Working Document

Context Assessment for Agroecology Transformation in the Tunisian Living Landscape

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The purpose of this Context Assessment is threefold: first, to characterize the environmental, social and economic and political contexts of the Tunisian ALL; second, to understand the data and information currently available in sub-region of the ALL, and third to characterize the extent to which agroecological principles are already being employed locally at the ALL levels. This report constitutes a basis of information and discussion to conduct the impact assessment. It is also valuable to all WPs in the Initiative as it provides critical quantitative or qualitative data and information regarding capacities assessment, policy influence, and other environmental attributes which can guide the initiative implementation and impact in 2023/2024.

The present Context Assessment in Tunisia has been elaborated from primary and secondary sources of data. The primary sources of data are issued from focus groups and formal and informal interviews conducted in the targeted area between June and December 2022, as part of WP1 and WP4 activities. The secondary sources of data came from previous research and development projects, in addition to formal and grey literature or technical reports and policy documents. This report will be enriched with a household survey planned during the first quarter of 2023.

This report contributes to Output 2.1. Baseline – current conditions of agricultural systems of small holder farmers in each ALL, Output 1.1 on establishment of the ALL, Output 4.1 on the identification of policies and local institutions and their role in the AE pathways.

The CGIAR initiative Transformational Agroecology across Food, Land and Water Systems develops and scales agroecological innovations with small-scale farmers and other food system actors in seven low- and middle-income countries. It is one of 32 initiatives of CGIAR, a global research partnership for a food-secure future, dedicated to transforming food, land, and water systems in a climate crisis.
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Executive summary

- Key highlights of the documents

The AE Initiative is built around the concept and approach of Living Landscape as a means to integrate the socio-system and ecosystems in one site to implement and test the agroecological transition. The Tunisian ALL landscape over the transect El Kef-Siliana is characterized by deep soil erosion problems, and climate change effects (Attiaoui and Boufateh, 2019). Conventional practices such as field crop monoculture or deep ploughing persist and aggravate soil and land degradation in the zone, phenomena that are aggravated by rising population and difficult geographical characteristics. Moreover, a significant percentage of cropped land is unsuitable for agricultural activities, which expedite its degradation. This issue of land and soil degradation through erosion will constitute the core issue for the co design of agronomic and livestock management practices and this in link with the agroecological principles of soil and plant biodiversity in synergy with livestock activities, one of the livelihoods resilience in the Tunisian ALL.

From the political perspective, land, water and forest conservation are on the top priorities of national policies. Despite the early care about these key resources, very limited progress in terms of policy design, implementation, and effectiveness has been recorded. New challenges of climate change, resources scarcity (and degradation) and social pressure are adding more complexity to policy making and implementation. Currently, policies at the regional level have shifted from the participatory approach towards inclusive and sustainable “value chain” perspective. A focus on value chains was seen, since the late 2000, as a mean to stimulate local economic and social dynamics, while keeping a focus on resources protection and preservation. The lack of strong administrative expertise on value chains in the regions (and locally) made it difficult to properly implement and use this approach for local development in rural areas.

- Relevance to the AEI's major outcomes

Cultivated soil health has been defined as the capacity of soil to function within land-use constraints while maintaining agricultural production for sustainable food system along the agroecological transition. So, the success of maintaining or enhancing soil health (and more generally ecosystem health) depends on our understanding of how the soil responds to agricultural land use in interaction of livestock management.

The motivation for farmers to investigate soil health is generally based on the goal of improving productivity in a sustainable way and involves an integrated assessment of the physical, biological, and chemical components of soil. In this context, soil health can be assessed mainly through soil properties that are sensitive to changes facing management practices such as tillage, crop rotation, cover crops, organic matter additions, and livestock grazing management that strongly influence soil quality components and thus crop performance. And the social organizations or policies are key-factors and key-influencers of the capacity to conduct these innovative pathways.

To design more appropriate research and facilitate communication with farmers, it is necessary to understand their knowledge, perceptions, and assessments of soil and soil fertility, economic diversification and the relative resilience of each activities faced to drought.

The transition of rural territories in Tunisia is considered to be potentially supported by the creation and reinforcement of farmers' collectives. These structures are susceptible to break with the logic of 'control' of the rural population that has prevailed for more than a century in these territories and re-draw the political programs and the roles of key-players actors.

- Potential users of the documents

This document will be shared and enriched with the knowledge of research and development actors involved in the Tunisian ALL to cross and combine the several regards and perspectives (ecological, agronomic, socio-economic and political) in order to have an integrated and common vision of the zone and its potential future pathways. By this way, this review document will feed the Tunisian theory of change in the Initiative.

It will also serve as basis to co-conceive the core indicators for the agroecological assessment transition in link with the Tunisian theory of change. Preliminary set of indicators are already proposed.

Glossary

ALL: Agroecology Living Lab

CTV : Centre technique de vulgarisation

CRDA : Commissariat Régional pour le développement Agricole

DG ACTA : Direction générale de l'Aménagement et de Conservation des terres agricoles

FO : Farmers‘ organization

GDA : Groupement de développement agricole (Agricultural Development Group)

GIZ : Deutsche Gesellschaft für Internationale Zusammenarbeit (Agency of international cooperation)

ICARDA : International Center for Agricultural Research in the Dry Areas

IFAD : International Fund for Agricultural development

OEP : *Office de l’Elevage et du Pâturage*

SMSA : Société Mutuelle de service agricole

N: Nitrogen

P: Phosphate

K: Potassium

MO: Organic matter

Description of the agroecological living landscape(s)

Location of the agroecological living landscapes (ALL)

The Tunisian agroecological living landscape (ALL), called 'Tunisian transect El Kef-Siliana', is located in the semi-arid zone of the northwest of Tunisia identified as priority zone by the national partners during the national inception workshop of the agroecology (AE) Initiative and where prevailed the mixed cereal-tree-small ruminants (sheep and goats) systems (Figures 1).

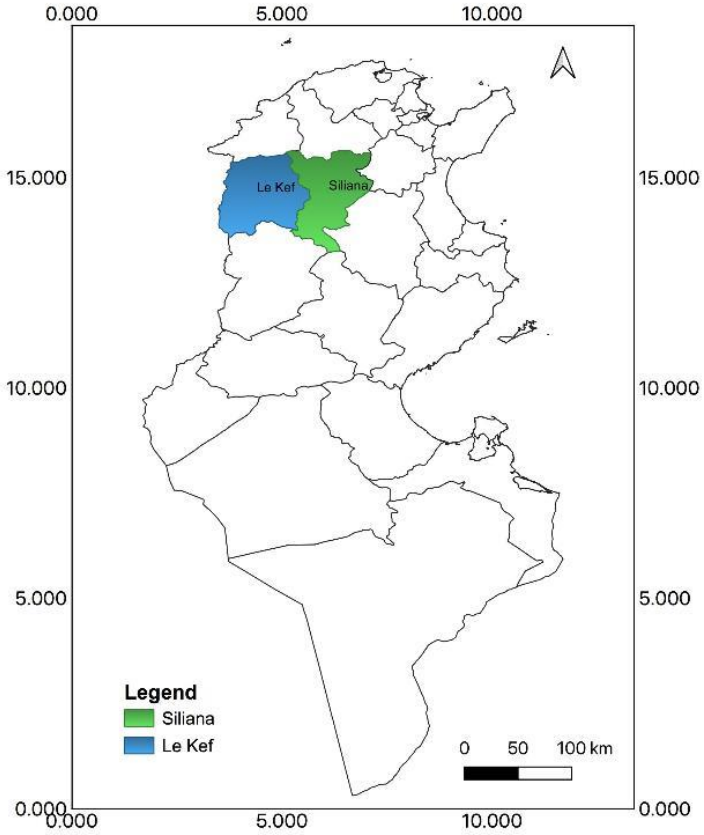


Figure 1. The 'Tunisian transect el Kef-Siliana' localisation in the Northwest of Tunisia (source: ICARDA, 2021)

The Tunisian ALL is composed of four farmers' organizations (FOs) in the targeted zone which have been selected along a gradient of partnerships (with international, national, and local partners) and agroecological (AE) technical packages. The gradient of partnerships allows testing how the degree of 'fairness', 'connectivity' and 'participation' built over the years influences the AE transitions. The AE

technical packages aim at achieving the diversity of likeliest AE transitions pathways identified along the agro-geographical transect.

Three AE transition pathways were identified, i.e. (i) the integration of crop-livestock systems from seed multiplication to animal products valorization towards more autonomous and resilient systems, (ii) the valorization of the olive products and by-products in the agroforestry systems through certified chains, and (iii) the promotion of local products as paths of diversification and gender inclusion, including the honey and carobs. Fig. 3 presents a short description of the four selected FOs.

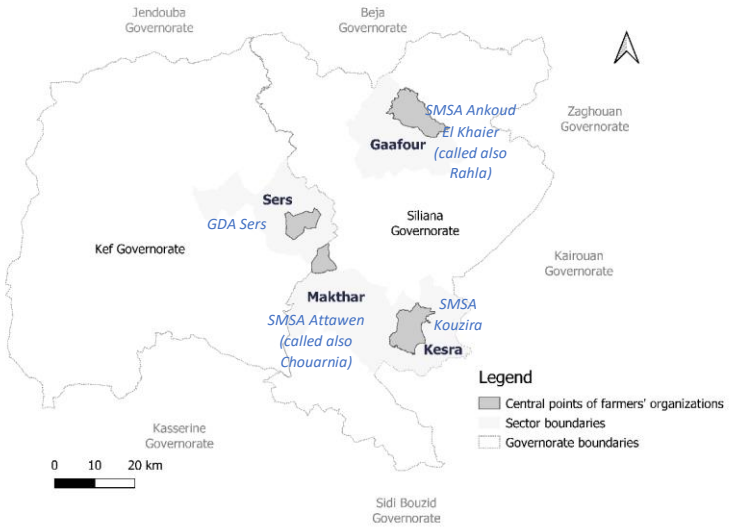


Fig 2. Localization of four FOs with three old ones (where ICARDA is already engaged with national partners) and one new one (identified as potential new FO) (source: ICARDA, 2022)

In the Tunisian ALL, SMSA ('Société Mutuelle de service agricole') and GDA ('Groupement de Développement Agricole') correspond to two legal forms of FO in Tunisia. They also cover the diversity of FOs from a governmental point of view. "*The Law 2005 defines SMSAs as companies with variable capital and shareholders constituted by natural and/or legal persons carrying out an agricultural activity, fishing or provision of agricultural services in the area of intervention of the society. The form of company with variable capital and shareholders is a logical consequence of the principle of free membership and withdrawal and open doors that govern societies cooperatives*" (citation translated from Belhaj Rhouma et al, 2018, p14). Besides, the Agricultural Development Groups (GDAs) are considered democratically legitimized local structures, gathering owners and users of natural and agricultural resources with some collective activities. They can also manage specific natural resources on behalf of the State. However, unlike SMSA farmers' organizations, they cannot conduct commercial activities to make profits.

The two FOs, e.i. SMSA Chouarnia and GDA Sers, have been part of a research and development project called CLCA-2 on the "*use of conservation agriculture in crop-livestock systems in the drylands",* coordinated by ICARDA and funded by IFAD. The main activities developed concerned:

- The implementation and management of the zero-and minimum tillage technique in accordance with the practice of small ruminant grazing ;
- The introduction of a mobile grinder and pelleting machines to valorize the crop residues from olive production, cactus, wheat bran, etc. and make them available for animal feeding;
- Development agronomic trials of mixed graminea-leguminous fodder crops, including vetch and oat.

The SMSA El Rhahla is one of studied zone of the project, ProSOL ('Protection et Réhabilitation des sols dégradés en Tunisie'), coordinated by the GIZ and DG ACTA, around the improvement of natural resource management, focusing on scaling of soil and water conservation technics. In the Rahla FO, and in partnership with the national office of Livestock and pastureland development institute, called OEP (Office de l'Elevage et du Pâturage), the project has developed on-farm trials of feed crops, especially *Sulla* and forage mixtures, on very degraded lands for animal feeding (CLCA report, Zied).

The new FO, SMSA Kouzira, was selected in link with their willingness to develop specific markets around their local products, or products of 'terroir,' such as the honey and fig confiture. Moreover, this SMSA comprises a majority of young (40% are less than 35 years old) and women representing 70% of adherents.

These four FOs will serve as living labs to co-conceive and implement technical and organizational innovations along three central 'values chains', e.i.:

1) Animal products' value chain from the seed multiplication and forage production/feedstock (with crop/tree residues) to the dairy and meat products marketing; here we consider the feed-food system.
2) Olive tree value chain in integration with all the other agricultural activities (livestock-cereal)
3) The honey value chain from melliferous plants to more direct sales to consumers (short circuits)

A FO (GDA or SMSA) is usually created at the level of a social community and an agroecological area, both not necessarily homogenous. For example, according to the agroecological zone and water infrastructure, the GDA Sers is composed of women with and without irrigation systems. They also do not share the same local network (neighboring). Besides, the SMSA Rahla comprises members of the same extended family. The social composition of this SMSA can raise problems when searching to scale the issues due to past social tensions with other extended families.

So, a FO is embedded in a diverse social- and eco-system case by case. Therefore, considering four FOs with various social and technical histories can allow capturing AET dynamics according to a certain diversity of social and policy configuration.

Moreover, these organizations are often the only agricultural associations allowed to develop a common project or action plan. It is also possible to find a situation where certain members of neighboring communities would adhere to a FO or benefit from its services (machines, sales of inputs, etc.) without

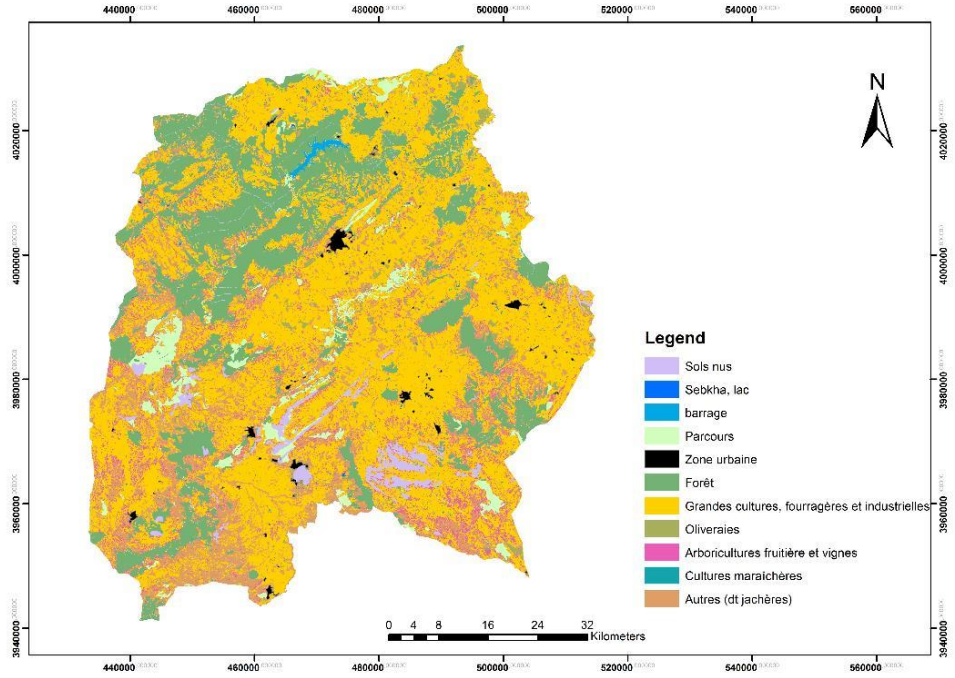
necessarily being members. The area and number of beneficiaries reflect the radius of actions of the FO and the capacity of scale-out. Our objective is to work on enhancing the representativeness of these FOs in their respective communities under the agroecology Initiative. In parallel, the Tunisian ALL can progressively include other neighbored FOs interested in these AE transition pathways along the transect Kef-Siliana as an illustrative zone of the hybrid crop-tree-livestock systems in the semi-arid area of Tunisia.

Finally, we selected four FOs, each of them would be 'representative' of several value chains (mostly for now – will be confirmed later – milk/meat, olive oil, and honey), and, in each of them, we will find strengths and weaknesses in terms of agroecology principles. We will then search for complementary investments in each of these FOs and will try to find a way to connect them to create a larger and more harmonious ALL.

Environmental Context

Topography, Soil and Agricultural Land Use in the Tunisian ALL

The transect El Kef-Siliana covers two governorates characterized by a rugged relief and compartmentalized with mountain ranges, high and medium plateaus and alluvial plains. Between the plains and the mountainous slopes of hard rock, we can find crusted glacis constituting transitional areas very affected by erosion (see Figure 3).



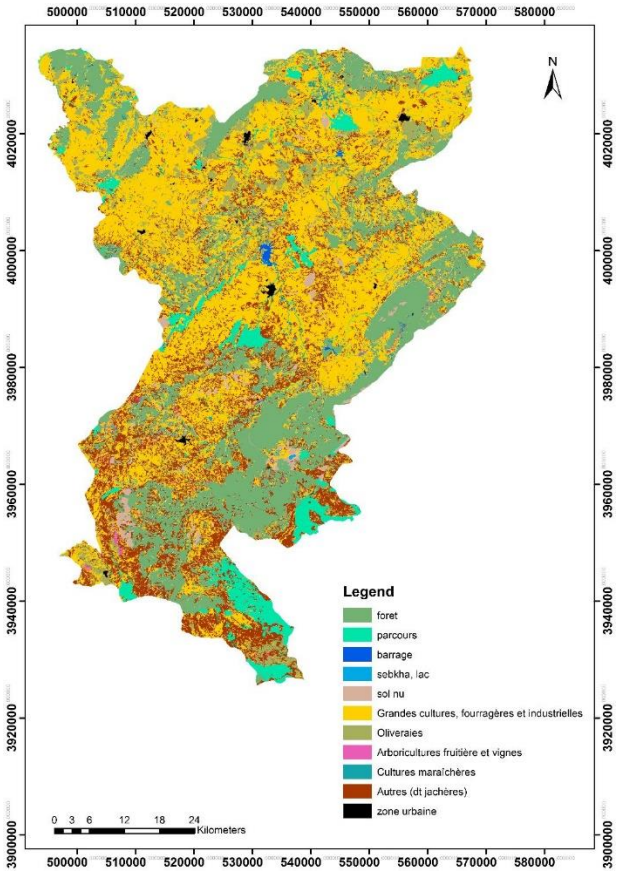
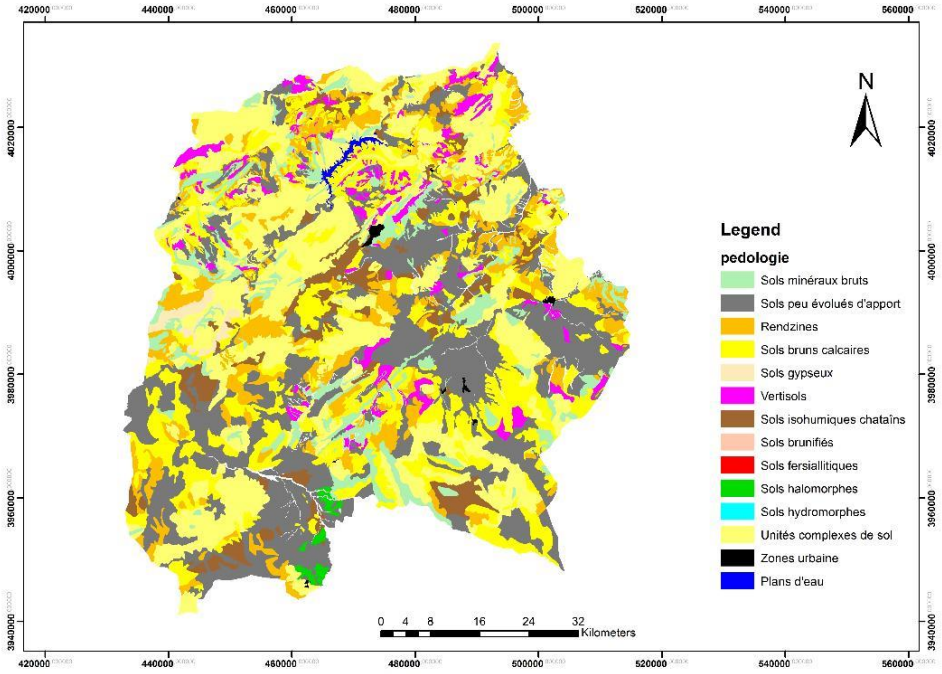


Figure 3. Land use map of el Kef (above) and Siliana governorates (below) (Tunisia) (source: ICARDA, 2021)



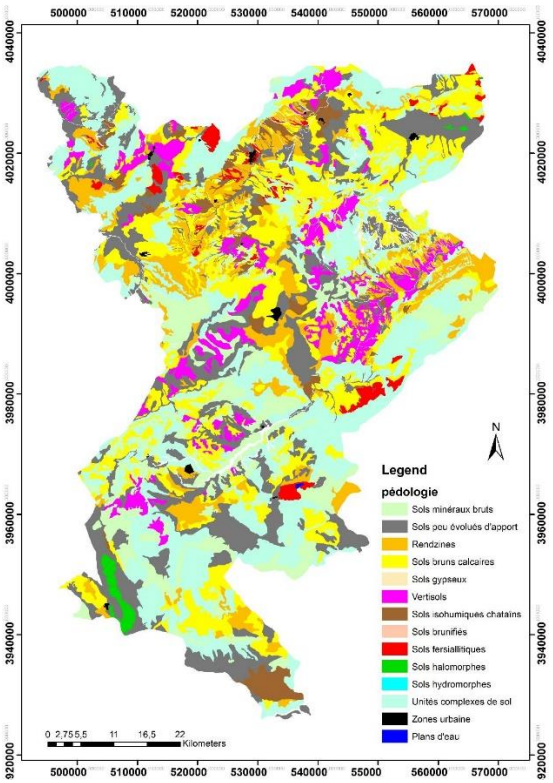


Figure 4. Agricultural Soil map of el Kef and Siliana governorates (Tunisia) (source: ICARDA, 2021)

Several studies were conducted to assess the soil health in Siliana and Kef regions using different soil indicators (physical, chemical, and biological) (See Annex 2). The results of these several studies showed that the indicators N, P, K, the organic matter (MO) content, and the structural stability are negatively impacted by cultural practices. They put in evidence that soil health can significantly be improved by reducing tillage intensity, planting cover crops, and keeping crop residue and that biological soil health indicators associated with labile carbon and nitrogen are most impacted by management practices such as tillage intensity.

However, some conventional practices such as field crop monoculture or deep ploughing persist and aggravate soil and land degradation in the north-western area of Tunisia, negative impacts that are exacerbated by rising population and difficult geographical characteristics (Fouzai et al. 2018; Attiaoui and Boufateh, 2019). A huge percentage of cropped land is unsuitable for agricultural activities, which expedite its degradation. This issue of land and soil degradation through erosion is also aggravated by overgrazing and pressure on the different topographic features, as they are all easily accessible to livestock (Jendoubi et al., 2019).

State of natural resources, including current exploitation/utilization

The natural resources on the Tunisian ALL are presented in table 1. The two governorates count noble forestry ecosystem with cork oak, Zen oak and holm oak among others, with a production function, but also functions of protection for soils and surface formations on slopes, protection of downstream infrastructure (dams), a role of improving the regime of water sources, maintenance of rare species, while contributing through its permanence, to maintenance of the environmental quality in the mountainous zones. However, this forestry ecosystem is submitted to the strong human and animal pressure. This pressure results in: 1) the decline of cork oak forests; 2) a higher load per hectare from 2 pastoral livestock units per year to 1942 at around 5 in 1995 (based on the national inventory from the Inventaire Forestier et Pastoral National, IFPN), 3) the high frequency of conflicts and/or infractions in the pasturelands (80% of the total infractions) and 4) overgrazing in forest rangelands with rates of 50 to 78% (reaching around 3.7 sheep /ha).

Table 1. Information and data related to forest cover and its trend (from Country concept note in AE-i)

Sime information	Siliana governorate	Kef governorate
Forest cover and area of agroecological zones	Forest cover 20% of agricultural lands (CRDA 2010). Due to the relief and the natural landscape of the governorate of Siliana as well as its low rate of urbanization, wildlife has been able to develop and conserve itself. This situation allowed the continuity of the hunting activity. The main species hunted are wild boar, thrushes and starlings.	A significant plant cover extending over about 24.3% of the region and consisting of 102,000 ha of forest (Aleppo pine, holm oak, cork oak), or about 13% of Tunisian forests, and 22,000 ha of rangeland. From 2001 to 2020, El Kef lost 3,000 ha of tree cover, which is equivalent to a 19% decrease in tree cover since 2000. The Sers sector land use can be described as follow: 91% arable land, 4.8 forest and 4.2 rangeland (ATLAS Kef, 2013)

Besides, the natural environment of the governorate of Siliana is characterized by a poor vegetation cover associated to the presence of water erosion, that seems very severe and threatening for the soil quality. During the last decades, with the intensification of land use and urbanization, other problems have appeared, including flooding, sanitation and waste management (ATLAS Siliana, 2013).

For the governorate of Kef, 61% of total area is affected by severe and moderate erosion. Also, three-quarters of lands are threatened by desertification. Many problems related to waste management result from poor infrastructure (ATLAS Kef, 2013).

At a more local level in the ALL, these four sites are exposed to many risks as shown in the table 2.

Table 1. the main risks in the 4 sites of the ALL Tunisia (derived from Atlas Siliana, 2013, Atlas kef 2018)

Site	Sector	Erosion risk	Desertification	Flooding risk	Pollution and waste management
El Rhahla	Gaafour	High exposure	NA	High	Sanitation problems
Kouzira	Kesra	High exposure	NA	Medium	NA
Chouarnia	Makthar	High exposure	NA	Medium	Sanitation problems
Sers	Sers	Medium exposure	Medium exposure	NA	Poor waste management

In the Tunisian ALL, forms of degradation appear as garrigue and steppe formation. These are located on the lands of rangelands, and are generally the most exposed to human and livestock pressure.

In summary, the natural environment is exposed to various risks including water erosion and flooding, aggravated by increasingly accentuated anthropogenic practices. Water erosion is severe there and sometimes associated with landslides. The rugged nature of the relief, the rocky outcrops tender, irregular and often torrential rainfall, the density of the hydrographic network and the weakness in certain areas of the vegetation cover are situations that favor erosion hydric. Running water that is difficult to control and natural conditions favorable to flood risks characterize the region.

Climatic characteristics of the Tunisian ALL?

At the national level, the northern region, which benefits from the Mediterranean environment, has moderate, wet winters and warm, dry summers, with an average annual rainfall of 600 mm. The center with a precipitation between 200 and 400 mm/year where the bioclimatic stage varies from semiarid to arid climate, is characterized by some relative hot temperatures specially in summers. The climate of rest of the country varies from arid to saharian characterized by hot temperatures as well as a large volume of irregular precipitation rarely exceeding 100 mm (Fig 5) (Mansour and Hachicha, 2014).

All over the country, respectively, from the north to the south annual evaporation varies from 1300 mm to even more than 2500 mm. Also, drought periods registered and experienced can be restricted to one or more regions but it can be generalized for the whole country with a variability in terms of duration and intensity of the drought periods (Louati and Bucknall, 2009).

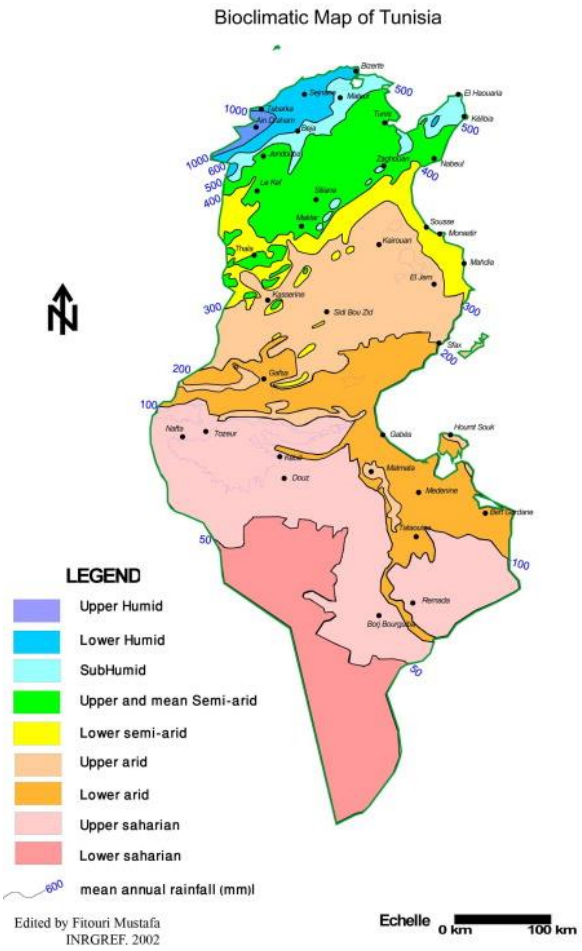


Fig 5. Bioclimatic map of Tunisia (INRGREF, 2002)

The governorate of Siliana is characterized by a continental climate with an average annual rainfall varying between 350 mm and 550 mm during 2017-2018 season. The lowest average temperatures in Siliana during the same season are recorded between 3.2° and 13.0 while the highest are recorded between 17.9° and 35.7° (ODNO, 2018a).

As a result of precipitation and temperature variability, the climate stage is very contrasted in Siliana, this is explained by the influence of the relief. The mountainous massifs of the northwestern part of the governorate are considered as a semiarid zone, the same for the southern mountainous sectors. In between, the other parts of the governorates have an arid climate which is more significant in the far southern parts where the lowest amounts of rainfall and the highest temperatures are registered (ATLAS Siliana, 2013).

For the governorate of Kef, this zone receives an average annual rainfall varying between 350 mm and 450 mm during 2017-2018 season. The lowest mean temperatures in Kef during the same season recorded is 7.3° (January) while the highest recorded is 26.5° (July) (ODNO, 2018b).

This governorate belongs largely to the bioclimatic semi-arid stage. However, some areas in the southwest of the governorate are part of the bioclimatic stage arid and others in the north belong to the sub-humid stage. Overall, it is a continental climate with cold and harsh winters with minimum temperatures among the lowest in Tunisia (ATLAS Kef, 2013).

At this level we can say that the bioclimatic context of these two governorates (Siliana and Kef) is similar and comparable, and we can consider this transect as a homogeneous entity with some internal differences.

At a more local level in the Tunisian ALL, these four sites are semi-arid areas with limited precipitations as shown in the table 3.

Table 3. Precipitation mean over the period 2010-2018

Site	Sector	Precipitations mm (Annual mean 2010-2011)	Precipitations mm (Annual mean 2017-2018)	Bioclimatic stage (ATLAS, 2013)
El Rhahla	Gaafour	433 (ATLAS, 2013)	496 (ODNO, 2018a).	Semi-arid Medium
Kouzira	Kesra	429 (ATLAS, 2013)	429 (ODNO, 2018a).	Semi-arid Sup
Chouarnia	Makthar	494 (ATLAS, 2013)	494 (ODNO, 2018a).	Semi-arid Sup
Sers	Sers	405.2 (ATLAS, 2013)	384.1 (ODNO, 2018b).	Semi-arid Medium

Water availability for production

The governorate of Siliana has benefited from 3 large dams associated to 38 hill dams that have a retention and reserve capacity of 55 Mm. In addition to the dams, the governorate of Siliana is rich in in hill lakes. There are 138 hill lakes with 10 Mm^3 capacity (ATLAS, 2013). For groundwater, 4167 surface wells and 373 deep wells are exploited. More especially in the Tunisian ALL, we have contrasted situations. In Gaafour sector (SMSA Chouarnia), 2081 ha are irrigated (mainly public perimeter). For Kesra sector, the irrigated area is more limited with a total surface of 198 ha (mainly public). In Makthar (SMSA Rahla), the situation isn't the same with 922 ha irrigated under private regime (ODNO, 2018a).

The governorate of Kef has a network of 24 hill dams, 71 hill lakes and only 1 large dam. The quantity of surface water mobilized represents only 70% of the mobilizable resources which shows the potential of surface water rather important. For groundwater, the water table is overexploited while the deep-water table is under-exploited (ATLAS, 2013). In Sers, we found 3 hill dams and 6 hill lakes. In this same area 2850 ha are irrigated (private irrigated perimeter) mainly (2000 ha) from surface wells. 354 ha are irrigated as part of the public irrigated area. In Kef there are 4685 surface wells and 537 deep wells of which 1012 and 71 are in Sers (ODNO,2018b).

In summary, the north western zone of Tunisia, which involves the four sites of the ALL is considered as the most important area for olive cultivation and rain-fed cereals. This transect is one of the most vulnerable regions characterized an excessive climatic variability. Drought and water scarcity are the main risks on agriculture and natural environment, which influence the yields. Also, the high temperatures are affecting crops in term of production and growth cycle. The impact of growth cycle shortening can affect yield quantitatively as well as qualitatively as a consequence of damages sustained during flowering and grain filling. All these facts and experiences may influence the agricultural calendar (starting from sowing until crops harvesting) (Mansour and Hachicha, 2014).

Economic Context

Key farming systems

According to the survey on farm structures in 2004-2005 (MARH, 2006), the governorate of Kef is characterized by the predominance of small-scale farming systems. Overall the governorate, 35% have less than 5 ha and 58% have less than 10 ha. As for farms with 100 ha or more, they represent 3% of the number of farms and 35% of the agricultural area. The Kef region remains marked by the predominance of a cereal activity based on a production system that is not very intensive and strongly dependent on climatic hazards. As a result, the yields of the crops have remained low (14 to 16 q/ha) and the annual production of cereals is quite uncertain. Practiced according to an unfavorable crop rotation and technical itinerary, this monoculture most often leads to soil exhaustion (loss of fertility) and erosion (approximately 61% of the total area of the governorate is affected by moderate to severe erosion).

The governorate of Siliana is characterized by a high population density, given climatic and soil constraints. The scarcity of land translates into fragmented land and low operating areas (average 17 ha per farm and 75% of farms have less than 10 ha). This scarcity of agricultural land is to be compared with the existence of a still significant national forest, in particular in the delegations of Kesra, Rouhia and Bargou (21% of the area of the governorate). Dry cultivation is nevertheless always subject to climatic hazards. Production and yields can vary from 1 to 6 from one year to the next (from 2-3 qt / ha to 19-20 qt / ha). Finally, technical progress has been concentrated geographically (plains) and socially (large and medium-sized enterprises).

The vast majority of the rural population, except those benefiting from irrigation projects, have found it impossible to intensify their production systems. To cope with the demographic growth, which is relatively low, but nevertheless significant, producers have had to increase the pressure on natural resources, pressure which has traditionally resulted in a decrease in the fertility of agricultural soils, overgrazing, increased water-borne erosion.

Cereal cultivation for own consumption dominates. Arboriculture (olive, fig, peach, apple) is present, both for self-consumption and marketing. This agriculture experiences the same problems as those mentioned for farms outside forest areas: fertility, sensitivity to drought, risk of erosion.

Farms in agro-pastoral areas, outside the forest domain, are faced with the degradation of rangelands, the decrease in the fertility of agricultural soils and a very strong erosion of hydraulic origin. These farms are essentially based on cereal agriculture in association with extensive livestock farming. Cereal cultivation and the tillage on which it depends promote erosion. Erosion has significant consequences on the siltation of many dams in the region. The protection of these dams by a soil and wtare conservation techniques (CES) development is a necessity. Apart from its mechanical aspects, the soils are often poorly suited to cereals, here too sensitive to drought. Yields are generally low to very low.

Overall, three production systems prevailed in the transect Kef-Siliana :

i) Dry cereal based systems system with cereal rotation, low integration of fodder crops, sheep activity, and existence of small number of dairy cows by household farm;
ii) Agrosylvopastoral farms dominated by extensive management of sheep and goats based on pastoral resources;
iii) and, in few areas, irrigated systems with market gardening intercropped with arboriculture but not a real intensification of crop rotation and the development of a dairy cow activity.

Major agricultural commodities and livestock

Table 4 gives a brief description of the farming systems in the four sites of ALL in Tunisia based on the focus group of characterization of the ALL realized in September 2022. This characterization of the farming systems will really be developped through a farm typology based on the household survey that will be done in january 2023.

However, we can see that the main agricultural commodities are cereals, mainly wheat for food consumption and barley for feed consumption, trees with olive and figs trees. We can also fing other plant and tree varieties such as almonds or apple for tree plantation and Gramineae or leguminous such as vetch, Sulla. These two last varieties have been developped over the last 10-years within several projects such as CLCA and ProSol projects.

In the irrigated perimeters, farmers developed also vegetable crops mainly for sale.

The quasi totality of the farming systems raise also ruminants, mainly cows for dairy products in the most favorable zone with irrigation facilities and sheep and goats in the less favorable zones, with sheep mainly for meat and goats for milk and meat. Except in the pastureland, manure is also collected and used on agricultural lands. Besides, majority of farms raise poultry, mainly to cover the needs of eggs and meat at the family level.

Other activities such as bee keepers are developing in the zone and constitute a non negligible source of income.

Table 4. Some general characteristics of farming systems based on the FO characterization (derived from the focus group, WP1, see Annex 1)

	GDA Sers	SMSA Rahla 'Ankoud El Khir'	SMSA Kouzira	SMSA Chouarnia 'ETTAWEN'
Nos of members	6	3+1 employee	3	9
Nos of adherents	55	27	114	120
Nos of beneficiaries	55	100	240	500
% less than 35 years old	20%	11%	40%	40%
Livestock system	Small ruminant breeders (owning less than 20 sheep and goats) represent 20% of adherents; breeders owning between 20 and 35 heads represent 60% and 20% are big breeders. Bovine breeders owning less than 8 cows represent 60% of adherents, more than 35% have between 8 and 15 cows and less than 5% of adherents have more than 15 cows	Only 5 adherents have between 1 and 3 cows. More than 50% of adherents are small ruminant breeders (average of 50 animals)		Lamb fattening and breeding (cattle and small ruminants) Around 80% of members have between 20 and 50 heads of small ruminants and about 4 cows (Brown-Swiss)
Crop system	The average farm size of adherents is between: - 2-2,5ha on irrigated area and/or - 3 ha on rainfed areas. All of them have less than 10 ha. Some of them are renting land.	50% of adherent have a minimum of 5-6 ha (rainfed). Others have between 15 and 20 ha(rainfed). Cereal crops: Wheat and barley Olive trees : between 100 and 400 trees.	Most of adherents own between 0.5-5ha (diversified family farming). 20% of adherents have more than 5ha. All access to irrigation (natural spring in the village). Crops: cereal (wheat & barley) The olive trees are planted in collective land.	Field crops, especially wheat and barley Olive trees (an average of 150 by farmer) 80% of adherents own or rent less than 20ha (rainfed) 15% own more than 20ha (rainfed) 5% have more than 200ha (irrigated)
Other activties	Bee keeping, poultry, saffron and vegetable production		Fig trees, Cherry trees Beekeeping	

Market information for both inputs and outputs

Agricultural inputs were largely subsidized and so the market of inputs is largely controlled by the government through parastatals enterprises or governmental agencies, especially for fertilizers and seeds. Other sectors have known a certain liberalization such as in the sector of chemical products for weed and pest control.

The majority of agricultural products are marketed through the local markets (*Souk*) and the prices follow the rules of supply and demand, i.e., their prices are determined by market forces. Besides, the marketing of agricultural products that are considered as strategic goods such as grain and their by-products are regulated by the government through public enterprises. For instance, the cereals are exclusively sold to the state-owned Office des Céréales, with a monopoly on buying locally produced cereal grains, and importing cereals from the international market. The 'Office National de l'Huile' is in charge of buying and exporting locally produced olive oil and importing vegetable oil. For cereals and oil, the prices are guaranteed at the farm level. And, government agencies have the responsibility to secure the supply through storage capacities at national level. Besides raw milk is mainly sold to dairy cooperatives and collectors who supply dairy processing units. However, for strategic and non-strategic goods, illegal or parallel markets are tolerated.

So, at the ALL level, we can distinguish two types of markets: the local market in the commune where farmers can find the majority of inputs for agricultural activities and sell some agricultural outputs and the regional markets, especially for live animals.

The table 5 gives the average distance of the communes involved in the Tunisian ALL from the regional markets in the two governorates. The main market day in the region is Thursday although farmers can sell or purchase out of the region

Table 5. Distance of the sites from the main regional markets (in km)

Distance matrix (km)	Sers	Kef	Makthar	Kesra	Gafour	Siliana
Siliana	40	95	35	43	36	0
Gafour	50	82	69	80	0	36
Kesra	55	101	18	0	80	43
Makthar	35	81	0	18	69	35
Kef	30	0	81	101	82	95
Sers	0	30	35	55	50	40

ODNO, 2018

Key factors affecting agricultural productivity

Along the transect El kef-Siliana, land degradation and soil erosion are the most severe natural and anthropic factors affecting agricultural productivity. As presented above, the landscape is characterized

by steep slopes and several ravines caused by all types of erosion. Based on a survey conducted in under SWC@scale/ ProSol project 'Towards the Effective Scaling of Soil and Water Conservation Technologies under Different Agroecosystems in North and Central West Tunisia' (2020-23), 62% of the respondents are suffering from very high-water erosion issues each year, especially during the autumn rainy season. Also, farmers consider that wind erosion has the same impact on their land, especially during summertime with hot southerner winds (Frija et al, 2022).

Another key limiting factor is the variability and uncertainty of the precipitations, especially in the seeding season (November) and before the flowering, especially for olive trees (February-march).

Land fragmentation with population growth is another critical limiting factor that threatens the socioeconomic viability of the farm and the social transfer of a viable piece of land to the next generation. Furthermore, this issue leads to a significant rural exodus of the young generation.

Faced with these natural factors that are exacerbated by the anthropic land pressure (with less than 5 ha on average per farm), the weakness and lack of training of extension services' development make farmers often alone face these natural challenges. Moreover, land degradation or erosion reduction needs important infrastructure investments that require State interventions through national or international projects.

Finally, the recent cereal crisis with the Ukraine-Russia war raised the problem of the dependence of the agricultural sector on feeds and concentrates in the international market. The current shortage of cereals and concentrates combined with the price increase on the legal and illegal markets conducted some farmers to reduce or even abandon some livestock activities, especially dairy cows.

Agricultural financing

Agricultural financing is usually done through the government with special interest rates and conditions for the agricultural sector. The national bank for the sector, Banque Nationale Agricole (BNA), is the main lending institution. This governmental bank provides also credit to medium-to-large farms, with a system of monitoring and supervision of loan uses. Around 120 regional offices are located at the regional level, with a majority in the northern part of the country.

The BNA managed also special funds such as the Special Fund for Agricultural Development (FOSDA), founded in 1963, based on governmental budget allowances. It constitutes a major credit source for the agricultural sector. The main issues of the agricultural credit system were (as mentioned by Thabet et al, 1998) : "1. The existence of a multitude of agricultural credit lines with different lending conditions and interest rates. 2. Late payments that make debtors ineligible for credit". Besides, some special bank systems have been developed to facilitate credit access to small and medium farmers. This kind of credit remains under the supervision of the Ministry of Agriculture, with support and training from agricultural services. Other credit systems are based on given in-kind to small farmers by government agencies such as the National Grain Board (Office des Céréales) or parastatal enterprises.

However, this formal credit remains the financial fund for medium-to-large farmers. From ONAGRI (2006), 87.5% of the farms at the national level haven't asked for an agricultural credit and 6.2% have asked a credit that has been refused. So in total only 6.3% received a formal credit. The demand of credit for agricultural campaign or investment concern 29.9% and 18.4% of large farms (> 100 ha) and only 3.7% and 5.2% of the small scale farms (lass than 5 ha).

During the focus groups conducted in September 2022 in the Tunisian ALL, other kind of credit systems were identified, such as:

- Union Tunisiennne de Solidarité sociale (UTSS) that provide small credit amount between 3,000-5,000 TND per person without interest rate; the main conditions are to follow training sessions on education & health & social issues;
- "Association SYRES pour le Développement" which is an association of the civil society that gives credit with 5% interest to invest in dairy cows (condition: follow training with certificate; land owner)
- Enda Tamweel is a microfinance institution based in Tunisia that offers financial services for micro-entrepreneurs with an iinterest rate 25%. The main advantage is that the conditions of access that are easy without special guarantees.

Physical and human assets and land tenure situation

In the Tunisian ALL, the main physical assets of farmers are composed of land and livestock in the two governorates (table 6). 98% and 70% of family farms in the two governorates depended only on the farm activities for their subsistence in 2004.

Small livestock holdings (2 to 3 cattle, 14 sheep and 3 goats on average) account for 83.5% of total livestock and hold 67% of the cattle population, 52% of the sheep population and 59% of the goat population.

Small-scale family farming covers 78% of the total number of agricultural holdings and only 43% of the total agricultural area (Marzin et al, 2016). 66.8% of small family farms have an area of less than 5 ha and 86.7% have an area of less than 10 ha in 2014.

Table 6. Various indicators regarding farm activities and assets

	Governorate level		At the farm level (average)	
	Kef	Siliana	Kef	Siliana
Number of farms	18110	19400		
Toral agricultural area (thousand of ha)	387	346		
Only one parcel	52%	76%		
land in inheritance	91%	80%		
Agricultural land				
SAU (ha)	380000	334000	21	17
Dry land (%)	61%	75%		
Mixed dry-irrigted lands	39%	25%		
cereal land	75%	57%		
Leguminous	--	< 2%		
Fodder crops	10%	17%		
vegetable crops	2%	1%		
Fruit trees	12-13%	25%		
Livestock				
cattle	26200	31700	1	2
Sheep	335000	295000	18	15
Goat	18900	34600	1	2
Equipments				
access to drinking water	25%	29%		
access to electricity	81%	89%		
Tractors	2 600	2 000		
Activities				
number of households living entirely from agricultural activities on their farms	17800	13600		
Without non ag lucrative act.	75%	55%		
Human and social				
No read no write	40%	45%		
Social & services				
Access to cooperative services	< 2%	< 2%		
Access to GDA services	< 1%	< 1%		
Access to GIC (groupements d'intérêt collectif)services	< 1%	< 1%		

Table 7 and 8 show different configurations of farm scale according to the four sites composing the Tunisian ALL, from a large majority of small-scale farms in Chouarnia and Kesra to a more diversified profile in Sers and El Rahla, even if the majority of farm have less than 10 ha.

Table 7. Percentage of small and very small farms (less than 5 ha in rainfed zone)

Site	Level of information	% of farms <10 ha
El Rhahla	Gaafour (sector Level)	46.6%
Kouzira	Kesra (sector Level)	72.5%
Chouarnia	Makthar (sector Level)	80.4%
Sers	Kef (governorate level)	58.6%

Table 8. The number of animal heads by species in each sites of the ALL Tunisia

Site	Level of information 2018	Sheep	Beehives	Cattle (pure)	Cattle (local)
El Rhahla	Gaafour (sector Level)	16198	1300	170	556
Kouzira	Kesra (sector Level)	18906	1800	30	280
Chouarnia	Makthar (sector Level)	22670	1300	396	1173
Sers	Kef (governorate level)	22451	28	445	672

Land tenure has evolved from the 1960s dominated by the cooperative system and state farms to the land privatization during the 1970s. Nowadays, we can mention at least three kinds of landownerships: 1) state ownerships or state farms with the purpose to secure some strategic goods, 2) private ownerships for the majority of cultivated lands by family or entrepreneurial farms and 3) collective or state land ownerships for pastureland and forest.

For land ownership, it is mainly a nuclear family ownership transmitted between generations or joint/undivided ownerships, with more than two adults living in separate households. The undivided ownerships is very frequent. Land transactions exist but not generalized.

Supportive infrastructure (roads, electricity, storage)

The table 9 gives a first overview of supportive infrastructure in the Tunisian ALL on terms of road, electricity access, drinking water access. If the electricity network is well developed in the ALL, we can see contrasted access to drinking water, especially with a lower level in Sers compared to the other sites. Also, if the sectors of Sers and Gaafour are well covered by roads, the sectors of Makthar and Kesra located in more accidented relief zones are less accessible.

Table 9. Infrastructure access in the 4 sites of the ALL in Tunisia

Sites	Sers	Makthar	Kesra	Gaafour
Road Network (km)	244	85	53	112
Electricity access (%)	99.3	98.3	97.5	97.7
Access to water (%)	71.3	86.4	96.6	88.9
Poverty (poor families)	1363	1511	1032	1030
Unemployment rate (%)	27	13.5	11.2	17

Social Context

Household structure and size, rural employment and poverty

At the national level, the average rural household size decreased from 5.7 persons per household in 1975 to 4.3 persons per household in 2014 (data from the Recensement Général sur la Population et l'Emploi (RGPH), 2014, cited by Marzin et al, 2016). In 2004-2005, family labor cover around 77.5% of agricultural work days, completed with 9% for occasional workers and 13.5% for permanent employees. However, this official statistics hide the huge contribution of women as occasional works in the agricultural sector. This increasing contribution of women can be related to the growing involvement of men in multiple non-farm activities and also the disinterest of youth for manual agricultural tasks. We can also link this disinterest to the growing level of education of the young generation with at least 50% with a primary certificate. *Vice versa* the increased mechanization of agricultural work, notably ploughing, had led to a significant reduction in the number of permanent paid workers, at the exception of entrepreneurial farms. Cited in Marzin et al (2016), "*According to the population census conducted by the National Institute of Statistics (INS), female employment in agriculture rose from 13.56% of the total agricultural employment in 1975 to 20.1% in 1985, 29% in 2005, and 36% in 2012*".

In 2004-2005, the average pluriactivity was estimated at 48.6%, up to 55.4% for small scale farms of less than 5 ha, and can represent up to 66% of the total income on irrigated holdings and up to 90% of total income in rain-fed holdings in the South (Chebbi et al, 2019).

The national poverty rate decreased from 25.4% in 2000 to 15.2% in 2015 and 13.8% in 2019 (World Bank, 2022). However, the rural areas count about 23 % of poor, compared to only 9 % in urban areas. Moreover, this reduction could be attributed to a national cash transfer program. However, the growing challenge would be the labor productivity for the young generation to cover the costs of intergenerational solidarity (Marzin et al, 2016).

Contrary to the overall trend at the national level, the rural areas of the Tunisian ALL are experiencing difficulties linked in particular to the rural lifestyle and the lack of infrastructure, especially in education and health (Table 10 & 11). The human potential, composed mainly of young people, suffers from a high illiteracy rate and a low level of schooling. Poverty and the lack of transport associated to high unemployment rate are the main characteristics of these areas (Shimi, 2014).

Table 10. Education and culture access in the 4 sites of the ALL in Tunisia (2018)

Sites	Sers	Makthar	Kesra	Gaafour
Primary Schools	16	23	14	13
Student/professor	13.8	12.6	14.24	13.9
Cultural associations	5	5	1	4
Person per chair in the library	103	106	142	99

Table 11. Health access in the 4 sites of the ALL in Tunisia (2018)

Sites	Sers	Makthar	Kesra	Gaafour
Population per Medical doctor	4651	3440	3650	3540
Medical bed per 1000	0.3	1.37	0.6	1.41

Community leadership in the ALL context

The community leadership is mainly organized at the village (*douar*) level with a local represent, *Omda*, at the interface between the community and the administration.

A second layer of leadership concerns the associations, farmers' association such as SMSA or GDA with a president and adherents or social associations. Generally, women are well represented as adherents or beneficiaries in the FOS. For example, in the Tunisian ALL, women represent between 20% to 50% of beneficiaries in mixed FOs and one FO is completely managed by women and the adherents are all women. So the FOs such as SMSA and GDA not based on land ownerships constitute interesting social space for women empowerment.

All farmers with land asset benefit support from CTV (Centre technique de vulgarisation) through the CRDA (Commissariat Régional pour le developpement Agricole)

Migration

At the national level migration movements between major regions are very significant and migrants leave the western and southern regions of the country (repulsive poles) to settle in the District of Tunis or in the north-eastern and central-eastern regions (attractive poles). These movement are explained by the decline in agricultural productivity and income from agricultural activities and the fragmentation of agricultural land (Chebbi and al., 2019).

At the regional level, the migration balance is negative during this last decade as we see in table 12.

Table 12. Migration balance in the transect Kef-Siliana

Migration balance	2014-2019	2019-2024 (prevision)
Kef Governorate	-6135	-4462
Siliana Governorate	-6431	-4677

ODNO, 2018

In the tunisian ALL, the departure of young generation was a common concern raised by people of the four sites during the focus groups (WP1, Visioning).

Political Context

Brief review of national policies over the last 15 years in favour/hindering the agroecological transition

In 2007, Tunisia developed a national strategy for adaptation to climate change for the agricultural sector. Following the Jasmin revolution of 2011, the country initiated a series of studies to develop a comprehensive national strategy on climate change (UNFCCC, 2014). In 2011, the Government published a 'Livre Blanc' to promote a new regional development strategy in Tunisia to upgrade backward regions by reducing socioeconomic inequalities. One of the main drivers would be connecting the lagging areas to the advanced areas to exploit the spillover and diffusion effects between the regions. Politicians used to call this policy as "positive discrimination" in favor of the least marginalized country areas, which are mostly rural with extreme poverty and low public infrastructure (& services) provision. This was also a first step towards the promotion of the "social and solidarity economic" law[1] which was promulgated by the parliament in 2020. Currently, a major (IFAD) development investment program[2], based on opportunities created by this law, is launched to promote social and solidarity enterprising in central Tunisia with a total investment of 51 Million USD, and aiming at directly benefiting 16,800 household in the region of Kairouan.

The agricultural policy adopted under the 12th Plan (2010-2014) sought to respond to a certain number of sectoral challenges, such as i) rational and sustainable exploitation of natural resources and their protection against overuse and degradation; ii) consolidation of food security in addition to social, especially in relation to reducing unemployment rates and migration in rural areas; iii) upgrading of the competitiveness of the agricultural sector in face of challenges of domestic market liberalization and standard requirements of international markets; iv) the intensification of farmers aggregation into different forms of associations and organizations, including the mutual service companies (type of small cooperatives), specialized inter-professional groups, and agricultural development groups (non-profit farmers associations aiming at facilitating collective management of natural resources), This aims at facilitating farmers access to agricultural supply of inputs and services, marketing and value chain integration, access to public research and extension systems and smooth (& efficient) technology transfer approaches; A final objective of this development plan is to v) improve the profitability of agricultural activity which can make it more attractive for investments and thus higher added value and consolidated growth over years, etc. In addition, there is also a growing recognition of the need to take up other emerging themes such as the inequalities and marginalization of some regions of the country, employment in rural areas in particular for young people, the weakness of farmers' organization as well as the pressure on natural resources (soil, water) and purchasing power, affecting food security and human health. The previous policy objectives of the 12th Plan (2010-2014) recognizes these weaknesses

[1] Law n° 2020-30 du 30 juin 2020, respective to the « économie sociale et solidaire ». Reference to this law in the public official journal/law book can be found in this link.

[2] The program is entitled "Economic, Social and Solidarity Project (IESS-Kairouan)" and can be found here: https://www.ifad.org/ar/web/operations/-/project/2000002075

and were trying to support a transition pathway towards a more efficient and sustainable agricultural sector.

The following five-year economic and social development plan for the period 2016-2020 (13th development plan) aimed at "*Increasing the agricultural sector's contribution to the national development effort*". Seven strategic axes have been considered as a priority for policy makers: 1. The development of natural resources, their sustainability and the mitigation of the impacts of climate change; 2. The regularization of key problematic land tenure situations which are leading to land insecurity and respectively lack of private investments. The objective was to also cope with the fragmentation of agricultural land and allow the optimization of the exploitation of public/collective lands; 3. Promotion of agricultural production systems, strengthening their competitiveness, developing their resilience capacity to climate hazards, and ensuring their sustainability; 4. stimulation of private agricultural investments and its related financing services and schemes; 5. Promotion of small-scale agriculture, family farming and strengthening its role in rural development; 6. Promotion and dissemination of knowledge and innovation in the agricultural sector; 7. Improving governance in the agriculture and fisheries sector.

A strategy for the development of the organic agriculture sector has been elaborated for the five-year plan 2015-2020. This strategy aimed to strengthen the contribution of professionals in the organic agriculture sector and to work on major axes such as the added value of the sector, the preservation of the environment and health. In this line, a label 'Bio Tunisia' has been established under the promulgation of Decree No. 2010-1547 of 21 June 2010.

A water and soil conservation strategy has been defined and promulgated to address the adaptation to climate change and biodiversity protection (Sghaier & neffati, 2017). The 2050 global strategic framework for the new Agricultural Land conservation and Conservation Strategy (ACTA) was as follows: "*Prosperous rural areas, having supported their development on productive agriculture sustainably managing natural resources, and resilient to climate change, established through SWC production-oriented practices that are implemented and shared by farmers* "(DGACTA / MARHP, EU, 2017). Within this DG ACTA (2050) strategy that promote agroecology practices (conservation agriculture, agroforestry, simplified crop techniques, no-till, direct seeding, permanent soil cover, etc.), agroecology is identified as a mean to cope with water erosion, improve soil quality and consequently contribute to the increase of agricultural yields. In addition, the National Strategy for Sustainable Development (NSSD) (ME, 2011) stressed as first challenge "to establish a sustainable consumption and production" and has included in its strategic choices "Promoting friendly farming ecological balance and adapted to changes climate ". Challenge 3 of the strategy is to "sustainably manage natural resources", one of whose strategic choices is the conservation of biodiversity. The same ACTA2050 strategy[3] recognizes the need to develop innovative business models (based on social animation and support for collective development of investments proposals by local communities) to support and sustain the scaling of agroecological practices and innovations.

[3] A summary description of the strategy can be found here: http://www.onagri.nat.tn/uploads/docagri/167-AG.pdf

Tunisia's Ministry of Environment and Sustainable Development submitted the country's INDC in August 2015. "*Overall the INDC is a well-crafted policy document, which presents a 41% decrease in its carbon intensity emissions target by 2030 (starting year 2010) covering the energy, industrial processes, agriculture, forestry and other land use, and waste sectors*". It outlines funding needs of over USD 17.5 billion for the period 2015 to 2030, primarily for implementation of the Tunisian Solar Plan, a transformational electricity sector plan Renewable (mostly solar) energy use in rural areas (for agricultural activities) is also being widely supported by the national policy.

In 2018, the agricultural research priorities by 2030 had been set-up by IRESA[4] following a participatory approach that involved farmers and farmers organizations, development, extension and research actors. Targeting research for impact, constraints and research needs communicated by farmers had been transformed to research themes that were grouped into six priority research programs: *1) improvement of the efficiency of production systems and development of their resilience, 2) protection of natural resources under the context of climate change, 3) improvement of fishery and aquaculture production systems, 4) better management of forests and collective rangelands, 5) empowerment of rural populations and agricultural policies, 6) farmers' organization and promotion of agricultural and fishery value chains*. Agroecology is among the research priorities. In addition, IRESA is coordinating since 2018, the reform of the training programs of the engineer cycle for seven disciplines. The objective of this work is to update these programs based on the needs and expectations of the socioeconomic environment and the emerging challenges like climate change. Agroecology had been included in education programs. Therefore, the targeted deliverables are *skills and training referentials*. These efforts are displayed by IRESA and its institutions to render research more impactful on agriculture sector and to improve the employability of agricultural diploma holders. Furthermore, co-generation and sharing of Knowledge are both subjects of high interest to policy makers in Tunisia, who are working on finding innovative and effective approaches for “technology transfer” and for filling the gap between research and development. Agroecology Initiative participates in many national and regional (African) dialogues aiming at enhancing the co-design and transfer of technological innovations.

Based on this rapid review of agricultural and environmental policies and their main priorities, we have allocated one or zero to each principle of the AE frame when a given policy addresses or not the principle. The figure 6 gives an overview of the main principles guiding the national policies for the three successive periods over the last 15 years.

[4] More information about these priorities can be found here: http://www.iresa.agrinet.tn/announce/PrioritesRechercheAgricole%202030.pdf

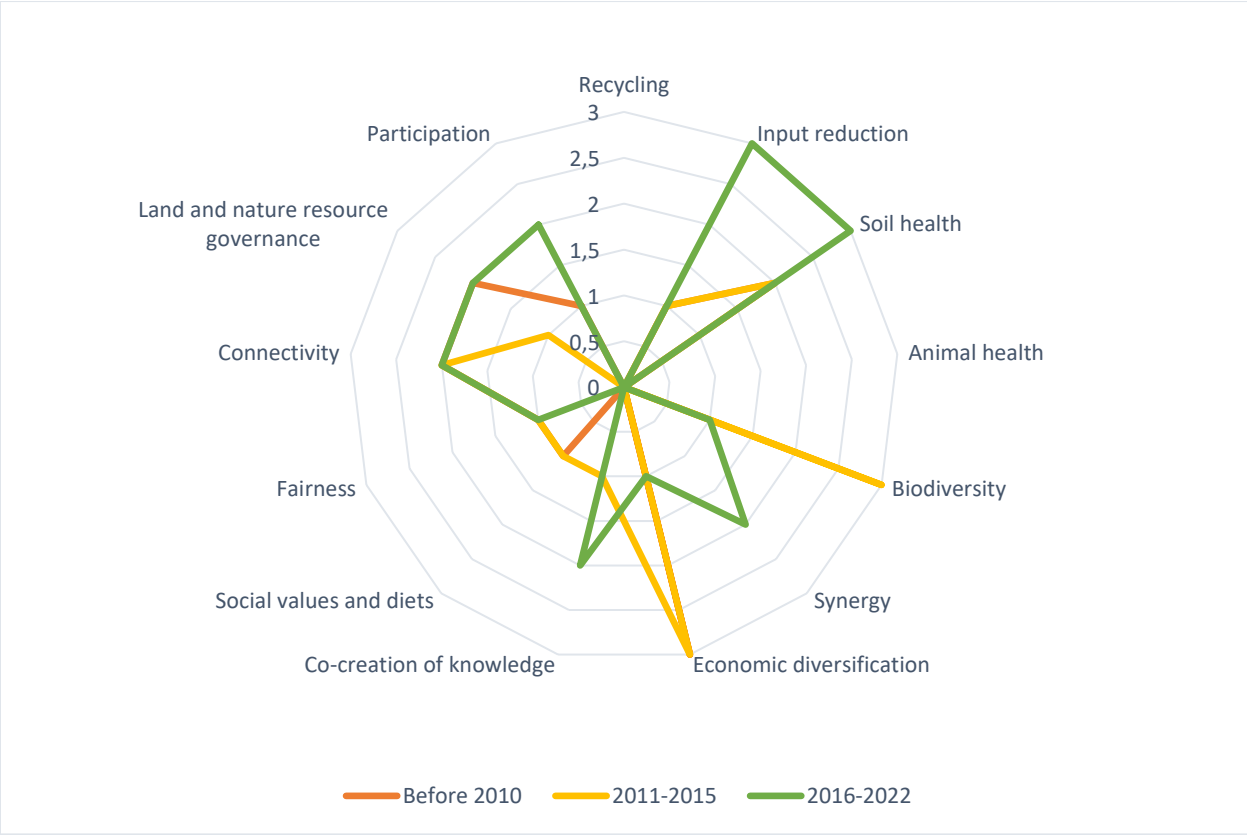


Figure 6. AE principles considered for different national policies for the three period (3 programs before 2010; 5 programs for 2011-2015; and 3 programs for 2016-2022)

A list of the considered policies in this analysis, and their respective (relation) mapping to the different agroecology principles, can be found in the below table 13.

Table 13. A first list of national policies promulgated in Tunisia over the last 15 years and their respective (relation) mapping to the different agroecology principles

Policies/programs	year	Recycling	Input reduction	Soil health	Animal health	Biodiversity	Synergy	Economic diversification	Co-creation of knowledge	Social values and diets	Fairness	Connectivity	Land and nature resource governanc	Participation
National strategy for adaptation to climate change for the agricultural sector	2007													
agricultural policy adopted under the 12th Plan (2010-2014)	2010													
a label 'Bio Tunisia' has been established under the promulgation of Decree No. 2010-1547 of 21 June 2010	2010													
Livre Blanc' as a new regional development strategy in Tunisia	2011													
National Strategy for Sustainable Development (NSSD) (ME, 2011)	2011													
Comprehensive national strategy on climate change (UNFCCC, 2014).	2014													
A strategy for the development of the organic agriculture sector has been elaborated for the five-year plan 2015-2020.	2015													
Country's INDC	2015													
five-year economic and social development plan for the period 2016-2020	2016													
The 2030 global strategic framework for the new Agricultural Land conservation and Conservation Strategy (ACTA)	2017													
agricultural research priorities at horizon 2030 had been set-up by IRESA	2018													

Regional policies

Today, land, water and forest conservation are on the top priorities of national policies. Despite the early care about these key resources, very limited progress in terms of policy design, implementation, and effectiveness has been recorded. New challenges of climate change, resources scarcity (and degradation) and social pressure are adding more complexity to policy making and implementation.

Participatory approach was used at the regional and local levels since the early eighties, where the local communities have been considered as main central players of any development action, and were consulted (mapped/identified) before undertaking development actions and investments. This has led to mixed performances and results, with cases of success and others of failure.

Currently, policies in the regions have shifted from the participatory approach towards inclusive and sustainable “value chain” perspective. A focus on value chains was seen, since the late 2000, as a mean to stimulate local economic and social dynamics, while keeping a focus on resources protection and preservation. The lack of strong administrative expertise on value chains in the regions (and locally) made it difficult to properly implement and use this approach for local development in rural areas. Thus, outcomes of these policies (and incurrent development and investment programs) were also mixed, so far.

As complementary to the VC approach, the transition of territories in the Tunisian mountains is considered to be potentially supported by the creation and reinforcement of farmers' collectives. These structures are susceptible to break with the logic of 'control' of the rural population that has prevailed for more than a century in these territories.

At more local level, the Tunisian ALL is concerned by some regional development programs as described above (value chains, social enterprising, Acta2050 for soil and water protection through sustainable financing models, etc.) in addition to other direct incentives (subsidies) provided especially to farmers operating under irrigated conditions (have access to a private or collective source of water). A national inventory of ongoing AE projects (WP5) shows that these zones (Siliana and Kef) are already the target local of other programs (Table 13).

Table 13. Development projects or Initiatives in the Tunisian ALL

Name of initiative	Type of initiative	Project activities were conducted to address AE principle(s)?	Intervention logic
ProSol	Project	Reinforcement of adoption of soil and water conservation practices at local level	Innovations for farmers
PROFITS	Project	The development of agricultural and forestry sectors as a lever for the socioeconomic development of vulnerable areas, to strengthen and energize inclusive territorial development processes	Value chains
PACTE	Project	Territorial management of AE practices	Multi-stakeholders platforms
IAAA	Project	Innovations in the agriculture and agri-food sectors have contributed to sustainable rural development in some rural areas; scaling up, capitalization, anchoring and sustainability of promoted innovations	Value chains

Mapping regional policy actors involved in the ALL in Tunisia

This section aims at analysing a list of more than 500 stakeholders who already participated in the different events of the Agroecology Initiative (either for coordination and planning meetings, or for focus groups, trainings, and policy dialogues) (Figure 7). Proxy variables to reflect on the level of policy involvement and influence of these involved actors was developed. The four (policy-oriented) dummy variables are each representing one of the below actors categories:

- No policy influence,
- Indirect policy influence
- Direct policy influence
- Policy changers/drafters

Descriptive statistics of these variables for the total sample of 500 involved stakeholders generated some insightful information, which can be used during the remaining initiative implementation period for active policy engagement and changes. Results of this "policy-oriented stakeholders mapping" exercise is shown below.

Figure 8 shows that around 61% of the involved (beneficiary and participant) actors in the different Agroecology initiative activities haver no policy influence. These are mostly farmers and farmers associations, which are supposed to be "policy-takers" due to their low level of organization and lobbying, respectively. Around 34% and 4% of the actors involved have indirect and direct policy influence, respectively. Finally, only 0.5% of the involved actors are actually "policy changers". This shows that more efforts need to be done to increase the participation and engagement of actors who have direct effect on policy changes, including actual policy makers and changers in Tunisia.

Figure 7. Typology of (around 500) participants (and beneficiary) stakeholders and actors involved in the activities of the Agroecology Initiative in Tunisia.

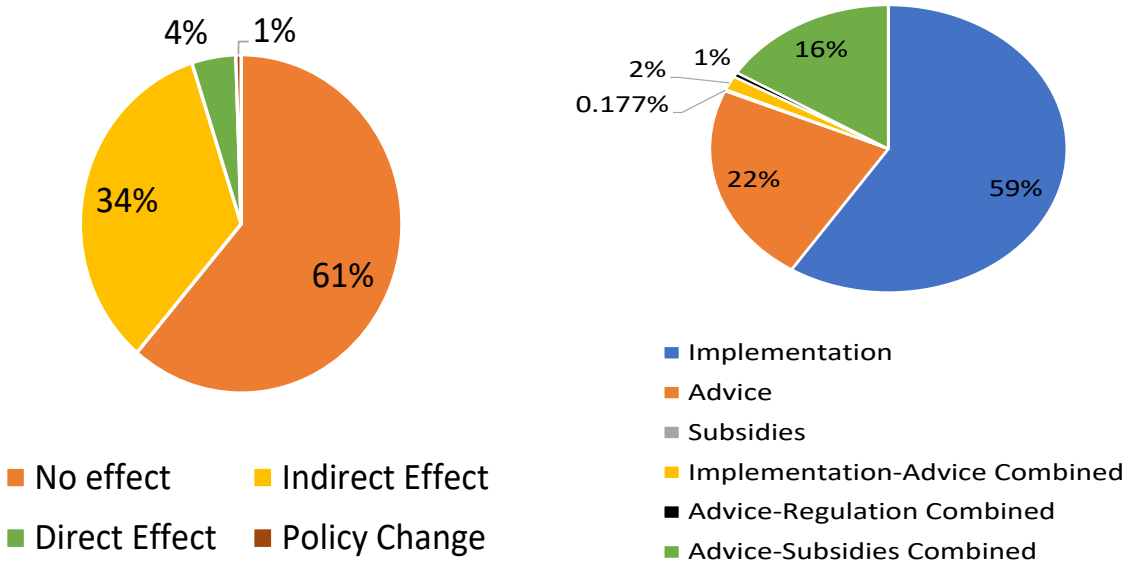


Figure 8. Stakeholders mapping from a policy-oriented perspective (left) and based on their respective roles in the ALL territories.

The same 500 actors were also characterized based on their respective roles in terms of territorial development. Each of these actors, depending on his administrative position (or type of activity locally), was attributed one of the below functions (Schulp et al. 2022)[5]:

- Implementation
- Advice
- Subsidies
- Implementation-Advice Combined
- Advice-Regulation Combined
- Advice-Subsidies Combined

Results of the territorial analysis shows that most of the involved actors in our ALL in Tunisia are working on implementation, advice, and "advice-subsidies combined" respectively.

[5] Schulp, C. J., Komossa, F., Scherer, L., van der Zanden, E. H., Debolini, M., & Piorr, A. (2022). The Role of Different Types of Actors In The Future of Sustainable Agriculture In a Dutch Peri-urban Area. *Environmental management*, 1-19.

Current state of agroecological principles in the ALL

Recycling

The 'recycling' principle aims enhancing the use and valorization of local renewable resources (nutrients and biomass) while respecting as far as possible the resource cycles. In the Tunisian ALL, we proposed to focus the recycling principle on the vegetable biomass at the interaction and integration between crop and livestock activities at the farm and local level. For that, we proposed to explore plant species and agronomic practices (such as leguminous-graminea associations, intercropping with fruit trees) that produce both food and feed nutrients. The multiple crop- and tree-residues (like barley bran, straw, olive pomaces and stems, etc.) can be recycled through gringer and pellets machines to constitute nutritive feed ration for animals as substitute to concentrates or grains.

The recycling activities of the crop- and tree- residues will be assessed at the farm and local (or regional) level to favor complementarities and economic valorization through the exchanges.

Input reduction

The ‘input reduction’ principle proposes to reduce the use of chemical inputs that negatively impact the health (human, animal and soil health) and to increase self-sufficiency and resilience of the rural families by decreasing the dependency on purchased inputs.

For that, in the tunisian ALL, it is proposed to work on manure collection and use and biofertilizers in substitute to chemical fertilizers. Secondly, pastureland constitute a reserve of biomass for ruminants and human to improve nutrient availability (inc. healthy products such as medicinal plants, natural honey, etc.). The pastureland improvement through tree plantation (cactus, carob) can reduced feed purchased.

Soil health

The ‘Soil health’ principle aims at improving the organic matter management and soil biological activity to favor vegetation growth.

Crop-livestock integration and diversification can participate to enhance soil health through organic matter (soil structure), worm and microbia flora (soil texture and biology). Intercropping system, agriculture of conservation or soil conservation practices allow to conserve soil humidity and activity.

The majority of soil health indicators were addressed in the Kef and Siliana regions by physical indicators such as texture, structure, bulk density, porosity, soil moisture, chemical indicators such as soil organic

matter content, CEC, nitrogen content, phosphorus, potassium content and $CaCO_3$ content and biological indicators such as microbial biomass and microbial biomass activity but all these indicators have been determined by researchers for specific purposes and do not reflect the knowledge of the farmers. It is therefore imperative to study the farmer's perception of the indicators of the health of his soil.

Animal health

When it comes to transition towards more agroecological practices in the area of animal health, the main idea is that we expect the farms to reduce the reliance on classic tools/means that may affect the ecosystems as well as human health. In other words, we should target indicators that aim to solve animal health problems without impacting human and environmental health.
Bearing this in mind, we can suggest the following indicators:
1. Introduction of new or improved schemes for vaccination against major pathogens. The transition here is the gradual move from chemical and antibiotic treatments towards vaccinations;
2. Use of acaricides and anthelmintic molecules with the lowest withdrawal periods for meat and milk (safer products);
3. Use of acaricides and anthelmintic molecules that are less detrimental to the environment (less residues in soil and water; example of the effect of the molecule ivermectin on soil health);
4. Adoption of new hygienic practices to reduce the use of chemicals against pathogens and disease vectors; such new practices mean less use of chemicals and their effectiveness can be assessed by their effect on the incidence of respiratory diseases, neonatal mortalities and incidence of udder diseases;
5. Adoption of improved, integrated herd-health strategies for the control of endemic diseases with reduced reliance on use of chemicals (for instance adoption of an integrated and rational program of anthelmintic preventive treatments at local/community levels to prioritize strategic treatments and reduce efficiently risks of heavy infections).

The level of complexity to measure such indicators is variable. However, increasing awareness among the target communities and the main players in the field of animal health will help to improve “pushing” these indicators towards the desired agroecological transition. Research to fill some gaps is also required especially when it comes to indicators 4 and 5.

Biodiversity

Biodiversity principle aims at enhancing the diversity of plant and animal species to maintain the overall agroecosystem, according to the principle of the diverse functional contribution of each species to the ecosystem.

In the Tunsian ALL, the biodiversity will be addressed through the use of multi-species in the crop, tree and livestock systems and their association or integration at the plot/farm level. In association with soil health principle, the diversity of plant species and plant-soil-microorganisms interactions promotes soil biodiversity.

The multi-species diversity will also be analysed in regards to their sensitivity and resilience of the introduced or developed species to dry events.

Synergy

The 'synergy' principle supposes positive ecological interactions from the diversification and integration of species and practices in the agro-ecosystems.

In the Tunisian ALL, the synergy will be addressed through different mechanism:

1. Diverse crop rotations and the integration over time offer plant diversity, which helps break up soil-borne pest and disease life cycles, improve crop health, help manage weeds, reduce nutrient losses from soils, and improve soil health (Larkin, 2015). Diverse plants in time and space in cropping systems release sugars, which support diverse food webs and energy chains essential for cropping systems and microbial activity in soils.
2. the grazing livestock management that enhance ecological balance/interactions (synergy) and usually integrate in a mixed feeding system (in link with the crop system). This enhances the complementarity between agroecosystems.
3. Healthy soil requires active decomposition, nutrient cycling, and soil functions, which can be accomplished with crop rotations, cover crops, and organic matter amendments.

Economic diversification

The 'economic diversification' is part the portfolio theory to manage social, economic and environmental risks.

In the Tunisia ALL, the economic diversification will be addressed through the diversification of economic activities (at the farm and off farm level) and their seasonal and annual economic contribution to cover the multiple nature of domestic and agricultural expenses at short, medium and long term.

Co-creation of knowledge

The 'co-creation of knowledge' principle aims to enhance and valorise the traditional and scientific knowledge at the local level by improving horizontal exchanges, i.e. between peers or farmer-to-farmer exchanges. Folke et al (2002) and Berkes (2007) emphasize on the human arrangements and the co-learning processes that support people living in harsh and uncertain environment.

In the Tunisian ALL, the four sites have been selected according to a gradient of agro-ecological practices. We propose to monitor the change of agro-ecological practices in and between each site to

assess the Knowledge sharing in the living landscape, focusing on the knowledge transfer and its transformation in the ALL.

Social values and diets

'Social values and diets' aim at developing agroecological transitions in respect to cultural values (based on identity and tradition) and culinary preferences, while providing healthy and diversified appropriate diets.

In this domain, we propose to focus on:

1. The diversity of diets and diet composition building on local food commodities (related to vegetable, cereal, animal products, etc.)
2. Knowledge of the nutritional facts of such food products (Source of information related to healthy food, the best frequence to eat meat?, Which foods can affect negatively the health ?)
3. Social and gender equity in terms of consumption of such food products

Fairness

The 'Fairness' principle aims at enhancing living conditions and the equity in regards to economic exchanges, employment or even treatment of intellectual property rights.

In the Tunisian ALL, we propose to look at:

1. Farm-gate versus market prices of agroecological produces, especially for products of 'terroir' such as honey and dairy products;
2. The added value distribution along the value chains, for instance between farmers and intermediaries;
3. Access to valuable market information
4. Wages/employment for agricultural workers along agroecological value chains by gender and age

Connectivity

The 'Connectivity' principle aims at ensuring exchange and confidence between actors.

In the Tunisian ALL, the connectivity will be assessed both along the agroecological value chains from the producers to consumers and in the ALL between the multiple actors engaged (considering the involvement of women and youth). At this two levels, we will consider different factors that can influence the degree of connectivity, i.e., the proximity and facilities/infrastructure, the nature of the

link (exchange of goods or services such as information or labor), and the frequency and intensity of the links.

Land and natural resource governance

The 'land and natural resource governance' principle focuses on institutional or organizational arrangements to sustain and even improve the natural resource and land management. Natural resources include soil, water and genetic resources. By management, it means the access and use of the resources.

In the Tunisian ALL, it is proposed to follow:

- The farmers' involvement in soil and water conservation techniques to reduce soil erosion and water shortage;
- The knowledge awareness in regards to legal governance? (rights and claims)
- Etc…

Participation

The "participation" principle is based on the involvement and inclusiveness of all farmers in social organization and decision-making process along the food systems.

The participation will be addressed at the farm and FO levels through the effective participation of the individuals in the ALL (according to sex and age) in the decision-making processes from the co-design to the AEP implementation.

Next steps

This contextualization document is considered as a preliminary document which cover the different dimensions and domains of the agro-ecology, but also to identify the gaps in terms of knowledge that needs to be considered in the baseline survey. So this document will be updated during the year 2023.
The description of each agroecological principle and its potential content in the Tunisian ALL will be the basis of discussion for co-designing the technical and organizational innovations packages with the stakeholders. This section will be completed with data collected in the baseline survey that will start in January 2023..

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Annexes

Annex 1. Characteristics, parnerships and challenges of the basic organizations (GDA, SMSA) in the Tunisian LLs

Team report: Udo Rudiger, Asmaa Soussi, Véronique Alary, Hassen Ouerghemmi, ICARDA)

As proposed in the "Guidelines and suggestions for stakeholder mapping and existing initiative assessment as part of WP1" based on the draft 23/08 proposed by Bernard Triomphe and Nadia Bergamini, we have used and adapted the "Appendix 2: Fiche for organizing the basics of an organization" to collect first data in the tunisian ALL. The guideline of this diagnistic proposes four sections:

1. Describe key characteristics of each STH or initiative (who? How are they organized?, compostion), their main activities and their area of influence
2. Explore the diversity of the key partners. This information will contribute to the STH mapping
3. Discuss the main issues/challenges and their propositions to see how the AE approach could be to their needs
4. The description of the main farm activities will be used as the main basic elements of the description of the agriculture today in the Visioning

WorkSheet GDA Sers

Table 1. general information

Fetature / characteristics	Organization: « GDA femmes rurales Sers »
Type of organization (e.g. academia, NGO, FO, private sector, etc.)	Agricultural Development Group (GDA)
Purpose & objectives (why?)	Empowerment of rural women Encouraging women to participate in sustainable rural development Capacity building and consolidation of negotiation power Foster livestock production and local products Group marketing / bulk sale with the sale of products of 'terroir' coming out of the GDA (indirect beneficiaries)
When created	2015
Size / membership (membres GDA (comité restreint)+adherents+beneficiares+clarifier) No of women Nos of youths (less than 35 years old)	6 members and about 55 adherents All adherents are women, 20 percent of them are less than 35 years old. About 40 adherents in the El marja irrigated perimeter, 15 adherents in rainfed area in Bouslia
Area of influence (geog zone/area) Main farm activities of the adherents in the targeted area (main farm activities, av. farm size of GDA adherents; % of large farms)	Sers (El marja and Bouslia) **- Breeding:** Small ruminant breeders (owning less than 20 sheep and goats) represent 20% of adherents, breeders owning between 20 and 35 heads represent 60% and 20% are big breeders. Bovine breeders owning less than 8 cows represent 60% of adherents, more than 35% have between 8 and 15 cows and less than 5% of adherents have more than 15 cows -**Cereal cultivation:** the average farm size of adherents is between 2 and 2,5ha on irrigated area and/or 3ha on rainfed areas. All of them have less than 10 ha. Some of them are renting land. -Bee keeping, poultry, saffron and vegetable production

Main lines of work & activities Activities GDA	**- Local food artisanal production:** cereal products (couscous, mhamsa, bsissa,..), piment, spicies, dried mint, garlic, dried tomato, saffron **- Dairy production:** about 50 l of milk are transformed by day to gouda, ricotta, mozzarella, , yogurt, butter, cottage cheese and spicy cheese **- Commercialization:** is made directly (from producers to consumers) in the GDA store inaugurated in June 2022 -**Mechanization:** providing access to grinder, pellet machine and handheld seeder -**Forage seeds:** Coordinate distribution of forage seeds -**Access to finance:** collaboration with UTSS for micro-credit (agric inputs) **-CapDev**: Participate at different trainings on FBS, milk and cheese production, bee keeping, etc by GIZ and AVFA **-Digitalization**: Receiving technical SMS messages for agricultural advices
Key technical staff GDA: How many? Profiles and topics / themes on which they work? Stability / turn-over	The president (every three years a new president is elected), 1 Treasurer, 4 administrative members and three 'controllers' 2 guardians recruited and paid by the CRDA that is offering the store and the guardians. However, the GDA may have to start paying the guardians very soon instead of the CRDA. Procedures to recruit a woman for the store management is in progress
Funding sources (public, projects, etc.), stability of funding over time, importance of external funding	The annual subscription of members is 20 dinars per year. the GDA funds managed annually do not exceed 800 or 900 dinars. However, the GDA Adherents can benefit from several credits reaching 5000 dinars through NGOs such as the UTSS Tunisian Union of Social Solidarity (UTSS) and micro credit associations such as ENDA and SYRES. Other associations such as 'Seine- maritime' and organisms GIZ, AISSA, ICARDA provide some equipment (e.g cheese processing, small scale mechanization, mobile phones) and trainings (10% of the sales contrubute to the GDA functioning)
How are main decisions taken? (1) (comment? Assemblée avec qui?)	Decisions are taken during meetings with adherents
Any significant recent (last few years) changes in the way the organization works?	No
Are there any documents you may share with us to understand your organization or its line of work?	There are no reports just some financial records and personal notes taken by the president
Miscelaneous observations	One of the controllers mentioned the need to have more knowledge of conflict management

Table 2: Who are your key partners

	Partner 1: **CRDA**	Partner 2: **OEP**	Partner 3 **UTSS: Tunisian Union of Social Solidarity**	Partner 4: **Microfinance ssociations such as Enda and SYRES**	Partner 5: **ICARDA**
Main purpose (1)	Providing the GDA store building, providing cars to visit fairs Providing advice CTV provides room for training	Experimenting new practices like forage mixtures (vetch / oats /triticale), capacity building ; providing new leguminous forage seeds, technical monitoring and demonstration; Providing car for participate at trainings and workshops	Providing funding (grant loans without interest) Providing a meeting room for meetings and trainings on social and health topics	Providing funding (Credits, 5% interest rate at SYRES, 25% interest rate at Enda) Give dairy cows with credit (5% interest) based on a certified training	Experimenting new practices (forage seed mixture, SMS, small scale mechanization)
Type of collaboration (2)	Bilateral agreement	Bilateral agreement	through a formal bilateral agreement	Bilateral agreement	Through projects
How important is it for your organization (3)	Vital	Important	Important	Important	Important
What Key activities do you implement together (4)	Coordination and joint planning (Store inauguration; Visit to many fairs; agricultural extension)	training events, coordination and joint planning Encouraging farmers to produce their own seeds	commercial relationship (providing cows or small ruminants with credit and 0% of interest)	SYRES commercial relationship (providing cows with credit and 5% of interest)	training events, trials
What type of approach is the collaboration based upon? (5)	Provider	provider, transfer of technology, capacity building	service provider	Service provider	Action-research, transfer o technology, capacity building
How satisfied are you with the collaboration? (6)	Excellent	Excellent	Excellent	Good	Excellent
Observations		supply fodder seeds, technical follow-up, choice of cereal-legume combinations, Demonstration days	Provide social services (free medical check up for women against breast cancer, psychological assistance, education advices, domestic violence awareness)	Enda interest rate:25% SYRES interest rate 5%	Providing equipment…, meteorological station , seeds, trainings

(1) E.g. accesing or providing funding, seeking or providing advice and building capacity, experimenting new practices, exchanging info, etc.

(2) e.g. ad hoc, through a formal bilateral agreement, through projects, as part of a multiSTH arena of some sort, linkage to input or output market (as provider, as buyer)

(3) Importance: 1 marginal 2 Regular 3 Important 4 Vital

(4) E.g. training events, trials, coordination and joint planning, developing proposals, commercial relationship (buying or selling inputs or products), policy dialogue, etc. It can be more than one type of activities

(5) Such as service provider, co-conception, action-research, transfer of technology, capacity building, etc.

(6) Satisfaction: 1 Poor 2 Regular 3 Good 4 Excellent

Table 3: main challenges and constraints by the main farm activities

Main farm activities	Who is concerned? (type of farm size; gender; how many farms?, etc..)	Identified problems	Causes	Proposed activities?	Link to PoW AE i
Fodder crops	All adherents	Drought unavailability of seeds, in particular legume forage seeds	Climate change Only 12 women have collected seeds Availability of legume seeds	Training about seeds mechanical production & harvest Crops/vegetable association choices	Land preservation (less use of ferti Biodiversity and Sustainability-adaptive management (seed production for next seasons) co-creation of knowledge
Breeding: Small ruminant Cattle breeding	All	Very expensive alimentation Overgrazing Spine cactus Problem of dust	Unavailability of feeding products (and expensive) Lack of grazing space The grinder is very heavy to move so not all GDA members can use it The breed 'Queue fine de l ouest' is non-milk producing	- Having more grinders to better recover the cactus and other biomass waste - Silage production and storage in plastic bags - Dairy sheep breeds introduction - cactus?	Valorization of cactus and waste fr the pruning of olive trees etc. (recycling)
Transformation: Cheese production Artisanal food products (cereal-based products, eggs, spices, mint, garlic, dried tomato)	5 Adherents Majority of the adherents	Commercialization issues. They have the capacity to transform up to 500 liters, but they are transforming 50 liters Commercialization	Small village No market access outside the region (For the milk and cheese: very perishable products difficult to store) Milk price The cooling chain of milk from farm to cheese processing unit / store is not functioning well Issues of recognition, competition, etc..	Marketing activities (developing flyers with products, radio spots, FB adds) -"Depot/vente" – place products in small shops in Sers Partners for the commercialization outside the village -test milk solar cooling units (from ex-GIZ project) Exchange with other GDA	Connectivity (producer-consumer) Diversified Diet Tradition Economic diversification
Beekeeping	4-5 Adherents	Most hives died due to drought	No bee plants no food for the bees	Introduction of "arbre melifere" – trees providing food for bees	Animal welfare Biodiversity
Poultry	All Adherents have (between 15 and 20 hens, turkeys, etc.)	Diseases and high mortality by summer	They cannot identify the disease to give the right treatment	Veterinary assistance Training of farmers on chicken diseases and treatment Use the selling point for eggs	Animal welfare

WorkSheet SMSA 'Ankoud El Khir' (Rahla)

Table 1. general information

Fetature / characteristics	Organization: SMSA 'Ankoud El Khir'. Gaafour , Siliana
Type of organization (e.g. academia, NGO, FO, private sector, etc.)	SMSA
Purpose & objectives (why?)	Facilitate access to inputs for adherents Agricultural machinery services in the region "United farmers are stronger"
When created	2022 (they are still waiting for the authorization of the governorate for the sale of treatments, fertilizers and feed)
Size / membership (membres GDA (comité restreint)+adherents+beneficiares+clarifier) No of women Nos of youths (less than 35 years old)	3 members (president, vice president and treasurer), 1 employee,27 adherents and a total of 100 beneficiaries 3 women 10 -12 of the adherents are less than 35 years old.
Area of influence (geog zone/area) Main farm activities of the adherents in the targeted area (main farm activities, av. farm size of GDA adherents; % of large farms)	Gaafoor/ Seliana 50% of adherent have a minimum of 5 or 6ha (rainfed). Others have between 15 and 20 ha(rainfed). Only 5 adherents have between 1 and 3 cows. More than 50% of adherents are small ruminant breeders (average of 50 animals) Cereal crops: Wheat and barely Olive trees (between 100 and 400 trees for each adherent)

Main lines of work & activities Activities GDA	Agricultural machinery services (seed cleaning and treatment and grinder?) supply of forage and leguminous seed associations (vetch-oat, vetch-triticale, triticale, oat) Sale of agricultural inputs (fertilizer and feed)
Key technical staff SMSA: How many? Profiles and topics / themes on which they work? Stability / turn-over	The three administration volunteers (elected president, vice president and treasurer) The technician (employee) taking care of agricultural machinery services
Funding sources (public, projects, etc.), stability of funding over time, importance of external funding	14 500 TND (actions) A total capital of 29 000 TND (adherents have paid just half of their actions for the moment); no annual fees; only ICARDA (no other donor)
How are main decisions taken? (1) (comment? Assemblée avec qui?)	Members meetings every 2 months (adherents don't come even if they are invited) General assembly;
Any significant recent (last few years) changes in the way the organization works?	No
Are there any documents you may share with us to understand your organization or its line of work?	Just meeting minutes and register for use of machinery; Certificate for right to sell Ammonitre
Miscelaneous observations	

Table 2: Who are your key partners

	Partner 1: OEP	*Partner 2: ICARDA*	*Partner 3: CRDA*	*Partner 4: GIZ*	*Partner 5: INRAT*
Main purpose (1)	Seeds supply Training (Sula and cattle feeding rations) as new practices	*Experimenting new practices, providing equipment*	*Providing advice and equipment, building capacity,*	*Building capacity through training in cattle breeding*	Installation of a demonstration plot of a vetch-oat association Suppling seeds of vetch, triticale, and oat
Type of collaboration (2)	Through project	Through projects	Ad hoc	*Bilateral agreement*	*transfer of the technical package through projects*
How important is it for your organization (3)	Important	Important	Marginal	Regular	Important
What Key activities do you implement together (4)	Training events	*Training events*		*Training events*	*Training events, trials on soil erosion and cultivation methods (minimum tillage, CA)*
What type of approach is the collaboration based upon? (5)	*Service provider, capacity building*	*Action-research*		*Capacity building*	*Action-research*
How satisfied are you with the collaboration? (6)	Excellent	Excellent	Poor	Regular	Good
Observations				The training is non-certifying, so it does not allow them access to microfinance to buy cattle heads	

(1) E.g. accesing or providing funding, seeking or providing advice and building capacity, experimenting new practices, exchanging info, etc.

(2) e.g. ad hoc, through a formal bilateral agreement, through projects, as part of a multiSTH arena of some sort, linkage to input or output market (as provider, as buyer)

(3) Importance: 1 marginal 2 Regular 3 Important 4 Vital

(4) E.g. training events, trials, coordination and joint planning, developing proposals, commercial relationship (buying or selling inputs or products), policy dialogue, etc. It can be more than one type of activities

(5) *Such as service provider, co-conception, action-research, transfer of technology, capacity building, etc.*

(6) *Satisfaction: 1 Poor 2 Regular 3 Good 4 Excellent*

Table 3: main challenges and constraints by the main farm activities

Main farm activities	Who is concerned? (type of farm size; gender; how many farms?, etc..)	Identified problems	Causes	Proposed activities?	Link to PoW AE i
Cereal crops	All adherents	-Seeds and fertilizers are unavailable (specially wheat, DAP, super 45) at moment when needed. -Erosion	Fertilizers are only sold to whole salers	-own Seed multiplication for future campaigns -purchase and sale of 100 t fertilizer -direct seeding against erosion	biodiversity
Cattle farming	Only 5 adherents	Most of the adherents want to start cattle breeding but they have no access to microfinancing	The training they received from GIZ is not certifying. Most of them can not go to training far from the village	They are looking for a training of the AVFA . With AVFA training certificate they can obtain credit from MFI for cattle	Sharing knowledge Economic diversification
Small ruminants breeding	All adherents	Unavailable and very expensive pellets and grains Subvention quota is too reduced		Producing their own animal feed Receiving wheat bran and barley grain quota as SMSA	Synergy Recycling
Olive trees	All adherents	Diseases Bad or no Olive tree pruning Erosion Drought	No knowledge of diseases and treatment	Training about olive trees pruning and disease treatment	

WorkSheet SMSA Kouzira

Table 1. general information

Fetature / characteristics	Organization: SMSA Kouzira in Kesra, Siliana
Type of organization (e.g. academia, NGO, FO, private sector, etc.)	SMSA
Purpose & objectives (why?)	Direct marketing of figs in the Tunis wholesale market , bulk sale; contract farming Bee-keepers assistance They have the objective of obtaining the organic certification of honey creation of an oil mill?
When created	2020
Size / membership No of women Nos of youths (less than 35 years old)	114 adherents, 70% are women and more than 40% are less than 35 years old A total of 240 beneficiaries (114+126) 3 members
Area of influence (geog zone/area) Main farm activities of the adherents in the targeted area (main farm activities, av. farm size of GDA adherents; % of large farms)	Kesra Fig trees, Olive trees, Cherry trees Beekeeping Cereals Most of adherents own between 0.5-5ha (diversified family farming). 20% of adherents have more than 5ha; all access to irrigation (natural spring in the village) The olive trees are planted in collective land.

Main lines of work & activities Activities GDA	Fig's commercialization Bee-keeping training and coaching Replacement of hives
Key technical staff SMSA: How many? Profiles and topics / themes on which they work? Stability / turn-over	The president, a general secretary, and a technical director. 20 volunteers, 1 treasurer, 6 beekeepers responsible for the marketing of honey, a coordinator (forest engineer) – no employee
Funding sources (public, projects, etc.), stability of funding over time, importance of external funding	8500TND (1 action costs 10 TND). 70% of produced honey. The project Profits provided the SMSA with 640 hives Part of honey return goes into the SMSA budget
How are main decisions taken? (1) (comment? Assemblée avec qui?)	Decisions are made at board level (there are meetings every 1-2 months)
Any significant recent (last few years) changes in the way the organization works?	No
Are there any documents you may share with us to understand your organization or its line of work?	Minutes and financial reports No
Miscelaneous observations	There is a conflict between GDA and SMSA

Table 2: Who are your key partners

	Partner 1: ***Profits***	*Partner 2:* ***CRDA***	*Partner 3:* ***The governorate***	*Partner 4:* ***Municipality***	*Partner 5:* ***'Emtiaz' association***
Main purpose (1)	the establishment of a promised oil mill did not take place *Providing 640 hives*	*Providing advice and building capacity*	Networking	*providing funding (a plot to install the olive mill) but finally the plot was not a property of the municipality, and the process is stopped*	Microfinance 2000-3000 TND With 6% of interest
Type of collaboration (2)	*through projects*	*bilateral agreement*	Ad hoc	*bilateral agreement*	*bilateral agreement*
How important is it for your organization (3)	Marginal	Regular	Regular	Regular	Important
What Key activities do you implement together (4)	Training for farmers	2 days of training on organic beekeeping with the CTAB	Information about a land that the SMSA can have to install the olive mill		*Providing funding to small beekeepers*
What type of approach is the collaboration based upon? (5)	Service provider	*Capacity building*	*coordination and joint planning*	*coordination and joint planning*	*Service provider*
How satisfied are you with the collaboration? (6)	Poor	Good	Good	Good	Excellent
Observations	The training was after the hives distribution, so it was not useful. A lot of beekeepers lost a big part of their hives				

(1) E.g. accesing or providing funding, seeking or providing advice and building capacity, experimenting new practices, exchanging info, etc.

(2) e.g. ad hoc, through a formal bilateral agreement, through projects, as part of a multiSTH arena of some sort, linkage to input or output market (as provider, as buyer)

(3) Importance: 1 marginal 2 Regular 3 Important 4 Vital

(4) E.g. training events, trials, coordination and joint planning, developing proposals, commercial relationship (buying or selling inputs or products), policy dialogue, etc. It can be more than one type of activities

(5) Such as service provider, co-conception, action-research, transfer of technology, capacity building, etc.

(6) Satisfaction: 1 Poor 2 Regular 3 Good 4 Excellent

Table 3: main challenges and constraints by the main farm activities

Main farm activities	Who is concerned? (type of farm size; gender; how many farms?, etc..)	Identified problems	Causes	Proposed activities?	Link to PoW AE i
Fig trees	All	-Pollination problems Commercialization problem -There are more than 64 local varieties of figs than may disappear -Drought	- Male trees are not synchronized with some fig varieties because of the climate - + highly perishable varieties -consumers want only black variety	-The SMSA is guiding farmers to plant male vines in an area where the microclimate is adequate - Transformation unit for fig products (dried figs, confiture, sirup) -direct marketing -CDO / tracability	Biodiversity
Beekeeping	56 beekeepers	-Commercialization -Transhumance (transport cost) -Mortality and diseases -Organic certification cost	-Consumer trust problem and absence of organic certification or a brand	- Purchase of a truck for transhumance -Collective treatment - Plantation of melliferous plants such as 'sulla' - Bio certification (is expensive 80 TND)	Biodiversity Synergy
Olive trees	all	No oil mill in the region Seasonality No pruning of trees	harvest with sticks damages the trees afraid of pruning	Installation of an oil mill Training on pruning Severe pruning to renew very old trees Grinder/chopper for olive residues to produce compost	

WorkSheet SMSA ETTAWEN (Chouarnia)

Table 1. general information

Fetature / characteristics	Organization: SMSA ETTAWEN in Makther, Siliana
Type of organization (e.g. academia, NGO, FO, private sector, etc.)	SMSA
Purpose & objectives (why?)	Providing farmers with seeds treatments,fertilizer, feeding products and machinery services (cleaning seeds, etc.) Training specially for young people and women Development of direct seeding in the region, and areas of vetch and Fenugrek seeds
When created	2017
Size / membership No of women Nos of youths (less than 35 years old)	9 members including 3 women 120 adherents (50 % are women and 40% of adherents are less than 35 years) More than 500 beneficiaries of non-subsidized products and machinery services. Only adherents can buy subsidized products
Area of influence (geog zone/area) Main farm activities of the adherents in the targeted area (main farm activities, av. farm size of GDA adherents; % of large farms)	Chouarnia and all the delegate of Makther -Field crops, especially wheat and barley - Lamb fattening and breeding (cattle and small ruminants) an average of 80% of members have between 20 and 50 heads of small ruminants and about 4 cows -Olive trees (an average of 150 by farmer) -80% of adherents own or rent less than 20ha (rainfed), 15% of adherents own more than 20ha(rainfed) including 5% have more than 200ha (irrigated)

Main lines of work & activities Activities GDA	Agricultural services such as seed supply, seed treatment, feeding information, follow-up of farmers Agricultural Machinery Services (seed clening, feed grinding, feed pelleting) Ensuring subsidized seeds and animal feed
Key technical staff SMSA: How many? Profiles and topics / themes on which they work? Stability / turn-over	Voluntary work carried out by the members based on the principle of 'tour de rôle' One technician paid by the farmers according to the service
Funding sources (public, projects, etc.), stability of funding over time, importance of external funding	Auto financing; only actions, no annual membership fees, no financial constraints, when needed adherents pay spontanously Planification each June after harvestings Some projects support…ProFids, ICARDA
How are main decisions taken? (1) (comment? Assemblée avec qui?)	All adherents attend an annual planning meeting (June)
Any significant recent (last few years) changes in the way the organization works?	Lack of feed+fertilizer (DAP) imply some changes. Change in the cooperation -> some cultivate together…
Are there any documents you may share with us to understand your organization or its line of work?	Minutes for meetings, annual report
Miscelaneous observations	Some adherents are looking for trainings about manure processing techniques (how to valorize it, what approach to better preserve it, its transformation into powder, etc.)

Table 2: Who are your key partners

	Partner 1: ICARDA	*Partner 2: INRAT*	*Partner 3: INGC*	*Partner 4: OEP*	*Partner 5: Private suppliers*
Main purpose (1)	Providing equipment and fodder seeds Direct sowing, Trainings	Direct sowing, provide seeder trainings on direct seeding Seeds provider	Trainings on cereals SMS (*providing advice and building capacity)*	Recycling of by-products (cactus) Training (cattle alimentation)	Providing with credits fertilizers, feed products, treatments, metallic threads, etc.)
Type of collaboration (2)	*Through projects*	*Through projects*	*Through projects?*	*As part of a multiSTH arena of some sort?* Co conception	Providers
How important is it for your organization (3)	Vital	Important	Vital	Vital	Vital
What Key activities do you implement together (4)	*Training events, trials*	*Training events, trials* Seeder equipement	Training events	Bee-keeping trainings Sula seeds providing Providing Subsided feeding products Training about the composition of rations of pellets)	*Commercial relationship*
What type of approach is the collaboration based upon? (5)	*Action-research*	*Action-research*	Capacity building	*Transfer of technology, capacity building, as service provider*	*Such as service provider*
How satisfied are you with the collaboration? (6)	Excellent	Excellent	Good	Excellent	Excellent
Observations	NB: ProFids provides 380 Volt access needed for feed production line; but poor relations				

(7) E.g. accesing or providing funding, seeking or providing advice and building capacity, experimenting new practices, exchanging info, etc.

(8) e.g. ad hoc, through a formal bilateral agreement, through projects, as part of a multiSTH arena of some sort, linkage to input or output market (as provider, as buyer)

(9) Importance: 1 marginal 2 Regular 3 Important 4 Vital

(10) E.g. training events, trials, coordination and joint planning, developing proposals, commercial relationship (buying or selling inputs or products), policy dialogue, etc. It can be more than one type of activities

(11) Such as service provider, co-conception, action-research, transfer of technology, capacity building, etc.

(12) Satisfaction: 1 Poor 2 Regular 3 Good 4 Excellent

Table 3: main challenges and constraints by the main farm activities

Main farm activities	Who is concerned? (type of farm size; gender; how many farms? etc..)	Identified problems	Causes	Proposed activities?	Link to PoW AE i
Cereal crops	All adherents	Direct sowing equipment is not available Unavailable treatments and fertilizers	The equipment is the CRDA property Lack of fertilizers in the market and high prices	For the next campaign, the SMSA will use of the CRDA seeder, early and proper request letter Make feed stock	
Breeding Cattle (Brown-Swiss) Lamb fattening	Majority of adherents	Imported feed concentrates are very expensive, and some products are not available		Processing of products such as cactus, tomato wastes and sugar beet wastes into feed pellets. Having their own feed production line with grinder, mixer, pelleting machine Manure stockage	
Olive trees	All adherents	No treatments againts the *Amra* disease Drought Problem of dams no protected (iirgation issues)	Climate change		

Annex 2. Soil health indicators review in the transect El Kef Siliana

Project team: Haithem Bahri, Isaf Mekki, Wael Toukabri, Mereiem Barbouchi, Mohamed Annabi, Hatem Cheikh M(Hamed), Review report, dec. 2022

Overview

Soils constitute "a major reservoir of global biodiversity". Living soil organisms play an important role in processes such as decomposition, nitrogen fixation and the regulation of greenhouse gas emissions. Soils are also a large store of carbon, contributing to climate change mitigation (FAO, 2020). Carbon sequestration in agricultural soils also contributes to improved soil quality, agricultural productivity, biodiversity and water conservation, and thus greater resilience to climate change (Ghimire et al., 2022).

The soil, a complex and dynamic system, represents a precious resource that needs to be protected to ensure agricultural ecosystem sustainability. Soil health includes physical, biological, and chemical aspects. In terms of physical aspects, healthy soils are free of compaction, erosion, clogging and crusting. Regarding biological and chemical aspects, healthy soils exhibit balanced nutrients and are not polluted by toxic substances. Healthy soils also host a diversity of living organisms, including bacteria, fungi, other microorganisms, invertebrates, and some vertebrate animals. Healthy soils continuously provide ecosystem services, such as food and biomass production, including in agriculture and forestry; water absorption, storage and filtering; and transformation of nutrients and substances, thus protecting groundwater (Toor et al., 2021).

Healthy soil performs as part of an ecosystem, supports crop productivity, maintains environmental quality, and promotes plant and animal health. The Global Soil Health (GSH) assessment characterizes soils by indicators related to physical, biological, and chemical components (Figure A2-1) (Moebius-Clune et al., 2016). These indicators allow the measurement of one or more soil properties essential to the healthy functioning of the soil, which are sensitive to changes in soil processes and reflect the relationships between biological, chemical, and physical properties. Indicators, calculated values, or estimated statistics relative to a threshold level are being increasingly used across biological, environmental, economic, social, institutional and political disciplines to assess current condition or trend of soil health. Currently, soil health monitoring relies on the soil health indicators. Indicators may be used as an indirect measure of soil function, serving to assess soil quality or health and its direction of change with time, by linking functional relationships among measurable attributes and monitoring for sustainable land management, including environmental impacts. According to The National Resource Conservation Service (NRCS), “indicators are measurable properties of soil or plants that provide clues about how well the soil can function.”

Indicators need to be easy to measure either through qualitative or quantitative techniques. Once indicators are gathered, you can evaluate patterns and compare results to neighboring fields or prior years to gauge how soil quality has improved.

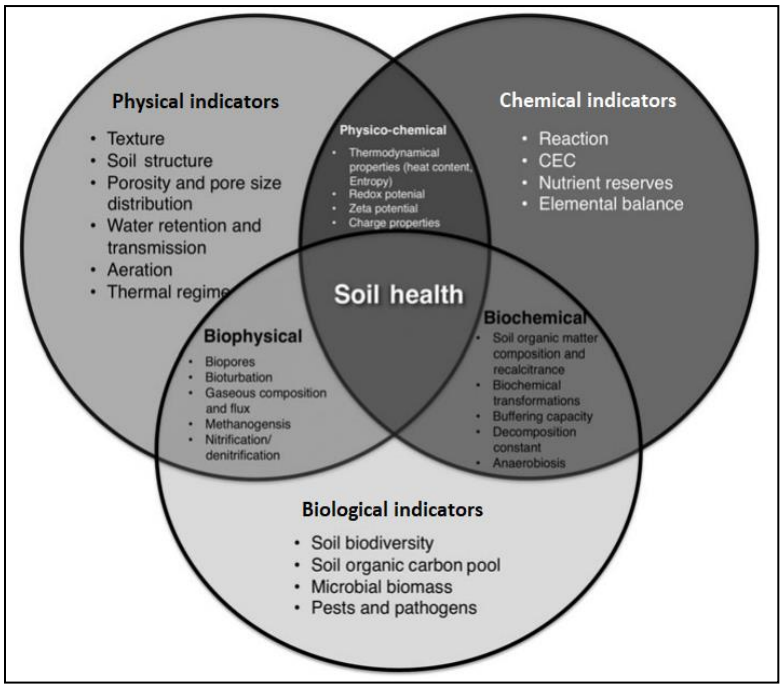

Figure A2-1: Soil quality indicators include a range of soil physical, chemical and biological characteristics. Soil quality indicators can help in guiding restoration, predominantly with respect to understanding the role of soil properties and plant–soil relationships that promote revegetation and enhance soil ecosystem function.

Soil Physical indicators

Soil physical properties provide information related to water and air movement through soil, as well as conditions affecting germination, root growth and erosion processes. Many soil physical properties thus form the foundation of other chemical and biological processes, which may be further governed by climate, landscape position and land use. A range of soil physical properties are highlighted as potential soil health indicators, and key soil physical indicators in relation to climate change include soil structure, water infiltration, bulk density, rooting depth, and soil surface cover, which are discussed below.

Soil Structure (Aggregate Stability, Porosity)

Soil aggregates are soil particles bound together. Stability refers to the ability of the soil aggregates to maintain their form despite disturbances caused by tilling, water, or wind. Changes in soil aggregate stability are indicators of improved soil health, organic matter content, biological activity, and nutrient cycling.

It is considered a useful soil health indicator since it is involved in maintaining important ecosystem functions in soil including organic carbon (C) accumulation, infiltration capacity, movement and storage of water, and root and microbial community activity; it can also be used to measure soil resistance to erosion and management changes. Because of its association with the storage of soil organic carbon

(SOC) and water, its measurement can be useful to guide climate adaptation strategies, especially in areas that are likely to experience high and intense rainfall and consequently increased erosion events. Since aggregate stability is measured in many different ways, standardized procedures are required within a soil health monitoring framework under climate change scenarios.

Porosity, a measure of the void spaces in a material as a fraction (volume of voids to that of the total volume), and pore size distribution provide a direct, quantitative estimate of the ability of a soil to store root-zone water and air necessary for plant growth. Pore characteristics are strongly linked to soil physical quality; bulk density and microporosity are functions of pore volume, while soil porosity and water release characteristics directly influence a range of soil physical indices including soil aeration capacity, plant available water capacity and relative field capacity. Since root development and soil enzyme activities are closely related to soil porosity and pore size distribution and because future climate change scenarios (e.g. elevated CO_2 and temperature, and variable and extreme rainfall events) may alter root development and soil biological activities, soil porosity and pore size distribution and consequently soil functions are likely to be affected in unexpected directions.

Available Water Capacity

Water capacity is the maximum amount of water stored in the soil for the plant. It's crucial to plant health when water is needed by the plant between irrigation or rainstorms.

Much of this depends on innate soil texture but can be impacted by the amount of soil organic matter and soil aggregation, both of which can increase water holding capacity.

Bulk Density

Bulk density is an indicator of soil compaction. When soils are too compact, it may restrict root growth which ultimately affects plant growth and crop yield. Additional dangers include increased runoff, erosion, and waterlogged soils.

It is considered as a useful indicator for the assessment of soil health with respect to soil functions such as aeration and infiltration. Since bulk density is in general negatively correlated with soil organic matter (SOM) or SOC content, loss of organic C from increased decomposition due to elevated temperatures may lead to increase in bulk density and hence making soil more prone to compaction via land management activities and climate change stresses, for example, from variable and high intensity rainfall and drought events.

Rooting Depth

Rooting depth is considered an important indicator of soil health, since changes in this property is likely to affect plant available water capacity, subsoil salinity, SOC content or other properties to indicate physicochemical constraints in the soil profile. Under prolonged drought, the impact of subsoil constraints such as salinity and high chloride concentrations is likely to be greater on plant available water and hence plant productivity. Also, Birka´s et al. (2008) included rooting depth as a soil health parameter for monitoring of soil condition and plant growth under extreme drought and variable rainfall

events to indicate the potential for adaptability and mitigation of climate stresses through alteration of rooting depth.

Soil Surface Cover

Soil surface cover provides a range of important ecological functions including protection of soil surface by dissipating raindrop impact energy, soil stabilization, reduction in erodible surface area, water and nutrient retention, C fixation and, in some instances, N fixation and support of native seed germination.

Soil structural conditions such as soil crust and soil seal formation, primarily related to sodicity, are also indicators that may be used to characterize soil health under climate change. The formation of soil crusts and seals can affect a range of soil processes, including water infiltration, oxygen diffusion, runoff, surface water evaporation and wind erosion. A range of methods exist to measure their thickness and strength, although research effort is needed to relate these properties with soil processes affecting ecosystem functions and plant productivity, as well as to evaluate their role in mitigating adverse climate change impacts, thereby assisting in climate change adaptation.

Soil Chemical indicators

Chemical indicators can provide a perspective on the following functions: promoting biodiversity, filtering, buffering, degrading, and detoxifying organic and inorganic materials, controlling water and solute flow, cycling carbon and nutrients, and physical foundation for plants, animals and humans.

pH

Soil pH, a function of parent material, time of weathering, vegetation and climate, is considered as one of the dominant chemical indicators of soil health, identifying trends in change for a range of soil biological and chemical functions including acidification, salinization, crop performance, nutrient availability and cycling and biological activity. Soil pH has thus been included in integrative soil health tests to assess impacts of land use change and agricultural practices.

Electrical Conductivity

Soil electrical conductivity (EC), a measure of salt concentration, is considered an easily measured, reliable indicator of soil health. It can inform trends in salinity, crop performance, nutrient cycling (particularly nitrate) and biological activity and, along with pH, can act as a surrogate measure of soil structural decline especially in sodic soils. Electrical conductivity has been used as a chemical indicator to inform soil biological quality in response to crop management practices. Clearly, there is a need for comprehensive assessment of the influence of drivers of climate change on soil EC as an important soil health indicator in different ecosystems.

Soil Nutrients availabilities

Measurement of extractable nutrients may provide indication of a soil's capacity to support plant growth; conversely, it may identify critical or threshold values for environmental hazard assessment. Nutrient cycling, especially N, is intimately linked with soil organic C cycling, and hence drivers of climate change such as elevated temperatures, variable precipitation and atmospheric N deposition are likely to

impact on N cycling and possibly the cycling of other plant available nutrients such as phosphorus and sulfur, although direction and exact magnitude of change in plant available nutrients need to be investigated in detail.

Soil Biological indicators

Soil is teeming with billions of soil organisms. Some of these organisms are observable with the naked eye (earthworms, millipedes, spiders, mites, reptiles, and mammals), others are microscopic (archaea, bacteria, fungi, nematodes, and protozoa).

These organisms play a key role in functions related to crop and plant health including: Nutrient cycling, making nutrients available to the plant, nurturing soil structure, soil pollutant degradation, and breaking down organic matter.

Soil Organic Matter

Main indicators for evaluating SOM status include SOC, since it comprises about 50% of SOM; organic N, since it is closely associated with organic C and is the most important nutrient for plant productivity; and readily mineralizable C and N. As SOM drives the majority of soil functions, decreases in SOM can lead to a decrease in fertility and biodiversity, as well as a loss of soil structure, resulting in reduced water holding capacity, increased risk of erosion and increased bulk density and hence soil compaction. Land use and management practices that lead to build up of SOM will help in absorbing CO2 from the atmosphere, thus mitigating global warming. By increasing water storage, SOM can play an important role in the mitigation of flooding impacts following extreme rainfall events, while storing water in the event of droughts thus increasing soil resilience.

Soil Microbiome

Soil microbes are involved in actually making soil work. Soil microbe's breakdown organic matter, cycle all nutrients, build soil structure, build soil organic matter, increase water holding capacity, suppress disease, and more. All of these affect important crop measurements like crop yield and resilience when faced with environmental stress.

Soil enzymes

Soil enzymes play a role in the decomposition and release of plant-available nutrients. They are derived from living and dead microbes (archaea, bacteria, fungi, nematodes, and protozoa) plant roots and residues, and soil organisms (nematodes, millipedes, insects, mites, spiders, reptiles).

Interpreting soil health indicator values and determining soil health score

When soil health indicators are combined into different scoring systems, often using complicated formulas to generate weighted values, they can be used to ultimately produce an index for assessment. This soil health assessment aims to enhance end-user knowledge to improve effective soil management. Thus, an aggregated representation of assessment results of different soil parameters, or a soil health index is desirable. However, choosing indicators is a daunting task since it is difficult to determine which indicators and threshold values of indicators would be the best representation of a particular soil type or

assessing the effectiveness of management practices to improve soil health. The rule of the thumb is to select indicators depending on soil management and specific soil functions that need attention for a particular soil type (Hubanks et al., 2018). Though it might be exciting to use a comprehensive list of soil health indicators to build an index, it is expensive and impractical. Many studies have indicated that selecting a few indicators is much more effective in detecting management impacts on soil quality (Andrews et al., 2002; Hubanks et al., 2018; Lima et al., 2013). Thus, a minimum set of easy indicators are more appropriate for use in assessment and to construct a soil health index that will be easy to interpret and use.

Field practices to improve soil health

Sustainable agriculture is underpinned by preserving and protecting two natural resources: soil and water. This implies improving soil health is achieved by using field practices that enhance physical, chemical, and biological properties. Soil health field practices, are based on four basic soil principles: (1) minimize soil disturbance, (2) keep soil covered, (3) maximize the period of living root growth, and (4) maximize plant biodiversity (USDA-NRCS, 2018). Building soil organic matter is increasingly recognized and viewed as the key principle of soil health improvement strategies. These four soil health principles essentially guide the broader framework for all soil health management practices.

Principle 1: Minimize soil disturbance. Soil disturbance can be physical, chemical, or biological. Physical soil disturbance is caused by conventional tillage systems involving primary operations such as soil loosening, weed removal, incorporating fertilizers, amendments, and secondary operations such as seedbed preparation before planting crops. Chemical disturbance includes fertilizer and pesticide applications (USDA-NRCS, 2018).

Biological disturbance includes over-grazing animals and monocultures, which can lead to compaction and biological imbalance, reduced root mass, and increased runoff (Larkin, 2015).

Principle 2: Keep soil covered. When either living plants or plant residues protect soils, there is a significant decrease in erosion and increases in microbial activity, organic matter, and soil fertility. Cover crops keep the soil covered during periods of time, i.e., winter when cash crops are not growing. Thus, cover crops protect the soil and decrease erosion and enhance organic matter due to the biomass addition. Other benefits of using cover crops include increased water infiltration, reduced nutrient loss, increased number of mycorrhizae, and weed and pest disease control (Sarrantonio and Gallandt, 2008). Cover crop residue also minimizes the impact of raindrops on the soil surface and serves as a habitat and food source for soil microbes. Cover crops also add carbon into the soil and help tie up nutrients, especially by scavenging nitrogen from the soil during winter (Hubbard et al., 2013). Cover crops can prevent some of the nutrient loss and recycle nitrogen, eventually releasing the nitrogen from the residue as soil organisms begin the decomposition process.

Principle 3: Maximize the period of living root growth. Keeping living roots with cover crops and perennial crops helps sustain the microbial population in the soil. When plants are alive, they produce sugars through photosynthesis, which are then released and lost in the soil through the roots. Live roots in the soil provide those exudates to the microbes to stimulate more activity, which leads to faster

decomposition and contributes to nutrient cycling in soils. Thus, growing plants throughout the year, such as long-season crops, crop rotations, cover crops, can provide multiple benefits for soil health.

Principle 4: Maximize plant diversity. The diversity of plant species and plant-soil-microorganisms interactions promotes soil biodiversity. Healthy soil requires active decomposition, nutrient cycling, and soil functions, which can be accomplished with crop rotations, cover crops, and organic matter amendments. Diverse crop rotations offer plant diversity, which helps break up soil-borne pest and disease life cycles, improve crop health, help manage weeds, reduce nutrient losses from soils, and improve soil health (Larkin, 2015). Diverse plants in time and space in cropping systems release sugars, which support diverse food webs and energy chains essential for cropping systems and microbial activity in soils.

Current research findings related to soil health indicators in Siliana and El Kef Tunisia-governorates.

Several studies were conducted to assess the soil health in Siliana and Kef regions using different soil indicators (physical, chemical, and biological).

Soil texture was investigated in the study of Moussaoui et al, (2010) as physical indicator to evaluate the impact of land degradation by erosion in Siliana region. In the same study, chemical indicators including mineral nitrogen content, phosphorus, potassium, and soil pH as well as organic matter content as a biological indicator were also used to assess the soil fertility of Siliana affected by erosion.

Masghouni, (2018) studied the effect of vegetation cover on soil properties in the Siliana region. In this work physical, chemical, and biological indicators were chosen. The physical indicators are water retention and structural stability. Chemical indicators include OM content, total nitrogen, phosphorus, and exchangeable potassium. Regarding chemical indicators, microbial respiration, microbial and fungal biomass, denitrifying activity, and the number of earthworms were considered. The results of this work showed that soil under plant cover positively affects physical, chemical, and biological indicators.

Other work has studied the effect of minimum tillage or reduced tillage on physical, chemical, and biological indicators in the two Kef and Siliana regions (Boudabbous, 2009; Jemai and 2012; Jemai et al., 2013). The results of this work showed that the indicators N, P, K, the MO content, and the structural stability are impacted by cultural practices. In fact, under a reduced tillage system, residue decomposes more slowly. One reason is that fewer aggregates are broken with less intensive tillage, so the less organic matter is exposed to decomposition. A second reason is that reduced tillage can make soil temperatures slightly cooler, which helps to preserve more organic matter because the residue is not rapidly decomposed. Moreover, reduced tillage does not disrupt earthworm burrowing and helps protect the network created by mycorrhizal fungi that connects them to their host plant. Leaving residue on the soil surface also acts as a barrier against raindrops and wind that could cause erosion. Overall, these studies suggest that soil health can be improved by reducing tillage intensity, planting cover crops, and keeping crop residue and that biological soil health indicators associated with labile carbon and nitrogen are most impacted by management practices such as tillage intensity. Therefore, Soil health indicators sensitivity to agronomic management systems.

Also, aggregate stability and organic matter are used as physical and biological indicators to study the effect of land use system in the Northwest region (Bouajila and Gallali, 2010). Results showed that the most stable samples were derived from a carbonated horizon. In carbonated soils, in addition to organic matter and clay, CaCO3 was considered an important agent of aggregation. In contrast where soils were characterized by sandy texture and low amount of $CaCO_3$, organic matter was the principal agent of aggregate stability. Therefore, soil aggregate stability and soil organic carbon fraction could be used as indicators to apply the most appropriate management practices to increase soil sustainability.

Allani et al, (2022) studied the distribution of nitrogen and phosphorus in the agricultural soils in the region of Siliana in order to optimize fertilizer application. In fact, soil microbiota is extremely sensitive to nutrient doses. With optimum nutrients, plants grow quickly and better withstand pest damage, soil microbes, and soil fauna thrive optimally for maintaining necessary soil functions. Results showed that the variation in the contents of essential elements such as nitrogen, phosphorus and the physicochemical parameters of the soil are significantly related to the seasonal contrast and to the depth of the Ap cultural horizon (figure A2-2). Laterally, the variation is very slight, it seems related to the homogenization of the studied soil. Relate to the dynamics and repair of nitrogen and phosphorus in vertebrate agricultural soil. Thus, it is time to properly manage agricultural practices and fertilizer rates added to the soil. The factors that influence the dynamics of nitrogen and phosphorus in this study site are essentially the physicochemical properties of the soil, such as: texture, clay content, structure and soil nature.

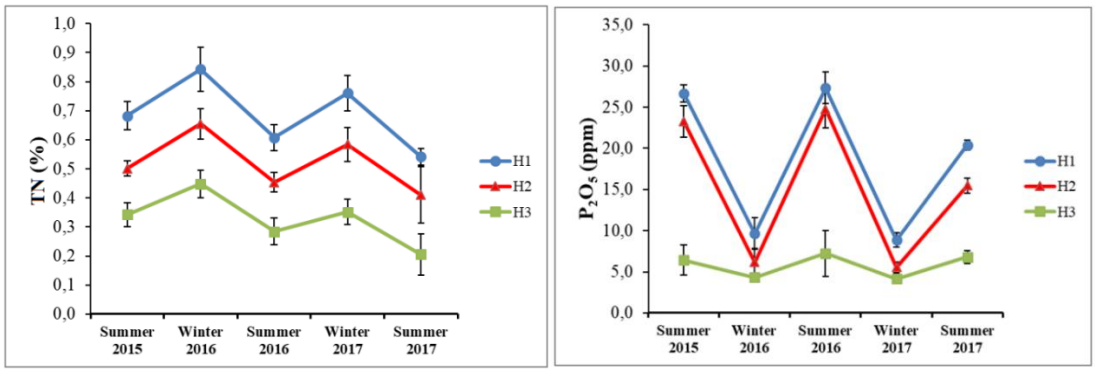

Figure A2-2 . Evolution of (a) total nitrogen TN (%) contents in the soil (b) P_2O_5 (ppm) in the soil ± SD

In the Kef region, Rezgui et al. (2014) studied the effect of tillage and the crop type on physical soil proprieties such as bulk density, structural stability, soil moisture and porosity. Results of this study indicate that for the two types of crops, no tillage increased the bulk density, structural stability and soil moisture of the soil by 5%, 75% and 19% respectively. On the other hand, sowing with reversal increased the total porosity by 10%, an increase of 29% compared to direct sowing. Indeed, no tillage enriches the soil with organic matter and therefore improves structural stability. It makes it possible to increase the proportion of medium pores (from 0.2 to 50 µm) in the surface layers of the soil (< 20 cm) to the detriment of macropores, without increasing the total porosity. The effect of tillage mode on physical characteristics differs with soil depth. At the surface (0-15 cm), no tillage increased the bulk density and

soil moisture. This technique limits the impact of precipitation on the physical state of the soil. Between 15 and 30 cm, the structural stability was maximal. This rhizosphere is generally richer in organic colloids produced by microorganisms. These substances help cement the soil particles together. At depth, conventional plowing with reversal increased bulk density and decreased porosity. Unsuitable cultivation practices promote the consolidation of the 30-40 cm horizon that has not been worked, which constitutes a real constraint to the hydrodynamic functioning of the soil and to root development. This layer has undergone the cumulative effect of the passage of machines and has remained unchanged with its massive structure constituting a real obstacle to any vertical evolution. In addition to tillage, it appears that organic matter on the soil surface caused an amplification of biological activity that increased porosity. The cultivated species significantly affected the physical and water parameters of the soil. The highest values of bulk densities and structural stabilities were observed at the level of faba bean soles conducted in no tillage. This species benefited more from the effect of straw residues left by the previous durum wheat crop.

In this two region Siliana and Kef, Erouissi et al., (2011) are interested to biological indicators such as soil invertebrates to compare conventional and no tillage management. No-till (NT) systems have less mechanical mixing of crop residues with soil minerals than the conventional till (CT) systems. So, NT systems are likely undisturbed ecosystems and may depend more on soil organisms for proper functioning. The results showed that NT enhanced the soil fauna populations either in diversity or in abundance in the two sites (figure A2-3), which confirm the negative effect of CT on richness and diversity of soil fauna community in relation to NT systems. The negative impact of CT on ecosystem engineers and functional guilds (arthropods and earthworms) was also clear in this study. The move from CT to NT improved soil biological component which could be explained by two factors: the change of soil properties and reduce of the number of machines passes over the field, so lack of disturbance

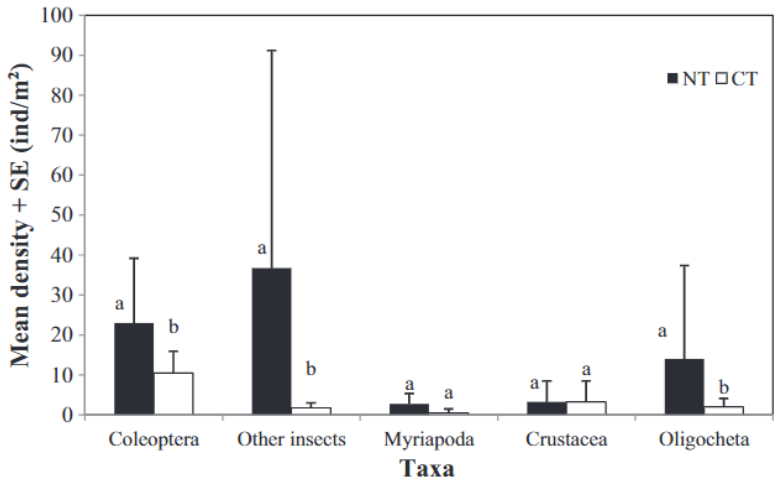

Figure A2-3. Distribution (mean density + SE) of soil invertebrates (major groups) as a function of the soil management system. Soil invertebrates were captured for each tillage system (CT or NT) at four times; 2 sites (Mahassen and Krib).

When residues are left on soil surface the ecosystem engineers (worms and other organisms) and litter transformers may become much more important than in disturbed (residues incorporated) ecosystems. Ben Moussa-Machraoui et al. (2010) showed that under semi-arid conditions in north-west of Tunisia (Kef, Siliana), NT improves soil properties when compared to CT. NT, significantly, improved soil content especially for K, K2O, P2O5 and N. The same authors indicated that clay and silt soils can be affected over a short time by tillage management. Soil organic matter showed higher values under NT, but results were not significant from those of CT. However, under NT agroecosystems earthworms and microarthropods played a dominant role in organic matter decay, therefore, nutrient flux patterns. Moreover, the soil fauna of natural ecosystems influences organic matter decay and mineralization process, making a better availability of nutrients in the soil.

Ben Moussa-Machraoui et al. (2010) found also that the cation exchange capacity (CEC) is a good indicator of the degree of mineral fertility of soil. It depends on the soil texture as well as the amount of SOM (figure A2-4). In their findings, the CEC values were slightly higher in NT than in CT. Also, the N content for both sites was significantly greater under NT than under CT. Soil and crop management practices may alter the quantity, quality, and placement of plant residues that influence soil C and N fractions.

Dridi and Guedari, (2019) studied the dynamics of the nitrogen mineralization as an indicator of plant growth in the region of Kef in order to classify them according to their potentially mineralizable nitrogen and kinetics and to identify the effect of the other soil proprieties on the nitrogen content. Results showed that nitrogen contents decreased with depth following different patterns depending on the soil type. The highest content of inorganic nitrogen was recorded in the Calcisol due to high organic carbon and nitrogen amounts and low C:N ratio throughout the profile. The lowest content was recorded in the Luvisol because of its large clay-silt fraction and low pH level especially in depth. The vertical distribution of ammonium and nitrate contents showed marked monthly variations. The laboratory results presented the following decreasing order of potentially mineralizable nitrogen and kinetics: Calcisol > Vertisol > Cambisol > Luvisol, and revealed two fractions constituting organic nitrogen supplies. An active fraction with a rapid mineralization and a passive fraction slowed down by clays and resistant to biodegradation.

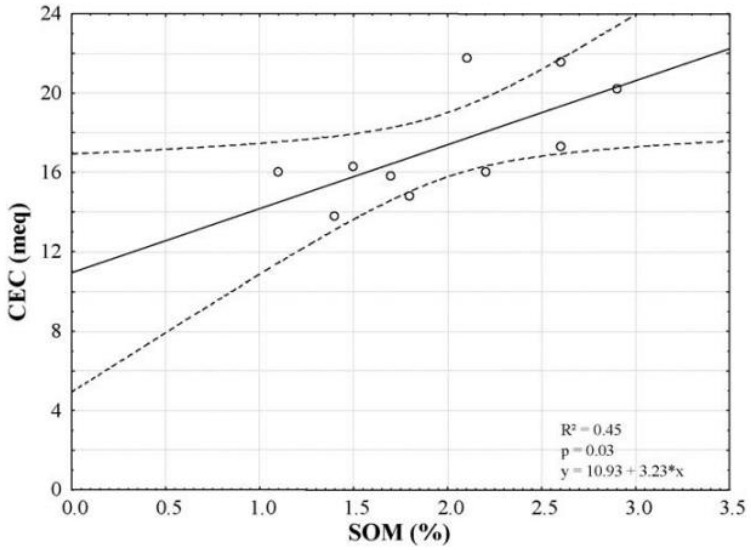

Figure A2-4. Correlation of the SOM content with the CEC values at both sites (Mahassen and Krib) and for all crops and tillage systems. Straight line indicates the confidential interval at 95%.

Conclusion

The majority of soil health indicators were addressed in the Kef and Siliana regions by physical indicators such as texture, structure, bulk density, porosity, soil moisture, chemical indicators such as soil organic matter content, CEC, nitrogen content, phosphorus, potassium content and $CaCO_3$ content and biological indicators such as microbial biomass and microbial biomass activity but all these indicators have been determined by researchers for specific purposes and do not reflect the knowledge of the farmers. It is therefore imperative to study the farmer's perception of the indicators of the health of his soil.

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