recognize intermediate outcomes. This analysis can support the acknowledgement of opportunities and bottlenecks to improve rural advisory and extension services.

The application of the adapted best-fit framework for CLCA have the potential to guide Decision-Makers, practitioners, and researchers to strength agricultural advisory and extension services. Depending on the context, this framework can target specific advisory and extension components and features that can be improved, strengthened, changed, or even acknowledged. It also provides a common ground for comparisons and learning.

In the long term, by leveraging points at different levels, agricultural innovation systems can change into a "new normal". The framework identifies bottlenecks and opportunities of different components of rural advisory services and can fit contexts and needs. It also has a holistic perspective and an impact pathway orientation. The application of the framework requires the design and use of quantitative and qualitative methods. Further research is needed to adjust and validate the framework according to CLCA project needs in each country. Additionally, this type of framework can improve learning process of agricultural innovation systems by identifying appropriate conditions and elements to foster sustainable change at scale.

Develop of network of on-field, multiscale innovation and validation sites

This section includes the description of the main actors of the networks that have started around the CLCA project, the characterization of some of the incipient relationships between them, and the physical infrastructure where interactions occur. In order to achieve this, the following will be considered:

- Agricultural production: actors in the production chain who are directly involved in cultivation and services required for implementation (farmers, extension systems, input suppliers);
- Scientific development: academic institutions, NARS, and independent scientists involved in obtaining, collecting and generating information to create innovations and new knowledge;
- Government and public policy: national, state and regional government agencies who manage and implement programs and initiatives regarding rural and agricultural communities (long-term programs, local and national governments, international agencies);
- Consumption and commercialization: public and private entities involved in the buying, distribution and commercialization of agricultural production (companies, intermediaries, consumers).

Hub Model

CIMMYT has been operating a long term public funded program in **Mexico**, MasAgro, for the last 9 years where an innovation model was implemented successfully. The program aims to achieve a vision of increased food security across the country, while promoting economic development, increasing labour and natural resource use efficiency, and boosting agri-food system resilience to shocks like those experienced in the 2008 food price spikes.

It was designed as a context-specific solution since it is driven by a series of hubs established on several agro-ecologies and composed of value chain networks. Each agro-ecological hub has a physical infrastructure that includes research platforms, demonstration modules, extension and impact areas, which serve as scenarios for networking, knowledge exchange and co-creation. Since inception, the hubs have been allowed to evolve independently in order to match their starkly divergent agricultural, stakeholder, and technological contexts, and to reflect the landscape of relationships between different actors in the agri-food system (Camacho-Villa et al., 2016). MasAgro has a user-centered methodology that starts with research and discovery paying significant attention to creating a new solution to a relatively general problem. Once this knowledge is there, “what if” experiments are conducted based on the interests and needs expressed by locals. Research workers collaborate with innovative local farmer leaders to assess “what wows” and finally through experimentation and iterative prototyping technologies are refined and applied to local conditions to have “what works” (Liedtka, Salzman, & Azer, 2017). Here is where knowledge co-creation and integration occurs.

In the research platforms, field research with local partners evaluates technologies (including traditional and regional common practices) chosen based on the limiting factors of the production system. In demonstration modules, farmers implement and adapt the best practices developed through the research platforms and compare them to conventional practice, with the support of farm advisors. Farmers in the modules are connected to other farmers, input providers, and other value chain actors. Extension areas are agricultural fields where farmers practice new technologies in connection with modules or research platforms, whereas in impact areas farmers have adapted and adopted knowledge, technology and innovations on their own.

MasAgro hubs prioritize the development of strong partnerships where operations and activities are defined through reciprocal alliances formed around common objectives. A network of these partnerships including national, state, local governments, international organizations and local partners allow to learn and follow pathways defined by equitable decision-making across stakeholders (Liedtka et al., 2017). Further, the elucidation of how stakeholders are expected to interact in partnership can be a first step towards more effectively navigating complex and often poorly defined power relationships between different actors. In this sense, CIMMYT has learned to engage as a facilitator and mediator that connects an intentionally broad and diverse network of actors, as well as providing technical and research services more in line with historical extension approaches. Partnerships, co-creation, prototyping and experimentation have shaped MasAgro and have allowed to work in collaboration with local communities to foster innovation and solve complex problems and increase both productivity and long-term sustainability (Liedtka et al., 2017). It is important to highlight, however, that in complex systems the mediating role need should not be filled necessarily by a formal research organization.

The self-deterministic, collaborative nature of the hubs has, over time, yielded a diverse array of knowledge management related results. After seven years of the project, new connections and communication channels have opened in both seed company networks as well as farmer market linkages, while socioeconomically and environmentally adapted machinery has been designed, prototyped, and tested with the aid of a wide array of stakeholders (Deschamps Solorzano, 2016). Traditional research advances including genetic diversity maps and genotypic atlas of Mexican maize have become more applicable and targeted to farmer and breeder requirements.

Perhaps most importantly, the MasAgro program has relied on advancements in communication and partnership through the construction and facilitation of collaborative networks, and through the development and deployment of ICT tools. Specifically, MasAgro uses an Electronic Logbook (bem.cimmyt.org), ODK forms, SMS services, GIS solutions (gismaps.cimmyt.org) and a DSS public and free mobile application called AgroTutor to integrate farm-level data and deliver added-value information products (Deschamps Solorzano, 2016; Govaerts, Gardeazabal, Curiel, & Vega, 2019). These tools, in conjunction with the infrastructural and relational networks built-in the innovation hubs, provide essential means of communication across the agri-food system and across a diverse array of stakeholders with different knowledge assets, priorities, and power dynamics.

Physical infrastructure

Based on the described model, the CLCA strategy intended to leverage existing knowledge and networks in Oaxaca to validate and roll out technologies. In **Bolivia**, the Mexican experience was used to begin the establishment of a validation network, the different plots (74) where CLCA alternatives are implemented are recorded and used as platforms for local capacity development and feedback from farmers to the collaborators (Figure 32). This network is still small and important efforts will need to be directed to expand the network and actively use it to strengthen the local AIS by including a wider range of partners.

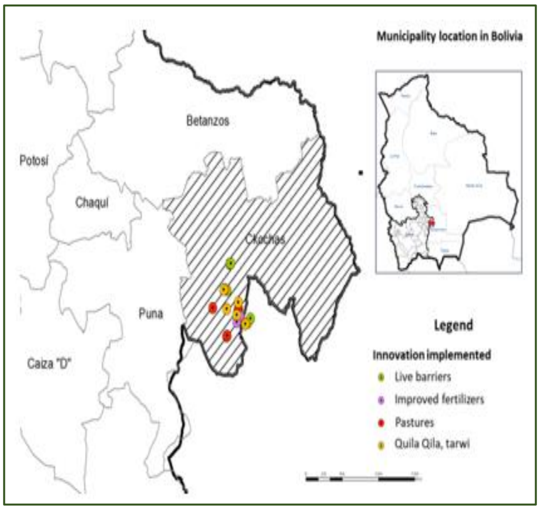


Figure 32. Network of testing, validation and extension plots of CLCA project in Ckochas, Bolivia

In **Mexico** on the contrary, considering the experience CIMMYT has in the region and the development of a local innovation hub for the last years, over 51 plots are recorded and actively used to test, exchange and scale cropping systems alternatives while additional 1,441 in the region have been implemented with alternatives developed by CLCA team/CIMMYT in the last years (Figure 33).

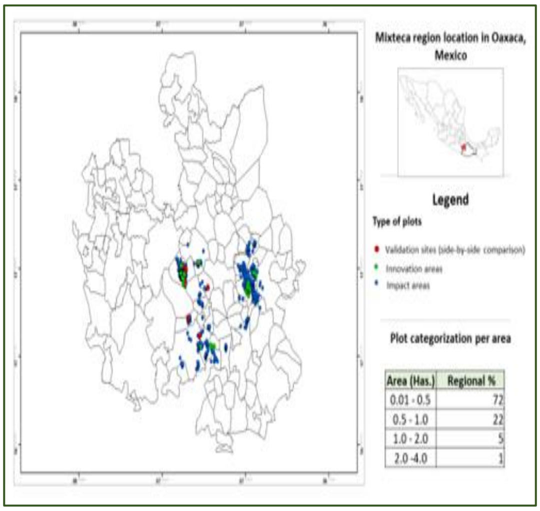


Figure 33. Network of testing, validation and extension plots of CLCA project in Mixteca region-Oaxaca, Mexico

This network will be further expanded in both sites and, with the data collection tools, information will be made available to all actors in the agricultural innovation systems.

- ✓ **Network characterization: case of Mixteca region-Oaxaca, Mexico**

As stated in the diagnosis of the innovation system, two (2) of the main characteristics of the Mixteca Alta, in Oaxaca are (**Mexico**) erosion and low precipitation.

Agricultural systems are generally mixed agriculture-lives tock where animals (i.e. goats, sheep, cattle, etc.) play a very important role in the livelihoods of farmers due to the generation of products for family consumption or sale, and as a means of saving system. Additionally, manure production serves to improve soil fertility. Rainfed agriculture – particularly maize, beans, and wheat – is widely practiced in the region. There are two (2) types of rainfed corn (*Zea mays*) systems: *cajete* (long term) and seasonal (short term). Additionally, in the Nochixtlan valley is common to produce corn (*Zea mays*) using irrigation systems. The three (3) corn systems differ significantly in their requirements for labor, technology, and social organization. Some other crops that are part of the production systems are beans, alfalfa, tomato, wheat, and vetch.

Conventional farm practices in the region include: biomass burning and residue removal; CT and clean cultivation; bare/idle fallow; continuous monoculture; low input subsistence farming and soil fertility mining; intensive use of chemical fertilizers; intensive cropping; surface flood irrigation; indiscriminate use of pesticides; and cultivating marginal soils. Other important challenges are poor management of water resources, extensive grazing and limited management of livestock, poor valuation of the produce by the markets. Additionally, key socio-political challenges include the abandonment of agricultural production, particularly due to migration of young people, unilateral public policy design and dissociation of agricultural public policy from the farmer organizations' requirements. Poor research results diffusion and lack of enough testing and validation of agricultural technologies in the field.

Scientific development

As stated in the hub model, scientific development is intended to result from a co-creation process where local researchers, universities and research centers interact among themselves, as well as with the farmers to understand context-specific needs, integrate traditional/explicit knowledge and validate potential solutions. In the case of the Mixteca region, the CLCA project has worked in bringing together key stakeholders to conduct the scientific development process (Table 30).

Table 30. Partners and roles within the project network

Name	Type of Institution	Role within the project network
INIFAP - Oaxaca	NARS	Research platform lead
Universidad Autónoma Metropolitana - Xochimilco	National university	Research platform contributor
Universidad Autónoma de Oaxaca - UABJO	Local university	Undergraduate students supporting research activities
Universidad Tecnológica de San Miguel Grande - ITSMIGRA	Local university	Undergraduate students supporting research activities
Instituto Tecnológico Superior De Teposcolula	Local university	Undergraduate students supporting research activities
Centros de Bachillerato Técnico Agropecuario (CBTAs)	Agronomic college	Undergraduate students supporting research activities

Livestock and agricultural production

Based on the technological options resulting from the scientific development process, key players from the agricultural production dimension need to be involved to ensure enough testing and validation in a wide variety of real conditions occur. Additionally, capacity development is expected to happen within this level of the network as well. Ideally, farmers, farmers´ organizations, extension services, input suppliers, agricultural NGOs and services providers should be integrated. Table 31 includes the progress on this matter during this second year.

Table 31. Involved Key players from the agricultural production dimension in the Mixteca region, Oaxaca for the project network

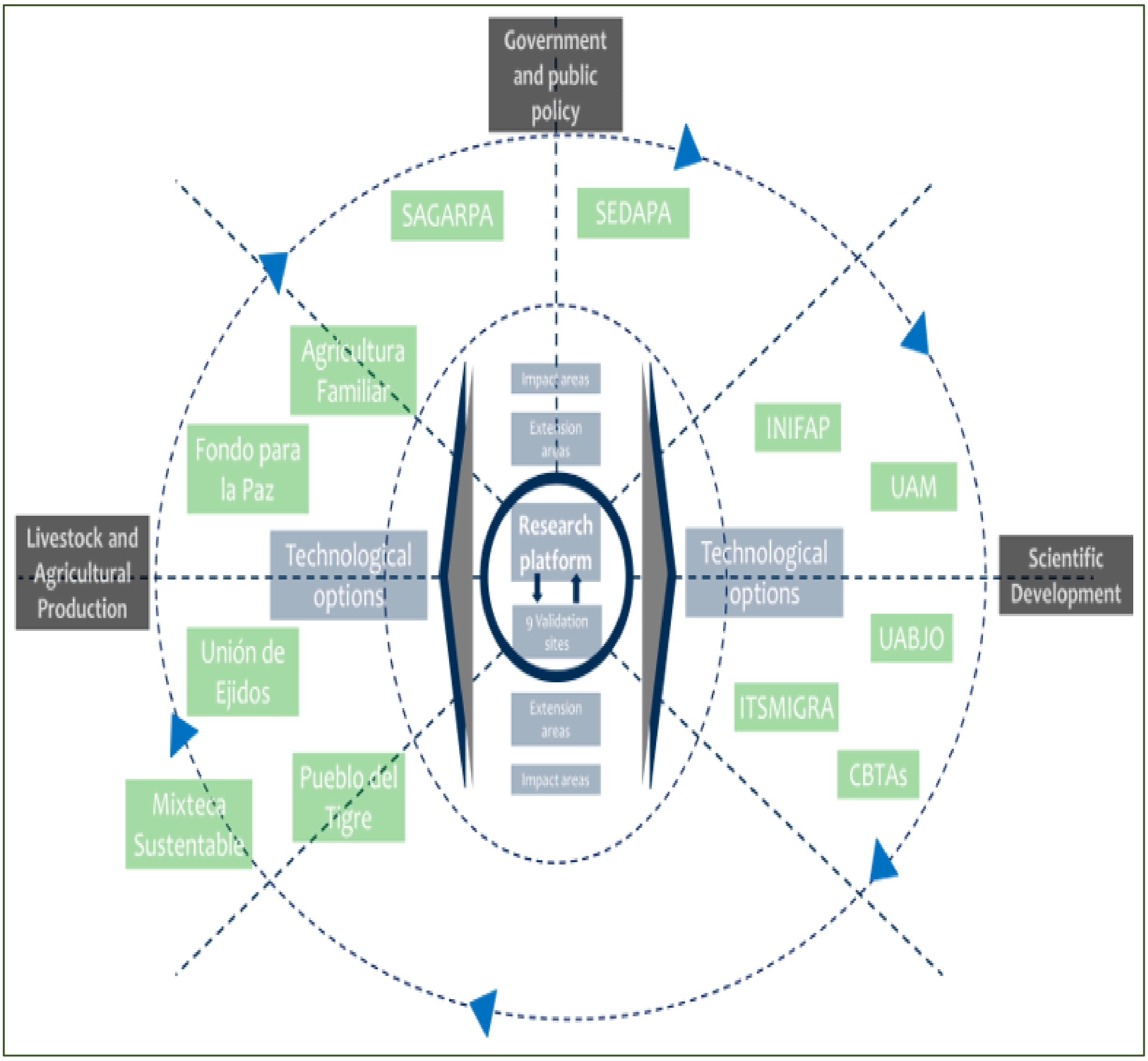
Name	Type of Institution	Role within the project network
Unión de Ejidos	Farmers´ organization	Validation and extension sites implementation, capacity development
Fondo para la Paz	International NGO	Validation and extension sites implementation, capacity development
Pueblo del Tigre	Farmers´ organization	Extension sites
Agricultura Familiar	Private extension service company	Capacity development
Mixteca Sustentable	Local NGO	Roll-out and replication

Government and public policy

Within the hub model, governments are expected to agree with the recommended solutions and if possible, align resources and efforts to enhance the impact of the context-specific generated knowledge. In the short time the project has operated in the Mixteca region, the existing hub and network enabled a smooth alignment with the local agricultural government – SEDAPA. The regional Secretary of Agriculture has received detailed information about the project and joined the scaling workshop conducted in Santo Domingo Yanhuitlán, Oaxaca, February 18th, 2020. Additionally, municipal governments have expressed interest to support the project with diffusion and calls to other institutions and stakeholders to join the project network.

Consumption and commercialization

The CLCA project does not include activities in this dimension. Therefore, conventional commercial networks will be continued to use to sell produce resulting from the project interventions. In livestock as well as agriculture, local brokers approach the farmers and bring products to the markets in other regions. For local commercialization, farmers individually will probably attend Nochixtlán and Tlaxiaco markets to sell native varieties for household income.



Network map in of Mixteca region-Oaxaca, Mexico

Develop multi-level capacities to manage integrated interventions from field to food

Please refer to the activity "Stakeholder engagement and rapid appraisal" under component 1 and to section "Knowledge management".

Implementation arrangements

Implementation of the project activities in the two sites of LAC (The Highlands of **Bolivia** and the Mixteca Alta of **Mexico**) are being successfully carried out in collaboration with local partners. During Year-II, a wide range of activities have been implemented in both sites such as the development of CLCA alternatives and their establishments in farmer's fields along with training events and workshops and the production of knowledge materials together with local partners.

In **Bolivia**, PROINPA, our main partner, has continued the establishment of demonstrative plots with selected CLCA alternatives and is already scaling some of these alternatives such as improved fallows and wind barriers with fodder bushes. Field days with farmers were carried out but since October 2019 we have had some difficulties to work in Bolivia because of the elections and following political unrest resulting in regime change and resignation of president Evo Morales. Since then, the technical supervision team from CIMMYT has not been able to travel to Bolivia. More recently, the Covid19 hit the region and travelling to Bolivia was not possible. We have had to cancel several visits to the field planned for March 2020 (end of the growing season) and a Systems Analysis course organized with the Universidad Mayor de San Andres (UMSA) which has been rescheduled for July 2020 as an on-line format. With ProCamelidos, we have exchanged results related to the characterisation of farming systems and some relevant field activities but, partly due to the political crisis, collaboration has been insufficient and hopefully IFAD can stress the need and the potential synergies of such collaboration.

In **Mexico**, in collaboration with local partners, the project area was defined and characterized as well as the predominant farming systems. Also, main challenges and alternatives for more sustainable CLCA systems were decided to be implemented in plots of about thirty (30) farmers. Collaborations with local partners were established for the implementation and monitoring of such plots as well as the organization of field days for their assessment by farmers. Current Covid19 pandemic has posed challenges in the implementation of the project but so far without major consequences (i.e. workshop with stakeholders was held and most of field work). However, the beginning of the cropping season and sowing of maize and other crops is few days away and it is uncertain today if we may be able to implement all planned field activities. Links with IFAD investments in **Mexico** still needs to be defined and support from central offices might be needed to stress the need and the potential synergies of such collaboration.

Overall, despite challenges related to external factors such as the political unrest in **Bolivia** and the Covid19 pandemic affecting field work, activities have been carried out resulting in several on-ground actions for empirical evidence of CLCA alternatives and several training events where more than one hundred farmers have participated.

In countries of North Africa, there have been no major deviations between what has been planned in the AWPB and the implementation in the fields. In some areas, the project was able to achieve more than previously planned and some target indicators were exceeded. We need to note that the scaling approach adopted in North Africa and the overall communication strategy around it has generated an unprecedented sense of excitement among national actors and farming communities. Sub-agreements between ICARDA and the partners in **Algeria** and **Tunisia** were signed in time and this has allowed our partners to receive their respective budgets in time. So far, COVID 19 pandemic did not have a major effect on the implementation of the planned activities. Activities requiring face-to-face gathering of several persons (workshops, trainings, field days, etc.) were all completed early March before confinement was decided in both countries. Follow-up of the trials in the field was not affected as our partners were able to secure special authorizations from their respective authorities to continue minimum needed activities and data collection.

Innovation

For the second cropping season of the project, we selected one innovation from **Tunisia** on the establishment of a PPP in Tunisia between public research and a private seed company for the commercialization of forage mixtures. The innovation is presented below using the CGIAR standard template. Details can be found in earlier sections of the report.

Title of innovation	Contextualized forage mixtures for the enhancement of CLCA systems in Tunisia: novel rotations, better balanced feed and reduced risk of crop failure
Innovation type	Genetic
Stage of innovation	Ready for uptake
Narrative	The National Institute of Agronomic Research of Tunisia – INRAT and COTUGRAIN, a private seeds company for multiplication and commercialization of seeds joined forces in a unique PPP to overcome the absence of a formal forage seed system in the country. INRAT designed, tested and evaluated contextualized forage mixtures as an alternative to the oat-based system. Forage mixtures based on different proportions of Vetch-Oat, Vetch-Triticale, Meslin were developed and these mixtures are now packaged and commercialized by COTUGRAIN. The innovation also refers to higher number of farmers engaged by COTUGRAIN and technically supported by CLCA team to successfully produce these seeds for the company. More than twenty (20) multiplicator contracts were established over an area of 300 ha in the different target sites of CLCA Project.
Geographic scope	Regional across the cereal-sheep belt of North Africa

Knowledge sharing and management

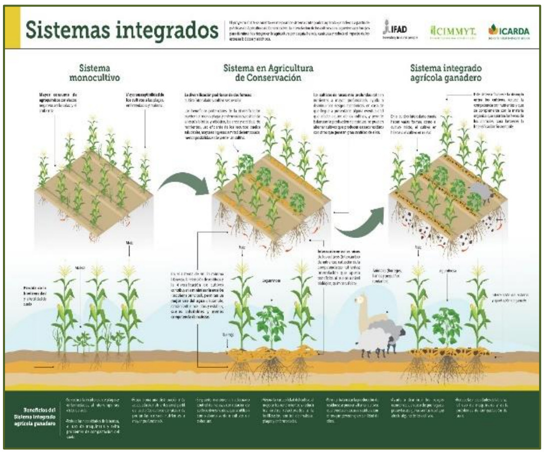
The objective of the KM component of this project is to develop a process of generating relevant information and closing adoption gaps through developing, testing and disseminating CLCA information packages to smallholders (men and women) via participatory instruments and processes. The participatory approach sustains the effort to ensure proper contextualization and adaptation of products aiming to support innovation and scaling processes as evidenced by the respective sections of this report.

The innovation systems model implemented in the project is based on the lesson learned from the first phase and focused on participatory research, capacity development, knowledge exchange, and dissemination events with focus on women's decision-making constraints and obstacles preventing effective CLCA adoption.

Participatory research led to better understanding of needs and aspirations of smallholder farmers and agro-pastoralists. This process has been supported by a review and improvement of existing KM models, products, and tools for data gathering, analysis and dissemination. Among different options implemented during the first year the project focused on a) printed materials; b) calibration of ICT-based data collection tools; c) use of media such as radio, video, TV, SMS; and d) face-to-face interactions.

One technical leaflet https://hdl.handle.net/20.500.11766/11119 titled "Prevention of sheep diseases in **Tunisia**" (in Arabic) was developed to provide women farmers (who are most in direct contact with livestock) with evaluation methods, knowledge and specific technical skills to prevent major animal diseases. In addition, a factsheet about the evolution story of the locally made "Boudour" Zero-till seeder in **Algeria** was produced https://hdl.handle.net/20.500.11766/11047.

In **LAC countries**, based on the assessment conducted during the first year of the project to identify opportunities and targeted objectives for the quinoa-llama communication strategy, and after validating that there was a similar need in Oaxaca, **Mexico**, an infographic, audio content and technical sheets per crop were generated. The main objective of all designed materials is to inform, raise awareness and work with quinoa and camelid and cereal-based systems farmers to implement technical solutions to the challenges they are facing.

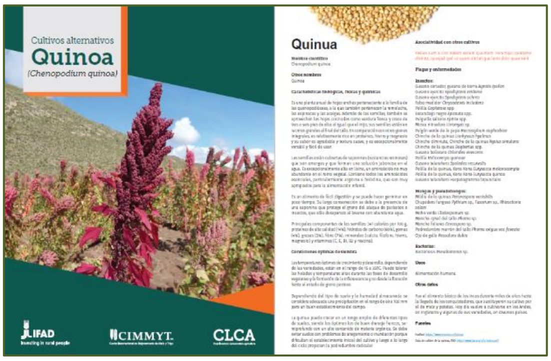


Infographics on Crop-Livestock integrated systems

Two (2) audio files were generated to support the communication strategy in both **Bolivia** and **Mexico**. The first one supports the infographic with general information on the CLCA strategy and the importance of combined practices and activities (e.g. intercropping, sequential cropping) to address soil erosion and productivity. It presents the benefits of diversification such as, less pest and disease, resilience to biotic and abiotic stresses, nutrient recycling, efficient use of resources, healthy soils, mid-season income, increased employment, and less chances of losing a crop. The second file details the importance of understanding the scaling feasibility of the potential technical solutions in order to fine tune the strategy and ensure a successful roll-out and adoption process. Both materials are less than three (3) minutes long and we intend to reproduce them in local radios, social media and WhatsApp networks.


Grabación de audio CLCA_OK1.aac


Grabación de audio CLCA_OK2.aac



Technical sheets on the different available crops for CCA systems

Radio was also used as common method for reaching out to the target audiences in **Algeria**. During this second year, CLCA team promoted project activities and disseminated its results in seven (7) broadcast events [one (1) national level and six (6) local ones].

In order to provide farmers, extension services and the network stakeholders with technical information on the different available crops for the CLCA systems, technical sheets for ten (10) crops were designed. Each sheet includes types and varieties, biophysical and chemical characteristics, optimal conditions for sowing, relation with other crops, pest and diseases and uses https://hdl.handle.net/20.500.11766/11444.

Social media used by CLCA team in Algeria and Tunisia to reach more target beneficiaries

In order to increase awareness and to overcome insufficiencies of the extension system, SMS as an ICT tool has been introduced in both North African countries. In **Tunisia**, thirty-two (32) technical SMS messages related to CA (9), livestock (14) and forages (9) are elaborated [in collaboration with other ongoing ICARDA project (ICT2scale)] and reaching out to 700 farmers in the target areas of CLCA project. About 70% of the messages were sent up to now. In **Algeria**, the project team has used Data SIM Application to send awareness SMS to 530 farmers (70 women) and invite them to CapDev events held in Setif, M'Sila, Oum El Bouaghi, and Bordj Bouareridj in Algeria. These tools are now being extensively used by the project teams in **Algeria** and **Tunisia** to keep momentum with the farmers during the COVID-19 crisis and to collect some of the data that farmers themselves can measure or report.

In **Algeria**, two (2) preliminary videos related to "Boudour" ZT seeder and best practices for weed control were produced. These videos will be distributed on ITGC social media (Twitter, Facebook, YouTube), used by CLCA team to reach more targeted beneficiaries.

Blogs have also played an active role in disseminating activities via institutional sites and generating interaction with the project teams in **Algeria** and **Tunisia**. Examples are:

- ✓ https://www.icarda.org/media/news/improving-integration-crop-livestock-systems-and-conservation-agriculture;
- ✓ https://www.icarda.org/media/events/monitoring-evaluation-and-learning-data-management-and-geo-informatics-option-context;
- ✓ https://www.icarda.org/media/drywire/protecting-dryland-crops-face-climate-change;
- ✓ http://www.itgc.dz/?p=9032.

The project has engaged with several stakeholders' groups using the most appropriate methods such as training, workshops, information events (for policy makers, students, and farmers) and more technical field days (Table 32). Long-term degrees (ESP, MSc, PhD) are also supported in order to create long-term sustainability in the national systems starting with the young generation.

Table 32. Summary of the stakeholders' engagement in Algeria, Bolivia, Mexico and Tunisia

Type	Algeria	Bolivia	Mexico	Tunisia
Trainings	-	50	-	174
Information days	80	-	-	190
Field days	420	-	-	143
Post-graduate students	22	-	-	15
Workshop/Conferences	195	39	60	243
Total (attending)	716 (F: 176, Y: 240)	89 (F: 25, Y: 30)	60 (F: 15, Y: 20)	768 (F: 287, Y: 300)

M: Male participants; F: Female participants; Y: Participants below 35 years of age

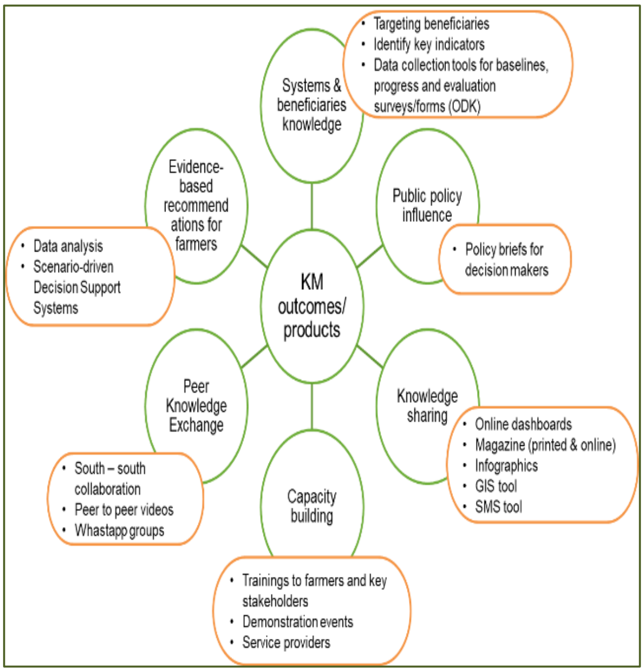
For the scientific audience, the Tunisian CLCA team succeeded to publish in this second year a prospective paper about long-term CA scope and impact in **Tunisia** from an agronomic and environmental perspectives. This publication was partly supported by CLCA Project. Main conclusion of this work is the importance of crop modelling approach as a tool to help policy makers in decision making. The study shows how CA based on Zero tillage and soil residue retention *vs* CT over 260,000 ha contributes to make wheat production more resilient to climate change in Tunisia through: i) Enhancing wheat yield (15%), ii) Improvement of water use efficiency (13% to 18%), iii) Increase organic carbon accumulation (0.13 t ha^{-1} $year^{-1}$ to 0.18 t ha^{-1} $year^{-1}$), iv) Reduction of soil loss caused by soil water erosion (1.7 t ha^{-1} $year^{-1}$ to 4.6 t ha^{-1} $year^{-1}$ of soil loss). The paper also demonstrates the importance of residue retention on the soil surface as a mulch to achieve the benefits of CA. https://hdl.handle.net/20.500.11766/10157 .

Three (3) other papers were generated by **Tunisia** and **Algeria** in the framework of CLCA project. The first one is related to the effect of supplementation by cactus (Opuntia ficus indica f. inermis) cladodes on reproductive response and some blood metabolites of female goat on pre-mating phase https://hdl.handle.net/20.500.11766/10555; the second, presents a socioeconomic assessment of NT in wheat cropping system in Algeria https://hdl.handle.net/20.500.11766/9761 and the third, sheds lights on the adoption of CA technologies by smallholder farmers in the semiarid region of Tunisia (Resource constraints and partial adoption) https://hdl.handle.net/20.500.11766/9988.

As result for the forage-livestock activity under CLCA project in **Tunisia** which started since the phase (I) and continued during the phase (II) of the project, Tunisian CLCA team participated by oral communication titled "Vetch Summer Grazing (VSG) Under Conservative Agriculture (CA): Promising Alternative to Cereal Residue Grazing for Better Barbarian Lambs Response" to the 6th International Conference on Sustainable Agriculture and Environment that was held in Konya, Turkey from 3rd to 5th

October 2019. This conference communication https://hdl.handle.net/20.500.11766/11188 shows that during summer period, dried vetch biomass provided a valuable alternative to cereal stubble and complementation which is rich in energy and protein and should sustain moderate growth performances of growing lambs. These relevant results could convince farmers to adopt this feeding alternative under CA. It allows to alleviate the pressure on stubble through its grazing only one time per day and to replace the stubble afternoon grazing time by vetch crop. This information is important to change practices so that they are more successful in livestock production and also show the differences in the research across countries and regions.

The South-South KM task force identified during the first year of the project needs to be reactivated among the team members of the different regions operating the extended project funded by IFAD. Methodologies and tools for knowledge management in Latin America have been shared and a KM products matrix would need to be filled in to categorize, systematize and compare experiences.



Specifically, for this project, it was agreed that the KM approach should be based on principles of the innovation system model, pay special attention to identify women's decision-making constraints and obstacles preventing effective CLCA adoption. Additionally, KM products (information packages generated within the project) will contribute to closing adoption gaps, support the upscaling of field successes, best practices and lessons learned and be culturally/regionally adapted, specific to the needs of the target populations and able to fill information gaps.

Next year KM activities will continue to support closely the implementation of the innovation system model with research and validation plots, training activities, and functional knowledge products for local researchers, farmers and stakeholders. The KM taskforce will operate to share processes, methods and results among regions and feedback from the field work will nurture the project plan.

Generated knowledge is made available through open access repositories (http://repo.mel.cgiar.org/; http://data.mel.cgiar.org/) and re-used during several technical and policy events.

The project design in relation to KM has been confirmed as aligned with target indicators as referenced in the M&E section of this report. However, an additional field KM staff have been hired to support the documentation of KM efforts implemented by national partners. While national partners are fully committed to the process it is important to systematize and document their action in order to create a solid baseline to evidence the effectiveness of the process at mid-term and final stage of the project. The systematized knowledge sustained the efficient finalization of the scaling strategies in each country. The strategies include the different tools and methods are to be strengthen in order to channel existing knowledge. It is also important the collective awareness of segment knowledge by target group in order to maximize its impact. Only through a more focus targeting knowledge value can be estimated, and processes made scalable.

Scaling up and sustainability

Many scaling-oriented activities have been undertaken during Year-II of the project. Some of these are related to research about enhancing the effectiveness of the delivery systems in the studied countries, while others are rather based on scaling scan and scaling road maps identifications and implementation.

In **Latin America**, Mexico, the best fit framework (Birner et al., 2009) was applied to analyze rural advisory and services provision for crops and livestock systems in Mexico. Furthermore, a diagnostic of the agricultural innovation systems was conducted and identified the articulation of these systems in the region of Oaxaca to ensure the design, development and use of effective delivery systems. This activity helped identifying organizational, structural and resources (including human) gaps on strategic innovations which will be considered by the CLCA project. Furthermore, a quick analyzing of the enabling environment for scaling was undertaken in Mexico using a scaling scan. The analysis identified the most constraining factors of the enabling environment which could encourage CLCA practices in addition to identifying the deep root causes of the major soil fertility and erosion.

For the case of **Algeria** and **Tunisia**, some scaling research activities were identifying major risks related to the CLCA adoption constraints by farmers and extensionists. Others were assessing the perceived effectiveness of the technology transfer methods to diffuse CLCA improved innovations, which helped identifying farmers perceptions regarding the use and effectiveness of existing sources and approaches for technology transfer in their regions (such as field schools, trainings, experiments). Farmers preferences for these approaches have been ranked and will be used in the remaining period of the project to prioritize some of the knowledge management activities.

These activities are intending to guide the scaling activities in the coming years of the project and to define partnerships that can enhance the scaling process and ensure its sustainability.

On the sustainability issue, both **Latin American and North African** CLCA teams are actively working on designing and setting effective knowledge hubs. In **Latin America**, the project started developing a network of field, multiscale innovations and validation sites to support the scaling activities around the identified hubs and technologies. The hub model includes testing plots in farmers' fields (called 'innovation modules') and experimental plots (called 'experimental platforms') as well as the fields were farmers have adapted and implemented the learned innovations (called 'extension area'). Furthermore, given the limited budget and time for this project it is important to leverage existing collaborations and work (as set by the scaling road maps) with those that already operate at scale and have the (potential) capacity and interest to engage in scaling CLCA.

In both **North African countries** , the scaling activities of the CLCA project are based on a suite of approaches starting from the "scaling scan" which evaluates the scaling readiness, opportunities, and constraints and generates "scaling road maps", and ending with what is called the "4-wheels approach" for effective scaling partnership.

The 4-Wheels approach is a comprehensive scaling framework of agricultural technologies and innovations which can be employed by agricultural Research for Development (R4D) projects for effective partnership and scaling. The approach mainly focusses on generating higher demand for the technology by building on three (3) main stakeholders arenas including the R4D project core team responsible for effective project activities design and scaling road map coordination; the four key change agents which are necessary for stimulating transformative changes; and the policy arena responsible for stimulating enabling environments. The 4-Wheels framework divides scaling partners - also called "change agents" - into four (4) categories including: i) farmers' groups and associations of different type, ii) civil society (including NGOs) and private sector, iii) National public development partners, and finally, iv) the leader farmers and extensionists which are key for local spread of the technologies.

The framework also considers a set of tools needed to interact within and between these arenas and partners. These are knowledge management tools, coordination mechanisms, handholding of scaling partners, and monitoring and evaluation. The framework was conceptualized and preliminary tested for scaling crop livestock integration technologies under CA in Tunisia. CLCA North Africa team are now exploring effective implementation of this framework to frame ongoing scaling road maps activities in five (5) innovation hubs applicable to both **Algeria** (M'Sila & Setif sites) and **Tunisia** (El Fahs, Zaghouan & Fernana, Jendouba & Chouarnia, Seliana).

The 4-Wheels approach suggests building on the existing CLCA scaling road maps generated from the application of the scaling scan tool. This was already done in the first year of the project and the logical framework of the project was modified-accordingly. The challenge is now about generation of real changes and transformation through the set of identified scaling activities. This refers to the effectiveness of activities implementation. To meet this aim, the followed 4-Wheels approach suggests being very inclusive in terms of scaling partnership through considering four types of partners with whom we collaborate (separately or together depending on the type of activity) in every single scaling activity. Grouping partners into these four categories, will contribute to set and design appropriate knowledge management tools, communication, and coordination which best fit to each of these partner types. Consequently, it will help assessing the impact of the project and estimate the level of awareness and demand for the technologies generated while ensuring the robustness and sustainability of the scaling partners networks (Figure 34, Table 23) built around the innovation hubs. The selection, design, and activities jointly undertaken within (in partnership) these aims will be primarily based on the sustainability criteria. The objective is to ensure the continuum of the scaling process in these hubs even after the project end.

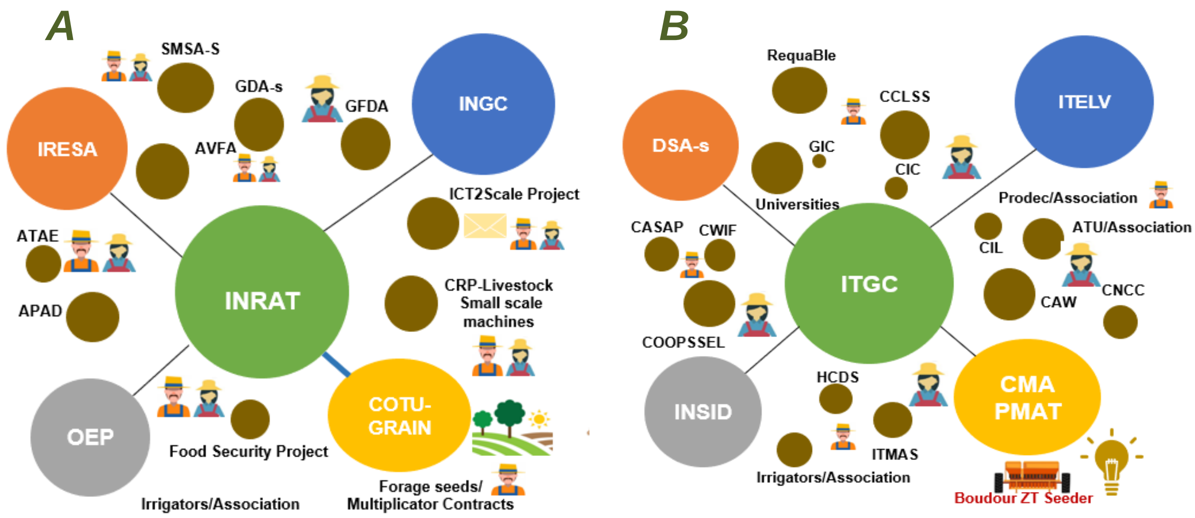


Figure 34. Scaling partners networks for Tunisia (A) and Algeria (B)

Gender focus

In **LAC countries**, we report here the different crop and livestock activities carried out by adult men and women as well as youth. Based on focus groups separated by gender in four (4) localities, two (2) in each country (Table 33) main topics covered included activities and decision making for both crop and livestock production as well as access and control over resources for both young and adult male and female family members.

Table 33. Farmers participating in focus groups in Mexico and Bolivia

Country	Villages	Adult male (> 36 Years)	Young male (15-35 Years)	Adult female (>36 Years)	Young female (15-35 Years)	Total
México	Xacañi	4	2	3	0	9
	La Providencia	4	1	2	1	8
Bolivia	Chacala	8	8	3	6	25
	Chita	11	2	2	3	18
Total		27	13	10	10	60

One of the most important findings of this section is that crop-livestock systems in both countries are family endeavors with major participation of adult women and men. Another relevant finding is that we cannot conceive the families as homogenous units, as there are diverse perspectives on who participates in what. Moreover, there are different levels of participation within the family members in the crop-livestock activities that should be considered. Results about the role of different age and gender groups in the two (2) case studies are presented in three (3) main components: i) cropping activities for maize (**Mexico**) and quinoa production (**Bolivia**), ii) Livestock activities for small ruminants (**Mexico**) and llamas (**Bolivia**) and iii) Access and control over productive resources.

Cropping activities for maize (Mexico) and quinoa production (Bolivia)

In both cases, several cropping activities are shared by men and women. In general terms, adult men and women have more engagements in cropping activities than youth. Among adults, the participation of women is slightly less than that of men. However, there are cases in which both claim to have equal participation (La Providencia Mexico). For the case of crops like maize and quinoa as Figure 35 illustrates most of the activities are shared by adult men and women although in some of them there is major participation either or men or women. This illustration also shows that steps of some practices like postharvest are divided between them. Another finding that should be considered in the project is the double workload for women that represent labor-intensive practices like sowing and harvesting because they participate not only in the activity but also in preparing food for participants. Decision making about these practices is commonly a negotiated process between the couples that justifies more the engagement of women in the project.

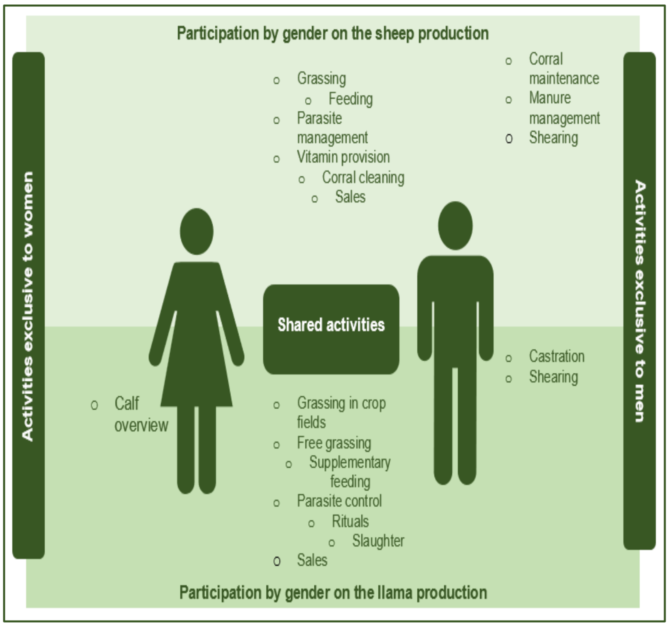


Figure 35. Activities by gender in sheep (Mexico) and llama (Bolivia) production

Livestock activities for small ruminants (Mexico) and llamas (Bolivia)

The case of livestock management practices is like crop practices, as both adult women and men participate in them. However, there is a general recognition that women take more time as they take care and manage the animals on a daily basis. This is especially the case in Bolivia with llamas as women not only participate but also decide as they ask men to undertake activities (like spaying) and men only perform them. In recent years, it has appeared the scheme of families who are community shepherds as they receive payment for taking care of other people llamas. For the case of Mexico, participation and decision making differs. Adult men tend to take care of cattle used for animal traction and decide about them. For the case of sheep and goats, women but also other family members (like children and youth) take care of them. However, decisions like the sell are made based on the necessity as animals are sold when money is needed. Figure 36 shows the different activities carried out by men and women in sheep and llama production for **Mexico** and **Bolivia** case studies respectively.

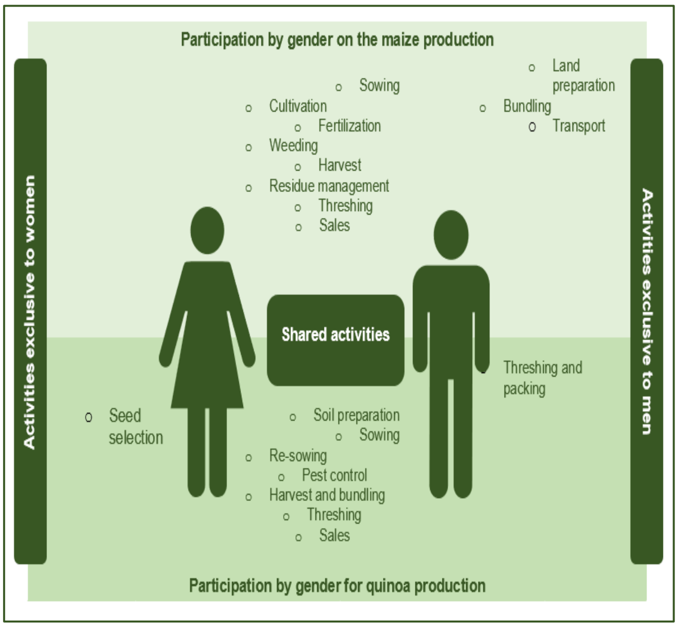


Figure 36. Activities by gender for maize (Mexico) and quinoa (Bolivia) production

Decision about the livestock activities are different for the two (2) cases. In **Mexico**, information was mainly gathered around the commercialization of livestock products. Livestock itself is seen as a saving strategy and the decision of selling them is not for women or men but more about the specific conditions such as the need for cash (e.g. social events, purchase of agricultural inputs, sickness), the age of animals and the amount of forage available to feed the herd. The price is decided by the couple in relation to the available information. In **Bolivia**, women are in charge of livestock production and the decisions about it. Men carry out some activities but mainly those indicated by women. Selling animals is a decision taken in couple or within the whole family.

Access and control over productive resources

Main resources were identified in this section: land, capital, agricultural products, livestock, manure, tools and equipment and infrastructure. Access and control to those resource play a crucial role into benefiting some members of the families more than others. There are some differences between **Bolivia** and **Mexico** referring to: i) *Access to productive assets*: In both case, adult men and women share the view that the younger generation have less access to productive resources and that men have advantages over their female counterpart because they are the owner or become owners of land more easily. ii) *Control over production assets*: In the case of control over productive assets, in both case it is again the youth that have less control as this is only distributed among male and female adults. Youth get access to resources (e.g. a plot or an animal) only when given by adults as a way to learn and they would decide on the products obtained. Within the adults of the farm households, in **Bolivia** it was mentioned that women had more control over the money of the household while in **Mexico** most control was for the male members.

To conclude, the crop and livestock activities as well as decision are carried out by both men and women together with some specificities in each region. In general terms, men dominate the cropping systems while women are more in charge of livestock systems. The participation of young women and men in crop-livestock deserves deeper exploration. As they were under-represented in the focus group discussions, information relies mostly on adults´ perceptions about them. Adults indicate that youth participation in crop-livestock activities is low because there are not opportunities due to land access for young person’s staying and making a living of crop-livestock systems. In fact, adult men promote that their children continue with their education for getting better life. There is a general perception also that young men and women are not interested in agriculture. Although this perception was confirmed by two young female high-school students who participate in one focus group, it was not shared by all. Other young female students express their interest to become agronomists and veterinarians to continue working on these farming systems. Young mothers in other community refer to their active participation in both crop and livestock activities and that they take decisions when their husbands are out of town. Young male students also express their interest in agriculture but indicate that they need the support of their parents. All these elements call for a deeper understanding of young women´s and men´s current and future participation in these systems. A finding that can be useful for their inclusion in the project, is the fact they not only participate but also takes decisions in plots or with animals in which they become responsible when parents let them have that experience. The project can take advantage of these experiences for achieving the inclusion of youth.

Based on the previous section and taking into account the different roles of family members within the farm households, including women, men, and youth; a preliminary assessment of the impact of CLCA alternatives in women’s involvement and empowerment in **Bolivia** and **Mexico** _ was conducted based on semi-structure interviews with partners in the implementation of the project and focus groups (separated by gender) with members of the communities, about the main challenges for women and youth to be included and play a role in agricultural development projects. The assessment includes the case of Mexico recognizing the previous efforts that CIMMYT and partners have done in the region. It contemplates: i) the strategies taken by selected partners in both sites (INIFAP in Mexico and PROINPA in Bolivia) for gender and social inclusion in their previous and current work, ii) previous experiences for different gender and age groups with innovations including the differentiated access to key elements of innovation such as information, capacity development and technical assistance as well as decision making process within the family household, iii) the main challenges for social inclusion within the CLCA project, and iv) some suggestions coming from young and adult women and men to be more inclusive in the implementation of a project like CLCA. The results of this preliminary assessment focus on three (3) elements that are key to the involvement of women and youth in the project.

The first element of assessment is the strategies that collaborators apply to promote innovations in the communities. The fact that neither PROINPA in **Bolivia** nor INIFAP in **Mexico** contemplate the inclusion of women or youth constrains the possibilities to reach these groups, especially because there are not current gender mainstreaming efforts in both institutions. In that sense, there is a need that the project is more explicit about its commitments on this topic and activities attending women and youth in collaborators´ work plans. The second element of assessment recognizes social differentiation concerning innovations access. Results of the assessment indicate that although diverse innovation interventions have been promoted for the crop-livestock systems, their access has not been equal for all. The document reports different access created by gender roles that make more difficult that women participate in the projects due to their reproductive and care role. Access is also more constrained for young women and men who need parents and schools´ approval and support for participating. Men also present challenges because of their role as breadwinners that implies their emigration for finding job opportunities. These different challenges to participate in the project should be considered in the strategy that collaborators apply to promote innovations. Finally, the third element are young and adult women and men suggestions for improving the project interventions referring to: a) implement strategies for working with the whole community and not only with individuals; b) facilitate not only technical training but also courses on human development (such as self-esteem and leadership form youth) and gender (masculinities, gender equality) for promoting social changes that facilitate not only access but also contribute to women and youth empowerment.

In **North African countries** and during this second year, CLCA team deployed an extensive effort to advance in the project commitment to reach 40% of women and 20% of youth as part of the target group.

In **Tunisia**, several activities were implemented during this second year to mainstem the integration of women and young farmers into CLCA project based on their needs. These activities were divided into five (5) key components:

- **Partnership with Women Farmers Associations**

The project targeted an important site in Oued Sbaihya Region which is located in the North eastern regions of Zaghouan, where livestock production (sheep and goats) is essential for the livelihood of the farming communities. Over seventy (70) households inhabit the area with an average of five (5) persons per family. This extensive farming is dominated by ruminant livestock (especially small ruminants), which are mainly reared by women farmers. To increase forage and livestock production, diversify rotation systems and enhance soil fertility, forteen (14) women farmers (influencers) (most of them are active farmers) were selected from this site and involved in on farm trials on CLCA systems, more precisely in the adoption of forage mixtures (Vetch-Oats). All of them are members of Women Farmers Association called “Women's group for Agricultural Development /Oued Sbaihya (Groupement Féminin de Développement Agricole - GFDA)” which is now a new partner of CLCA project having about seventy-nine (79) permanent members.

A training on forage mixtures was organized for seven (7) men and seventeen (17) of the women members of the women group (GFDA) in Oued Sbaihya. The objective of the training was to raise awareness, promote and educate women farmers on the benefits of planting this cereal-legume mixture. After the training, forteen (14) women farmers asked for seeds and as such we provided them with planting material to cultivate forage mixtures of vetch-oat seeds from the GFDA for sowing areas varying between 0.5 ha and 1 ha. As the women of the GFDA have asked us to expand our work in the region we will double the number of women beneficiaries next year in Oued Sbaihya.

As part of the capacity building activities and based on the global assessment of the major animal diseases/health issues hampering integration of crop and livestock in the different farming communities/project targets areas https://hdl.handle.net/20.500.11766/10824 and to pave the road for extending the project activities in conformity with the scaling road map in Tunisia, an animal health training was executed on the 24th of February 2020 at Community Based Organization of Oued Sbaihya for their members. Twenty-six (26) men and thirty (30) women attended this training. The purpose was to initiate the "Community Conversation of Oued Sbaihya" in animal health where we identified animal health issues as a major constraint for profitable crop-livestock integration. The training was developed to provide women farmers and young farmers with evaluation methods, knowledge and specific technical skills to avoid the major animal diseases for better crop-livestock integration under CLCA systems. Animal health is here presented as a novel entry point for profitable crop-livestock integration systems.

To conclude, two (2) kinds of women-related groups have become a significant partner of our out-scaling plans: i) women-only groups, and ii) gender-inclusive farmer groups. During this second year, two (2) women groups have been involved with CLCA project in Oued Sbaihya (one formal and one informal). Furthermore, two (2) gender-inclusive farmer groups are involved in El Fahs (SMSA Melyen), Chouarnia (SMSA Ettaouen), and next year _ the project will target three (3) more GFDA-s in Kef site. In year-III, the project will ensure the leadership strengthening of these women association by involving them actively in dissemination and through field days.

- **Capacity Building Activities**

Thirteen (13) CapDev events were implemented, where a total of 430 participants consisting of local farmers, extension staff, local authority, experts, researchers, policy-makers and students have been provided with skills and information concerning: i) CA practices including crop residue management, ii) direct seeder use, iii) best agricultural practices under CLCA systems, iv) best agroecological practices under CLCA package, v) forage crops & mixtures, vi) animal health for profitable integrated crop livestock systems and vi) the procedures and steps to organizing a smallholder Farmers' association (SMSA). From this total, at least 30% (122 women) of the participants were women, achieving one of the targets of this project to promote gender inclusiveness.

The knowledge management coordinator made extensive efforts to recruit women through persistent requests for INGC, OEP, ARCD, and farmer groups to recruit and invite women participants to the training. Another issue was tailoring the trainings to specific women needs. This included addressing requests on the part of women for the planting of forage seeds, which required training. Animal health was another training which was based on the mentioned community conversation on animal health (based on what diseases etc) findings and FGDs.

- **Individual degree for students (defended & ongoing)**

Fourteen (14) female out of fifteen (15) individual degrees [MSc (05), PhD (02), ESP (8)] were involved on the different CLCA topics (Annex 4). The students are recruited through existing partnerships between ICARDA, INRAT and ITGC with local universities (INAT, ESAM).

- **On-farm trials**

In **Tunisia**, CLCA directly implemented with 92 farmers (70 men, 22 women) 1,450 ha between October and December 2019 in the different sites of the project. The twenty-two (22) pioneer women farmers have been involved in on-farm trials and demonstration plots under CLCA systems in the different target areas.

Empowering women in integrated crop-livestock farming under conservation agriculture through on farm trials in semi-arid Tunisia

INGC and OEP partners has a regional focal point in each CLCA site which the project has requested to recruit influential women and men farmers. An additional 14 women farmers are from the GFDA Oued Sbaihya were recruited through another ICARDA project. This project was focused on feeding of livestock (mainstay of livelihoods in the region) and this region, like many others, had shortage in feed which the project has contributed to addressing.

- **Enhancing seeds quality and forage production through entrepreneurship and farmers associations**

The CLCA team in **Tunisia** engaged on generating business models for livestock-based small machinery. This is particularly in the area of forage seeds treatment and cleaning machines as well as the feed grinders.

Over 1,000 households (members of farmers' associations – SMSA) will benefit directly from the four (4) mobile seed cleaning and treatment units which are operated by male youth. Almost 1,080 beneficiaries (members of farmers associations) including young farmers and women are now benefiting from the six (6) mobile grinders which placed with young entrepreneurs and farmers associations engaged directly with CLCA project.

Small machinery can be ideal solution for smallholder farmers to improve their incomes which represents an opportunity for improved livelihoods in traditional small-scale farming. They can lead to reducing costs and thus increasing income. The use of these tools can reduce the labor time spent on seeds cleaning & treatment and feed-farming operations, hence enabling more time for small-scale farmers, especially for women farmers because these tasks are usually manually done by them.

Young farmers and women were considered among the beneficiaries. Next year CLCA team planned to monitor and coach the six (6) farmers associations on the use of CLCA-streamlined machinery to assess and evaluate how these small machines are managed in an economically sustainable way. More than 1,500 farmers including more than 40% youth and women will be involved. Sex as well as age-disaggregated data will be provided and protocols on how women labour is eased off will be developed.

Agricultural engineers from the national system in **Algeria** as well as the Rural Women Unit were trained on conducting women focus groups during the first year of the project. This second year, a focus group held with sixteen (16) women farmers in Setif to understand gender roles and needs in integrated livestock-crop production as well as understanding the impacts and costs of adopting CA and means to mitigate them. These women farmers will be directly integrated into CLCA component activities during the third year of the project.

Similar to Tunisia, several events were offered to about 695 participants (farmers, extension agents, local authority, researcher, Decision-Makers) in Algeria covered the different CLCA topics. From this total, 175 participants were women.

Student involvement and exposure is important to generate the awareness and leadership for the next generation of agricultural workers. In **Algeria** a total of fifteen (15) female students out of twenty-two (22) individual degree were involved during this second year (Annex 4).

Environment and climate focus

This year selected topic for this section relates to the long-term effects of a complete CLCA system (no till, rotations, forage inclusion, sheep-controlled grazing, stubble retention) on soil health characteristics. By soil health, we are here referring to water use efficiency and soil microbial activity. Data is unique and CLCA project is dedicating small investments and operational funds so that these long-term trials initiated since 1999/2000 as part of other projects, can be maintained, generate strong scientific evidence and be a model from which dissemination can start.

In order to assess the effect of long-term adoption of CA on WUE of durum wheat, on-farm trials were carried out in El Krib region/Siliana district (**Tunisia**). Trials were related to the comparison of the agronomic performances and WUE of durum wheat between CA and CT. Soil moisture was monitored during different growth stage of durum wheat. Water balance, ETR, ETC and grain yield of durum wheat was determined under both systems (CA and CT).

WUE was calculated as follows:

$$\textbf{WUE-g (kg ha}^{-1}\textbf{mm}^{-1}\textbf{) = grain yield (kg ha}^{-1}\textbf{) / ETR (mm)}$$

$$\textbf{WUE-TDM (kg ha}^{-1}\textbf{mm}^{-1}\textbf{) = Total Dry Matter (kg ha}^{-1}\textbf{) / ETR (mm)}$$

Daily real water consumption (ETR) of durum wheat under CA and CT

Results showed that at the beginning of the growth cycle, daily water consumption (ETR) was equal to the water needs (ETC) under both systems (CA and CT). Subsequently, a decrease in the cumulative ETR compared to the ETC was recorded. This decrease was greater under CT than CA, which is due to water deficit period installed from the 180 to 200 days after sowing. This drought period was more affected the crop growth under CT than under CA, since during this period there was better soil moisture under CA conditions and therefore better use of available water. At the end of the growth cycle, from 200 to 220 days after sowing, the ETR was similar to the ETC. This is mainly due to the rain received during the month of May. Indeed, at the harvest, the cumulative ETR of durum wheat during the growth cycle was 532.5 mm and 509.7 mm, respectively under CA and CT, with an increase of the water availability under CA by 23 mm compared to CT (Figure 37).

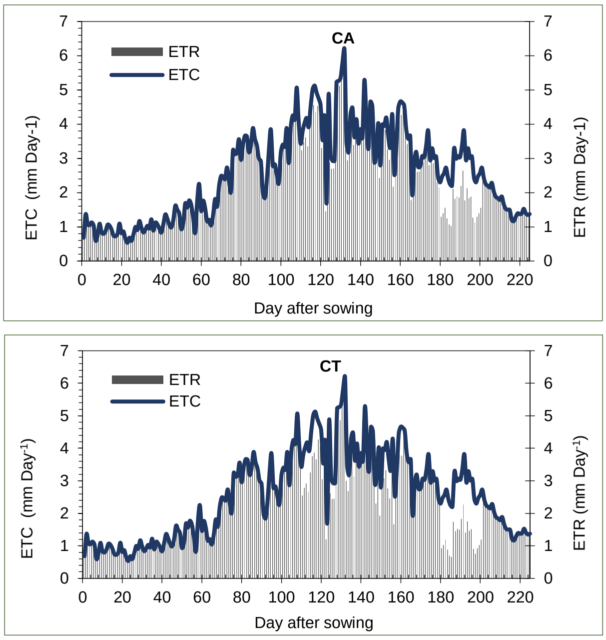


Figure 37. ETR and ETC during the growth cycle of durum wheat under CT and CA – El Krib Site, Tunisia

Results showed a significant difference between CA and CT for the WUE of the production of TDM of durum wheat. Indeed, the WUE-TDM was higher under CA (23 Kg /mm/ha) than under CT (17.7 Kg /mm/ha). The increase of WUE-TDM under CA compared to CT system was 23%. This improvement was 15% for WUE of the grain production (WUE-g). Indeed, WUE-g for durum wheat was higher under CA (8.2 Kg /mm/ha) compared to CT (7.0 Kg /mm/ha Kg /mm/ha) (Figure 38).

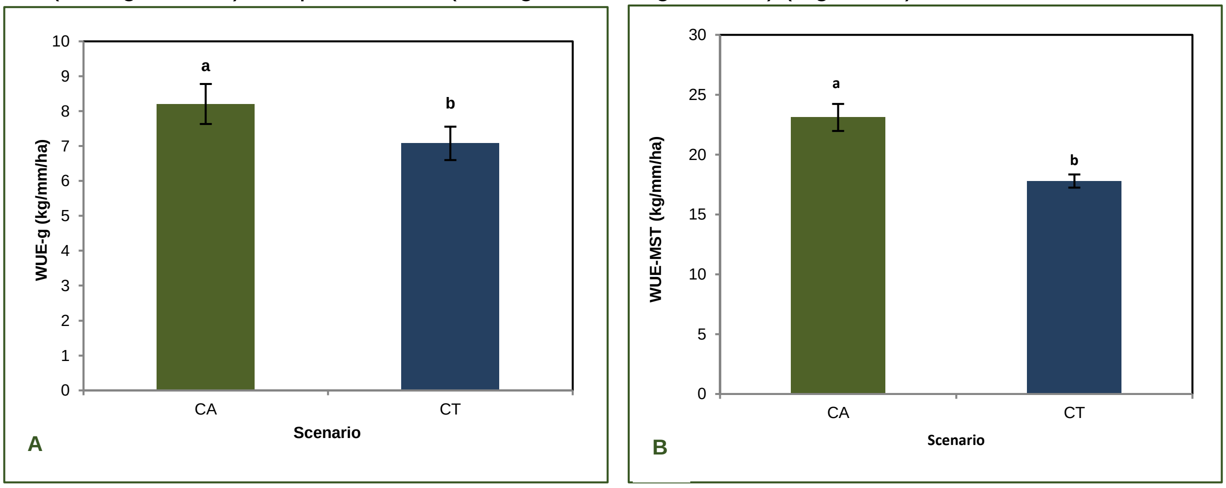


Figure 38. WUE-g (a) and WUE-TDM (b) of durum wheat under CA and CT – El Krib Site, Tunisia

Soil microbial activity under CA vs CovA

Soil microbial activity is an indicator for soil fertility. In this context, a soil sampling (from CA and CT plots) were carried out from the same trials above mentioned. In order to assess the effect of long-term CA adoption on soil microbial activity, an experiment was conducted under laboratory conditions (soil incubation during 77 days for monitoring microbial respiration). Results showed that soil microbial activity was higher under CA than CT for different studied soil layers (0-15 cm, 15-25 cm and 25-45 cm) (Figure 39).

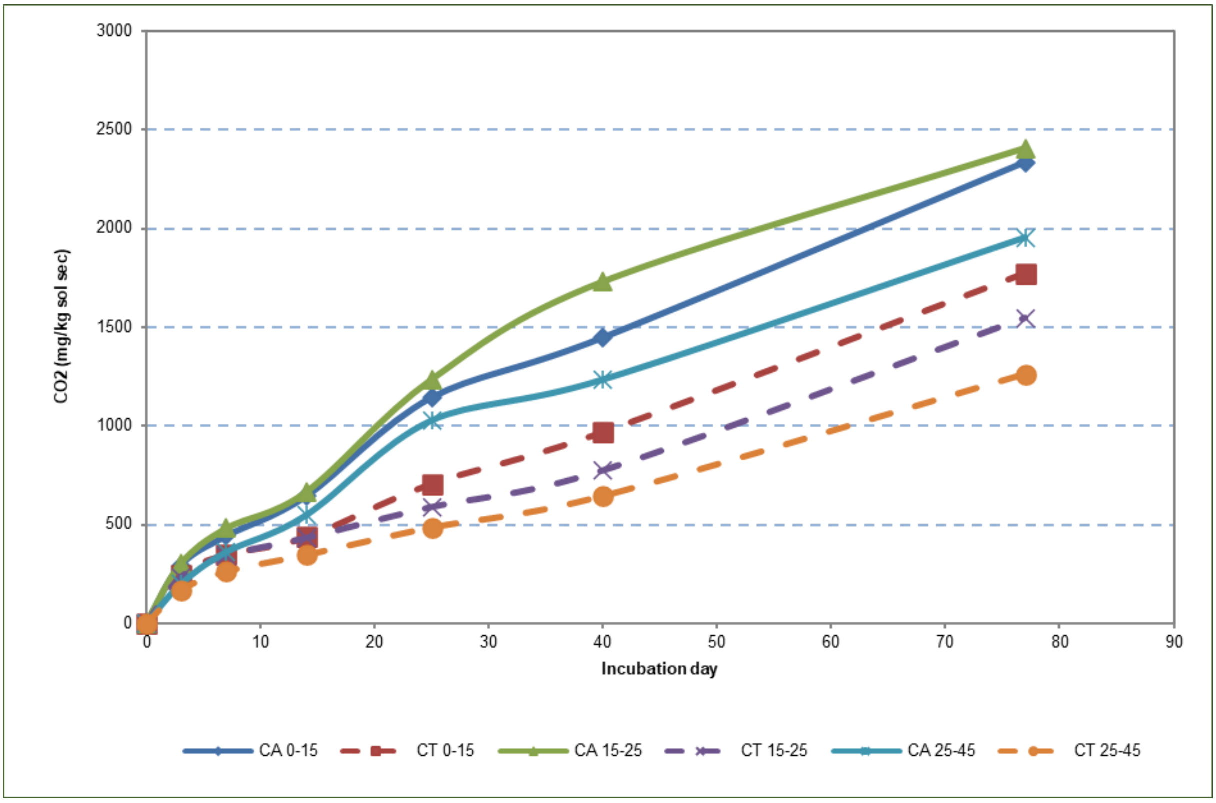
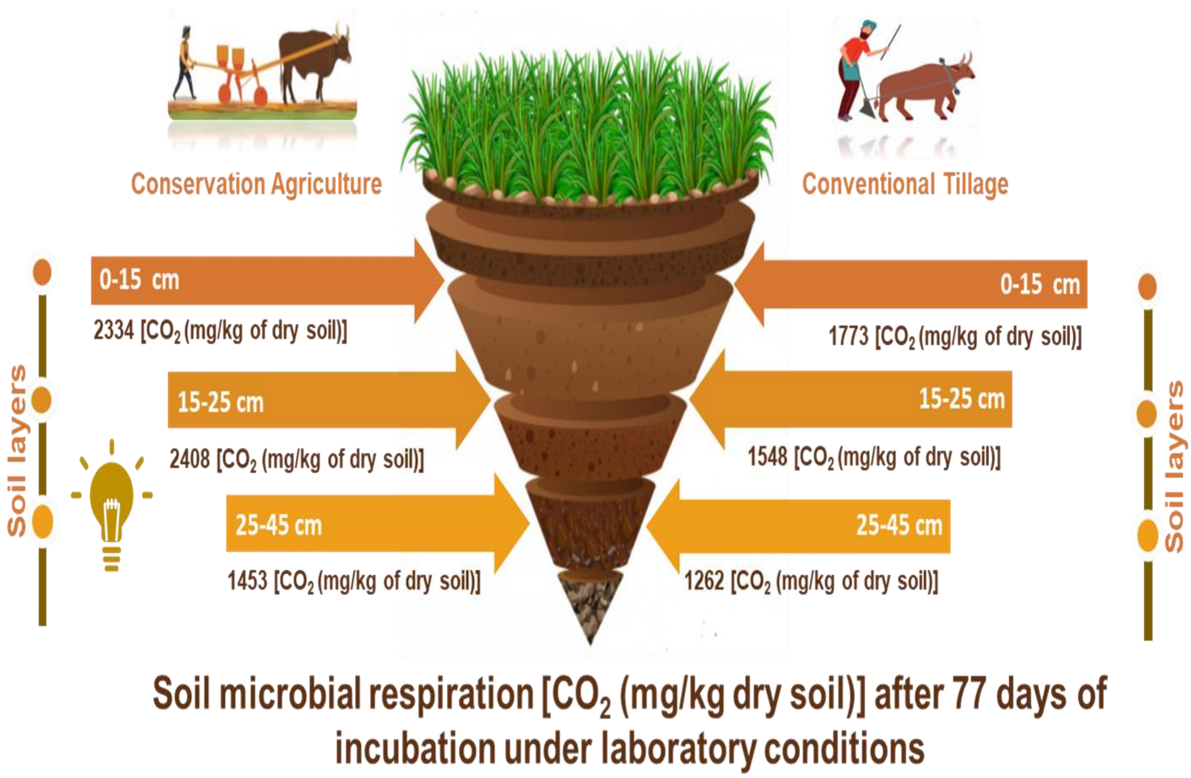


Figure 39. Soil microbial activity [CO2 (mg/kg of dry soil)] under CA and CT for different soil layer (0-15 cm, 15-25 cm and 25-45 cm) – El Krib Site, Tunisia



Monitoring and evaluation

- **Monitoring**

During the second year, the M&E Team sustained the effort under output 1.4 to mainstream ITC-based M&E tools for usage and adoption by NARES and collaborators. In addition to backstopping support in configuring Open Data Kit (ODK)-based application for field data collection, the team organized a full training week dedicate to collection, curation and use of data. The Monitoring, Evaluation and Learning (MEL), Data Management and Geo-informatics Option by Context (GEOC) Learning Week took place in **Tunisia** 1-7 November 2019. The main objectives were to: i) Conduct joint/participatory curation of datasets from Tunisia. This will use the datasets uploaded to MEL as a basis and also include data recorded by CLCA project. At the end of each curation session, a Communication Specialist/Officer shall collect information on the history of data collection and the process and generate a knowledge product, and ii) Conduct training on mobile open data collection – Open Data Kit (ODK) for participants drawn from CLCA project and CRP Livestock. The demo tool for ODK data collection training was based on the Module A of the CLCA-II project data collection tool. It was used to guide the training using both the ODK builder and ODK XLS approaches https://hdl.handle.net/20.500.11766/10369.

After this training, two (2) CLCA data collection forms were designed and operated in ODK tool for use in **Algeria** and **Tunisia** (https://hdl.handle.net/20.500.11766/10570 & https://hdl.handle.net/20.500.11766/10569). The required data will be used to monitor and systematize the progress on the fields. Trials' and farmers' data describing the management of crops, yields, costs, dates and crop status will be captured through these tools. Data collectors will be local stakeholders and their extension agents who can work online and offline in the field, save submissions at any point and – once they are finished – send them to the project servers. ODK Collect uses the Android platform and supports a wide variety of question types: text, number, location, polygons, multimedia, and barcodes. The M&E Team also supplied national partners with field tablets for data collection.

The intensive work on the use of the ODK tool in the framework of the project was taken up by participating university lecturers who included teaching of the tool as part of the curriculum of an MSc untitled Integrated Water Resources Management and Sustainable Agriculture (GIREAD) at the Higher School of Agriculture of Mograne (ESAM) in **Tunisia**. We shall follow up on the evolution of the ODK tool in the MSc because this may be an interesting outcome story on how the project influenced the teaching curriculum of an MSc.

In **North Africa countries**, routine monitoring with partners was regularly implemented during this second year in order to follow up on activities implementation, data collection for reporting and internal team brainstorming.

Different protocols and data collection tools have been developed and implemented to be used in **Bolivia** and **Mexico** system in order to gather and organize data collected such as workshop participants, primary soil and crop information, land use classification. In each site, a network of forty (40) plots has been established where CLCA alternatives have been or will be implemented and used to assess the performance of the different alternatives and as support to discuss with farmers and generate capacities around the technologies developed and recommended. Three (3) main forms were designed to collect data: Agronomic logbooks to collect dates, detailed practices, costs and income; field visits to identify, for instance, pest and disease problems on time; and training forms to collect attendants' lists, training topics and duration in number of hours. These forms were operated in Formstack and CIMMYT's data collection in-house systems:

- ✓ Training event report (Bolivia) https://cimmyt.formstack.com/forms/reporte_eventos_clca_bolivia;
- ✓ Field visit form (Bolivia) https://cimmyt.formstack.com/forms/formato_de_visita_clca_bolivia;
- ✓ Beneficiaries form (Bolivia) https://cimmyt.formstack.com/forms/beneficiarios_indirectos_clca_bolivia.

During data collection, a dynamic cleaning system will take place in order to verify with the agents in the field weather outliers are mistakes that can be modified or are actual atypical data. Once the agronomic cycle is over, a final cleaning process will be conducted to specify ranges and particular conditionals.

Collected data will be cleaned through several scripts developed in R-language (https://www.r-project.org), which automatically will obtain data from an Excel file, identify and separate outliers, and then graph specific variables for interpretation per region, system type, or technology (ex. yield variation and net income per crop, region and production type).

This analysis will be based on the M&E framework presented for the project which includes a set of indicators that will be disaggregated in socio-economic aspects including gender and age, and particular outcomes of the project as number of farmers adopting CLCA technologies, trainings, productivity, climate resilience and strengthening of the network.

In order to improve the monitoring of events including field days, training and workshop, the MEL team improved the M&E Platform with a feature to evidence each single event and expose the open access material used for further use (https://hdl.handle.net/20.500.11766.1/21b09c). This will support annual planning and reporting following IFAD suggestions on 1st year reporting format. The team will now use an improved template (Annex 2) to report progress against the log-frame targets disaggregated by country/region, sex/age and stakeholder typology.

- **Evaluation**

As the project has completed the first half of its implementation period, an external review will be conducted to evaluate the project`s progress against planned outcomes and milestones as detailed in the project logframe, and impact pathway (https://mel.cgiar.org/projects/clca2). The M&E Team developed an evaluation/selection report to document the whole bid selection process; including the criteria, mechanics, reference instruments, and pre-inception arrangements. It aimed to foster transparency and objectivity in the selection process and can serve as reference for future selection exercises by the partners of this project and/or those of comparable setting. As stipulated in the CLCA Phase (II) proposal document https://mel.cgiar.org/projects/clca2 , the mid-term evaluation is the first of two external review processes ICARDA and CIMMYT will undertake which aims to:

- ✓ Appraise the activities and outputs achieved by ICARDA, CIMMYT and NARES;
- ✓ Identify and assess outcomes of the project including South-South collaboration;
- ✓ Identify the enablers and/or constraints to the attainment of project results and lessons learnt;
- ✓ Make practical recommendations for corrective action required to achieve the envisioned project results within the remaining period of the project.

The external evaluator will refer to the 2nd edition IFAD-IOE Evaluation Manual when designing the framework for the CLCA-II mid-term evaluation from reviewing the theory of change, techniques for data collection and analysis, engaging stakeholders in evaluation processes, communication and outreach of results, to lessons learned. This will enable the whole process to adhere to IFAD`s evaluation policy, and the internationally agreed criteria of relevance, effectiveness, efficiency, sustainability of benefits and rural poverty impact. The progress of CLCA-II will be evaluated against these criteria, translated into evaluation questions as sampled in the CLCA-II mid-term evaluation TOR.

Financial and fiduciary management

The financial statement table for the period between April 1st, 2019 and March 31st, 2020 is presented in annex 5. The second-year budget of the IFAD grant is US$ 693,900 of which US$ 13,878 correspond to the 2% CSP contribution. The funds available for ICARDA and CIMMYT amount to US$ 680,022 of which US$ 346,985 were allocated to ICARDA for work in **North Africa** and US$ 333,037 were allocated to CIMMYT for work that was performed in **LAC countries**. Up to January 2020, the amount disbursed by IFAD to ICARDA is US$ 1,205,500. By March 31st, 2020 (end of Year-II of the project) the balance was US$ 225,007. The underspending mainly corresponds to CIMMYT engaging late in **Mexico**, the second country in LAC, to procurement delays in purchasing equipment for North African countries and also to open commitments related to advances made to NARS partners which have not yet been settled and could not be recorded as actual expenditures.

Relevance to IFAD target group

The proposed grant is aligned with IFAD corporate priorities. The project focuses on the continuing and growing challenges of food security, climate change, and land and natural resource degradation faced by mixed smallholder farmers in drylands. The grant reflects rural development priorities in **NA** and **LAC** countries where food security, climate change and natural resource degradation are of outmost importance for the low end of the wealth gradient and marginal households, notably for rural women and youth. The project will contribution to the three (3) strategic objectives (SO) of IFAD's current Strategic Framework (2016-25). It will in particular contribute to SO_1, "Increase poor rural people's productive capacities" and SO_3, "Strengthen the environmental and climate resilience of poor rural people's economic activities". The main target groups are 3,000 HH of small crop-livestock producers in NA and LAC, whose livelihoods are dependent on crop production (barley and wheat-based systems in NA, and maize, wheat and Andean cereal-based production systems in LAC) which also have a livestock component. Through the support to innovation systems supporting adoption, the involvement of NARES and linking to IFAD investment projects, the spillovers are expected to reach 20,000 HH, who will indirectly benefit from the project. Processes and practices developed will be made available to national innovation systems to expand adoption to areas outside of the project implementation area through processes and approaches developed within the project lifetime. Specific strategies will be used to integrate women from both women-headed households and men-headed households in participatory activities and their needs and priorities will be included in the development of the adapted CLCA practices to ensure benefits for women. Likewise, specific strategies for reaching women will be included in the development of processes for promoting the wider uptake. An effort will be made to involve young farmers and capture their innovative ideas and potential role as change agents. In **Bolivia**, the communities and farmers to implement the activities of the project in its first year were selected based on a typology analysis using the IFAD-funded investment project Pro-Camelidos targeting small-scale mixed farmers within the existing indigenous communities. While in **Mexico**, the project activities are aligned with those of the IFAD-investment project PRODEZSA. For **Algeria** and **Tunisia**, we privileged the communities and farmers where the first phase of the project was implemented in order to ensure continuation and engagement. For new sites, the project teams based their choice on the outcomes of the typology carried out in the first phase and clearly targeted small to medium-sized farms practicing crop and livestock production in which the sustainable use of natural resources is threatened by a high risk of soil erosion and a depressed water use efficiency.

Linkages to IFAD investment portfolio and other development initiatives

In **Bolivia.** The CLCA team has used the baseline survey of ProCamelidos to develop a typology of farming systems for five (5) municipalities. These typologies were shared and discussed with ProCamelidos agents and gave their positive feedback on the usefulness of these kind of studies to better target their interventions. Further collaboration was planned where we cross these typologies with agroecological mapping developed by the ProCamelidos team but with the political situation in Bolivia the program got into stand stall and reorganization and it has been impossible to re-connect. ProCamelidos agents were registered to follow the course on systems analysis but it was postponed. Such course can become an important opportunity to intensify the dialog between the CLCA project and the ProCamelidos program.

In **Mexico** project activities should seek alignments with the program Sustainable Development Project for the Rural Communities of Semi-arid Zones (PRODEZSA). PRODEZSA has a focus on non-timber forest products for rural livelihoods and, taking into account the important pressure on forest and community pasture for livestock production, there are some opportunities for collaboration. We are currently planning more landscape approaches which include the forest as well as detailed tracking of herd management to identify where the livestock spends time and what they graze. CLCA team, will also pursue the identification of synergies with the Mixteca Alta, Oaxaca UNESCO Global Geopark.

In **Tunisia**, CLCA project continues to work in the same intervention area of the IFAD-PROFITS project "Siliana Territorial Development Value Chain Promotion" (Makthar & Bargou Sites). Some of the farmer groups we are supporting are also benefiting from the support of PROFITS project (Figure 40). A mobile seed cleaning and treatment unit and a local feed grinder were delivered and distributed to farmers' association having 350 members. Out of this number, at least 40% are young farmers (age <35 years). The seed treatment and cleaning machine is helping the farmer association to improve their farm seeds and forage production and consequently promoting forage seeds multiplication. We have also quantified the very encouraging higher integration of forage crops into farm rotations in the target site as a pillar of a sustainable crop-livestock integration under CA. https://hdl.handle.net/20.500.11766/11134.

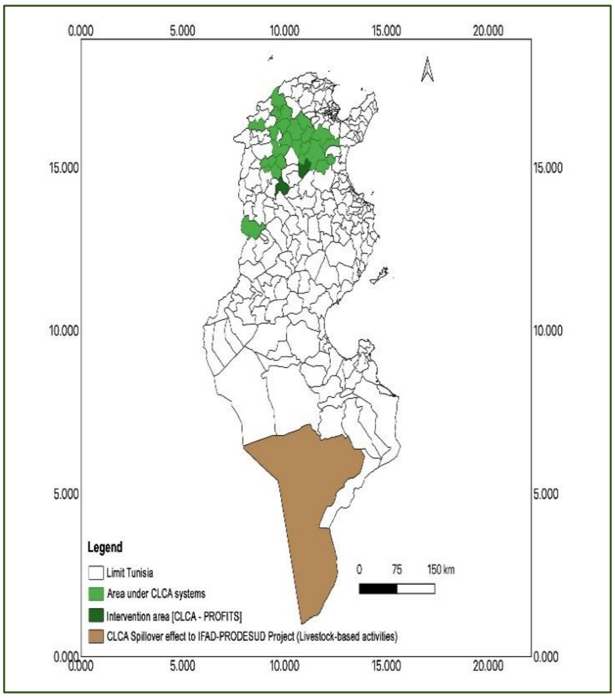


Figure 40. Map of CLCA intervention areas corresponding with IFAD Programs for enhancing seeds quality and forage production through entrepreneurship and farmers associations in Tunisia

Further to this and to quantify impact on natural resources, the CLCA project has established at the landscape level, where PROFITS projects has its interventions, a measurement network of erosion. This is happening with Chouarnia farmers' association where CLCA packages have been in place for several consecutive agricultural campaigns.

Tunisian CLCA team also consulted with PRODESUD – Tataouine "Agropastoral Development and Local Initiatives Promotion Programme for the South-East" to define groups of farmers who can benefit from feed grinders for more efficient feeding systems of small ruminants. Tataouine is not an area for cropping but this is a spillover effect to IFAD-investment projects particularly in the area of livestock. More than 100 farmers, members of an Agricultural Development Group – GDA Nekrif, supported by PRODESUD are now benefiting from this equipment & related training (Figure 40). This farmer's association is operating in an irrigated area of Tataouine governorate, Ramada district (extreme South and Arid region) – where they are cultivating forage crops for their livestock in complementarity with rangeland grazing and the feedlot system. More quantified data on the use of the feed grinders and its impact on livestock feeding is being collected.

In **Tunisia**, discussions with PMU of PROFITS project are very advanced. CLCA team met with IFAD focal point in Tunisia since the start of the project to discuss the collaboration between CLCA project and PROFITS project. CLCA and PROFITS teams met several times to discuss potential collaborations and the terms of an agreement that can be signed between them. Concretization of such an agreement lies within the priorities of CLCA team in 2020/21. Spillovers to PRODSUD (Agropastoral Development and Local Initiatives Promotion Programme for the South-East) & PRODFIL (Agro-pastoral value chains in the governorate of Medenine) will be expanded and limited to livestock-based activities in particular a larger dissemination of feed grinders, alternative feed resources and small ruminants improved management.

Conclusions and recommendations for follow up

The engagement in Mexico as a second country in LAC has now allowed the project to reach the initial number of target countries. The selection of **Mexico** as second LAC country will allow the project to capitalize on the huge work of CIMMYT in Mexico over the last decades, CIMMYT legacies and partnerships to speed up the work and implementation.

In Year-II of the project, teams were successful in shaping the scaling hubs by identifying the main actors and partners as basis of the innovation system, in increasing their visibility as knowledge providers and in consolidating their knowledge support (tools - and network of technical partners) for CLCA to ensure the continuity of the knowledge transfer after the project ends; and further build the social networks around these hubs using the 4-wheel approach of "partnership for scaling". The project resources in Year-III and Year-IV will be strategically deployed to "personalize" each of these hubs and to continue to nurture them in order to make them grow and gain maturity within CLCA thinking.

With relation to the previous point, hubs in **North Africa** are already growing, achieving more than what was expected from them and more importantly, are generating more demand (in terms of knowledge products, light investment for appropriate pedagogic tools and capacity building of human resources in charge of disseminating knowledge) for the joint NARES-ICARDA project team.

Gender mainstreaming in the project thinking and targeting in Year-II was considerably increased on both continents. Working with lead-women in **Tunisia** implementing trials and influencing their neighborhoods can be flagged as a promising approach. In the four countries, livestock, feed and forages were key entry point to recruit women and prepare them for a full involvement into CLCA integrated activities.

The project is also starting to generate more compelling evidence on the environmental benefits of CLCA. Enhanced water use efficiency, healthier soils while seeking for ways to reduce the doses of the environment-unfriendly glyphosate while stabilizing yields show that CLCA system can provide real solutions for more sustainable cereal and livestock production in drylands.

While this document is reporting achievements of the project until end of March 2020 coinciding with the COVID-19 pandemic and with various restriction measures taken by governments in all target countries, we have not recorded, so far, a major impact on the project implementation. While the current improvement of the epidemiological context in **North Africa** is favorable for the project, our colleagues at CIMMYT are closely monitoring the situation in **Bolivia** and **Mexico** for any drawback caused by the pandemic. The pandemic in **North Africa** had, to some extent, generated some positive repercussions such as a more decentralized and proximate organization of the activities, a more intensive use of ICT tools and we were successful in accessing some funds from a call addressing the immediate consequences of the COVID-19 crisis on the livelihood of rural women which we channeled to our CLCA sites in **Tunisia**.

Annexes/Appendices

Annex 1. Detailed work plan April 2019 – March 2020 (Outputs completed are marked with √)

Component	Sub-component	Activity	Description of activity and in which country it will be implemented.	Time frame	Implementing entity and responsible person	Activity Outputs
Component 1: Adaptive research with integrated capacity development of key partners to fully implement and evaluate CLCA systems	Sub-component 1.1: CLCA system optimization (filling research gaps and full implementation and integration of technologies developed by both centers for the two (2) regions	Ac. 1.1.1 Stakeholder engagement and rapid appraisal	Conducting multi-actor regional national meeting in Algeria, Tunisia, Bolivia and Mexico.	April to October 2019	CIMMYT & ICARDA (Santiago Lopez and Mourad Rekik)	Stakeholders identified and invited to collaborate and strongly involved in the project √
		Ac. 1.1.2 Developing integrated improved crop management systems	Develop and disseminate integrated improved crop management systems through the generation of empirical evidence (especially on-farm).in Algeria and Tunisia Identify and test technical alternatives for crop management adapted for different agro-ecologies (Bolivia and Mexico).	June 2019 to March 2020 April 2019 to March 2020	CIMMYT & ICARDA (Ravi Gopal and Mina Devkota Wasti)	Reports and protocols describing establishment of on-farm and on-station trials, draft scientific paper in North Africa: √. Reports: - Main technical alternatives for CLCA systems, data available and research gaps in Oaxaca, Mexico √. -Assessment of identified alternatives in Bolivian Highlands, fine tuning and identification of complementary options for CLCA √.
		Ac. 1.1.3 Fine-tuning crop residue use in different geographies and socioeconomic environments	Identify and test technical alternatives for crop residue use and alternative feeding sources (Bolivia and Mexico).	April 2019 to March 2020	CIMMYT Only (Santiago Lopez)	

Annex 1. Cont'd

Component	Sub-component	Activity	Description of activity and in which country it will be implemented.	Time frame	Implementing entity and responsible person	Activity Outputs
Component 1: Adaptive research with integrated capacity development of key partners to fully implement and evaluate CLCA systems (Cont'd)	Sub-component 1.1: CLCA system optimization (filling research gaps and full implementation and integration of technologies developed by both centers for the two (2) regions (Cont'd)	Ac. 1.1.4 Advocating alternative feeding systems and livestock enterprises	Define the current feeding systems used by smallholder farmers (400 observations from M'Sila site-Algeria and 500 obs. from 5 different sites in Tunisia) Advocate alternative feeding systems through integrating forage options Tunisia: establish 500 ha of forage mixture with 60-farmers Tunisia & Algeria: establish 250 ha of common vetch Establish forage seed multiplication with farmers Algeria: 200 ha of seed multiplication of forage crops for 25 farmers including 10 t of quality vetch seeds Develop quick and reliable field tools to estimate stubble biomass, biomass intake, residual biomass, grazing intensity Piloting feedlot systems for greater efficiency	June 2019 to March2020	ICARDA only (Mourad Rekik)	Reports, drafted scientific paper, and book on vetch√ Book on vetch drafted and under clearance prior to publication
		Ac. 1.1.5 Financially viable business models for no-till service provision enterprises	Improve the local low-cost direct seeder and modify the conventional seeder to a no till seeder (Two conventional seeders will be modified to no-till seeders each in Algeria and Tunisia) Support the development of innovative business models and business plans suitable for small entrepreneurs willing to invest in machinery services	October 2019 to March 2020	ICARDA only (Aymen Frija)	Seeder prototypes available √ Completed for Algeria and other small machinery in Tunisia. ZT seeder prototype in Tunisia not yet Business models and plans √ Still ongoing in Years 3 and 4
		Ac. 1.2.1 Reducing irrigated water use in CLCA systems; optimizing in-situ water use in rain fed systems	Assess soil fertility, erosion and water productivity under CLCA systems in Algeria and Tunisia (monitoring on 30 farms in the three target areas in Algeria and 60 demonstration plots in 3 different sites in Tunisia). Testing and adapting identified alternatives for improved water use efficiency (WUE) and decreased erosion under CA (Bolivia)	June 2019 to March 2020	CIMMYT & ICARDA (Ravi Gopal and Mina Devkota Wasti)	Reports, baseline database, drafted scientific paper √
		Ac. 1.2.2 Reducing erosion in soils with steep slopes	Identify and test technical alternatives, data available and research gaps for improved WUE and decreased erosion (Mexico).	April 2019 to March 2020	CIMMYT & ICARDA (Mina Devkota Wasti)	

Annex 1. Cont'd

Component	Sub-component	Activity	Description of activity and in which country it will be implemented.	Time frame	Implementing entity and responsible person	Activity outputs
Component 1: Adaptive research with integrated capacity development of key partners to fully implement and evaluate CLCA systems (Cont'd)	Sub-component 1.2: Appropriate system development methodology to support adoption and decision-making	Ac. 1.3.1 Developing comprehensive trade-off models	To assess the technical feasibility, economic viability and environmental performance of CLCA system and CA adoption for 140 farmers in 2 different sites in Algeria and 150 farmers and150 extension agents and policy makers in Tunisia. Collect farm level data for trade-off modelling parametrization (Bolivia and Mexico). Start up on the application of the MESMIS framework for sustainability evaluation (Bolivia and Mexico).	August 2019 to March 2020 April 2019 to March 2020	CIMMYT & ICARDA (Santiago Lopez and Aymen Frija)	Reports, field surveys, and drafted scientific paper √ Report: Farm level modelling and protocols for the assessment of indicators (Mexico and Bolivia) √ Report on: Course(s) on systems analysis. Not realized because of COVID-19
		Ac. 1.4.1 Establishing appropriate monitoring and evaluation frameworks	Develop appropriate monitoring and evaluation of the different project activities in particular for components 1 and 2 in Algeria, Bolivia, Mexico and Tunisia Identify and deploy MEL frameworks in the sites/countries and compile with CIMMYT and other dev projects initiatives for comparison and complementarity	April 2019 to March 2020	CIMMYT & ICARDA (Enrico Bonaiuti)	Reports (Internal document) Report on: Data collection, cleaning and analysis√ and products can be visualized @ https://mel.cgiar.org/projects/clca2

Annex 1. Cont'd

Component	Sub-component	Activity	Description of activity and in which country it will be implemented.	Time frame	Implementing entity and responsible person	Activity Outputs
Component 2. Development of a delivery system/participatory farmer-led extension system for accelerating of adoption		Ac. 2.1.1 Develop a road map – based on previous CLCA initiatives by ICARDA and CIMMYT - for large-scale adoption of CA within dryland crop livestock environments	**Large scale adoption of CA within dryland crop livestock environments- based on the scaling road maps -through participatory processes for agricultural innovation: 2,000 farmers reached, 300 have directly adopted CLCA farming systems (1,000-ha) in Tunisia, and 250 farmers (700-ha) for Algeria and 100 direct beneficiaries in Bolivia, We therefore expect more than 1500 farmers to be indirectly reached by the project through trainings, field days or exposed to the different KM products which are developed in the framework of the project** **In LAC, 45% of the direct beneficiaries will be women.**	April 2019 to March 2020	CIMMYT & ICARDA (Lennart Woltering)	Reports, baseline database Inventory reports for Bolivia - Report. Process of development of network of on-field, multiscale innovation and validation sites. √ - Report. First draft of adapted framework for effective rural advisory and service provision for machinery, agronomic and livestock services. √ Work on the rural advisory service provision is ongoing
		Ac. 2.1.2 Develop of network of on-field, multiscale innovation and validation sites			CIMMYT & ICARDA (Lennart Woltering)	
		Ac. 2.1.3 Identify women's (both women-headed households and women in male headed households) decision-making constraints and develop opportunities to effective			CIMMYT & ICARDA (Dina Najjar and Carolina Camacho)	

Annex 1. Cont'd

Component	Sub-component	Activity	Description of activity and in which country it will be implemented.	Time frame	Implementing entity and responsible person	Activity Outputs
Component 2. Development of a delivery system/participatory farmer-led extension system for accelerating of adoption (Cont'd)		Ac. 2.2.1 Developing a framework for effective rural advisory and service provision for machinery, agronomic and livestock services	**Identify partners for scaling CLCA initiatives and their participation in innovations systems based on on-field testing of innovations, delivery systems and service provision as well as the capacity building needs for the new site (Oaxaca)**	April 2019 to March 2020	CIMMYT & ICARDA (Lennart Woltering and Boubaker Dhehibi)	Inventory reports for new site (Oaxaca): - Report. Innovation systems diagnostic document for new site (Oaxaca) √ - Report. Innovation systems proposition with actors and their role for new site (Oaxaca) √
		Ac. 2.2.2 Testing of effective service delivery mechanisms for machinery, agronomic and livestock services			CIMMYT & ICARDA	
		Ac. 2.2.3 Develop multi-level capacities to manage integrated interventions from field to food			CIMMYT & ICARDA	
		Ac. 2.2.4 Integrate scaling partners with the network of on-field, multiscale innovation and validation sites			CIMMYT & ICARDA	

Annex 1. Cont'd

Component	Sub-component	Activity	Description of activity and in which country it will be implemented.	Time frame	Implementing entity and responsible person	Activity Outputs
Component 2. Development of a delivery system/participatory farmer-led extension system for accelerating of adoption (Cont'd)		Ac. 2.2.5 Examine implications for women's involvement and empowerment in above approaches	-To enhance capacity building of women farmers in CLCA farming system, 30 women farmers directly reached in Algeria and 120 women farmers in the different target areas in Tunisia. -Involvement of women farmers in on farm trials on CA and community-based forage seed production: establishment of on farm trials for 3 women farmers in the different sites for both countries. -Leadership support to women farmers (along with involvement of young women and men) by working with the women champions in the scaling road map through encouraging women to join farmers' associations in Tunisia along with working with these groups for scaling purposes (to reach 3 women farmers champions in the different sites in Tunisia and Algeria. -Review and identify existing institutional / policy factors and how they impede or facilitate women's involvement and empowerment of CLCA practices and scaling strategies in each site	June 2019 to March 2020 April 2019 to March 2020	CIMMYT & ICARDA (Dina Najjar and Carolina Camacho)	-Report: Identification of diversity of farming systems in relation to social inclusion determinants (gender, age, ethnic group, etc.) for Oaxaca and Bolivia. √ -Report: Identification of main CLCA activities carried out by different gender and age groups in Oaxaca √ -Report: Preliminary assessment of the impact of CLCA alternatives in women's involvement and empowerment in Bolivia √ -Reports summarizing gender-disaggregated focus groups in Algeria and Tunisia to understand gender roles and needs in integrated livestock-crop production as well as understanding the impacts and costs of adopting conservation agriculture and means to mitigate them √ -Design and implementation of the intervention phase in North Africa around the following themes: 1. Capacity building of women farmers in a-prophylaxis and b-feeding √ 2. Involvement of women farmers in on farm trials on CA and community-based forage seed production √ 3. Leadership support to women (along with involvement of young women and men) by working with women champions in the scaling roadmap (e.g., through encouraging women to join SMSA and GDA in Tunisia along with working with these groups for scaling purposes) √ 4. Youth as students are to be involved in the project and as participants in above activities √
Cross cutting knowledge management component		Participate in developing and disseminating CLCA information packages to smallholders via KM participatory tools in Algeria, Bolivia, Mexico and Tunisia -2,000 farmers and 500 policy makers & extension agents (PM&EA) reached in Tunisia and 1,500 farmers and 500 PM&EA in Algeria. -300 farmers and 250 policy makers & extension agents (PM&EA) have directly adopted CLCA packages in Tunisia and 250 farmers and 300 PM &EA in Algeria.		June 2019 to March 2020 April 2019 to March 2020	CIMMYT & ICARDA (Andrea Gardeazabal and Enrico Bonaiuti)	-Generated databases and related narrative reports, project documents (books), survey tools and data generated including field books per site and lists of participants in courses (training activities, workshops, field days, focus group discussions) are and any other --knowledge product documented and evidenced in MEL. √ -Infographics to better describe what the CLCA project does and where it operates √ -4 Videos on best-bet agronomic practices under CLCA and livestock feeding management Not achieved -At least 6 SMS related to best agronomic practices, CA implementation and animal feeding designed and delivered √ -At least 15 graduate and post-graduate students enrolled in specialized course n aspects related to CLCA √ -Capacity development: training activities for farmers and extension agents, demonstration events, service providers empowerment √ -South-south taskforce √ -Data analysis and report √

Annex 2. The project logical framework matrix

CLCA-II LRA-Matrix.xlsx

Annex 3. Current CLCA-Oaxaca Stakeholder Matrix

Name	Type of organization	Incentive to scale	Form of collaboration	Role(s) in CLCA
International Maize and Wheat Improvement Center (CIMMYT)	CGIAR	Core mandate is to reach impact with agricultural innovations among poor	Contract with ICARDA for implementation CLCA in Latin America	Lead CLCA-Oaxaca Project. Agronomic advice, access to seeds and (new) varieties, Making available MasAgro network.
International Center for Agricultural Research in the Dry Areas (ICARDA)	CGIAR	Core mandate is to reach impact with agricultural innovations among poor	Contract for project implementation	Overall lead CLCA. Knowledge exchange across continents.
International Fund for Agricultural Development (IFAD)	Donor	Core mandate is to alleviate poverty in poor countries	Contractor to consortium ICARDA-CIMMYT	Advocacy, convening partners, financing, organizational support, client.
Secretaria de Agricultura y Desarrollo Rural (SADER)	Government	Mandated to lead rural development in Mexico	Formal: directly with SADER via MasAgro program.	Create an enabling environment for CLCA uptake.
Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP)	Research institute (of SADER)	To generate scientific knowledge and technological innovations in agriculture and forestry	Formal	Raise awareness with extension agents and public sector. And support research and innovation.
Secretaria de Desarrollo Agropecuario, Pesca y Acuacultura (SEDAPA)	Government	To strengthen food security, especially for vulnerable population	Informal	Support the scaling of CLCA for enhanced water use efficiency, soil fertility and productivity via advocacy, coordinating leadership and alignment of resources.
Local authorities (ex. municipalities)	Government	Mandated to lead rural development in the municipalities	Informal	Support coordination of efforts across the region.
Universidad Autónoma Metropolitana (UAM) – Unidad Xochimilco	University	To apply research and develop students' skills and knowledge	Service contract for research on local adapted CLCA	Research and development implementation partner. Experts on livestock management.
Fondo para la Paz	Non-governmental organization (NGO)	To promote the development of indigenous communities living in extreme poverty, increasing people's capacities to generate their own living conditions	Formal – MasAgro/CIMMYT partnership	Broker of innovation, technical support in the implementation (crop and livestock) and advocacy of CA principles.
Sociedad de Producción Rural "Ñuu Kuini Pueblo de Tigre"	Farmers' Organization (Sociedad de Producción Rural-SPR)	To catalyze productive and service activities.	Formal – MasAgro/CIMMYT partnership	Broker of innovation, technical support in the implementation (crop and livestock) and advocacy of CA principles.
Agricultura Familiar y Agronegocios (AFA)	NGO	To catalyze productive and service activities	Formal – MasAgro/CIMMYT partnership	Broker of innovation, technical support in the implementation (crop and livestock) and advocacy of CA principles.
Centro de Bachillerato Tecnológico Agropecuario (CBTA) 51	Academia	To improve technical/practical knowledge and soft skills of students	Social services and/or informal alliances	Reference point to put demonstration plots. Social services are important to support follow trials, and to data collection. Spaces to develop future leaders, farmers, extension agents, etc.
CBTA 302	Academia	To improve technical/practical knowledge and soft skills of students	Social services and/or informal alliances	Reference point to put demonstration plots. Social services are important to support follow trials, and to data collection. Spaces to develop future leaders, farmers, extension agents, etc.
CBTA 51	Academia	To improve technical/practical knowledge and soft skills of students	Social services and/or informal alliances	Reference point to put demonstration plots. Social services are important to support follow trials, and to data collection. Spaces to develop future leaders, farmers, extension agents, etc.
Universidad Autónoma Benito Juárez de Oaxaca (UABJO)	Academia	To improve technical/practical knowledge and soft skills of students	Social services and/or informal alliances	Reference point to put demonstration plots. Social services are important to support follow trials, and to data collection. Spaces to develop future leaders, farmers, extension agents, etc.

Annex 3. Cont'd

Name	Type of organization	Incentive to scale	Form of collaboration	Role(s) in CLCA
Unión de Ejidos y Comunidades del Valle de Nochixtlán	Farmers' Organization	To improve crop-livestock systems to increase income and reduce costs.	Informal	Lobbyist, articulator and engaged in the implementation process.
Comité Estatal del Sistema Producto Maíz-Frijol de Oaxaca, A.C.	NGO	To solve specific challenges of the maize and bean system, from production, transformation to commercialization.	Informal – alliance	Advocacy leaders, negotiators with other stakeholders, and advisors.
Comité Estatal Del Sistema Producto Caprino de Oaxaca, A.C.	NGO	To solve specific challenges of the production, transformation and commercialization of small ruminants	None	Advocacy leaders, negotiators with other stakeholders, and advisors.
Proyecto Mixteca Sustentable, A.C.	NGO	To foster the integration of biodiversity conservation in the use of natural resources and in development planning	Formal – MasAgro/CIMMYT partnership	Broker of innovation, technical support in the implementation (crop and livestock) and advocacy of CA principles
Food and Agricultural Organization of the United Nations (FAO)	Intergovernmental organization	Mandated by UN to lead international efforts to defeat hunger.	TBD	Observer, knowledge exchange, donor.
Centro de Desarrollo Integral Campesino de la Mixteca (CEDICAM)	NGO	To disseminate knowledge and integrated sustainable development.	TBD	Observer, knowledge exchange.
Geoparque Mixteca Alta	NGO	To catalyze their activities for the sustainable development of the region by fostering sustainable farming practices.	None	Observer and knowledge exchange.
Instituto de Investigaciones en Ecosistemas y Sustentabilidad,	Academia	To foster scientific research, capacity development and linkages with society.	Formal –CIMMYT partnership	Research and development implementation partner. Experts on sustainable rural development.
Universidad Autónoma Nacional de México (IIES-UNAM)	Academia	To foster scientific research, capacity development and linkages with society.	Formal –CIMMYT partnership	Research and development implementation partner. Experts on sustainable rural development.
Catholic Relief Services (CRS)	NGO	To foster their integral human development model.	None	Observer, Donor.
Grupo Autónomo para la Investigación Ambiental, A.C (GAIA)	NGO	To support community territorial management processes, through the reconstruction of the rural landscape	None	Observer and knowledge exchange.
Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO)	Government	To promoter basic research on conservation and sustainable management of natural resources	None	Observer
Community radio	NGO	To raise awareness about solutions and problems of crop-livestock systems	Informal	Lobbying

Annex 4. Individual degree for students in Tunisia and Algeria

Country	Student #	Gender	Degree	Topic/Title	Stage of Progress
Tunisia	S1	F	ESP*	Analyse de l'adoption et la diffusion de l'agriculture de conservation sous systèmes de production mixtes Céréales-Elevage dans les zones semi –aride en Tunisie	Def - 24/6/2019
	S2	M	ESP	Caractérisation agronomique et nutritionnelle de trois association fourragères installées à Z'hir, Safsafa, Ksar Cheikh, et à Fernana	Def - 26/6/2019
	S3	F	MSc	Assessment of trade-offs related to the use of cereal residues in mixed Crops-livestock production systems of Northern Tunisia	Def - Dec. 2019
	S4	F	MSc	Analysis of options for enhancing the large-scale adoption of Conservation Agriculture practices in small mixed-farming systems of North Africa: Case of Tunisia	Def - 28/6/2019
	S5	F	MSc	Impact de l'érosion hydrique sur la dynamique du carbone organique des sols agricoles	Def - 12/7/2019
	S6	F	MSc	Caractérisation des sols cultivés après conversion en agriculture de conservation	Def - 12/7/2019
	S7	F	ESP	Perception des acteurs locaux de développement de l'AC : principaux problèmes et stratégies de développement proposées.	Ongoing
	S8	F	ESP	Evaluation des techniques de vulgarisation pour une meilleure diffusion de l'AC	Ongoing
	S9	F	ESP	Agriculture de conservation et allocation optimale des ressources	Ongoing
	S10	F	ESP	Analyse coût-avantage de l'agriculture de conservation dans le gouvernorat de Zaghouan	Ongoing
	S11	F	ESP	Agriculture de conservation et analyse spatial : identification des sites potentiels dans le gouvernorat de Zaghouan	Ongoing
	S12	F	ESP	Nutritional evaluation of multi- species mixture forages	Ongoing
	S13	F	MSc	L'agriculture de conservation comme système pour optimiser l'efficience de l'utilisation de l'eau et l'azote du blé dur dans le semis aride Tunisien : Essais de longue durée.	Ongoing
	S14	F	PhD	-	Ongoing
	S15	F	PhD	Résilience des systèmes culturaux basés sur le blé à travers le semis sous couverture végétale vivante permanente	Ongoing
Algeria	S1	F	MSc	Etude de l'effet de trois techniques culturales (SD, TCS et TC) sur la culture de blé dur en zone semi-aride dans la région de Sétif	Ongoing
	S2	F	MSc	Etude de l'effet de la rotation culturale conduite en semis direct en zone semi-aride dans la région de Sétif	Ongoing
	S3	F	MSc	Etude de l'effet de la rotation culturale conduite en semis direct en zone semi-aride dans la région de Sétif	Ongoing
	S4	F	MSc	Etude de l'effet de trois techniques culturales (SD, TCS et TC) sur la culture de blé dur en zone semi-aride dans la région de Sétif	Ongoing
	S5	F	MSc	Evaluation de la symbiose microbienne chez une variété de blé dur conduite en semis direct	Ongoing
	S6	F	MSc	La réponse de quelques variétés de blé dur vis à vis de l'agriculture de conservation	Ongoing

Annex 4. Cont'd

Country	Student #	Gender	Degree	Topic/Title	Stage of Progress
Algeria	S7	F	MSc	Evaluation de la symbiose microbienne chez une variété de blé dur conduite en semis direct	Ongoing
	S8	F	MSc	La réponse de quelques variétés de blé dur vis à vis de l'agriculture de conservation	Ongoing
	S9	M	PhD	Effet de la rotation de quatre cultures sur les propriétés chimiques et physiques du sol sous agriculture de conservation dans la région de Sétif	Ongoing
	S10	F	PhD	Effets des propriétés physiques et chimiques du sol sur les mécanismes rhizosphériques dans une agriculture de conservation	Ongoing
	S11	F	PhD	Statut phosphaté dans la rhizosphère des céréales	Ongoing
	S12	F	PhD	Les microorganismes rhizosphériques et la tolérance aux stress abiotiques chez l'orge (Hordeum vulgare L.) en Algérie	Ongoing
	S13	M	MSc	Impact de l'apport de margines sur la germination et la croissance de Hordeum vulgare L. variété Fouara en conditions contrôlées	Ongoing
	S14	F	MSc	Variation des propriétés des sols en agriculture de conservation sous climat semi-aride : cas des sols de Sétif	Ongoing
	S15	F	MSc	Effet du travail du sol sur l'abondance des invertébrés sous climat semi-aride	Ongoing
	S16	F	MSc	Effet du travail du sol sur la dynamique des macro-invertébrés sous céréales	Ongoing
	S17	M	MSc	Impact de l'apport de margines sur la germination et la croissance de Hordeum vulgare L. variété Fouara en conditions contrôlées	Ongoing
	S18	F	MSc	Effet du travail du sol sur l'abondance des invertébrés sous climat semi-aride	Ongoing
	S19	M	PhD	Analyse des effets agronomiques et environnementaux des techniques culturales simplifiés en Algérie	Ongoing
	S20	M	PhD	L'effet des techniques culturales simplifiées sur le rendement des céréales à Sétif	Ongoing
	S21	M	PhD	-	Ongoing
	S22	M	PhD	Analyse des effets agronomiques et environnementaux des techniques culturales simplifiés en Algérie	Ongoing

* ESP: End of Studies' Project, Def: Defended - Date

Annex 5. Financial statement for the period between January 1st, 2020 and March 31, 2020

Name of the Centre: ICARDA
Grant Number: 2000001630
Name of the Programme: Crop-Livestock under Conservation Agriculture Phase II
Reporting period from: 01 January 2020 to 31 March 2020
Amounts in US Dollars

Project Code: 200116
Bus Number: 200341 & 200376

	Budget in USD			Actual 13 Apr 18 to 31 Dec 19			Actual 01 Jan 20 to 31 Mar 2020			Balance available			Co-financing
Category of Expenditures	**ICARDA**	**CIMMYT**	**Total Budget**	**ICARDA**	**CIMMYT**	**Total**	**ICARDA**	**CIMMYT**	**Total**	**ICARDA**	**CIMMYT**	**Total**	
Salaries and allowances	331,000	288,000	619,000	112,095	154,121	266,216	54,816	24,772	79,588	164,089	109,107	273,196	87,900
Travel and allowances	60,000	139,000	199,000	31,701	34,085	65,786	5,383	(2,133)	3,250	22,916	107,048	129,964	12,900
Workshop + Training + Consultant	190,000	180,000	370,000	80,092	4,378	84,470	11,899	7,414	19,313	98,009	168,208	266,217	900
Goods, Services and Inputs	341,000	277,000	618,000	140,990	95,240	236,230	13,974	-	13,974	186,036	181,760	367,796	15,600
Equipment and Material	115,000	120,000	235,000	-	-	-	-	-	-	115,000	120,000	235,000	18,300
Operational Costs	117,000	110,000	227,000	61,065	25,434	86,499	24,764	3,775	28,539	31,171	80,791	111,962	14,400
Total Direct Costs	**1,154,000**	**1,114,000**	**2,268,000**	**425,943**	**313,258**	**739,201**	**110,836**	**33,828**	**144,664**	**617,221**	**766,914**	**1,384,135**	**150,000**
Management Fee	92,605	89,395	182,000	34,076	34,459	68,535	8,894	(4,931)	3,963	49,635	59,867	109,502	-
CSP 2%	25,441	24,559	50,000	12,330	-	12,330	11,800	-	11,800	1,311	24,559	25,870	-
Total	**1,272,046**	**1,227,954**	**2,500,000**	**472,349**	**347,717**	**820,066**	**131,530**	**28,897**	**160,427**	**668,167**	**851,340**	**1,519,507**	**150,000**