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Stakeholder views on restoring depleted cereal fallows in arid Tunisia: Societal barriers and possible crevices

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ABSTRACT

All dryland countries struggle with manmade dryland degradation and climate change will reinforce this trend. In arid Tunisia (100–200 mm annual rainfall), depleted cereal fallows are a prominent feature of the desertified landscape. Based on long-term agro-ecological work with promising native steppe grasses, this work explores the societal barriers to restoring cereal fallows with these species. Interviews were conducted with 23 stakeholders (researchers, local decision makers of development agencies and land users) and 40 statements were drawn from these interviews as well as from written sources. These were sorted by 27 stakeholders (some of whom were interviewed before) following a distinct Q-sorting technique inspired by Q-methodology. Principal Components Analysis of these Q-sorts revealed three major types of barriers. (1) A widespread knowledge barrier was obvious since opinion on several agro-ecological statements was often opposite to the scientific evidence. (2) Strong convictions about the sacred nature of barley cropping and olive growing pointed to a cultural barrier to sowing steppe grasses on cereal fallows; (3) Finally, especially non-scientific agropastoralists expressed a lack of trust in any state-backed project aimed at combating desertification. Without the living proof of economic benefits of reseeding, no spontaneous uptake of reseeding can be expected.

1. Introduction

This paper develops an *ex ante* case study on societal barriers to ecological restoration of degraded drylands. Published literature on large-scale ecological restoration success of drylands is rare and yet a lot of effort has gone into research and development of resource conserving techniques in these areas (Thomas, 2008; Wezel and Rath, 2002). From a biophysical point of view, remedies are known but not adopted by dryland users. Clearly, important barriers to their adoption have not been overcome. Our starting point is that no universal remedies exist and that solutions should be developed in tune with social demands and with local, sometimes very local societal dynamics. If the countering of global dryland degradation is to be translated in locally relevant action, the first stakeholders to be approached are the local land users, who are the ultimate decision makers on the ground, and without whose spontaneous appropriation of ecological restoration techniques there can be no large-scale restoration success. This appropriation is a social phenomenon and is still ill understood.

Most studies of factors explaining (non-) adoption processes of innovations in farming, whether endogenous or exogenous, are *ex post* in nature (Alary, 2006; Chatterton and Chatteron, 1982; Marra et al., 2003; Pannell, 1999; Place and Dewees, 1999; Subhrendu et al., 2003). Taken together, these studies show the idiosyncratic nature of the adoption process: each story of success or failure is highly context specific. Findings of one study cannot be used to predict adoption outcomes in another context. However, it makes sense to contrast top-down versus bottom-up approaches to bringing about a desired change of land use. In the world of farming, the lack of social appropriation of “technological packages” proposed within a top-down framework of technology transfer was and still is at the heart of many (context specific) stories of failure and low return on investment. These include most international and expensive programs combating dryland degradation, within the realm of state-funded R&D, even when these claim to be integrated and participatory in nature (Alary, 2006). By contrast, *ex post* studies of farmer-led innovation and agrarian change show that

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farmers do change their land use but they do this bottom-up, whether assisted or not by state-funded research and development (Reij et al., 2005; Rey et al., 2009; Zaal and Oostendorp, 2002). If these land use changes are desirable for society as a whole, then bottom-up processes are fine examples of a high return on investment for the state and should be fostered.

We can thus reframe our research question: how can we translate desirable change in dryland use in concrete local action? Our case study is situated within the dynamics of agropastoralism in a coast plain of arid Tunisia (Genin et al., 2006), that should be considered within the wider ecoregion of North Africa and West Asia (Thomas, 2008).

1.1. The wider context: desertification in West Asia and North Africa (WANA)

The countries of the WANA region share many ecological and societal features and one major problem: insidious desertification. In the Maghreb countries in particular, the desertification debate has traditionally been dominated by plant ecologists and pastoralists describing and denouncing the overgrazing and clearing of that steppe vegetation (Aïdoud et al., 2006; Le Houérou, 2005). However, overgrazing and clearing was the direct result of a post-independence demographic explosion, the forced settlement of nomadic groups near deepwater boreholes and the limitation of the seasonal transhumance of their herds. The accompanying hunger for privately owned land drove the transition from extensively grazed and collectively owned steppes to the current mosaic of privately owned cereal fallows and olive orchards on the best land, interspersed with overgrazed steppe leftovers on the most marginal land (Visser et al., 2002). Concomitantly, the once huge migratory herds split up in a large number of sedentary micro-herds most of which are now stable-fed with subsidised concentrates (mostly barley) for the major part of the year for lack of local resources (Alary and Boutonnet, 2006; Elloumi et al., 2006), even though the demand for local forage remains high. This has led to a situation in which whatever steppe grazing is left merely provides roughage for fibre-hungry small ruminants rather than protein and minerals, which are provided for by the concentrates (Aïdoud et al., 2006; Le Houérou, 1991). Ironically, for resource-poor agropastoral households (the majority), off-farm income is what keeps them afloat, often covering agropastoral losses during drought (Bourbouze, 2006).

1.2. The local context: the Jeffara coast plain

The post-independence transition in land use and herd tenure of the WANA region is most advanced in arid Tunisia (Bourbouze, 2006). This work focuses on the Jeffara coast plain immediately north and east of the 100 mm desert limit and the hinterland of its main town Médenine (Genin et al., 2006). In Tunisia, the privatisation of the commons became a state-backed pursuit. Since planting land is a prerequisite for accessing land deeds according to sharia law, enormous tracts of theoretically unsuitable land have been planted, mainly with olive trees (Bourbouze, 2006). Typically, planting is preceded by a period of barley cropping, during which the land is gradually cleared of all steppe perennials with a tractor-pulled disk plough. Planting is followed by a period of intercropping during rainy years, when barley can be grown in the 24 m spacings between the young olive trees. Barley cropping, olive tree planting and orchard maintenance are extremely erosive activities in these Mediterranean drylands. Arguably, the disk plough has overtaken overgrazing as the most important cause of soil depletion and steppe fragmentation (Jauffret and Visser, 2003). On the other hand, the chances of success of any ecological restoration project are better on privatised land with better productive potential and better defined user rights (Genin et al., 2006; Visser et al., 2002).

1.3. Why reintroduce which steppic species?

In arid Tunisia, desertified cereal fallows with near zero perennial plant cover and productivity are a prominent feature of the landscape. The Jeffara coast plain is not an exception (Genin et al., 2006). Besides perennial plant cover, a comprehensive parameter to quantify and compare the desertification status of arid lands is Rain Use Efficiency (Le Houérou, 1984; Le Houérou et al., 1988; Le Houérou, 1991). In a dry year, when no barley is sown, Rain Use Efficiency (RUE) is close to 0 kg dry matter (DM) ha^{-1} $year^{-1}$ mm^{-1}. Even in a rainy year, the RUE of the barley crop is low, not exceeding 3 kg DM ha^{-1} $year^{-1}$ mm^{-1} (optimistic scenario for 150 mm of rain: 300 kg grain + 150 kg straw ha^{-1} = 450 kg DM). The main advantage of this product is that it can be stocked to overcome part of the dry periods. Upon abandonment, the likelihood in ecological time of spontaneous return of the original steppe is extremely low. The soil is eroded and depleted while the soil seed bank and the local seed rain are dominated by annual weeds. The active reintroduction of steppic species is the only option left to jumpstart the ecological recovery process (Aronson et al., 1993a; b; Jauffret and Visser, 2003). As for the choice of species, these are usually not the grazing resistant dwarf shrubs (such as *Rhanterium suaveolens*) or fibrous giant grasses (such as *Stipa tenacissima*) that form the matrix of the North African steppe. Species most promising for restoration purposes are resource-responsive and highly palatable interstitials of the steppe matrix, for the most part extinction-prone perennial grasses and legumes. This resource-responsive component has declined most under the effects of overgrazing and steppe clearing (Jauffret and Visser, 2003). In the Jeffara, research has focused on two complementary perennial grasses (*Stipa lagascae* R. & Sch., *Cenchrus ciliaris* L.) and one herbaceous pluriannual legume (*Argyrolobium uniflorum* (Decne.) Jaub. & Spach) which are all held in high esteem by the most experienced pastoralists (Visser et al., 1997). In the Jeffara coastal plain, *S. lagascae* and *C. ciliaris* (as well as other even more rarefied grasses) are assumed to have co-dominated the sandy (and most productive) steppes together with *R. suaveolens* at one point in time (Chaïeb et al., 1990). Their loss corresponds to the conversion of arid grassland to shrubland which is symptomatic of desertification and very difficult to reverse (Valone et al., 2002). Loss of perennial plant cover and of these resource-responsive species goes hand in hand with loss of Rain Use Efficiency (Le Houérou, 2005; Visser et al., 2001). Restoring desertified cereal fallows using the most productive and palatable component of the original steppe therefore has the potential to restore RUE beyond current RUE of dwarf shrub steppe devoid of this component, up to 10 kg DM ha^{-1} $year^{-1}$ mm^{-1} (Ewing, 1999; Visser et al., 2008). The ecological restoration of these steppe clearings also presents us with an opportunity to reintroduce steppe grasses in a context where their spontaneous reappearance within the remaining dwarf shrub steppe is highly unlikely. In the Jeffara, the probability for these grasses to grow in the vicinity of cereal fallows, hence to contribute seed to the local seed rain, has become extremely low.

1.4. Obstacles to ecological restoration in arid Tunisia

Reseeding desertified dryland is an agro-ecological and societal challenge. In arid Tunisia, a first category of obstacles rallied around the question: where should the seed come from? That question can be considered resolved now (Visser, 2001; Visser et al., 2008). The second category of obstacles is related to the technicalities of reseeding in a very agriculture-unfriendly environment. Reseeding is a high-risk endeavour even if quality seed is available. Very few reseedings have been reported on in the Maghreb. We are aware of just two publications (Le Floc'h et al., 1999; Visser et al., 2010) and many (not always failed) reseedings go unreported. In fact, the technicalities of reseeding cannot be solved without tackling a third and most important category of obstacles: for whom and for which immediate use will we reseed desertified cereal fallows? The research question of this paper can thus be refined as follows: In this local context, what are the main barriers to restoring cereal fallows, what are the crevices in these barriers and how can we exploit these crevices to foster spontaneous uptake of dryland reseeding?.

2. Material and methods

The methodology used is inspired from Q-methodology, which was originally developed by psychologists for the scientific study of subjectivity (McKeown and Thomas, 1988). It has been used in rural studies to analyse farmers' views on farming (Fairweather and Keating, 1994; Walter, 1997) and is becoming increasingly popular to study environmental conflicts and define different stakeholder groups with a limited number of cases (Addams and Proops, 2000; Barry and Proops, 1999; Visser et al., 2007; Webler et al., 2001). Q-methodology is particularly appealing because it involves a statistical multivariate study of opinions with minimal researcher's bias. Four stages can be recognised: (1) A theme is delimited, interviews with stakeholders are carried out and relevant literature is read to set the context of this theme. (2) Statements are drawn from these sources that should carry the "quintessence" (Barry and Proops, 1999) of the issues at stake. (3) These statements are scored by a limited sample of stakeholders following a distinct Q-sorting technique. (4) The scores resulting from this Q-sorting are analysed with Principal Components Analysis (PCA) and the resulting stakeholder typology is interpreted.

2.1. Interviews and Q-sorting

On top of published and unpublished literature, our context was set with the help of three sources of opinion: (1) dryland users (or ex-users): pastoralists and agropastoralists, even if they live of off-farm income; (2) scientists from the Institute of Arid Regions (IRA) in Médenine and outside the IRA, reputed for their insight into the problem and (3) decision makers of different levels of the Tunisian state bodies involved in combating desertification. These were collected through collective and individual interviews using an interview guide with open-ended questions, which were progressively modified as insight progressed (September 2007). All interviews were recorded with a MP3 by one and the same investigator and annotated to extract a first list of statements of the interviewees. A small number of statements were added from scientific articles. Out of the initial 156 statements, 50 were shortlisted for piloting the Q-sorting. While piloting these (8 Q-sorts with agropastoralists, one with a scientist, all not interviewed before), the number of statements was further trimmed down to 40. The final set of 40 statements was then submitted to an extra 12 agropastoralists of the Jeffara coastal plain, none of whom had been interviewed before, five scientists (all interviewed before) and one development agent (also interviewed before). Out of the 27 Q-sorts, 6 thus come from Q-sorters who were interviewed before (Table 1). This means that the opinions submitted to Q-sorters for their (dis)approval mostly originated from other people.

All dryland users were introduced to the Q-sorting with a short questionnaire relating to identity, the importance of their cereal cropping, olive growing and lifestock activities as well as checking basic agro-ecological knowledge. They were presented with a flowering culm of both *S. lagascae* and *C. ciliaris* and asked to name and compare them. For the Q-sorting, all stakeholders were asked to score the statements on a scale from −3 to +3 according to their degree of (dis)agreement. Statements were written in French and in standard Arabic and given a numbering code. Statements and codes were printed on distribution cards. Q-sorting was done by putting each distribution card in a column carrying the heading corresponding to the degree of (dis)approval of the Q-sorter with that particular statement in relation to the degree of (dis)approval with the other statements. For this, a laminated A1 sheet was used on which seven columns corresponding with the seven possible ratings were drawn with the following headings from left to right: I could not disagree more (−3), I strongly disagree (−2), I disagree (−1), I don't know (0), I agree (1), I strongly agree (2), I could not agree more (3).

Table 1
Distribution of interviews and Q-sorts among interviewee types.

Respondent type	Agropastoralist	Researcher	Decision maker	Total
Interview only	0	7	10	17
Q-sort only	20	1	0	21
Interview and Q-sort	0	5	1	6
Total interviews	0	12*	11	23*
Total Q-sorts	20	6	1	27

*plus four exchanges per email.

Statements were always Q-sorted in the same order. One Q-sort is the collection of ratings of one stakeholder (sorter) for all statements. The resulting 27 Q-sorts were obtained either by direct assistance (all pastoral-farmers and some scientists, November–December 2007) or by post with the necessary material and guidelines to carry out the Q-sort (remaining scientists and the development agent, all interviewed before, December 2007–March 2008). No particular statistical distribution was forced on the rating of the statements (Barry and Proops, 1999; McKeown and Thomas, 1988).

For the assisted Q-sorts with the agropastoralists, an interpreter accompanied the main investigator to translate French and standard Arabic to Tunisian Arabic. Ideally this should have been one and the same person but in reality three different people accompanied the main investigator. For the Q-sorts sent by post, the A1 sheet was replaced by headings printed on distribution cards (McKeown and Thomas, 1988) to be placed by the sorter at the far side of an empty desk from left (−3) to right (+3). Both the assisted and unassisted Q-sorters were invited to comment on the statements and to further explain their ratings. It could be argued that different methods of administering the Q-sorts introduced a bias. The postal method was adopted because of resource constraints. However, only scientists who had been interviewed before and mastered French and written standard Arabic have carried out unassisted Q-sorts. Since they remained 100% loyal to the initial statements extracted from their interviews, it can be assumed that mailing the Q-sorts has not biased the outcomes.

2.2. Types of assisted Q-sorting

Two types of assisted Q-sorts can be distinguished, depending on the type of guidance and interpreting work. The first type of Q-sorting was done with the help of a freelance interpreter who proactively selected knowledgeable agropastoralists. The candidate Q-sorter would be an acquaintance of the interpreter, was briefed beforehand about the issue and agreed to an appointment at home outside the office hours (8 Q-sorts). Q-sorting typically took 1–2 h. The second type of Q-sorting was done with the help of interpreters of the IRA during office hours. An IRA-driver would drive the main investigator and at least one IRA-interpreter to different localities of the Jeffara. The interpreter would stop the IRA-vehicle to ask bypassers to do the Q-sorting exercise on the spot (12 Q-sorts). Q-sorting typically took less than 1 h.

2.3. Data analysis

Two Principal Components Analyses were carried out:

(1) following Q-methodology, on a data matrix with the 27 Q-sorts as variables (columns) and all statements as objects (rows) with the aim to group the stakeholders on the basis of the degree of commonality of their opinions on the statements.
(2) to map the variety of agro-ecological knowledge among stakeholders, on a data matrix with a selection of eight agro-ecological statements that can be backed or rejected with scientific evidence, published and unpublished (columns). A dummy Q-sort was added to the 27 existing ones to create a point of reference reflecting the scientific state of the art (Table 3) to which the other Q-sorts could be related.

To test differences in rating of specific statements between groups of stakeholders, Mann-Whitney tests were applied on non-transformed ratings. All analysis was done using the statistical package SPSS (version 17.0).

3. Results

3.1. Principal components analyses

The first PCA yielded 7 components with an eigenvalue > 1. The first two principal components (PC1, PC2) carry 38.4% of the total variation (27.6% and 10.8% respectively). The loadings of the original variables (Q-sorts) on PC1 and PC2 (Fig. 1) show that all Q-sorts, except two, have a positive PC1 score but split into two groups according to the sign of their PC2 score. This split of stakeholders along PC2 corresponds roughly with the distinction «scientists» versus «non-scientists» (the one decision maker was assigned to the group of the scientists, since he worked for years as a dryland geographer prior to taking up positions in international development agencies).

Other possible explanatory variables, such as type of assisted Q-sorting, group membership, age, knowledge and appreciation of *S. lagascae* and *C. ciliaris*, type of agropastoral activity, importance of agropastoral income as compared to off-farm income, importance of spending on off-farm fodder etcetera did not yield other useful overlays. Likewise, principal components of higher levels (3–7) could not be sensibly interpreted either with any of these explanatory variables.

Fig. 2 is the score plot on PC1 and PC2, which shows the spread of the statements, the positions of which should be interpreted along with the positions of the Q-sorts with regard to the same axes (Fig. 1). A majority of stakeholders rated a large proportion of statements in the same way: mostly agreeing with them (high density of statements towards the positive side of PC1), a few times disagreeing (lower density towards the negative side of PC1). The statements triggering this common (dis)agreement are all situated close to PC1 (low absolute PC2-scores), which explains the positive loading of all Q-sorts on PC1 (Fig. 1). PC1 hence stands for the commonness of opinion among all stakeholders as the main source of variation in our dataset (27.6%). On the other hand, a small number of statements triggered opposed ratings between scientists and non-scientists. Scientists (positive loadings on PC2 in Fig. 1) strongly agreed with a few statements with highly positive PC2 scores but strongly disagreed with other statements with highly negative PC2 scores. Non-scientists held the opposite view with regard to these statements. PC2 hence stands for this opposition.

Table 2 lists all statements with their label (on Fig. 2) and some basic statistics of their ratings. Average ratings were calculated overall and for scientists and non-scientists separately. Table 2 displays full *P*-values resulting from the Mann–Whitney tests to interpret the significance of difference between these average ratings. It is reasonable to accept that a difference of rating is only meaningful if it

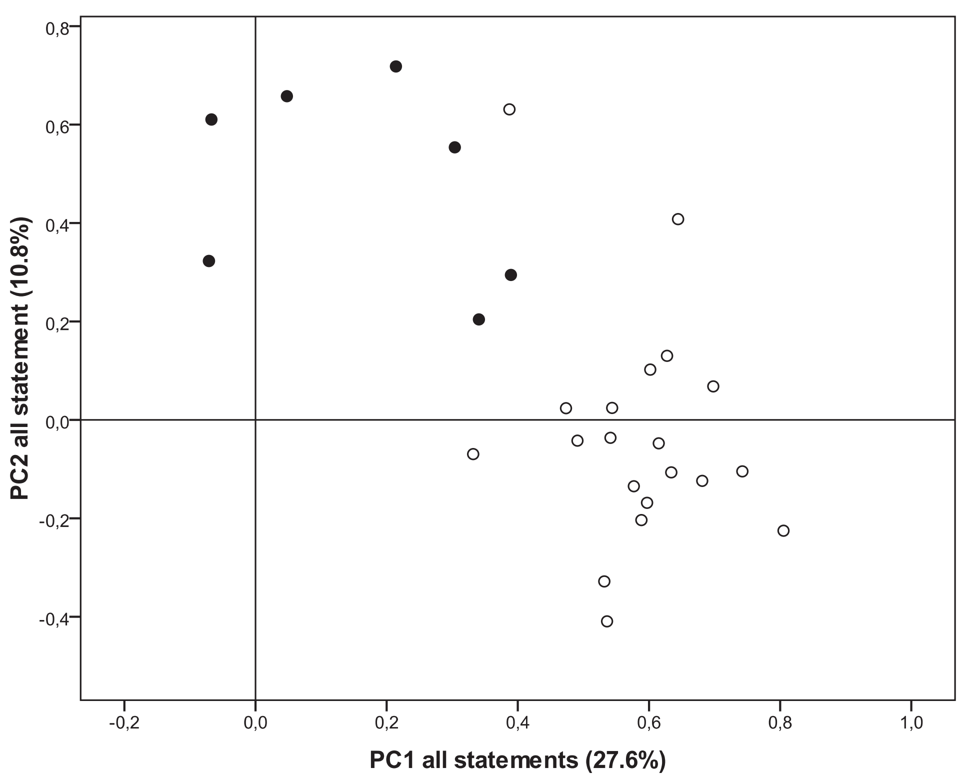

Fig. 1. Loading plot of the PCA on all statements. Black circles are scientist's views; open circles are non-scientist's views.

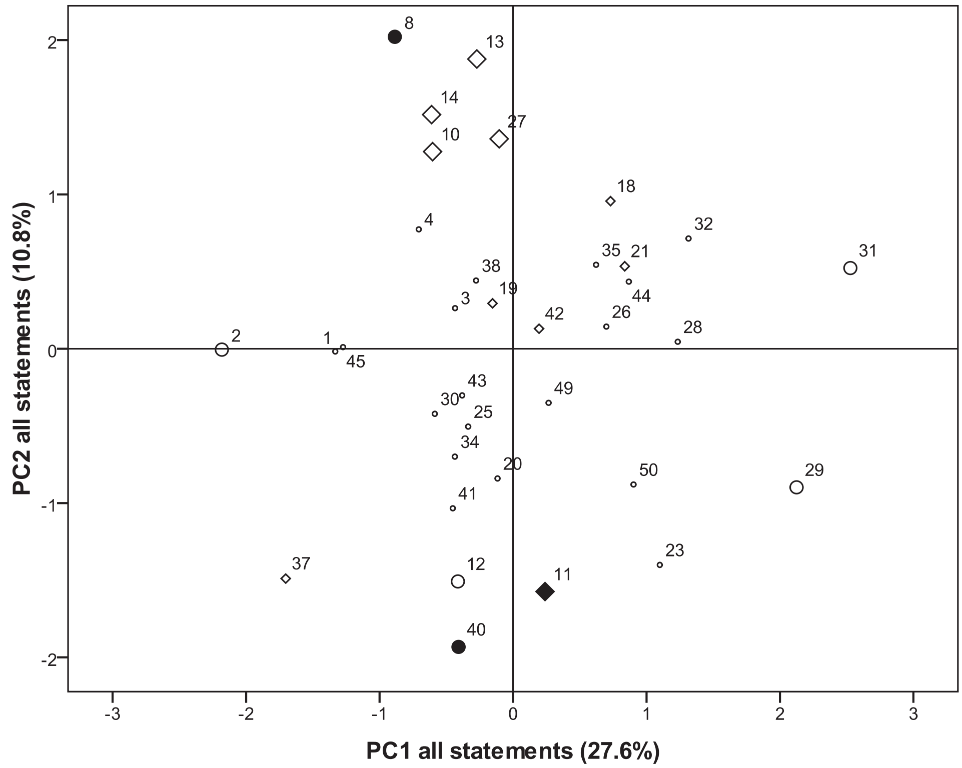

Fig. 2. Score plot of the PCA on all statements, numbered as in Table 2. Diamonds represent agro-ecological statements (in bold in Table 2); circles are other statements. Statements scored for differently ($P < 0.05$) by scientists and non-scientists are marked by large open diamonds and large open circles. Statements scored for differently ($P < 0.05$) by scientists and non-scientists and representing opposed views are marked by large black diamonds and large black circles.

corresponds to a different column on the A1 sheet that held the distribution cards during Q-sorting. So two means of interpreting the significance of the P-values were combined: (1) with the conventional threshold of $P \leq 0.05$ and (2) with the condition that the averages have to be at least one unit apart. Of the eleven statements that triggered significantly different ratings between scientists and non-scientists ($P \leq 0.05$), only three show a genuinely opposed view (negative versus positive score, Table 2). For the other 8 statements, the significance of their differences points to a difference in nuance (e.g. between "I agree" and "I strongly agree") or a difference in strength of opinion ("I don't know" versus "I (dis)agree") rather than to an opposed view.

3.2. Agreement among stakeholders

Statement 29 ("Barley is sacred") and 31 ("The olive tree is sacred") stand out with the highest positive scores on PC1, implying an overwhelmingly common agreement among stakeholders even if the scientist group agrees significantly less with them than the non-scientist group (Table 2). Statement 2 ("Cereal growing is getting unpopular here") is overwhelmingly disagreed with. Statements 28 ("Barley growing is part of an ancient tradition that should be conserved") and 32 ("Having a bit of cereal crop to produce some grain and straw is an insurance against the erratic climate") trigger the next most common agreement among all stakeholders and reinforce the same idea. Taken together, these scores point to a cultural barrier to reseeding steppic species on any dryland that could be planted with olive trees or cropped with cereals as well.

3.3. Disagreement among stakeholders

The separation of the scientist and the non-scientist stakeholders according to their scores on PC1 and PC2 is more pronounced along PC2. Of the 11 statements that triggered significantly different scores between both stakeholder groups (Table 2), eight have PC1-scores close to zero and strongly positive or negative PC2-scores. Five of these eight statements are about agro-ecological knowledge. Scientists rather strongly agree with statements 10 ("Today's hay is less nutritious than hay of the past"), 13 ("With the same quantity and quality of rainfall, the land yielded more biomass 30 years ago"), 14 ("A simple exclosure does not bring back the species that disappeared") and 27 ("A big problem for reseeding arid lands with native species is to make sure we have at our disposal large quantities of quality seed at any time"). Non-scientists express, on average, no opinion on any of these statements, implying they do not know or bother. Statement 11 ("In a year with ample rainfall, the range regenerates and all species reappear with the same abundance") is the only agro-ecological statement triggering a real opposition between both stakeholder groups. The scientists disagree (mean score -1) whereas the non-scientists agree (mean score $+1$). This divergence in opinion on these five agro-ecological facts points to a knowledge barrier to reseeding drylands: there is a lack of awareness of what is actually going on with the land, even among the scientists.

Of the three remaining statements with PC1-scores close to zero and extreme PC2-scores, statement 8 stands out most. "Hay of *S. lagascae* and *C. ciliaris* is nutritious and people would be ready to pay more for it than for hay of *S. tenacissima* or hay of annual weeds" gets the strongest possible opposition between scientists ($+2$) and non-scientists (-1) as well as the highest standard deviation of the set (Table 2). Unfortunately, it combines two statements in one because it is an agro-ecological and economical assessment at once. There is no hard but a lot of circumstantial evidence to back the opinion that hay of annual weeds and of *S. tenacissima* is inferior to hay of *S. lagascae* and *C. ciliaris*, therefore the market should reward the latter with a higher price. The rating of statement 8 thus reinforces the idea of a knowledge barrier to ecological restoration.

Table 2
Statements and statistics. Statements testing agro-ecological knowledge are in bold. The reference score for these statements is added between brackets after the median score.

Number. Statement	Score statistics					
	Median	Grand mean	Standard deviation	Mean scientists	Mean non -scientist	P(diff)
1. Cereal growing is above all an act of presence to claim land ownership.	−1	−0.30	1.660	0	−1	0.304
2. Cereal growing is getting unpopular here.	−1	−1.00	1.544	0	−1	0.024*
3. If agropastoralists make up the bill of cereal growing, they realise they lose more money every year.	1	0.37	1.471	1	0	0.393
4. Today, people do not grow barley anymore for human nutrition.	−1	−0.04	1.454	1	0	0.124
8. Hay of *Stipa lagascae* and *Cenchrus ciliaris* is nutritious and people would be ready to pay more for it than for hay of *Stipa tenacissima* or of annual weeds.	0	0.15	1.916	2	−1	0.002*¥
10. Today's hay is less nutritious than hay of the past.	**1 (3)**	**0.37**	**1.573**	**1**	**0**	**0.046***
11. In a year with ample rainfall, the range regenerates and all species reappear with the same abundance.	**1 (−3)**	**0.52**	**1.649**	**−1**	**1**	**0.023***¥
12. If *S. lagascae* and *C. ciliaris* have almost gone extinct, it's because the local populations did not have an interest to conserve these grasses.	−1	−0.07	1.730	−1	0	0.009*
13. With the same quantity and quality of rainfall, the land yielded more biomass 30 years ago.	**1 (3)**	**0.78**	**1.553**	**2**	**0**	**0.000***
14. A simple exclosure cannot bring back the species that disappeared.	**1 (3)**	**0.56**	**1.739**	**2**	**0**	**0.044***
18. If the rainfall suits to sow barley, it also suits to sow steppe grasses.	**2 (3)**	**1.59**	**1.152**	**2**	**1**	**0.113**
19. Steppe grasses grow too slowly and their establishment needs a lot of time.	**1 (-3)**	**0.33**	**1.617**	**0**	**0**	**0.813**
20. Haying *S. lagascae* and *C. ciliaris* is less demanding than harvesting barley or wheat.	1	0.33	1.569	0	1	0.178
21. Once S. lagascae and C. ciliaris have survived the establishment year, they cannot fail anymore.	**2 (3)**	**1.52**	**1.122**	**2**	**1**	**0.436**
23. To make sure the reseeding is feasible, it should be economically viable and that's more important than any socio-cultural constraint.	1	1.04	**1.743**	**0**	**2**	**0.078**
25. If it comes to reseeding the arid lands of Tunisia, the OEP* and the CRDA* are handicapped by the lack of appropriate plant material.	1	0.41	1.421	0	0	0.751
26. Only the agropastoralists themselves can come up with a sound management plan for reseeded land.	1	1.11	1.577	1	1	0.493
27. A big problem for reseeding arid lands with native species is organisation to make sure we have large quantities of quality seed at any time.	**1 (3)**	**1.04**	**1.506**	**2**	**0**	**0.010***
28. Barley growing is part of an ancient tradition that should be conserved.	2	1.52	1.477	1	2	0.287
29. Barley is sacred.	3	2.02	1.357	1	3	0.001*
30. Reseeding of *S. lagascae* and of *C. ciliaris* bears a high-risk of failure.	0	−0.07	1.299	0	0	0.469
31. The olive tree is sacred.	3	2.59	0.888	2	3	0.034*
32. Having a bit of cereal crop to produce some grain and straw covers against the erratic climate.	2	1.70	1103	2	2	0.780
34. If you reseed your private land with steppe grasses, it becomes a pasture that your neighbour can decide to graze.	1	−0.15	1.703	−1	0	0.312
35. To protect your land, you need to plant fruit trees.	1	0.93	1.542	1	1	0.682
37. S. lagascae and C. ciliaris are of less grazing value than Rhanterium suaveolens.	**−1 (−3)**	**−0.78**	**1.805**	**−1**	**−1**	**0.583**
38. Agropastoralist households live off non-agropastoral income because the agropastoral income has become derisory.	1	0.44	1.281	1	0	0.084
40. The only landowners possibly interested in reseeding are the ones who do not use it any longer.	1	−0.11	1.625	−1	1	0.002*¥
41. Soon there will be no pastoralism left; all animals will be sedentary and live off imported fodder.	0	0.19	1.665	−1	1	0.099
42. The practice of supplementing with concentrates means that the role of the steppe is limited to providing fibre.	**1 (3)**	**0.81**	**1.241**	**0**	**1**	**0.543**
43. As long as barley is subsidised it is very difficult to get people interested in cultivating steppe grasses.	1	0.48	1.553	1	0	0.979
44. Without barley subsidies, the agropastoralists could not pay for the feed and would overgraze the rangelands even more.	1	1.48	1.189	1	2	0.516
45. The Tunisian state should recognise the reseeding of steppe grasses as a way to get land deeds.	−1	−0.41	1.647	0	−1	0.385
49. The fact that our research structures do not match our developments agencies is the direct cause of the series of failed state projects to combat desertification.	1	0.70	1.613	0	1	0.226
50. Agropastoralists do not feel confident reseeding their land and are merely on the lookout for compensatory payments.	1	1.22	1.761	0	2	0.060

OEP: Office des Elevages et Pâturages and CRDA: Commissariat Régional du Développement Agricole (two important state-run agricultural development agencies).* Statements for which the scores of scientists differ from non-scientists ($P < 0.05$). ¥ Statements with * for which the scores are opposed.

Table 3
Evidence to support agro-ecological statements.

Number. Statement	Reference score	Evidence
10. Today's hay is less nutritious than hay of the past.	3	(Genin et al., 2006; Visser et al., 2001)
11. In a year with ample rainfall, the range regenerates and all species reappear with the same abundance.	−3	(Chaïeb et al., 1990; Le Houérou, 1991; 2005)
13. With the same quantity and quality of rainfall, the land yielded more biomass 30 years ago.	3	(Aïdoud et al., 2006; Le Houérou, 2005)
14. A simple exclosure cannot bring back the species that disappeared.	3	(Aïdoud et al., 2006; Le Houérou, 2005)
18. If the rainfall suits to sow barley, it also suits to sow steppe grasses.	3	(Le Floc'h et al., 1999)
19. Steppe grasses grow too slowly and their establishment needs a lot of time.	−3	(Visser et al., 2010)
21. Once *Stipa lagascae* and *Cenchrus ciliaris* have survived the establishment year, they cannot fail anymore.	3	Authors' experience
27. A big problem for reseeding arid lands with native species is the organisation to make sure we have large quantities of quality seed at any time.	3	(Visser, 2001; Visser and Reheul, 2001)
37. *S. lagascae* and *C. ciliaris* are of less grazing value than *Rhanterium suaveolens*.	−3	(Jauffret and Visser, 2003)
42. The practice of supplementing with concentrates means that the role of the steppe is limited to providing fibre.	3	(Le Houérou, 1991)

To further analyse the divergence between current opinion and scientific evidence, a second PCA was realised on the subset of agro-ecological statements (variables) with a reference Q-sort (case) added to represent the scientific state of the art. The score plot thus produced (Fig. 3) makes it possible to compare the distance between stakeholder opinions and the reference Q-sort. Fig. 3 clearly shows that some non-scientists produce more scientific Q-sorts (closer to the reference Q-sort) than some scientists, that even the nearest scientist's Q-sort is still quite apart from it and that both scientists and non-scientists display widely varying views (widely spaced scores). As for the non-scientists, it clearly points to both the erosion of agro-ecological knowledge (rating the best steppe grasses as inferior to *R. suaveolens* for example) and/or a lack of effort to communicate scientific consensus towards the land users. As for the scientists however, Figs. 1–3 suggest there is in fact no consensus within the scientific community in the first place. The knowledge barrier is therefore also a general communication barrier.

Statement 40 ("The only landowners that could be interested in reseeding are the ones who do not use it any longer") is the third statement (together with statement 8 and 11) triggering genuine opposition between both stakeholder groups. Non-scientists agree whereas scientists disagree. The reaction to this statement should be read in conjunction with statements 23 and 50, both with negative PC2-scores and nearly significant differences between both stakeholder groups. Non-scientists also strongly agree with Statement 23 ("To make sure the reseeding is feasible, it should be economically viable and that's more important than any socio-cultural constraint") and statement 50 ("Agropastoralists do not feel confident reseeding their land and are merely on the lookout for compensatory payments"), whereas the non-scientists express no opinion on these. Taken together, they translate reticence towards the whole idea of reseeding, fuelled by a lack of confidence in what the state has to offer. A third barrier to reseeding dryland thus becomes clear: the lack of trustworthy references and of living proofs that reseeding can be beneficial to the land user. This trust barrier is the legacy of a long series of failed national and international programs to combat desertification since the seventies.

4. Discussion

To the best of our knowledge, this is the first case study of its kind about societal barriers to dryland restoration in the Maghreb, possibly even in the WANA region. From the onset, we were aware of obvious difficulties. The main investigator is a woman yet none of the interviewees was. The study was about expressing and typing the diversity of opinions, yet getting frank personal opinions is not easy in the Maghreb. Local non-scientific Q-sorters should have been chosen for their agro-ecological knowledge and status as opinion leaders in their community, yet only the first type of assisted Q-sorts has worked that way. There was also the problem of double translation: from French to standard Arabic on the cards, then from standard Arabic to colloquial Tunisian Arabic, by interpreters who gave their own slant to the same statement while translating it, with no means of control by the main investigator. Such adverse conditions could have led to totally meaningless Q-sorts, but this was not our case. Getting meaningful results despite adversity demonstrates the power of Q-sorting. The technique relies on the relative impartiality with which the investigator can extract opinions from interviewees, despite the general reluctance to talk freely and despite language and gender issues. This is partly thanks to (1) giving due attention to catching the quintessence of the issues at stake with a minimal number of statements and (2) offering statements written on cards, in this way creating a distance between the statement and the source emitting it.

In the remainder of the discussion, we first analyse the local interpretation of the three barriers we identified. We then discuss

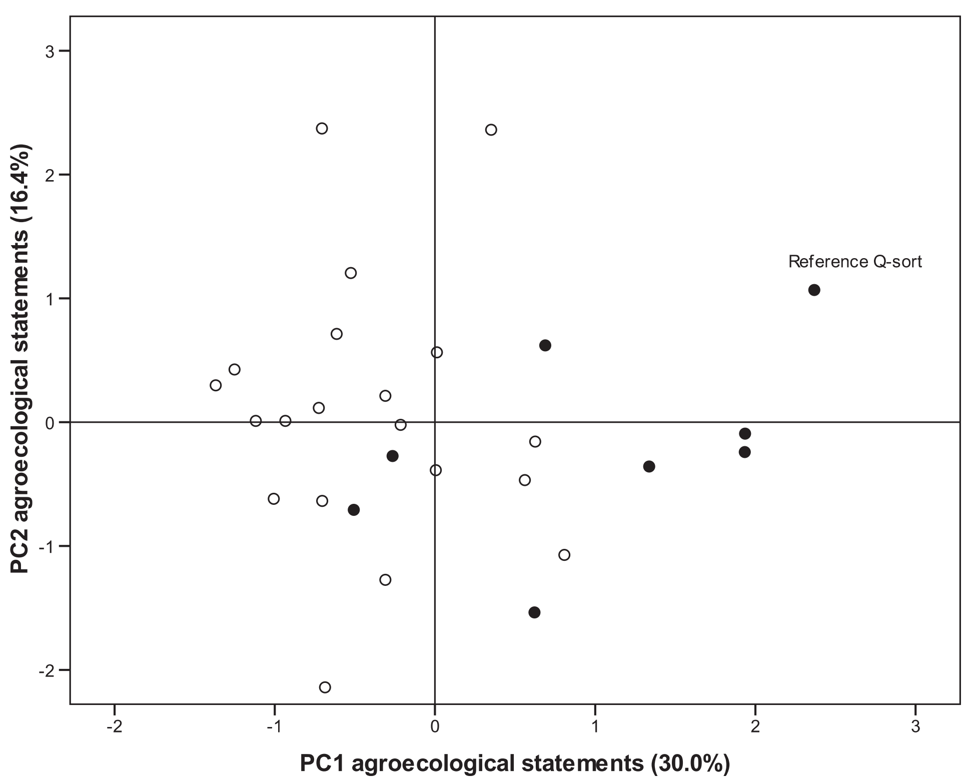

Fig. 3. Score plot of the PCA on agro-ecological statements, showing the distance of scientist's (black circles) and non-scientist's (open circles) views compared to the reference Q-sort. The reference Q-sort is composed of scores indicated between brackets after the median of the statements in bold of Table 2.

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our findings in the broader context of the adoption of techniques to counter dryland degradation.

4.1. The knowledge barrier

Previous surveys had already shown that especially the younger agropastoralists cannot recognise well rarefied steppic species (Visser et al., 1997) and that they react with disbelief to the prospect of actually producing and using seed of these (Visser et al., 2001, 2002). The paradox is that all interviewees agree more forage should be grown locally (Statement 9 of the piloting phase), and those agropastoralists who can name *S. lagascae* and *C. ciliaris* appreciate them tremendously but do not seem to make the link with actually growing more forage locally from local species. This study has further shown widespread unawareness of the declining quality of the land. Overcoming the knowledge barrier thus requires a massive focused communication effort, firstly within the scientific community and secondly with the arid land users. As most of the non-scientific land users interviewed are practically illiterate, the best way to reach them would be to produce high-quality documentaries and broadcast these on TV repeatedly during primetime, show and distribute them during workshops and field days of research institutes and development agencies, organise school viewing events etcetera. However, the knowledge barrier cannot be treated independently from the cultural and trust barriers.

4.2. The cultural barrier

That there was a huge cultural barrier to be overcome was already obvious (Visser et al., 2002) but this is the first time it was made overwhelmingly clear through the strong positive approval of the sacred nature of local barley growing and olive trees. In the minds of agropastoralists (scientific land users included) land is either cultivated with domesticated species or it is not. During the piloting phase, statement 6 ("*S. lagascae* and *C. ciliaris* can be cultivated as dryland forages") got negative scorings. It seems inconceivable to sow steppe grasses as a dryland crop because whenever the opening rains are promising, the reflex is to sow barley. However, it should be possible to overcome this competition with barley if ways can be found to combine both crops in time (ley-farming) or in space (alley cropping). For instance, they can be sown together with the cereal crop so that the ley takes over spontaneously after the cereal harvest. Alternatively, alley cropping in combination with contour ploughing could be tested. In this way, the steppe grasses can be requalified as companion species of the barley crop rather than competitors. The general expectation is that these leys and alley crops could boost rather than bring down barley harvests all the while providing valuable local fodder, even in years too dry to sow barley. Yet these ideas need experimenting in a participatory way, implying that bringing down the trust barrier must get priority.

4.3. The trust barrier: a local crevice in a global barrier

It is an understatement to write that the Tunisian state, through forty years of serial failure of international and national projects to address the desertification problem, has lost the confidence of its target audience (for a mid-term report see Floret, 1987). Many stakeholders interviewed on the matter were very reticent towards the idea of working with local species to restore productivity. After all, the idea could simply be on its way to become the next failure. A solution to this problem could be to finance a local NGO whose main objective is to organise the seed multiplication at a local level and to promote the use of this seed in a participatory way with the land users. The role of state-funded R&D bodies would be confined to providing quality base seed of superior genetic quality as outlined earlier (Visser and Reheul, 2001, 2002; Visser et al., 2008). Agropastoralists have made overwhelming clear that only economic gain can convince them (Statements 23 and 40), either through compensatory payments (statement 50, which would be the wrong motive), or through the actual proof of statement 8, that hay of *S. lagascae* and *C. ciliaris* fetches better prices than hay of *S. tenacissima* and of annual weeds (Visser et al., 2002). The main objective of our NGO should then be to actually produce this proof. However, the problem with dryland reseeding is climatic uncertainty. The slightest drought ruins any time-limited dryland reseeding project that is expected to deliver durable results before the funding ends. Therefore, instead of waiting for the first cereal fallows to have yielded their first hypothetical hay crop, it would be much more convenient to get the proof of the superiority of steppic grasses by producing hay on irrigated plots, with the added advantage of producing quality seed on these plots afterwards. As resource-responsive species, both *S. lagascae* and *C. ciliaris* react very well to irrigation and fertilisation and the first hay crop can be produced as soon as nine months after seeding. This hay could be put up for sale alongside other types of local forages at the main forage market of Medenine. The former habit of haymaking of *S. lagascae* in remote steppes can work as a historical reference to renew interest in it (Visser et al., 2001, 2002). Once demand for this hay is firmly established, it would become much easier to convince dryland users to take part in reseeding experiments on cereal fallows, especially those users who appreciate *S. lagascae* and *C. ciliaris* as native steppe species. They could even produce valuable seed from their upgraded drylands. In other words, it would help to bring down all three types of barriers in one go. By that time, the technicalities of dryland reseeding (Statements 18, 19, 21) would have become mere detail.

4.4. Looking up: the adoption of ecological restoration practices by agropastoral households

The types of barriers we identified are by no means unique to this context. Cultural barriers to changes in land use are universal. In fact, "wrong" mindsets of "end-users" of technological packages have often been an excuse for the failure of large top-down projects to tackle dryland degradation in the region (Chatterton and Chatteron, 1982; Springborg, 1986). Knowledge and communication barriers are cited by Wezel and Rath (2002) as important impediments to the spread of resource conserving techniques in West-African drylands. Narratives about state-backed dryland development programs that were run opposite the nature of (agro) pastoralism implicitly or explicitly refer to a lack of trust between development agencies and agropastoralists (Davis, 2005; Roe et al., 1998). What is specific to this study is that by thorough interviewing and analysing contradictory discourses with Q-methodology, it was possible to prioritise the barriers, understand the interactions (e.g. because of lack of trust there can be no efficient communication) and come up with ideas for local action *ex ante*. Finally, it should be said we did not identify some factors commonly cited for the lack of adoption of innovation elsewhere such as land tenure uncertainties (probably because we chose to focus on privatised land), labour constraints and access to credit or markets. These should be given due attention in any follow-up project.

5. Conclusion

Marginal lands of the arid belt of the WANA region and arid Tunisia in particular hover between overuse and abandonment. Climate change combined with higher costs of agricultural

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operations might force agropastoralists to cease growing barley altogether in the near future. Concomitantly, there is a renewed interest in local grazing resources to save on expenses on imported fodder, but the best species need to be reintroduced. The negative side is that the climate becomes ever more hostile to any agricultural operation, including reseeding with local steppe species. Cereal fallows are among the most desertified drylands yet potentially also the most productive if only land users would restore their ecological functioning. The starting point of this case study was that some particular steppe grasses and legumes have good potential, that quality seed of quality native species is available locally but that agropastoralists are unlikely to use this seed spontaneously because of a number of barriers. Uptake could be triggered by creating a demand for (irrigated) hay of these species first, to refocus on the rainfed production of this hay in a later phase. The localness of this approach is obvious: we seek in fact to rehabilitate an old haymaking practice that was strongly linked to the former transhumance patterns of that coast plain. In other dryland contexts with similar problems, the same type of survey would have led to different ideas for local action.

Since resource conserving and ecological restoration techniques are known and tested worldwide, the question why they aren't being more adopted by dryland users despite all the official R&D efforts over the last forty years frustrates many researchers and decision makers. The idea for this study came from the realisation that context-relevant local action with these techniques can only come from (close contact with) local land users. For outsiders, survey techniques inspired from Q-methodology, or other methods of discourse analysis, can be very helpful to disentangle problem situations and gain new insights, but at the end of the day it is up to insiders to translate these insights into local action. All the barriers identified will work much less against local action by local stakeholders than against official R&D programs. The challenge then is to design national and regional policies to foster, not smother this potential for local action.

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