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Adoption of Conservation Agriculture Technologies by Smallholder Farmers in the semiarid region of Tunisia: Resource constraints and partial adoption

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Abstract – Tunisia, like many other countries, suffers from land degradation. Conservation agriculture is among the proper solutions to overcome this issue. The objective of our investigation is to determine the factors that influence the adoption of CA in Siliana, one of Tunisia's most affected regions by erosion. A field survey was conducted to collect adoption data used for descriptive analysis, and for the estimation of a choice model (Logit). Results show that the adoption of CA technology is positively determined by the level of farmers' education, quality of extension services, the type of land ownership and production of durum wheat in conventional seeding. In contrast, the decision to adopt CA technique is constrained by the low farming experience, existence of off-farm income, and by the number of livestock units per hectare available at the farm level.

Keywords: Land degradation, Conservation agriculture technology, Logit model, Adoption, Direct seeding.

1. Introduction

Today, agriculture is facing two serious problems: lack of productivity and environmental threat, such as dangerous spread of erosion.

In this context, conservation agriculture seems to be a suitable solution especially in the developing countries, including Tunisia, that have the good fortune not to suffer the same environmental damage that Europe has suffered because of the inappropriate implementation of adaptation practices for the conventional seeding.

Soil erosion caused by soil tillage through using heavy mechanical tools has forced policymakers to look for alternatives and to reverse the process of soil degradation. To overcome the aforementioned problems, CA has been considered as an alternative to conventional agriculture. However, the implementation of agricultural friendly practices is still constrained by many factors such as socio-economic, legal, political and technical factors. The most important one is farmers' willingness to adopt new technology.

CA is based on different agricultural practices that aims to ensure the economic and environmental viability of farms, e.g. organic farming, fallow or uncultivated land and No tillage. The latter is used as new technique to promote CA in Tunisia.

Our present study aims to determine the factors governing the adoption of CA in the governorate of Siliana, which is classified nationally as the most threatened by land degradation. However, this adoption faces a real pitfall, which is the increased presence of livestock farming. This traditionally represents a major discordance between cropping and livestock farming.

This paper is divided into three parts, the first from a literature review that encompasses both the process and the factors of adoption of the CA and the CA and livestock integration. The second is followed by methodological approach that clarifies the goals. The third, finally, contains the results obtained through a descriptive analysis of the survey first, and then those of the estimated econometric model. These results are accompanied by clarifying the interpretations.

2. Conservation Agriculture versus Integrated crops-livestock systems – Brief Synthesis of the Literature

2.1. Conservation Agriculture

Conservation agriculture – the practice of minimizing soil disturbance, maintaining soil cover, and rotating crops – is a proven technique that improves soil fertility and eliminates the efforts and costs associated with plowing. Long practiced among farmers in developed countries, research has shown that conservation agriculture could have an even greater impact on food production and livelihoods in the

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dry areas of the developing world (ICARDA). The decision to adopt a new technology can be defined as a result of a fine balancing act between its profitability and the farmer's attitude towards the risk associated with it. Farmers mainly focused on the benefits of adopting new technology and it return on investment. The adoption process depends on the speed with which the new technology is used and adjusted with other activities over a long period of time. This definition highlights the fundamental characteristics of the adoption, such as intensity, time spent in its application and the rational choice of the farmer (Sidibé, 2005). Indeed, it is a learning process, often influenced by dynamic groups and therefore implying the existence of different phases.

Before analyzing the farmers' decision to adopt CA, adoption/adaptation process can be divided into four theoretical phases (FAO, 2014). Such division allows us to analyze the farm activities and the impacts of new technologies on the production process. The first phase corresponds to the improvement of tillage techniques. Farmers expect lower yields and incomes during the early stages of conversion. In addition, during this phase, CA is being less labor demanding than conventional practices. It is well know that during the initial period of conversion the employment of agro-chemical pesticides plays a vital role in ensuring high immunity against pests and diseases. Furthermore, it is completely normal during this period to expect a reduction of production compared to conventional agriculture. The second phase corresponds to build up of soil organic matter to improve soil micro-fauna and flora. Adaptation to the new production system allows improving yields; which in turn increase the net farm income. The third phase corresponds to the diversification of cropping pattern. This phase is marked by an increased and more stable yields and soil fertility. The final phase corresponds to the integrated farming system. It is functioning smoothly and production and productivity becomes more stable. Over time, farmers can benefit from the technical and economic advantages of conservation agriculture.

Adoption process is motivated by several factors and motivations. In order to make an accurate study about the conversion to CA, it is important to understand why farmers change their production system. Previous literature has shown that farmers perceive CA as an important production system with which they feel comfortable knowing its agronomic, economic and environmental benefits. Innovative farmers, who are looking for alternative farming systems in order to reduce production costs, improve their productivity and their soils quality and fertility, are likely to be the ones who will adopt CA first and encourage their neighboring to follow them. It is expected that new CA farmers will often need some period to become experienced with the innovation. Those farmers require information and training courses on the use of new tools. On the other hand, experienced farmers can help to spread the new agricultural techniques by encouraging new farmers and helping them to adapt rapidly to this new system.

Environmental conditions might speed up the development of CA. The Environmental problems resulting from agricultural activities: erosive rainfall, arid climate with very hot and dry periods, degraded and eroded soils, high production costs, diminishing labor capacity and diminishing agricultural subsidies can motivate farmers to convert quickly to CA. Another important factor may contribute to promote the adoption is the presence of conservation agriculture organizations, farmer organizations and experienced farmers in CA (Abdulai et al., 2011; Alcon et al., 2011). Ervin and Ervin (1982) suggested that the application level, or the effort made, are very essential for adoption process.

Farmers' decisions regarding conservation practice adoption are motivated by maintaining and adopting measures of soil and water conservation when these are fully integrated into the production system of the farm (Kessler, 2006). In fact, it is very interesting to take into consideration the economic potential of CA (costs of production, profit, yield, soil conservation) when promoting the diffusion of new technical innovations (Ellis, 1993 ; De Graaff et al., 2008; Jara-Rojas et al., 2013). Consistently, FAO (2014) confirmed that the positive impact of CA on the reduction in labor requirement and costs are the main reasons for farmers in Latin America to adopt CA.

To have a broader idea about the factors that determine the choice of adoption, several studies were employed in this report to focus on the decision of adopting best management practices (BMPs). The latter are considered as part of the CA system (Greiner et al., 2009). The adoption of an innovative technique such as conservation practices is mainly influenced by farmers' preferences for environmental preservation. Baumgart-Getz et al. (2012) suggested that the adoption decision is a result of an interaction of agronomic, social, economic and environmental factors. On the other hand, economic, cultural, social factors and the scarcity of natural resources, affect the speed at which farmers adopt new technologies (Lapar et al, 1999; Soule et al., 2000).

Beside the agronomic, economic and environmental factors, there are factors related to the socio-demographic characteristics of farmers. Age can affect positively or negatively the adoption of conservative measures (Baidu-Forson, 1999; Lapar et al, 1999. Bekele and Drake, 2003). Aged farmers, often associated with long years of experience in agriculture, could positively influence the adoption decision. In contrast, young farmers are more likely to invest more in conservation practices (Amsalu and De Graaff, 2007). They also have an advantage of more flexibility to credit access and they are more aware by the environmental benefits of these parctices (Ervin and Ervin, 1982; Baumgart-Getz et al, 2012).
The education level is often argued as a variable that influence positively the adoption (Alcon et al., 2011). Farmers with higher education level tend to be more aware by the importance of adopting new technical innovations as well as by the performance of CA (Abdulai et al., 2011). Moreover, it is shown that family size has a positive impact on the adoption decision, since it is usually associated with more labor availability, which is likely to respond positively to the demands of the establishment conservative measures (Bekele and Drake, 2003).
On the other hand, expecting high productivity level can affect positively the NT adoption decision and encourage more famers to implement BMPs (Johansson et al., 2004). Furthermore, Ervin and Ervin (1982), Norris and Batie (1987) and Shiferaw and Holden (1998) suggested that farmers' awareness of the problem of soil erosion is the first step in the process of adoption and would have a positive correlation with the adoption decisions. Farmers' lifestyle is an important motivation to convert to CA. These farmers are more motivated by ideological reasons and non-economic considerations than financial motives (e.g. subsidies, governmental intervention, financial motives) (Austin et al., 1998; Burton, 2004; Greiner et al., 2009).
At farm level, farm size plays a relevant role to implement BMPs. Big agricultural holdings are generally willing to invest on new technologies allowing to increasing returns to scale (Guerin, 1999; Robinson and Napier, 2002). Consequently, the investment requirement precludes small farmers to adopt new production system (Amsalu and De Graaff, 2007). Farms located in less favored areas (steep slope) are more concerned by adopting CA to avoid erosion problem (Lapar et al., 1999; Bekele and Drake, 2003). On the other hand, bad soil quality can preclude farmers to adopt CA, which jeopardize the agricultural system viability because farmers do not expect improvement of productivity in that soil (Jara-Rojas et al., 2013). Finally, land tenure regime could affect the adoption of BMPs. However, its effect is still ambiguous (Bultena and Hoiberg, 1983; Feder et al., 1985; Daberkow and McBride, 1998; Khanna et al., 1999). Regarding the agricultural policies, it is expected that subsidies encourage farmers to convert and that the legal framework can fasten the conversion to new production system (Karaa et al., 2008; Alcon et al., 2011).
However, new technology may face different constraints. One of them is the fear of the result of converting and loosing the high performance reached in conventional system. In addition, farmers' attitudes to risk should also be taken into consideration (Feder et al., 1985; Anderson et al., 1988; Greiner et al., 2009). Such behavior might generate opposition within the community to adopt CA since soil tillage is considered by farmers as a traditional practice that is necessary to improve soil quality and give higher yields. Investment at the first stage of conversion constitutes another restriction making the conversion more difficult. The agricultural technologies are often adopted progressively to allow famers being more familiarized with new practices. Finally, in long term all these problems may be resolved especially with experience and learning-by-doing.
CA represents economic, environmental and agronomic advantages that could positively influence farmers' decision to adopt. Despite the relevant role of the CA, the number of farms who adopt these practices is still insignificant (Fowler and Rockstrom, 2001; Garcia-Torres et al, 2003; Derpsch, 2003; Hobbs, 2006). However, CA techniques have been widely introduced in Brazil and Australia where the adoption rate achieves high level (Wall, 2007). On the other hand, the diffusion of CA in Africa still subject to some financial and non-economic problems (Feder et al., 1985).
In spite of the recent relevant growth of CA worldwide, the literature on the adoption of CA is very scarce (Knowler and Bradshaw, 2007; Mazvimavi and Twomlow, 2009). The study by Ben Salem et al. (2006) constitutes a notable exception in Tunisia. The authors used a sample of 76 farmers distributed between Siliana and Zaghouane to determine the factors behind the adoption of seeding on plant cover. They concluded that big farms, off-farm revenue, information and training courses offered by technical centre of cereals and education level are significant variable that affect the adoption decision.

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2.2. CA and Integrated crops-livestock systems

Agriculture in Siliana (our study area) is very specific and relies mostly on livestock farming. In most cases, CA is constrained in integrated crops-livestock systems. In this perspective, the introduction of CA must be inquired through the lens of livestock agriculture. In what follows, we present a review of literature concerning the conversion to CA in a livestock farming environment.
In spite of the integrated crops-livestock systems drawbacks, such as soil compaction and interference with new crop growth, studies have presented many benefits of this integration.
In developed countries, agricultural intensification and specialization had detrimental impacts on the environment and questioned the economic viability of a huge number of farms (Wilkins, 2008), while integrated crops-livestock systems produce about half of the world's food (Herrero et al., 2010).
The introduction of CA in livestock farming has not only simplified farm work, but has also brought new benefits for fertility, vegetal cover enhancement, and enrichment of rotations (Walligora, 2009).
Benefits of integrating both cattle and annual crops include adding value to crop residue, reducing the cost of feeding livestock, reducing water requirements for crop production, and reducing the environmental impact of livestock production (Sanderson et al., 2013).
Mixed crop-livestock systems also benefit the environment by improving nutrient cycling (Hendrickson et al., 2008). Mixed crop-livestock systems generate higher economic efficiency too, by saving production costs through complementarities between crop and livestock (Wilkins, 2008).
Direct seeding has helped farmers in Brazil, New Zealand and France to diversify and enrich crop rotation (Walligora, 2009). The presence of vegetation is a tremendous asset in farming system. It is a source of diverse and inexpensive biomass, a help to better compete with regrowth and weeds, and a path for less nitrogen pollution. Corn is completed by legumes, freeing the ground early, which can be followed by another crop the same year. The biomass produced per hectare and per year is thus considerably increased. Livestock brings fertilization by spreading organic manure. This steady supply of organic matter is therefore a boon for the biological life of the soil.
The CA provides at a lower cost better performing soils with better soil crop mixtures and with high added value for livestock.
One example of junction of CA with livestock agriculture is the use of grass and/or legume plants erosion-control hedges that can be used in livestock feed (Barber, 1996).
If the production system emphasizes a single component, the benefits of the Crop-Livestock integration synergy are lost (FAO, 2014).
If best management practices are adopted, soil-livestock virtuous circle emerges from the introduction of CA.
The farming systems that combine cropping and livestock can benefit from synergy effects of these two activities, both in terms of agricultural production and agro-ecological environment. Sanchez (1995) examined the case of integrating livestock (primarily ruminants) and perennial crops. Benefits include diversification of income sources through livestock products (milk, meat, manure and skins), weed control and increased crop yields.
However, in many regions, agriculture and livestock are competing for the same resources, they must be managed appropriately to fit the CA.
In such cases of conflict of interest, it is possible to consider several types of solutions, such as the evaluation of the residues necessary for soil protection, the integration of cover crops with dual interest in the crop rotation plan, the creation of permanent fodder plots, the temporary movement of livestock, alternative forage sources, conservation of surplus forage, and treatment of crop residues (FAO, 2014).
Diversification makes mixed crop-livestock systems less sensitive to market price fluctuations (Ryschawy et al., 2012).
On the environmental dimension, mixed crop-livestock systems had the most diversified farm land use, what is known to enhance birds and insects biodiversity through spatial heterogeneity (Fahrig et al., 2011). Mixed crop-livestock systems were shown to represent a lower risk of nitrogen pollution than the other systems, in accordance with Russelle et al. (2007) and Schiere and Kater (2001). Nutrient cycling is one way of mitigating external inputs in autonomous systems (Schiere et al., 2002).
Mixed crop-livestock systems have been marginalized by the European agricultural development. Mixed crop-livestock systems need a large level of labor to combine both crops and livestock. In particular in unfavoured areas, such as in our case-study, the lack of successors is high and led to abandonment of mixed crop-livestock systems even for farmers who did not want to (Ryschawy et al., 2011).

The wide variability observed within mixed crop-livestock systems was also linked to the wide range of farmers' practices. Advantages exist only if coordination between animal and crops is maximized through careful management (Hendrickson et al., 2008). An integrated approach of the whole mixed crop-livestock farm as a Farming System is needed to link our results with knowledge on farmers' decisions and practices (Ryschawy et al., 2012).

3. Methodological framework

3.1 Theoretical and empirical model

The Logit model turns to be well adapted to our case, because it is a dichotomous model. By this designation, it is meant a statistical model in which the dependent variable can take only two terms (dichotomous variable). It is, generally, to explain the occurrence or non-occurrence of an event. The objective of dichotomous models is to explain the occurrence of the considered event, based on a number of observed characteristics of the sample's individuals. We are looking into these models to specify the probability of occurrence of this event (Hurlin, 2003).

Considering our sample of N farmers indexed i = 1, ... N. For each farmer, it is to observe if he chose to adopt the Direct Seeding (DS) or not, and we note Yi coded dichotomous variable associated with the event.

We set ∀ i ε [1, N]

$$Y_i = \begin{cases} 1 & \text{If there is adoption of DS by the individual } i \\ 0 & \text{If there is not adoption of DS by the individual } i \end{cases}$$

The choice of coding (0.1) is traditionally used for dichotomous models. Indeed, it defines the likelihood of the event as the expectancy of the variable coded Yi.

The advantage of choosing a Logit model is essentially that the logistic law tends to attribute extreme events a higher than normal probability distribution. It helps, too, in the interpretation of β parameters associated with the explanatory variables Xi because it involves the Odds Ratio.

The empirical formula of the estimation model is therefore as follows:

DS_ADOPT = f (Experience, Education's level, Off-farm agriculture, Vulgarization, TAS owned, TAS rented, Leasing of agricultural equipment, Durum wheat production in DS, LU/ha)

3.2. Data analysis

The study area involves three delegations from the governorate of Siliana: El kreeb, El Aroussa and Makther. The choice of region of Siliana mainly comes from the deep erosion problems of this area: Siliana is one of the most threatened regions in Tunisia by soil degradation. In addition, agriculture represents the main activity and income for a big majority of the population in this governorate. Further, all the mentioned delegations above have benefited from programs that integrate the conservation agriculture. The poor cereal rotations combined with extensive sheep breeding also provide a scope for CA to add some solutions to the erosion problem. Overall, this area can be considered as the most adequate area to disseminate the CA practices for all farmers in Tunisia. A sample of 364 farmers was interviewed about conservation agriculture and Direct Seeding in governorate of Siliana. The survey that will serve as a database was carried out by the CLCA team in the period from September to mid-December 2013.

Data collected from 364 farmers in the governorate of Siliana, were the subject of an econometric analysis through an estimated Logit model to respond to our research question of identifying the factors determining the choice of adopting or not of DS.

Indeed, the adoption of DS can be treated as a matter of choice. The decision to adopt or not is thus translated into a dichotomous variable that takes two forms: "1" if the farmer is engaged in the adoption of DS and "0" for the opposite option.

The model is defined by a dependent variable and several socioeconomic (experience, education, off-farm activity) or technical (rented or owned lands, leasing of agricultural equipment, production of durum wheat in DS) explanatory variables. All these variables are plainly explained in the table below.

Table 1. Description of the model's variables

		Designation	Expected sign
Dependent variable	DS_ADOPT	The dependent variable for the logit model is a dichotomous variable reflecting the achievement or not of an event, in this case, the adoption of SD. If adopted, it is set to 1 otherwise 0.	
Explanatory variables	EXPERIENCE	This is a continuous variable, which refers to the experience of the farmers interviewed in years. Thus, it is expected that the management time reflects a degree of perception of land degradation, particularly soil erosion.	+
	OFARM_ACT	The off-farm activity is a binary variable. It takes the value 0 if the farmer is completely devoted to agriculture and 1 otherwise. It may also shed light on the existence or absence of off-farm income.	-
	EDU_LEVEL	The level of education is a variable that admits five terms; i) Not educated; ii) Kotteb; iii) Primary; iv) Secondary; v) University. This variable expresses the degree of openness in the farmer's ability to assimilate the complexity of DS and its ability to adapt to its requirements.	+
	VULG	Vulgarization is a binary variable that takes value 1 if the farmer is in contact with Vulgarization services and 0 otherwise. Such contact is essential to the dissemination of information and ability to convince the farmers to opt for adoption.	+
	TAA_OWN	This variable is continuous. It represents the total owned agricultural area (in hectares).	+
	TAA_RENT	This variable is continuous. It represents the total rented agricultural area (in hectares).	-
	MAT_RENT	This variable is binary: it takes the value 1 if the farmer leases land and 0 if he does not.	-
	DW_PROD_CS	This variable is continuous. It represents the production of durum wheat in conventional seeding (in quintals).	-
	LSU_Ha	The livestock unit per hectare is a continuous variable. It expresses the density of livestock on agricultural land.	-

(Source: Personal elaboration)

Table2. Descriptive statistics of variables used in the Logit model

Variable	Number of observations	Mean	Min	Max	Standard deviation
DS_ADOPT	364	0.0741758	0	1	0 2624175
EXPERIENCE	364	24.8956	1	70	15.09876
OFARM_ACT	364	0.3708791	0	1	0 .483705
EDU_LEVEL	364	2.601648	1	5	1.214285
VULG	364	0.1868132	0	1	0.390298
TAA_OWN	364	11.65082	0	155	20.35181
TAA_RENT	364	6.731786	0	750	45.44608
MAT_RENT	364	0.9697802	0	1	0.1714272
DW_PROD_CS	364	6.008242	0	48	8.374659
LSU_Ha	364	0.6928006	0	18	1.427815

(Source: Data base examination)

4. The Logit model estimation results

Table3. Results of the estimation of the Logit model

ADOPT_DS	Coef.	Odds ratio	Std. Err.	Z	P > |Z|
EXPERIENCE	-0.0034456	-0.0000762	0.0190663	-0.18	0.857
OFARM_ACT	-0.1408932	-0.0030654	0.5210839	-0.27	0.787
EDU_LEVEL	0.1539738	0.0034063	0.2559204	0.60	0.547
VULG	2.093692	0.0973439	0.4996078	4.19***	0.000
TAA_OWN	0.0259498	0.0005741	0.006896	3.76***	0.000
TAA_RENT	-0.0023046	-0.000051	0.0027673	-0.83	0.405
MAT_RENT	-0.2970886	-0.0075292	1.12529	-0.26	0.792
DW_PROD_CS	0.064678	0.0014308	0.0205217	3.15**	0.002
LSU_Ha	-1.282315	-0.028368	0.7839112	-1.64*	0.102
_cons	-3.917976	-	1.571406	-2.49	0.013

(*): Significant at the level of 10%; (**): Significant at the level of 5%; (***): Significant at the level of 1%

(Source: The Logit model estimation's results)

The parameter assigned to the variable (EXPERIENCE), reflecting the duration of farmers' management, negatively affects the choice of adopting of the DS. This result is contrary to theoretical expectations, as experience is supposed to reflect the farmer's perception of erosion. This can be explained, however, that the experience is related to age, suggesting that older have more limited planning horizon than younger; they expect only gains in the medium and long terms, which discourages

adoption. In addition, the experience also reflects the degree of attachment to traditional agricultural activities. It is difficult to convince someone raised in land to get rid of it permanently.
The variable off-farm activity (OFARM_ACT) is negatively correlated with adoption, which is in line with our expectations. Indeed, on the one hand, the off-farm business requires a relative involvement of the farmer at his farm, which may encroach upon his perception of the problems of degradation of his land. On the other hand, this same activity generates additional income, which can be a financial immunity against the possible decline in farm income. Such a state hinders adoption, since the farmer no longer seeks to improve its performance and to cope with the inherent risks of farming.
The level of education (EDU_LEVEL) has a positive coefficient parameter, which confirms our expectations. Indeed, the most educated are showing more flexibility to assimilate new concepts of this technology and to settle in.
Contact with vulgarization services resulted in a positively significant parameter (at the level of 1%). The information it produced advantageously determines the choice of adoption.
The variable (TAA_OWN) representing the total owned agricultural land is significant at the level of 1% and positively influences the adoption of DS.
The variable (TAA_RENT) representing the total rented areas is significant and negatively influences on the adoption of DS. Indeed, renters are less likely to adopt DS because they are convinced that DS is not profitable, they are all convinced that the prospect cannot be achieved in the short term.
The variable related to the rental of farm equipment (MAT_RENT) is negatively correlated with the adoption. Indeed, the fact of using the rental supposes that the farmer does not have a high capital allowing him to buy. As well, the specific drill for DS is not available for rent, he is, in turn, unable to adopt. In addition, DS requires an initial investment capital for the acquisition of a new drill and pesticides, which remains out of reach.
The variable (DW_PROD_CS), which represents the production of durum wheat in CS, contrary to our expectations, is positively correlated with the adoption of DS at the 5%. In fact, logic suggests that the higher the yield is, the less the need to change practice is experienced. However, this variable reflects among others the fertility of the land. This result may be explained by the fact that the marginal productivity loss due to erosion will be higher in plots with fertile soils that are supposed to give a greater yield. For their part, the farmers whose land is less good are less likely to adopt DS because they expect limited gains in productivity and believe that the adoption is far from benefit them.
The variable (LSU_ha) representing the livestock per hectare, as expected, is negatively correlated with the adoption of DS at a threshold of 10%. Indeed, livestock requests grazing, and CS in turn requires the maintenance of vegetation cover. Both can’t naturally coexist.

5. Concluding remarks and policy implications

As a conclusion, we remind that the issue that has been addressed in this study was to determine the factors affecting the adoption of CA in the governorate of Siliana. The project exposed critical limitations and challenges both in practical CA options, socio-economic, cultural and promotion approaches, especially in relation to widespread adoption of CA practices.
The results delivered edifying answers to our main question. They state that the adoption of DS is based on various factors, including experience and education of farmer, non-agricultural activity, contact with vulgarization services, total agricultural area in property, total agricultural land rent, lease or not of farm equipment, production of durum wheat in CS and livestock units per hectare.
Other prominent challenges noted were CA equipment (Physical and financial accessibility to appropriate CA equipment could decisively affect farmers’ adoption decision and reduce CA expansion. It will be necessary encouraging local commercial systems, retailers and after sales services to commercialize more CA tools and equipments. This is a main issue for all collaborated farmers. For some farmers it involves lack of information and knowledge about required equipment and tools used in the application of CA practices. The most common farmers question is about equipment accessibility in common markets and prices. In addition, inaccessible due to what comes as high cost to the local farmers in the initial phases of CA adoption. Past failure experience with CA introduction in Tunisia raises farmers fear and discourage machinery providers to sell CA appropriate equipment which reduce obviously equipments availability in common markets);
That being said, it would be wise to provide some recommendations that can help stimulate the adoption of CA and boost its distribution. Shifting to conservation agriculture is not an encouraging step for many smallholder farmers. Project participating made cautious by their vulnerability and resist change that

contradicts what they learn and believe handed down from parent to child. Policy environment is enabling to provide information and education to change farmers perceptions forward CA. conservation tillage should come accompanied by an effective policy that encourage public-private partnerships to develop and deliver the seeders and all needed inputs for CA to succeed.
Moreover, it would be appropriate to address the problem of CA abandoning rates after the termination of the project sponsors, as was the case for previous projects. This means that the adoption did not come from a real belief in the effectiveness of the CA from the farmer, but from financial and technical assistance. We must therefore rely more on voluntary adoption for better dissemination of CA.
Eventually, CA has to be mainstreamed in relevant Ministries, departments or institutions and supported by adequate provision of material, human and financial resources to ensure that farmers receive effective and timely support from well trained and motivated extension staff. Support for the adaptation and validation of CA technologies in local environments is, therefore, required to adapt CA principles and practices to these conditions. Capacity building is needed too.

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