Science for resilient livelihoods in dry areas

Improving dissemination strategies to increase technology adoption by smallholder farmers in Tunisia

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Key messages

With the human population increasing drastically in recent times, improving agricultural productivity will be important in maintaining livelihoods and raising living standards. This project investigated the adoption of farming technologies in two governorates of Tunisia: Zaghouan and Kairouan. Through a questionnaire approach, a total of 700 farmers from both governorates were stratified according to access to inputs, to technical information, and to market information. Preliminary results revealed a general low knowledge of improved barley varieties, with less than 40% in both governorates knowing only three local varieties: Rihane, Swihili, and Arbi. Distance appears to be an important factor determining the knowledge/adoption of technologies in both governorates, with a high proportion of farmers having to travel more than 13 km to access markets and extension offices. Considerable proportions of farmer respondents indicated that they had heard of technologies such as feed blocks and ear tags (10–30% in Zaghouan and 30–60% in Kairouan); however, only low proportions of farmers actually used these technologies. The potential gains to farming from technology adoption in arid environments could be immense, although more effort through extension work is needed to ensure that farmers adopt new innovations and so enhance agriculture production.

Highlights

- Among other factors, distance of villages from extension offices negatively influences access to information concerning technologies.
- The smallholder farmers' willingness to adopt improved farming technologies (mainly linked to the livestock sector) is important for adoption of new technologies.

1. Introduction

1.1 Background

Agriculture plays a leading role in Tunisia's economy, where approximately 16% of the working class are employed in the agricultural sector, and it contributes 10–14% to GDP (Sebri and Abid 2012). Traditionally, Tunisia's agricultural system has been based on small family farms that grow subsistence crops with little market integration, but larger agricultural enterprises are now on the increase (Zaibet and Dunn 1998). Despite agriculture's contribution to the economy, a high proportion of Tunisia's rural population continues to have low incomes and poor living conditions (Foltz 2004; Chebbi 2010). The agricultural sector faces challenges related to scarcity of natural resources, with water being the most limiting. The agriculture sector also faces technical and institutional challenges, which include limited access to credit, especially for small-scale farmers, weak farmers' organizations, a weak relationship between research and farmers, poor technology transfer techniques and their adoption, as well as the poor quality of extension services (Chebbi and Lachaal 2007).

Technology adoption – broadly defined to include improved agricultural practices, from inputs to crop varieties and animal breeds so as to increase agricultural productivity and improve livelihoods – by smallholder farmers is an essential component of agriculture, which contributes toward economic prosperity in less developed countries in arid environments (Marenya and Barrett 2007; Noltze et al. 2012). For most developing countries, genuine natural resource management has to address the balance of broad food security and income generation needs for a rapidly growing population with natural resource sustainable recovery (Arnold and Pérez 2001). A simple focus on meeting long-run sustainability criteria at the individual farm or household (HH) level is inadequate, given that the problems of poverty and low feed availability for livestock production are immediate and require solutions (Omer 2008). Due to uncertain and fluctuating rainfall distribution in arid and semiarid environments, increasing food supply and improving the livelihoods on smallholder farms will depend on sustainable agricultural intensification (Harris 2000).

The need for sustainable intensification of agriculture has gained focus, in part because of the growing acknowledgment that smallholder farm productivity is a major entry point to break the vicious circle underlying rural poverty in arid environments (Garnett et al. 2013). Consequently, an ICARDA initiative – "Mind the Gap" – is testing the delivery of innovative technology packages to rural communities in Tunisia using a randomized controlled trial approach. This initiative also seeks to establish how limited access to inputs can be an important adoption constraint for smallholder farmers.

1.2 Research problems

Challenges for smallholder farmers: Agricultural productivity is a key driver of rural livelihood sustenance, employment, industrialization, and growth in developing countries such as Tunisia (Ellis 2000; Barrett et al. 2001). Despite the potential to dramatically increase yields, the adoption of agricultural technologies in Africa remains generally very low (Collier and Dercon 2014). For the agricultural sector to continue playing its pivotal economic and social development role in Tunisia, a shift in the level of growth will be necessary, which will strengthen food security and improve the livelihoods of smallholder farmers. Part of this shift also needs to focus on the appropriate transfer of technology, through improving the links between information obtained from research and the smallholder farmers (Kassie et al. 2013). Smallholder farmers lack the support of policy makers and frameworks to invest in productivity-enhancing technologies and sustainable agricultural practices, such as ideal feeding technologies for their livestock (Shiferaw et al. 2009). In many developing countries in arid environments, smallholder farmers still have limited access to the innovations, technology, knowledge, and information needed to enhance productivity and incomes, which are critical for sustaining their livelihoods (Collier and Dercon 2014). Therefore, it is crucial to connect smallholder farmers to sources of knowledge (e.g. extension services), inputs and credit, and stakeholder investment in research and development tailored to improve productivity.

Technology adoption: Successful technology adoption and use by smallholder farmers requires more than just the transfer of technical information, because issues relating to the development and dissemination of improved agricultural technologies merit attention (Kassie et al. 2013). If certain groups of farmers do not adopt improved technologies or adopt them at a lower rate than other groups, then it will be important to determine why, because only by understanding these reasons will appropriate and affordable technologies be developed (Giné and Yang 2009). Therefore, establishing agricultural practices that target less use of external off-farm inputs and employing locally available natural resources and purchased inputs more efficiently, ideally in a complementary and synergistic approach, are important for a sustainable future (Kassie et al. 2013). To ensure the sustainability of agriculture production systems for smallholder farmers in developing countries, identifying and strengthening agricultural technologies and practices which seek to improve livelihoods will also contribute toward sustaining smallholder farmer livelihoods.

Approach toward successful technology adoption: Modern agricultural technologies have a high potential to contribute to reducing poverty and increasing economic growth. However, technology adoption remains low in many developing countries in arid environments (Shiferaw et al. 2009). This is because in many of these countries, such as Tunisia, there is a clear need to improve and bridge the gap created by the decline of public-sector extension services (Abebaw and Haile 2013). Key to establishing effective adoption of proposed strategies is understanding which extension approaches have the greatest success rate and will help improve future agricultural technology dissemination efforts (Kassie et al. 2013). Therefore, there is a need to conduct specific technology adoption studies in areas where extension and research programs are implemented to understand the important factors affecting adoption in these areas.

2. Research approach

The technology transfer models tested here comprise three components: access to technical training and subsidized inputs, access to economical and organizational training, and female empowerment. These three components were combined in various ways, and the combinations implemented in different treatment groups to test and compare their individual and combined effects. In total, four different treatments with and without certain components included were compared, and one control without any treatment. Each treatment was implemented with 140 randomly selected farmer HHs. Together with the control group, also consisting of 140 randomly selected farmer HHs, the total sample size was 700 farm HHs.

The different treatments and their individual components will be rigorously evaluated in terms of their costs and effects on innovation adoption, farm productivity, and HH livelihoods (especially income). Data for the impact analysis were collected through a baseline survey (before implementation of the treatments) and a follow-up survey (after implementation) will also be carried out. Significant differences in technology uptake between women and men will be evaluated to identify the most successful technology transfer model to empower women. Advice will be given to the Tunisian Government as well as to other development cooperation stakeholders in order to improve their current practices of agricultural extension and technology transfer, as the project continues.

The research project has the following objectives:

- Increase adoption of new agricultural technologies by smallholder farmers,
- Reduce transaction costs for farmers through improved access to inputs,
- Induce a process of organizational learning and continuous discussion about technology transfer models within development cooperation.

This paper presents the first step of the research project and presents the results of the baseline study.

2.1 Methodology

The project works in two governorates with similar agro-ecological conditions: Zaghouan and Kairouan. In 2016, the Tunisian national partner (Office de l'Elevage et des Pâturages or OEP) provided a list of 700 smallholder farmer HHs in the two governorates. The HHs were identified based on the following criteria: (i) ownership of 0–5 ha of land and (ii) ownership of 1–50 small ruminants. Villages (douars) where at least 10 farmer HHs fulfilled both criteria were selected. Ten HHs of the same village were put in one group, such that 70 villages each with 10 farmer HHs were selected from the two governorates. Based on the selection criteria, the number of HH/village differed between the two governorates, resulting in 480 and 220 HH/village in Kairouan and Zaghouan, respectively. After selection of the 70 villages, farmers were divided into five treatment groups comprising 140 HHs (or 14 villages). The HHs consisted of both male and female HH heads. The different innovative technologies intended for adoption in the project were intensively discussed with the National Agricultural Research and Extension Services (NARES) partner organizations, National Institute of Agricultural Research of Tunisia (INRAT) OEP and Agence de la Vulgarization et de la formation Agricoles. This led to a decision on two technologies: (i) feed blocks and (ii) the new barley variety Kounouz. The female HH heads within treatments 3 and 4 (T3 and T4) were given training, through what was termed 'female empowerment'. This incorporated added trainings and visits to the government and cooperative organizations where the HH heads attended presentations and were also taken through demonstrations concerning best agricultural practices. The rest of the farmers were further exposed to the following training sessions as treatments (Table 1):

Table 1: Overview of the treatment groups

Treatment number	Treatment information	
T1 (n = 140)	Technical training	
T2 (n = 140)	Technical training	Economics/organization training
T3 (n = 140)	Technical training	Economics/organization training and female empowerment
T4 (n = 140)	Technical training	Female empowerment
Control (n = 140)	None	

Source: Mind the Gap Project.

- Technical training and input
  - Two training sessions within one day on Kounouz and feed blocks, including practical feed-block feeding sessions,
  - A field visit to INRAT (agricultural research station) to compare Kounouz with other varieties and see Kounouz grown under best agricultural practices,
  - A field visit to a Kounouz-producing farmer,
  - Access to Kounouz seeds and feed blocks (first season 30% subsidy on seed and feed blocks and second season no subsidy),
  - Sending of technical advice via SMS.

- Economic and organizational training
  - One-day cost/benefit and gross margin calculation of both technologies,
  - Two training sessions within one day on farmer cooperatives (including creation procedure),
  - One-day visit to a farmer cooperative practicing mixed farming,
  - One-week training according to the 'Farmer Business School' approach.

- Female empowerment
  - Six-day training focusing only on female entrepreneurship, the 'Bauern Unternehmer Schulung (Farmer Entrepreneurial School)' delivered over two sessions,
  - One-day visit to a women farmer cooperative,
  - One-day training on access to credit and subsidy programs of the Tunisian Government.

2.2 Data collection and analysis

The questionnaire was divided into different modules, each with an objective which guided the specific questions being asked. Module A focused on the profile of HHs represented by the head, with questions centering on HH characteristics from education to amount of land owned. Modules C and D focused on HH assets, and questions included amount of land owned, total cultivated land, and the money spent on the land per hectare. Module K focused on technology awareness and also on the decision makers regarding the adoption of a certain technology. Module O focused on access of the HH to socio-economic infrastructure, such as distances traveled to the nearest market and to the nearest extension office.

For the purposes of this working paper, the preliminary findings from the survey are presented using descriptive statistics based on frequencies and percentages.
The proportions reported in this working paper were calculated based on the total survey population from the two governorates (700). The analysis was disaggregated by region/delegation/gender and level of education of the HH head. This approach has been adopted to better understand linkages between technology, extension approaches, and socio-demographic variables such as gendered decision-making, educational levels, poverty status, per capita income, and other welfare measures such as food security and dietary quality, in relation to technology adoption. Linking the different aspects in this way enables a more robust interpretation of the reasons behind the adoption or otherwise of the technologies and allows for better understanding of the implications of the findings concerning the influence of the different factors considered in the questionnaire.

3. Preliminary survey findings

3.1 Profile of respondent HH heads

In both Zaghouan and Kairouan, higher proportions of HH heads were male (92% and 94%, respectively) compared to female (8% and 6%, respectively) (Figure 1a). The HH heads in Zaghouan were mostly within the age range 56–65 years (33%), while the highest contribution of HH heads was from the 46–55 years age group (26%) in Kairouan (Figure 1b). Kairouan had a similar pattern to Zaghouan, although the highest contribution of HH heads was from the 46–55-year age group (26%). In both governorates, 2–5 members per HH was most common (52% in Zaghouan and 45% in Kairouan) (Figure 1c) compared to fewer (<2) or more (>9) HH members. Relatively high proportions of HH heads in both governorates (91% in Zaghouan and 90% in Kairouan) were married, and low proportions were divorced, single, and widowed (Figure 1d).

With reference to the level of education of the HH head, 90% in Zaghouan had spent six years or less at school, compared to 78% in Kairouan. Both governorates had low relative proportions of HH heads who had spent more than six years at school (Figure 2a). Years spent practicing agriculture were slightly higher in Kairouan, with 57% of the total respondents indicating that they had more than 31 years of experience compared to 55% in Zaghouan (Figure 2b).

Figure 1. Profiles of households interviewed in Zaghouan and Kairouan, Tunisia. The profile includes (a) the gender of the household heads, (b) age of HH head, (c) household size from the HH head, and (d) marital status of HH head.

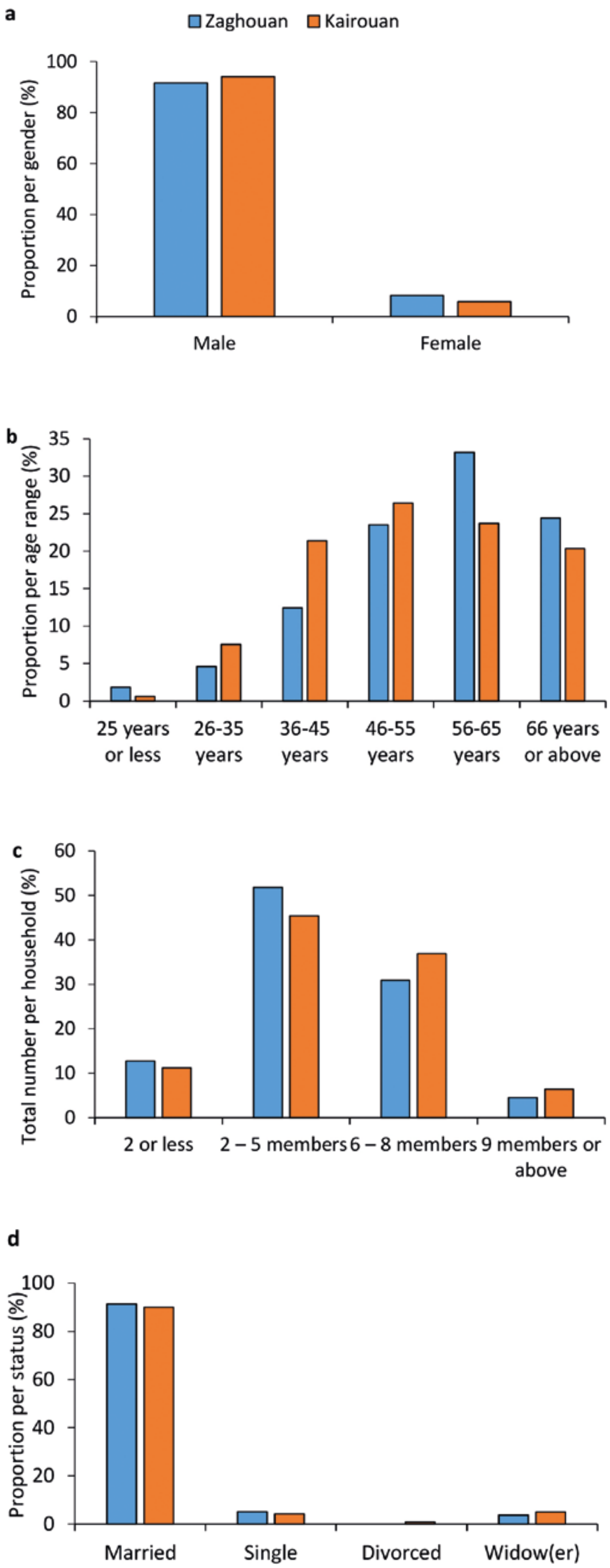
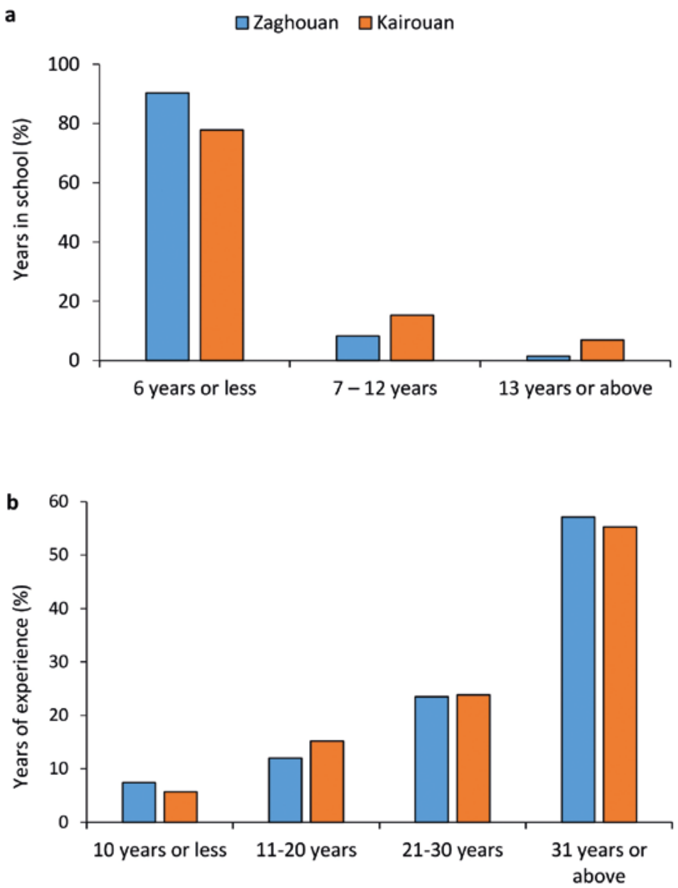


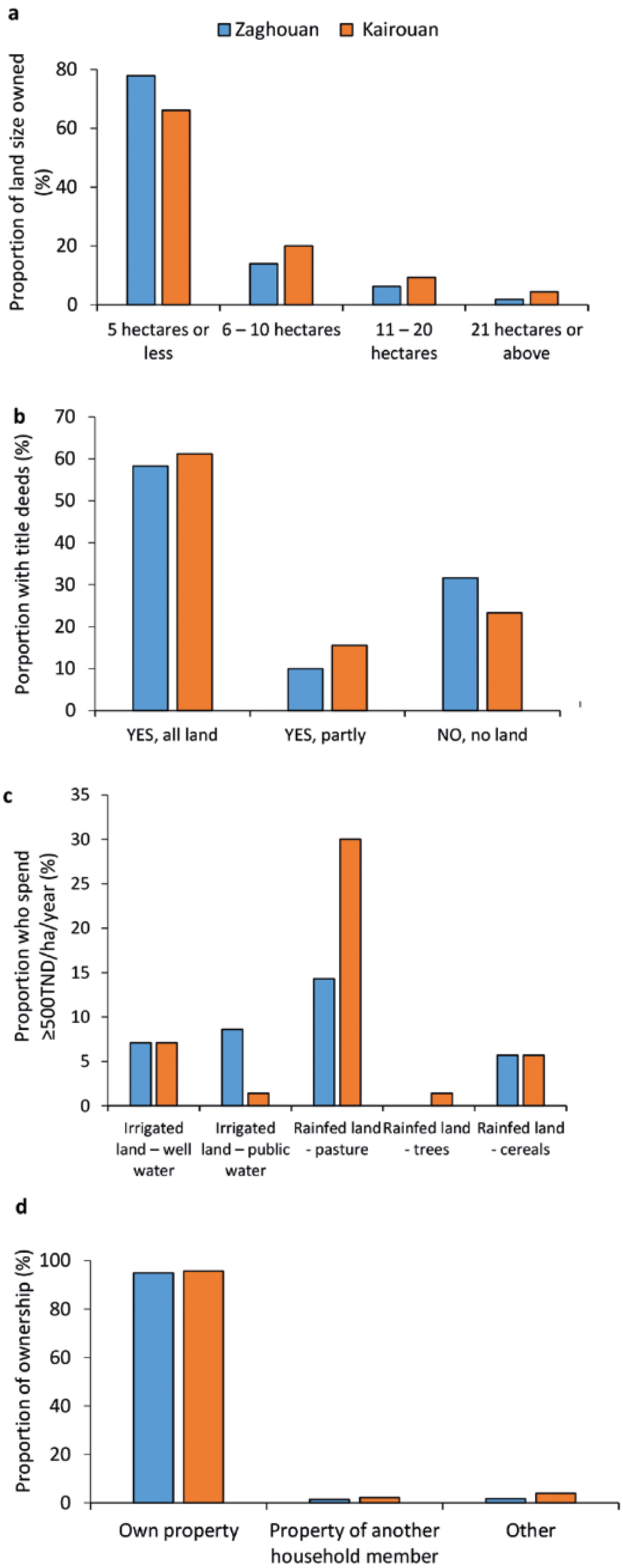
Figure 2. (a) Level of education and (b) level of experience in agriculture of HH heads in Zaghouan and Kairouan, Tunisia. Source: 2017 field survey data.



3.2 Total area owned by respondent HHs

In Zaghouan, most farmers interviewed (78%) occupied a total ≤5 ha of land (Figure 3a), with 58% indicating that they owned that piece of land with title deeds as proof of ownership (Figure 3b). In Kairouan, 66% of HHs occupied ≤5 ha, with 61% having title deeds as proof of ownership. The proportion of farmers who spend ≥500 TDN (≥US$175) per hectare annually was low in both governorates, with 14% of the farmers in Zaghouan and 30% in Kairouan spending ≥500 TDN on rainfed and pasture land inputs such as fertilizer and hiring tractors for plowing (Figure 3c). At least 94% of farmers owned their pieces of land outright in Zaghouan, compared with 96% in Kairouan (Figure 3d).

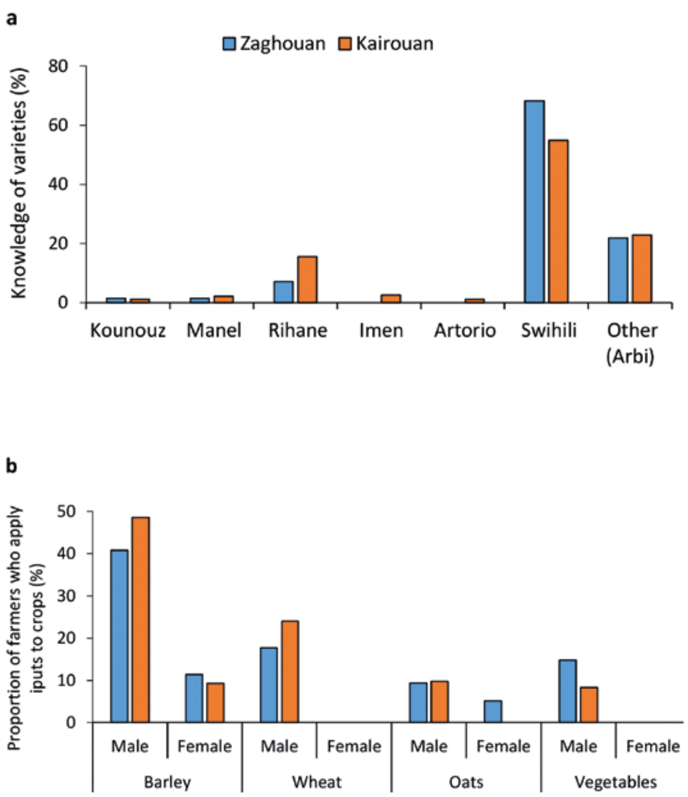
Figure 3. Land owned by respondent farmers in Zaghouan and Kairouan, Tunisia: (a) the portion of owned land, (b) possession of title deeds for the piece of land, (c) money spent (Tunisian Dinars), and (d) mode of ownership. Source: 2017 field survey data.



3.3 Knowledge of barley varieties and input use for planted crops

When considering the HH knowledge of technology (varieties), Swihili was the best known barley variety (68% of respondents in Zaghouan and 54% in Kairouan); the second most known variety was Arbi (22% and 23%, respectively) (Figure 4a). These numbers imply some knowledge of barley varieties in both governorates. There is potential to increase knowledge of these varieties with more intensive extension programs. Concerning the utilization of inputs for planted crops, males in both governorates were dominant in terms of utilizing inputs (Figure 4b). For instance, 41% of male farmers in Zaghouan incorporated inputs, such as fertilizers, when cultivating barley, compared with 11% of female farmers. A total of 18% of male farmers in Zaghouan incorporated inputs for wheat, compared with 0% of female farmers; the corresponding numbers for Kairouan were 24% and 0.1%.

Figure 4. Proportions of farmers (a) with knowledge of barley varieties and (b) who apply inputs such as fertilizers to their crops in Zaghouan and Kairouan, Tunisia. Source: 2017 field survey data.



3.4 Access to socio-economic infrastructure

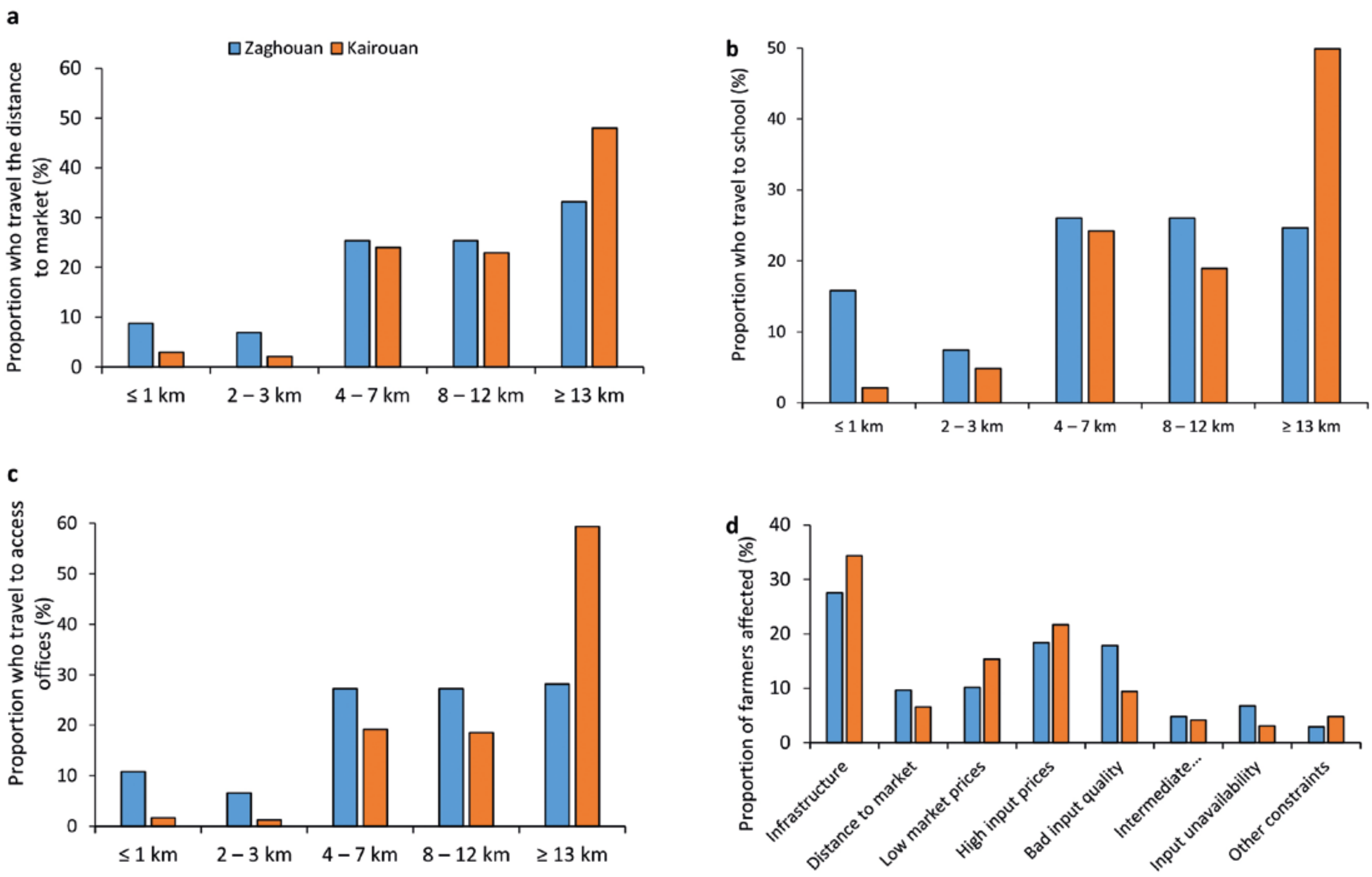
At least 33% of farmers in Zaghouan indicated that they travel >13 km to the closest market if needing to sell their produce and this compared to 48% in Kairouan (Figure 5a). Similar values were obtained for the distance that farmers' children traveled to the nearest secondary school, with >13 km traveled by high proportions in both governorates (Figure 5b). A considerable proportion (28% in Zaghouan and 59% in Kairouan) of farmer respondents also had to travel >13 km to access information from extension offices (Figure 5c). Farmers highlighted that infrastructure (28% in Zaghouan and 34% in Kairouan) and high input prices (18% and 22%, respectively) were the main constraints limiting productivity in their farming areas (Figure 5d).

3.5 Knowledge of technologies/crop varieties

When considering familiarity of the respondents regarding innovative technologies/varieties of barley used in Tunisia and in other countries, 90% of respondents in Zaghouan had not heard of the barley variety Kounouz compared to 2% who had (Figure 6a). Kounouz is an improved and certified Tunisian dual-purpose variety that is well adapted to drought. High proportions of farmers in Zaghouan indicated that they had heard about technologies such as using ear tags to mark livestock (90% had heard of it and 7% had not), artificial insemination (correspondingly 72% and 24%), and use of pellets as a form of preserving feed (95% and 4%) (Figure 6a). In Kairouan, at least 96% of respondents indicated that they had not heard about Kounouz (Figure 6b); in comparison, 85% indicated that they had heard about the use of ear tags compared to 13% who had not, and 74% had heard of artificial insemination and 24% had not (Figure 6b).

In Zaghouan, males made most of the decisions concerning which particular technology to, or not to, adopt (Figure 6c). For example, more than 50% of the represented HHs indicated that men were responsible for deciding on the adoption of technologies such as pellets, use of anthelminthic parasite vaccination, and enterotoxaemia vaccination in Zaghouan over 50% (Figure 6c). Correspondingly, in Kairouan, over 50% of respondents indicated that men took most of the decisions concerning similar technology adoption (Figure 6d).

Figure 5. The (a) distance traveled to access markets, (b) distance to the nearest secondary school, (c) distance traveled to the nearest extension offices, and (d) most important constraints faced by respondents, which limit agricultural production, in Zaghouan and Kairouan. Source: 2017 field survey data.



3.6 Livestock numbers and technology measures for preventing diseases/ parasites

In both governorates, sheep were the dominant livestock type compared to goats and cattle (Figure 7a). Cattle had the lowest population in both governorates, with 50 recorded in Zaghouan and 100 in Kairouan (Figure 7a).

In Zaghouan, the highest proportion (47%) of the total livestock population belonged to the local breed, whereas improved breeds contributed 36% of the total cattle population (Figure 7b). For sheep, the highest proportion (85%) was the local breed and the lowest proportion was crossbred; a similar pattern was apparent for goats, with the local breed contributing 92%.

In Kairouan, improved race contributed slightly more (47%) of the total cattle population compared to the local breed (40%), but sheep (71%) and goat (88%) populations were dominated by local breeds (Figure 7c). Goats and cattle had only low populations sold in both governorates (Figure 7d).

3.7 Reasons contributing toward selling of livestock

In Zaghouan, the highest proportion of respondents sold cattle, sheep, and goats to meet HH emergencies and expenses (Figure 8a). A total of 53% of respondents sold cattle, 50% sold sheep, and 42% sold goats to meet HH demands such as buying food and paying for electricity. A low proportion of respondents indicated that they sold their livestock due to lack of productivity (11% for cattle, 5% for sheep, and 4% for goats) or diseases (0%, 1%, and 2%, respectively) (Figure 8a).

Figure 6.[1] Technology awareness for Zaghouan (a) and Kairouan (b), and decision-making concerning technology uptake in (c) Zaghouan and (d) Kairouan, Tunisia. Source: 2017 field survey data.

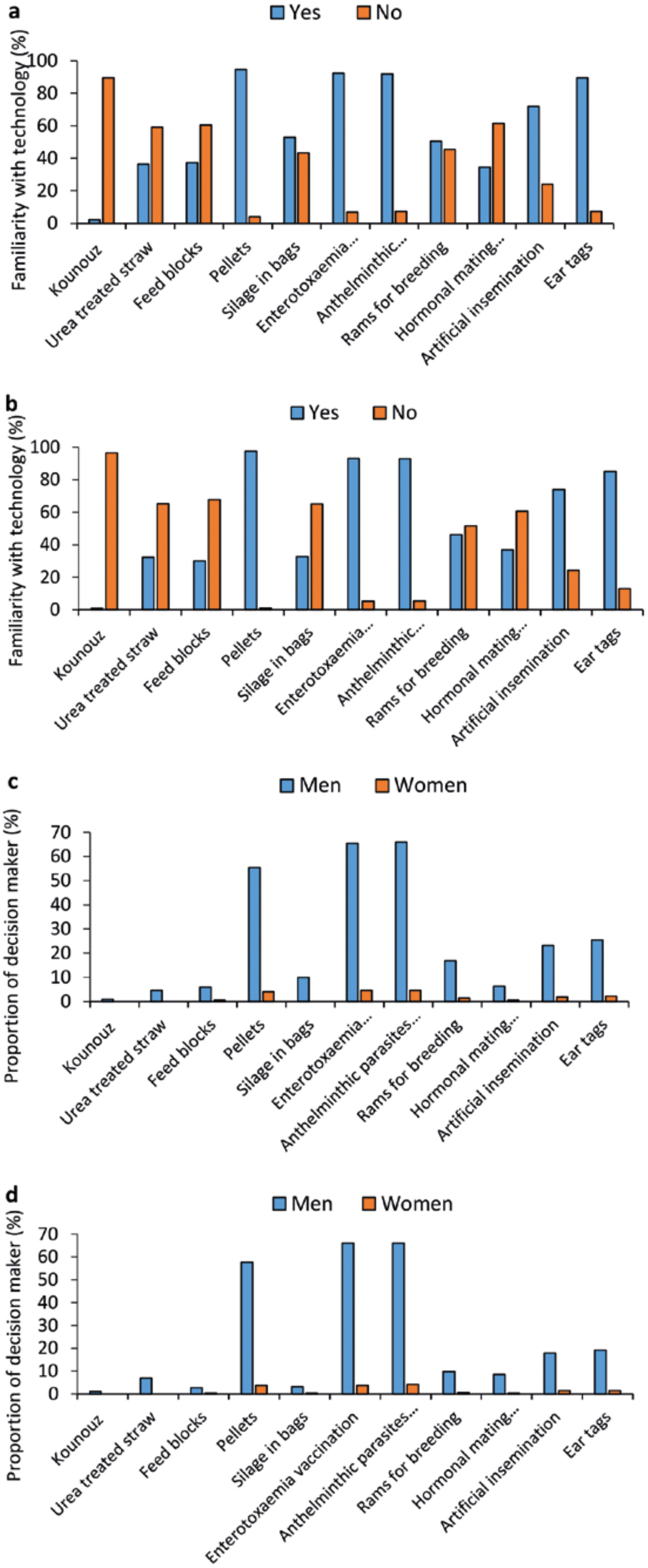


Figure 7. (a) The livestock numbers, and proportion of breeds per livestock type in (b) Zaghouan and (c) Kairouan, and d) the number of animals sold per year in Zaghouan and Kairouan, Tunisia. Source: 2017 field survey data.

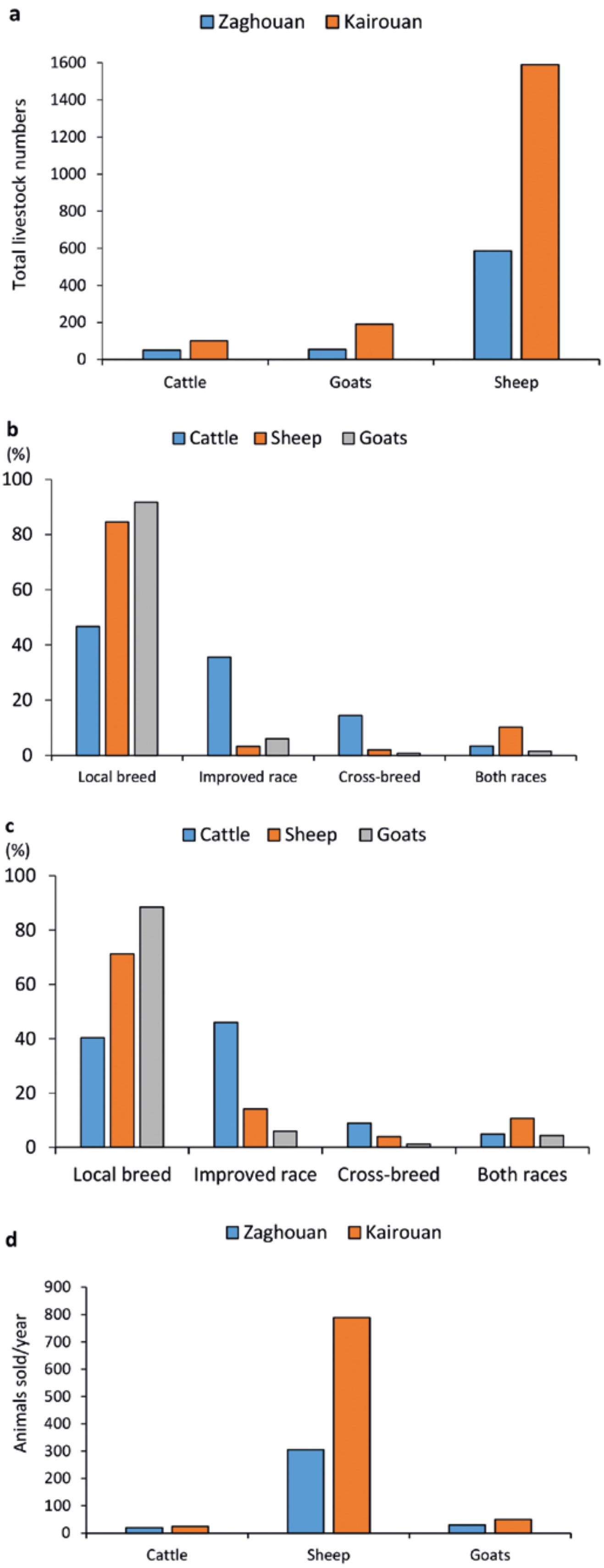
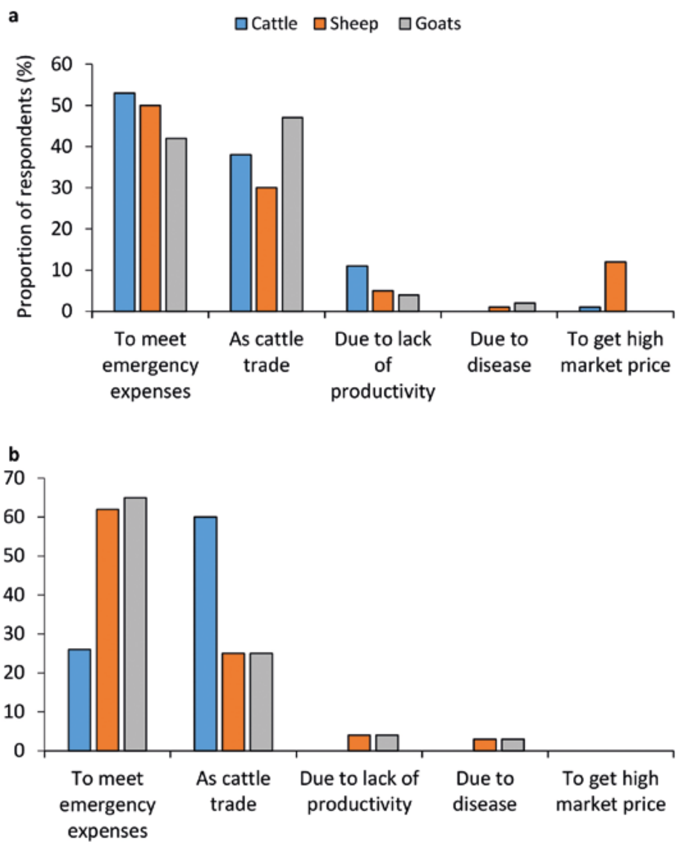


Figure 8. Reasons for farmers selling their livestock in (a) Zaghouan and (b) Kairouan, Tunisia. Source: 2017 field survey data.



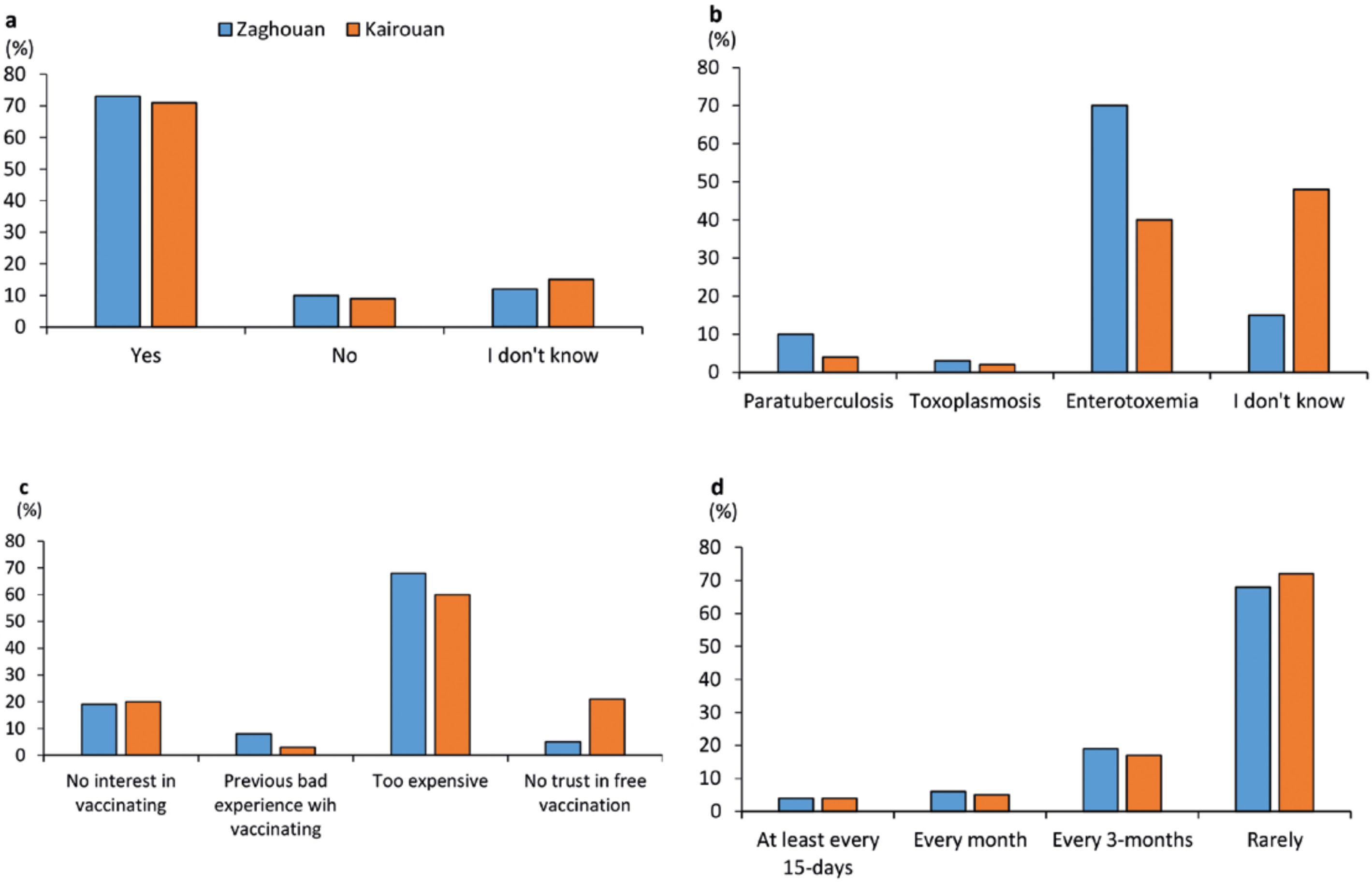
In Kairouan, the highest proportion of respondents indicated that the most important reason for selling their cattle was for trade (Figure 8b) possibly for income to meet HH expenses, or to get younger and more productive animals. They sold sheep and goats to meet HH expenses and emergencies (62% and 65%, respectively) (Figure 8b).

3.8 Use of medicinal technologies for animal health

A high proportion of respondents indicated that they vaccinated their livestock against parasites, 73% in Zaghouan and 71% in Kairouan, compared with those who did not vaccinate (10% and 9%) (Figure 9a). When respondents who did not vaccinate their animals were further asked for reasons why they did not vaccinate, high proportions (68% in Zaghouan and 60% in Kairouan) highlighted the fact that vaccinations were unaffordable (Figure 9c). A considerable proportion of respondents (at least 21% in both governorates) indicated that they had no interest in vaccinating their animals. Enterotoxaemia was a common problem for livestock owners, with a high proportion of all respondents (70% in Zaghouan and 40% in Kairouan) indicating that they vaccinated for it (Figure 9b). A surprisingly high proportion (68% in Zaghouan and 72% in Kairouan) mentioned that they had rarely visited a veterinarian within the last 12 months for any consultations. Only a handful of farmers in both governorates said they had consulted every month within the last 12 months: 6% in Zaghouan and 5% in Kairouan (Figure 9d). These results reflect a lack of effectiveness of extension programs in reaching out to farmers. A lack of interest by farmers suggests a lack of education of farmers on the need to vaccinate livestock to improve animal performance and productivity.

[1] Note: Excluded here are respondents who took no decision and highlighted no involvement regarding technology adoption.

Figure 9. The (a) adoption of vaccination against parasites, (b) vaccinations during last 12 months, (c) reasons for not vaccinating livestock, and (d) frequency of visits to a veterinarian within the last 12 months in Zaghouan and Kairouan, Tunisia. Source: 2017 field survey data.



4. Discussion and conclusion

The factors influencing farm HH adoption of modern agricultural production technologies were grouped into three main categories: economic, social, and institutional factors. The economic factors included farm size and cost of adoption. The social factors included age of farmers, level of education, and gender; and institutional factors included access to extension services. In general, a low proportion of farmers knew about the mentioned technologies, and a low proportion adopted these technologies. One of the main factors suggested to influence technology adoption is farm size, because farm size can affect and in turn be affected by other factors influencing adoption (Ndiritu et al. 2014). The majority of farmers in this project owned land of ≤5 ha, implying that large fixed costs were a constraint to technology adoption, especially if the technology required a substantial amount of initial set-up cost. Therefore, only larger farms would be expected to adopt high-cost innovations, such as expensive vaccinations or rams for breeding.

A high proportion of the farmers highlighted the fact that technologies such as vaccinations were too expensive for them. This means that if the technology is costly to the farmer, there is a low probability that they will adopt it. We suggest that the fear of losing livelihood is a social cost that farmers consider in their adoption decisions (Caswell et al. 2001). The location of the nearest developmental and important infrastructure such as extension offices was at most ≤13 km from the villages in both Zaghouan and Kairouan. The effect of distance on possible technology adoption was highlighted in this project by the high proportion of farmers who rarely visited the veterinarian to consult concerning the health of their livestock. Easier and frequent access to extension offices would increase the familiarity of farmers with the technologies currently adopted by other farmers in Tunisia. The effect of education also affects the adoption levels of farmers (Caswell et al. 2001). Generally, education creates a favorable mental attitude for acceptance of new innovations, especially information- and management-intensive innovations (Waller et al. 1998; Caswell et al. 2001). According to Akudugu and Dadzie (2012), technology complexity has a negative effect on adoption and this can only be dealt with through education. Farmers in this project often had only six years or less of education, and we suggest that their level of education may negatively influence their adoption and enthusiasm for some of the innovations highlighted in this project. However, further analysis is needed to ascertain the relationship between the level of education and the adoption of different technologies described here.

As the project continues, it will be interesting to establish how age influences the adoption of certain technologies or innovations. For example, at a younger age, farmers may not be able to adopt modern agricultural production technologies, especially capital-intensive ones because they may not have adequate resources to do so. At an older age, farmers' volume of economic activities reduces; hence, they may be unable to pay for technologies. Also, older farmers have accumulated years of experience in farming through experimentation and observations and may find it difficult to change to new technologies (Akudugu and Dadzie 2012). Therefore, efforts to encourage adoption of modern agricultural production technologies must focus on providing those that are affordable (e.g. Kounouz barley variety and feed blocks), especially for poor rural dwellers, who mostly depend on agriculture for their livelihoods. It is important for policy makers and different stakeholders to focus resources on mechanisms that encourage the adoption of sustainable farming technologies. Also, increasing the involvement of private sector, non-governmental, and development organizations that will provide extension services will be pivotal in enhancing the adoption of technologies.

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