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Traditional knowledge and community resilience in Wadi Allaqi, Egypt

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Abstract

In this study, we investigate the impact of the formation of Lake Nasser in the mid-1960s and the establishment of a new village in the vicinity of the lake in the early 2000s on traditional knowledge of a Bedouin community. We focus particularly on items relating to rangeland and settlement. Questions, based in part on literature, were asked in interviews with Bedouin people living in non-permanent settlements along the shores of Lake Nasser and people living in the village. Our results reveal significant knowledge differences between groups of people older and younger than 50 years of age. We also found significant gender differences with regard to issues relating to rangeland, but not with regard to those relating to settlement. No differences could be attributed to whether people were living in non-permanent dwellings on the shores of Lake Nasser or in the village. The results further revealed that new agricultural knowledge has been developed with regard to the use of aquatic species for animal feed. The combination of preserving some knowledge domains and developing new ones fits to the concept of community resilience: the capacity of communities to withstand disturbances and adjust to changing circumstances by adapting their knowledge systems.

Keywords: Traditional knowledge; community resilience; rangeland-related knowledge; settlement-related knowledge; Wadi Allaqi; Egyptian Bedouins

Introduction

Throughout the world, socio-economic developments are placing pressure on traditional knowledge systems, on which indigenous or traditionally living people have often depended for their subsistence for centuries. At the same time, however, traditional knowledge systems are increasingly being regarded as important elements of adaptive environmental management approaches (Berkes, 1999), the preservation of sociological and cultural diversity (CBD, 1992), and approaches to socio-

ecological resilience (Berkes *et al.* 2000). From this point of view, we aim to assess how the traditional knowledge system of Bedouin people in Wadi Allaqi, located in southern Egypt, has been affected by developments in recent decades, including the formation of Lake Nasser and the development of the village, both which have had a major impact on the livelihoods of these people. We conclude that, although the traditional knowledge system was indeed affected, it has also demonstrated the ability to adapt to new circumstances, which could be regarded as an example of community resilience.

The concept of traditional knowledge refers to knowledge and practices that are embedded and maintained within long-standing traditions of regional, indigenous, or local communities. It is thought to evolve as a result of adaptive processes within the environment over long periods, often centuries (Berkes, 1999; Turnbull, 2009; Dutfield, 2001). Traditional knowledge is usually transferred and expressed orally through stories, legends, rituals, songs, laws, beliefs, and practices (Berkes, 1993; Turner *et al.* 2000). It encompasses knowledge about traditional skills, in addition to knowledge and technologies related to such aspects as hunting, agriculture, midwifery, navigation, astronomy, medicine, household economy, trade, religion, and environmental resources (Morin-Labatut and Akhtar, 1992).

Although traditional knowledge may reflect generations of thoughts and habits, many studies have emphasized that it is a dynamic combination of past and current experiences (Mugabe, 1999), as people continuously cope with and evaluate information, experiences, and new opportunities. It therefore reflects learning, adaptation, and innovation in response to changing circumstances (Gunderson *et al.* 1997). It should not be regarded as static but as versatile, as being produced and reproduced, and as being both discovered and lost (Springuel, 2004; Briggs *et al.* 2007). Traditional knowledge has been characterized as fluid and flexible, as transitory and highly negotiable, and as varying in time and space (Sillitoe, 1998; UNCCD, 2000).

The adaptivity of traditional knowledge is relevant within the context of both ecological disturbances (e.g., natural fires, flooding, drought, windstorms, and disease outbreaks) and anthropogenic disruptions (e.g., de-forestation, agriculture, mining, oil spills, the overuse of natural resources, pollution, and the introduction of invasive exotic species) (Peterson *et al.* 1998; Folke *et al.* 2004). Traditional knowledge may therefore be seen as an inherent component of traditional disaster-management systems for preventing, mitigating, preparing for, responding to, and recovering from the impact of disasters, in addition to adapting to changing environments (Dekens, 2007).

The ability to cope with disturbances and adapt to ever-changing environmental conditions is increasingly being recognized as relevant, given the intense pressure that is being imposed on natural systems (Falkowski *et al.* 2000; Leykin *et al.* 2013). Within this context, the concept of resilience is regarded as a key feature needed in order to understand socio-environmental changes (Christopherson *et al.* 2010; Kaul and Thornton, 2014). It refers to a system's ability to absorb and cope with the

impact of shocks, stressors, variability, and extreme events, while maintaining its essential structure, function, and identity (Gunderson, 2003; Walker *et al.* 2004; UNISDR, 2005; Magis, 2010; Segnestam, 2014; Berkes and Folke, 1998; Carpenter *et al.* 2001). The concept of resilience also applies to skills, capacities, and behaviors for coping with adverse events (Redman and Kinzig, 2003), including a variety of social, political, and environmental changes (Adger, 2000). Reyes-García and colleagues (2014) use the term “knowledge system resilience” to describe the adaptive role of traditional knowledge under changing environmental conditions.

The adaptivity of knowledge systems implies both the loss and development of knowledge. Several studies have demonstrated the loss of knowledge as indigenous and local societies undergo changes (Godoy *et al.* 2009; Reyes-García *et al.* 2005). Others have highlighted the development of new forms of knowledge and livelihood strategies under conditions of change and uncertainty (Adger *et al.* 2005; Eakin *et al.* 2012; Mavhura *et al.* 2013; Liao *et al.* 2016). Politics, lifestyle changes, and habitat loss are the most significant factors affecting traditional knowledge (Keller *et al.* 2005). The content of traditional knowledge also appears to be affected by the emergence of new species (Briggs *et al.* 1993; Springuel *et al.* 1997).

In this study, we examine the dynamics of the traditional knowledge of the Bedouin community in the Wadi Allaqi area (in the Southeastern Desert of Egypt) in response to major socio-politically induced changes: the formation of Lake Nasser behind the Aswan High Dam in the 1960s and the establishment of a new village in the 2000s. These events forced the members of the Bedouin community to transform their nomadic lifestyle into a much more sedentary one. In our analysis, we distinguish between several demographic groups, as traditional knowledge is not necessarily distributed equally among all community members. More specifically, we consider differences according to gender (Briggs *et al.*, 2003), age (Gedif and Hahn, 2003; Sharif *et al.* 2015), and place of residence (Briggs *et al.* 2007). In one study, Kandal and colleagues (2016) report a loss of knowledge of plant species related to gender and especially to age, hypothesizing that these differences reflect socio-economic developments. In this article, we report on the dynamics of traditional knowledge concerning grazing and charcoal production, traditional treatments, medicines, and diseases, vegetation, handcrafts, navigation, water use, and spirituality according to age, gender, and place of residence. We interpret our findings in terms of community resilience.

Site description

Located about 180 km south of Aswan (Figure 1), the Wadi Allaqi area in the Eastern Desert of southern Egypt is a hyper-arid environment (with an aridity index of less than 0.050). Annual rainfall in this area rarely exceeds 5 mm, and it is highly variable in both time and space. The region is characterized by “wadis” (singular “wadi”), an Arab word that refers to both a valley and a dry riverbed that only incidentally contains water. In Wadi Allaqi, the largest wadi in the southern part of

the Egyptian eastern desert, many years may pass without any rain. It extends over 150 kilometers south-eastward into the northern Sudan and drains from the Red Sea hills into the Nile valley. Despite the harsh conditions in this area, scattered nomadic populations have inhabited the region for thousands of years.

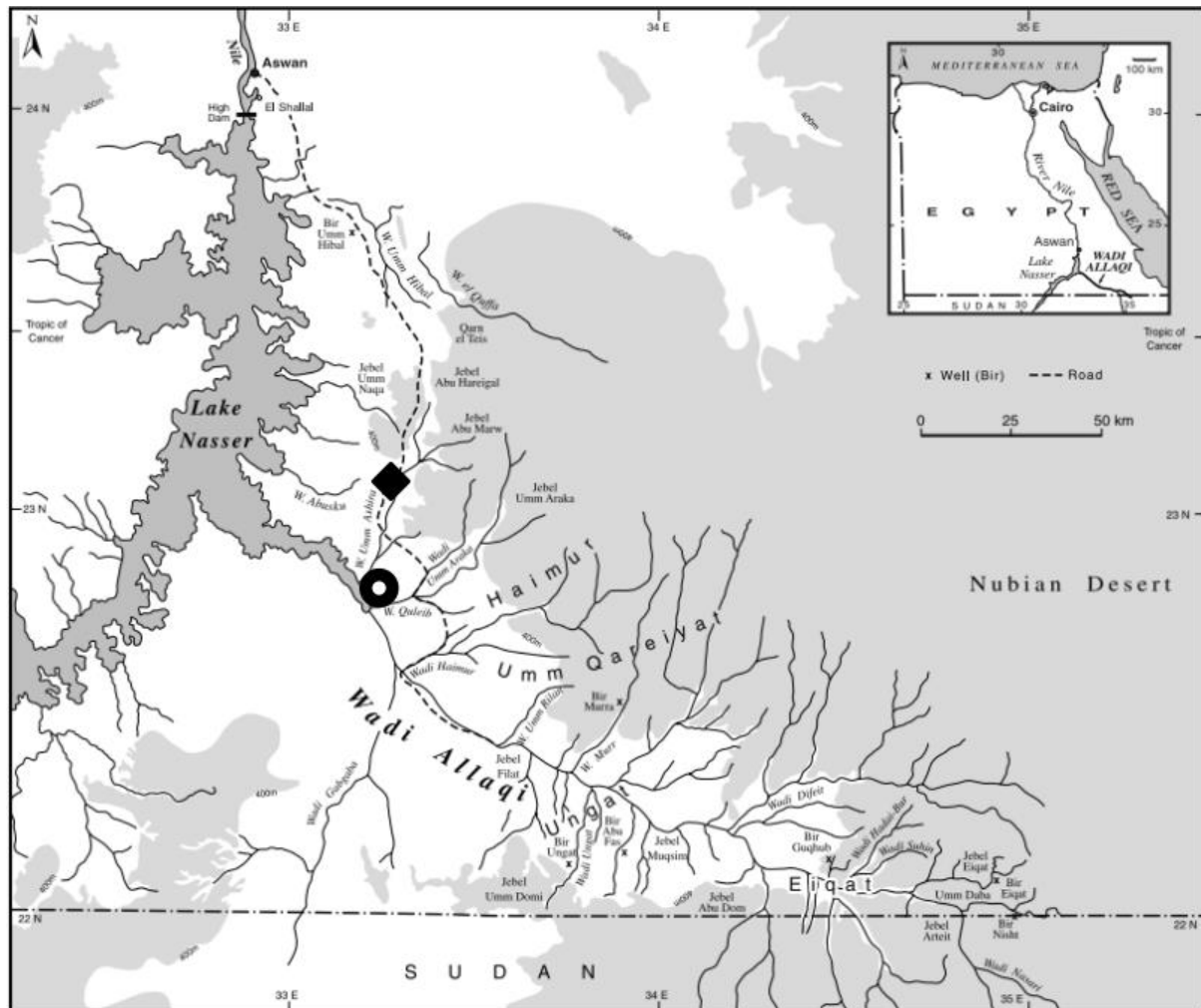


Fig. 1. Location of the study area. Legends: ◆: Allaqi Village;●: Shore of Lake Nasser where Bedouin people live.

The community of the dry Wadi Allaqi region consists of two ethnic groups: the Ababda (singular Abadi) and the Bishari (or Bisharin). Both of these groups are referred to as Bedouins, a generic term derived from the Arab word *Bedu*, which refers to desert nomads (Belal *et al.* 1998). The Ababda may have Arabian roots, they have inhabited Egypt's Eastern Desert at least since the 16th century, and they account for about two-thirds of the population (Mohamed *et al.* 1991). The Bishari stem from the Gebel Elba region and the Red Sea Hills in Sudan, and most written sources regard them as members of the Beja ethnic group (Hobbs, 1989). In some cases, therefore, the Ababda see Bisharin people as “guests,” living within a relatively small area of land in the wadi. Although there are some minor

differences between their livelihood systems, the two groups have similar general characteristics, live together as one community, and are exposed to the same environmental conditions. Moreover, cordial relations exist between the two groups, intermarriage occurs, and the reciprocal use of territory is common. To our knowledge, no substantial conflicts over resources have taken place between them (IDRC, 1997; Solway and Mekki, 1999).

Before the formation of Lake Nasser, the Bedouin lifestyle in Wadi Allaqi was essentially nomadic, with a largely pastoral livelihood. Members of this community lived in the desert in mobile groups without fixed dwellings, using tents constructed from dead acacia wood covered with blankets made from goat and sheep wool (see Figure 2), which could easily be dismantled and rebuilt (Hobbs, 1989; Upton, 1995). They raised animals (sheep, goats, and camels), following the seasonal pastures across the Eastern Desert, carrying all of their belongings with them. The scarce vegetation provided them with food, clothing, fuel, shelter, protection, and medicine (Briggs *et al.* 1993; Belal *et al.* 1998). In addition to grazing their herds, they produced charcoal and collected medicinal plants in the distant hills and wadis. Knowledge of plants and the other Wadi Allaqi resources enabled them to adapt to and survive in the hostile environment (Briggs *et al.* 1999; UNESCO, 1999).



Fig. 2. Bedouin tent. Photo: Hoda Yacoub.

In recent decades (from the 1960s to the 1990s), the Wadi Allaqi area experienced substantial changes in environmental, ecological, socio-economic, and political conditions. One of the most important developments was the construction of the High Dam near Aswan in the 1960s, which led to an

enormous new water reservoir: Lake Nasser (see Figure 3). The reservoir inundated the wadis upstream for about 80 km, resulting in substantial and rapid changes in environmental, ecological, and socio-economic conditions in the surrounding area (Briggs *et al.* 1993; IDRC, 1997).



Fig. 3. Tamarix trees in Lake Nasser during high water. Photo: Hanaa Kandal.

The massive scale and wide variety of Lake Nasser's water level impacted the Wadi Allaqi ecosystem and amplified human-environment interactions (Briggs *et al.* 1993; Solway and Mekki, 1999). A new transitional ecosystem (ecotone) between the completely dry land upstream and the permanently inundated land downstream has developed since the formation of Lake Nasser. As a consequence, the natural resource base for Bedouins in this region has undergone substantial changes as well (Pulford *et al.* 1992; Briggs *et al.* 1993; Briggs, 1995; Briggs *et al.* 1999). The newly developed ecosystem is now dominated by the woody shrub *Tamarix nilotica* (Springuel *et al.* 1989; Pulford *et al.* 1992), accompanied by species that had not been recorded in Wadi Allaqi prior to the formation of Lake Nasser (e.g., *Myriophyllum spicatum* and *Vallisneria spirales*). In addition, the lake has resulted in the massive appearance of various species of *Najas* (an aquatic plant), which have proven useful as a fodder resource (Kassas and Girgis, 1970; Ali, 1987; Yacoub, 2009).

In response to these changes, several Bedouin communities moved to the downstream Wadi Allaqi area and transformed their lifestyles into non-nomadic or semi-nomadic pastoralism, in order to

take the advantage of both the reliable supply of water from the lake and the associated available grazing resources for livestock (El-Dingawy, 1990; Briggs *et al.* 1993). These communities started to settle into semi-permanent residence around Lake Nasser and became more sedentary (White, 1988; Belal, 1992). They used frames of *Tamarix nilotica* wood instead of Acacia for their tents, and they started to use purchased plastic floor mats (Springuel *et al.* 1991). Significant new economic opportunities emerged. In addition to grazing, charcoal production, and medicinal plant collection, the Bedouin people started to practice small-scale agriculture or became involved in trade and wage labor (Mekki and Briggs, 1991; Yacoub, 2018). As a consequence of the new semi-nomadic lifestyle, the men of these communities moved to the previously inhabited higher areas of the Red Sea Hills and wadis only during the winter season, due to the higher incidence of rainfall and, hence, the availability of grazing. The women no longer migrated with them, however, instead remaining close to the water supply of the Lake and surrounding grazing areas, tending to their children and small animals (Briggs *et al.* 1993).



Fig. 4. Houses in Allaqi Village. Photo: Hanaa Kandal.

A new development occurred in the early 2000s, when the Egyptian government built a new village for local inhabitants about 16 km from Lake Nasser to avoid unpredictable inundation. In addition, the government provided Wadi Allaqi people with houses, education, and health facilities in response to the Bedouin people's request for improvements in living standards and facilities (Springuel and Belal, 2001; see Figure 4). Since that time, the process of sedentarization has occurred relatively quickly and smoothly. As a result, most Bedouins in Wadi Allaqi have now adopted a semi-nomadic lifestyle close to Lake Nasser, and some have settled in the new village.

Methodology

This study is based on questionnaires, interviews, and literature. The research was conducted in the Wadi Allaqi area in the Southeastern Desert of Egypt between 2011 and 2015. The questionnaire and interview studies were conducted with Bedouin people settled in the Allaqi Village, as well as with people still living in tents along the shores of Lake Nasser. The village comprises 50 households with 274 inhabitants (EEAA, 2012), although most are not permanently settled in the village. According to unofficial estimates (EEAA, 2014), the Bedouin population has settled on the shores of Lake Nasser, and thus not in the village, in semi-nomadic groups of around 40 people. Accurate population figures are difficult to obtain for people in Wadi Allaqi, as the actual population size in the wadi is continuously affected by many factors, including water levels and available economic opportunities (Mohamed *et al.* 1991).

In all, 81 individuals were involved in our study: 47 respondents had settled in the Allaqi village, and 34 were living as semi-nomadic Bedouins on the shores of Lake Nasser. Familiarity with the respondents had been established through several previous visits (Kandal *et al.* 2016). Survey topics covered key events that have altered the Wadi Allaqi environmental system and the subsequent changes of Bedouin livelihoods.

Data were collected during several visits to Bedouin communities and linked to three demographic features: gender, place of residence (village or shore), and age. In order to obtain a sufficient sample size for assessing age-based differences, we distinguished between people younger than 50 years of age and those 50 years of age and older. This distinction is based on the assumption that older people had experienced life in the desert before the formation of Lake Nasser and that the life experiences of younger people had taken place exclusively or predominantly on the shores of Lake Nasser or in the Allaqi Village.

Table 1. Gender, age and location characteristics of the respondents in the Wadi Allaqi Biosphere Reserve.

Socio-demographic characteristics of the respondents	n = 81	Percentage
Gender		
Male	32	39.5
Female	49	60.5
Age of respondents		
<50 years	54	66.7
≥50 years	27	33.3
Location of respondents		
Lake Nasser	34	42
Allaqi Village	47	58
Men living in Allaqi Village	18	22
Women living in Allaqi Village	29	36
Men living at Lake Nasser	14	17
Women living at Lake Nasser	20	25
Old people living at Lake Nasser	13	16
Young people living at Lake Nasser	21	26
Old people living in Allaqi Village	14	17
Young people living in Allaqi Village	33	41

We used two questionnaires to assess changes in Bedouins' knowledge, practice, and usage of plants and resources. Because the respondents did not understand English, the questionnaires were translated into the native local Arabic language by the first two authors.

Questionnaire I (see Appendix 1) was based on information obtained from previous literature on Wadi Allaqi (Briggs *et al.* 1993; Belal *et al.* 1998; Solway and Mekki, 1999; Briggs *et al.* 1999; Badri and Hamed, 2000; Briggs *et al.* 2003; Sharp *et al.* 2003; Belal *et al.* 2009; Yacoub, 2009). The research objective for Questionnaire I was to evaluate changes in the knowledge of Wadi Allaqi Bedouins by comparing their answers to predefined answers concerning issues relating to rangelands and settlement, which we had derived from the literature. The 15 questions covered four main topics pertaining to variation in key activities and knowledge areas: charcoal production, grazing, medicinal and veterinary plants, and handcrafts. In order to identify personally experienced knowledge and practices, we asked respondents whether their knowledge was based on personal experiences or whether it had been obtained indirectly, e.g., by having heard about it. In this respect, we distinguish

between “experience-based knowledge”, “indirect knowledge”, and “no knowledge” (see Appendix 1). Given our particular interest in experienced knowledge, however, this article focuses on experience-based knowledge.

The use of predefined knowledge statements in Questionnaire I limits the representation of knowledge to the researcher’s frame. In order to identify a wider perspective, we prepared Questionnaire II, which consists of 11 open-ended questions (see Table 2) based on literature (Briggs *et al.* 1993; Belal *et al.* 1998; Briggs *et al.* 2003; Sharp *et al.* 2003; Briggs *et al.* 2007; Belal *et al.* 2009). Questionnaire II allowed informants to present their knowledge of and strategies for various aspects of their livelihoods, especially with regard to issues relating to rangeland and settlement, including desert navigation, water sources, agriculture, spiritual issues (especially with regard to newborns), and the slaughtering of animals in connection with celebrations.

Table 2. Open-ended questions in questionnaire II.

No	Item	Question
1	Navigation and time	How do you recognize your way in the desert?
2	Camel tracking	If one of your camels went away how could you find it?
3	Species for grazing since Lake Nasser	What species do you use for grazing since the formation of Lake Nasser?
4	Water sources since Lake Nasser	Do you use the permanent available water source of Lake Nasser as a resource?
5	Best places for Agriculture	What are the best places for agriculture?
6	Treatment human ailments	How do you treat illness as e.g. headache, stomach ailments, broken legs, etc.?
7	Treatment animal ailments	How do you cure and taking care of livestock and camel illness?
8	Role of evil eyes	Do you believe in evil eyes and how do you deal with this matter?
9	Stranger’s ban on seeing newborn babies	Why are strangers not allowed to see newborn babies?
10	Jewelry and newborn babies	Why do you use jewelry (silver, and shells) for newborn babies?
11	Animal slaughtering at celebrations	How do you manage animal slaughtering for your celebrations?

The Bedouins were interviewed individually, so that their responses would not be affected by others. The interviews were performed by the first two authors, assisted by researchers from the Wadi Allaqi Biosphere Reserve Office at Aswan. All interviews with women were performed by the first two

authors of this study, as non-family males are not permitted to enter the women's area in the Bedouin settlement or home. For these interviews, female researchers sat with women in their houses in the village or tents on the shore, while the men in our research team stayed outside in the guest area with Bedouin men. At first, many Bedouin women were quite worried about the visits; some avoided speaking to us by doing something else, and others avoided us entirely. After a number of visits (Kandal *et al.* 2016) and frequent discussions, the Bedouin women grew accustomed to our visits and became more friendly, relaxed, and welcoming towards the researchers. For the interviews with men, the first two authors of this paper were accompanied by a male research assistant, as it is considered dishonorable for men to meet with female strangers. Bedouin hosts always made *Gabana* (Bedouin coffee), which is a way of showing hospitality.

Each interview lasted about one hour. Because our respondents often expressed reluctance with respect to the use of electronic equipment or handwriting in front of them, the researchers took written notes only with explicit permission from the interviewee. In many cases, the researchers had to memorize the discussion with an interviewee and write up the results as soon as possible thereafter, in collaboration with the interviewers.

Data analysis

We investigated the state of Bedouins' knowledge within several subgroups (men and women, older and younger people, and people living on the shore or in the Allaqi village) by determining how many members of these subgroups gave particular answers to our survey questions. Because we were not able to individualize the collected data from the multiple visits (see above) and because none of the subgroups were identically composed with respect to gender, age, and location, it was necessary to normalize the data *using* the subgroup sizes (see also Kandal *et al.* 2016), such that each normalized subgroup had the same composition with respect to age, gender, and location. Normalization was performed with the formula $S_N = S_{SG} N_T / (N_G * N_{SG})$, where S_N is the normalized score, S_{SG} is the score for a given subgroup (number of people in a subgroup with experience-based knowledge), N_T is the total number of respondents (81 people), N_G is the number of subgroups (a total of 8 groups: based on bifurcation with respect to gender, age, and location), and N_{SG} is subgroup size.

In accordance with this procedure, we classified the normalized scores into three categories – high (H), moderate (M), and low (L) – in order to determine whether the answers were shared by the respondents to a high, moderate, or low extent. A high score was assumed when 2/3 or more of all respondents agreed on a certain item, and a low score when less than 1/3 shared that knowledge. A moderate score fell between these two cut-off point. Because of the sample size (81 respondents), the cut-off point between low and moderate scores and between moderate and high scores were 27 and 54 respondents, respectively. The answers on both questionnaires were analyzed using SPSS 21. Chi-

square, Fisher, and Wilcoxon signed rank tests were used to test for significant differences related to age, gender, and place of residence.

Results

Questionnaire I

Questionnaire I examined the experience-based knowledge of respondents based on predefined questions and answers concerning issues relating to natural resources (e.g., charcoal production, grazing, traditional medical knowledge, and handcrafts). The normalized scores (see the Methods section) and associated Chi-square values for the gender, age, and location subgroups are presented in Table 3. Although there were no significant differences between the location subgroups for any of the items relating to experience-based knowledge, there were several significant differences between the gender and age subgroups.

All of the respondents had relatively high (H) scores on experience-based knowledge for 4 of the 15 items, with no significant differences between the groups according to gender, age, or location (Table 3). These results indicate the preservation of traditional knowledge across all subgroups. Items with high scores on experience-based knowledge include “Favored plant species” and ‘Best season’ for making charcoal, ‘Best species for livestock grazing for goats and sheep’ before Lake Nasser, and “New grazing areas for goats and sheep” after the formation of Lake Nasser. Only two items had low (L) scores for experience-based knowledge: “How to make charcoal?” and “Making handmade pots” (see Table 3). However, with regard to “How to make charcoal?” the subgroups of men and older people had significantly higher scores as compared to women and younger people. In addition, the total score for “Making handmade pots” was extremely low, and only some of the women had any experience-based knowledge with regard to this handcraft.

The experience-based knowledge scores on the remaining nine items were moderate (M). Except for “Treatment of skin diseases”, all exhibited significant differences with respect to gender, age, or both. Both men and older people had significantly more experience-based knowledge concerning “Best places for making charcoal” and “How to make charcoal”. Men also had significantly more experience-based knowledge concerning “Best plant species” and “Best grazing areas before Lake Nasser formation” with respect to sheep and goats grazing. We found no significant age effect for the grazing items (see Table 3).

Women had significantly more experience-based knowledge than men with respect to the treatment of measles, skin diseases, and gynecological diseases and discomforts. In addition, the subgroups for men and older people had significantly more experience-based knowledge on the treatment of camel scabies. Older people also had more knowledge concerning the treatment of eye diseases and making bags from goatskin. Although women did have more experience-based

knowledge concerning making handmade pots than men, very few respondents of either gender possessed this kind of experience-based knowledge (as noted above).

Table 3. Normalized scores (see the section Methods) and statistics of Experience Based Knowledge (EBK) on predefined questions and answers from questionnaire I (see appendix 1). Legends: H, M, L: high, moderate, and low scores of normalized numbers of respondents, where L: $\# < 27$; M: $< 27 \leq 54$; H: $\# > 54$. M, F, O, Y, S, and V: normalized scores of males, females, old people, young people, people living at the shore of Lake Nasser, and people living in the village, respectively. M–F, O–Y and S–V: comparisons of scores for male and female, old and young, and Lake Nasser and Village people, respectively. *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$; ****: $p < 0.0001$; no indication: not-significant.

General topic	Items questionnaire I	Score	Normalized numbers of respondents			
			Total	M – F	O – Y	S – V
Charcoal	What are the favored plant species for making charcoal?	H	71	36 – 36	41 – 31	36 – 36
	What are the best places for making charcoal?	M	40	32 – 9 ***	27 – 14 *	20 – 20
	How do you make charcoal?	L	20	20 – 0 ****	20 – 0 ****	10 – 10
	What is the best season for making charcoal?	H	67	33 – 34	41 – 26	33 – 34
Grazing	Which species are best for livestock grazing (goats & sheep)?	H	71	37 – 33	41 – 30	31 – 40
	Which species are best for camel grazing?	M	32	32 – 0 ****	20 – 12	14 – 18
	What were the grazing areas for goats and sheep before the formation of Lake Nasser?	M	48	34 – 14 **	34 – 14	24 – 23
	What are the new grazing areas for goats and sheep after the formation of Lake Nasser?	H	77	41 – 36	41 – 36	38 – 39
Traditional medicines	How do treat you eye diseases?	M	32	12 – 20	24 – 8 **	17 – 15
	How do you treat measles?	M	34	10 – 24 *	21 – 13	17 – 17
	How do you treat skin diseases?	M	28	16 – 12	17 – 10	14 – 13
	How do you treat gynecological diseases?	M	36	0 – 36 ****	20 – 16	18 – 18
	How do you treat camel scabies?	M	27	27 – 0 ****	20 – 7 **	14 – 14
Handcraft	Do you have the skills to make handmade pots?	L	9	0 – 9 **	6 – 2	5 – 3
	Do you know how to make goat skin-made handbags?	M	40	18 – 22	27 – 13 *	19 – 20

For many items, the results reported in Table 3 indicate a difference between older and younger people, as well as between men and women. These differences are not significant, however, possibly due to the low numbers of respondents with experience-based knowledge on some items. To address this issue, we combined the various items into more general categories: “Topics relating to rangeland” (including charcoal production and grazing issues) and “Topics relating to settlement/home,” (including traditional knowledge concerning medicines and handcrafts). The experience-based knowledge scores for these two general categories are presented in Figure 5. In this case as well, the Wilcoxon signed rank test confirms that location had no impact on experience-based knowledge. Nevertheless, older people had significantly more experience-based knowledge on topics relating to rangeland and settlement. Men had significantly more experience-based knowledge relating to rangeland, but not to settlement.

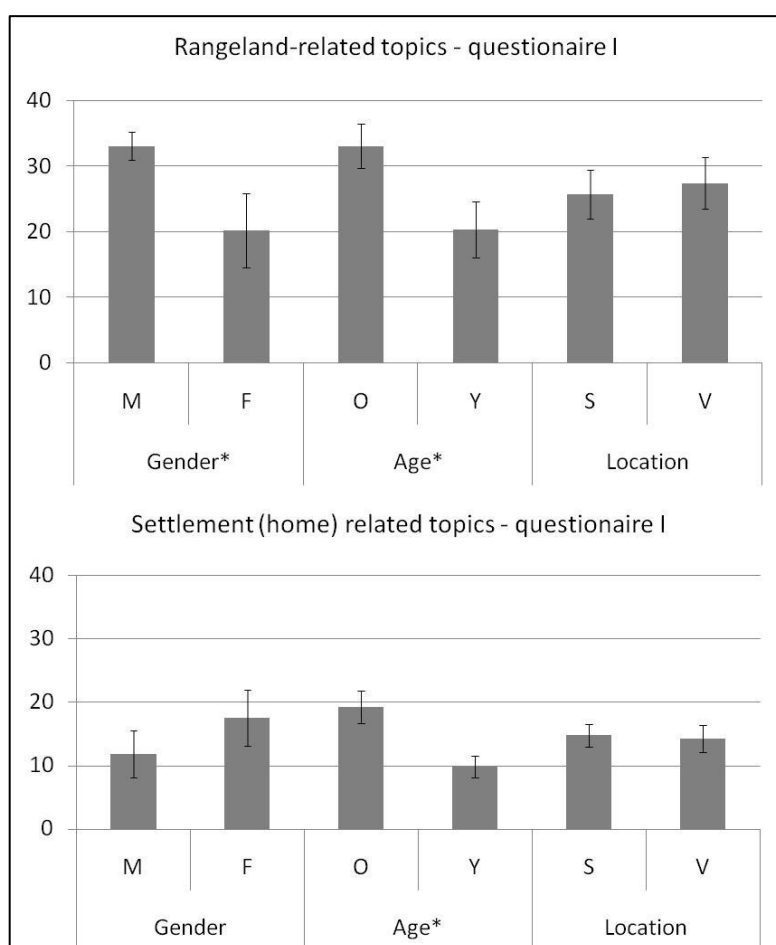


Fig. 5. Means scores of Experience Based Knowledge on rangeland and settlement (home) related topics according to questionnaire I. Legends: Mean \pm SEM of normalized scores of Experience Based Knowledge (questionnaire I) among Bedouin people in Wadi Allaqi. Top: rangeland-related topics: charcoal production and grazing issues. Bottom: settlement (home) related topics: medical knowledge and handcraft making (M=male, F= female, O=old, Y=young, S=shore, V=village, see text). *: $p < 0.05$ (by the Wilcoxon signed rank test in SPSS 21).

Questionnaire II

In contrast to Questionnaire I, Questionnaire II consisted of open-ended questions, and it was intended to identify the respondents' knowledge and strategies relating to several aspects of their livelihoods. In addition to issues relating to rangeland and settlement, these questions and answers included topics that emerged only after the formation of Lake Nasser: agricultural activities and the use of certain plants (*Najas* and *Tamarix* species) for animal feed. Instead of measuring the respondents' levels of knowledge (as in Questionnaire I), these items examined the types of traditional knowledge that they had retained. Similar to the results for Questionnaire I, the results from this questionnaire provided no evidence of differences between the two locations, thus underscoring the high level of knowledge

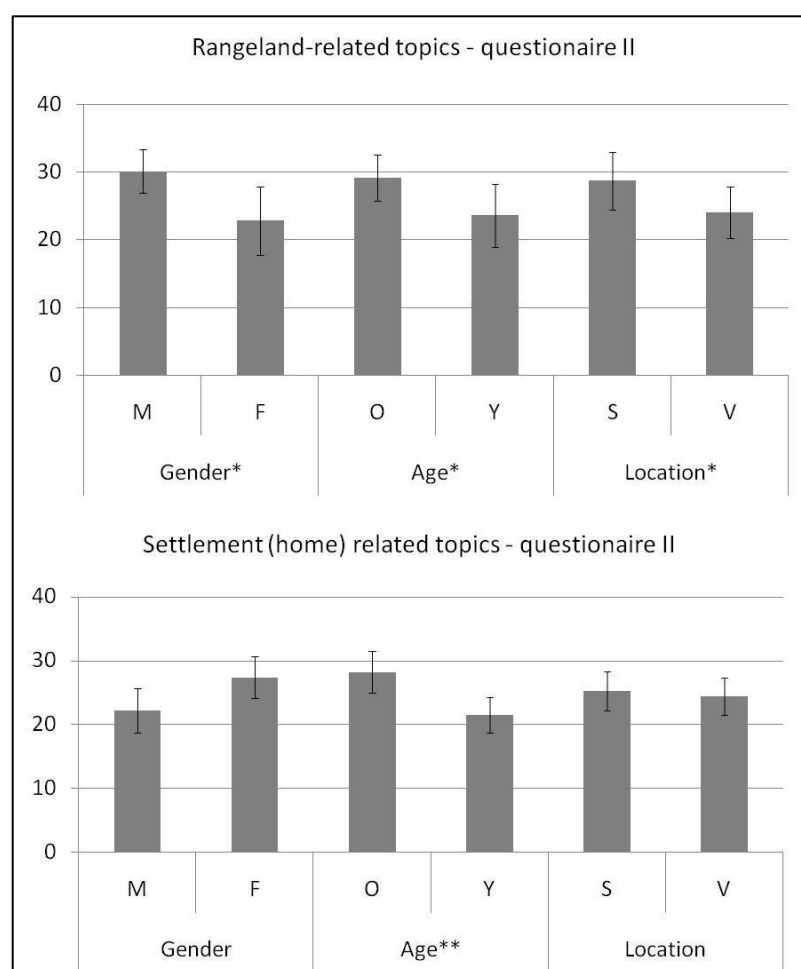


Figure 6. Means scores of types of answers on open questions with respect to rangeland and settlement (home) related topics according to questionnaire II. Mean \pm SEM of normalized scores of answer types to open questions (questionnaire II) by Bedouin people in Wadi Alaqi. Top: rangeland-related topics: items 1-5 in Table 4. Bottom: settlement (home) related topics: items 6-11 in Table 4. (M=male, F= female, O=old, Y=young, S=shore, V=village, see text)*: $p < 0.05$; **: $p < 0.01$ (by the Wilcoxon signed rank test with SPSS 21).

Table 4. Answers to and normalized numbers of open-ended questions (questionnaire II). Legends: H, M, L: high, moderate, and low scores of normalized numbers of respondents, where L: #<27; M: 27≤#<54; H: #>54. M, F, O, Y, S, and V: normalized scores of males, females, old people, young people, people living at the shore of Lake Nasser, and people living in the village, respectively. M–F, O–Y and S–V: comparisons of scores for male and female, old and young, and Lake Nasser and Village people, respectively. The numbers in the first column refers to the question numbers in Table 2. *: p<0.05; **: p< 0.01; ***: p<0.001; ****: p<0.0001; no indication: not-significant.

No.	General topic	Bedouin answers	Score	Normalized numbers of respondents			
				Total	M – F	O – Y	S – V
1	Navigation and time	At night through orientation on star constellations	L	13	13 – 0 ***	11 – 2 *	7 – 6
		At night through orientating on hills and mountains contours	M	28	28 – 0 ****	20 – 8 *	15 – 14
		At day through hill, mountain, and rock signs	H	63	37 – 27	38 – 26	33 – 30
		At day through the length of tree shadows for time measurements	H	77	40 – 37	41 – 36	40 – 37
2	Camel tracking	By looking at footprints on camel tracks	L	14	11 – 3 *	12 – 2 **	6 – 7
		By looking for camel feces	H	72	39 – 34	38 – 34	41 – 32
3	Species for grazing since Lake Nasser	<i>Najas</i> species from Lake Nasser throughout the year without grazing	H	76	38 – 38	38 – 39	41 – 36
		<i>Najas</i> spp. only in the winter and grazing, <i>Tamarix</i> spp. in the summer	H	68	34 – 34	33 – 35	41 – 28
4	Use of water sources since Lake Nasser	Yes, and wells and (<i>gamama</i>) when Lake Nasser has low water tables	M	31	26 – 5 **	22 – 8 *	19 – 11
5	Best places for Agriculture	Near lake Nasser	H	57	24 – 33	27 – 30	33 – 23
		Any place with sufficient water resources	H	80	41 – 40	41 – 40	40 – 41
6	Treatment human ailments	Heated oil on fixed heads against headaches	H	66	33 – 33	41 – 25	37 – 29
		Herbs against stomach ailments	H	65	31 – 34	41 – 25*	36 – 29
		Splinting of broken arms and legs	L	5	4 – 1	5 – 0 *	3 – 2
		Cauterization (heating a body part, usually with a small hot iron rod)	L	5	5 – 0 *	5 – 0 *	2 – 3
7	Treatment animal ailments	Cauterization	H	75	38 – 37	41 – 34	38 – 37
		Splinting of broken arms and legs	H	72	35 – 37	41 – 32	37 – 36
		Using herbs against diarrhea	H	77	38 – 39	41 – 36	39 – 38
		Care taking of pregnant animals	M	43	3 – 40	20 – 23	21 – 21
8	Dealing with threats from 'evil eyes'	Quran reading and prayers (<i>Doaa</i>)	H	67	32 – 35	34 – 33	32 – 35
		Do nothing	L	14	9 – 5	6 – 8	8 – 6
		Incense burning	H	61	27 – 34	38 – 23 *	30 – 31
9	Stranger's ban on seeing newborn babies	In order to prevent evil eye impact	M	32	7 – 24 **	21 – 11	15 – 17
		It is just not good to have strangers around	H	63	26 – 36	33 – 30	32 – 31
10	Using silver and shell amulets in case of newborn babies	For making babies more beautiful	M	49	8 – 41 ****	24 – 25	25 – 24
		In order to prevent evil eye impact	L	24	7 – 18	16 – 8	12 – 12
11	Animal slaughtering at celebrations	In former times there were sufficient animals for celebration with tribe members	H	59	36 – 23	35 – 23	29 – 30
		Nowadays families share animals because of the lack of livestock	H	68	39 – 29	38 – 30	33 – 35

agreement across the locations. Of the 28 responses to 11 questions, 17 reflected a high level of knowledge, with 5 indicating a moderate level and 6 reflecting a low level of knowledge. None of the high scores differed according to gender, and older people had significantly higher scores for only two responses: “Herbs against stomach ailments” and “Incense burning” as treatment for devil eyes.

As indicated by the results reported above, the individual open-ended questions demonstrated a relatively high level of correspondence among the respondents, with only a few answers reflecting significant differences according to gender or age. As we had done with Questionnaire I, we combined several topics from Table 4 into more general categories relating to rangeland (Topics 1-5) and settlement/home (Topics 6-11). As indicated in Figure 6, location also had no impact in this regard, although there was a significant age effect. Men expressed significantly more knowledge on rangeland-related topics, and older people expressed significantly more knowledge on topics relating to both rangeland and settlement/home.

Discussion

As described in the “Site description” section, the history of Wadi Allaqi could be regarded as a process of modernization, illustrated by two prominent events: the formation of Lake Nasser and the subsequent establishment of the village. This process of modernization is obviously much more complicated, however, as demonstrated by Yacoub (2018), who describes the emergence of overgrazing and soil degradation resulting from the formation of Lake Nasser and the appearance of the new grazing fields so close to the Lake. The situation was exacerbated by climate change, prolonged drought, erosion, salty wells, and pesticide pollution from the newly created farmland, forcing some families who had settled permanently on the shores of the Lake to leave the area and migrate to Aswan city. Families who remained learned to cope with these circumstances and developed a grazing strategy involving the use of *Najas* species from the lake as fodder, thereby allowing the rangelands on the shore to recover from grazing each year. The permanent establishment of Bedouin herders along the Lake Nasser shores ultimately led to the establishment of a village, which was also consistent with a strong policy of the Egyptian government. From this perspective, the knowledge base of these communities was likely to have been under pressure since the formation of Lake Nasser in the early 1960s.

Our results confirm this expectation. As indicated by the data summarized in Figures 2 and 3, men and older people in Wadi Allaqi have more experience-based knowledge on rangeland issues, as compared to women or younger people, respectively. For knowledge relating to settlement, older people had significantly more knowledge, but there were no significant differences between men and women. We nevertheless did find significant gender differences for some topics (see Tables 3 and 4). No significant differences in knowledge were found between people living in the village and those living on the shores of Lake Nasser.

Rangeland issues

The age-related decrease in scores on rangeland items indicates a decline in traditional knowledge relating to the Bedouin livelihood. This decline is probably related to the disappearance of the fully nomadic lifestyle in favor of a settlement-based lifestyle following the formation of Lake Nasser (given its associated advantages, as described above). This lifestyle change has also affected other uses of the desert resources. For example, charcoal production was previously regarded largely as a task for men, in conjunction with grazing and the collection of medicinal plants, often in distant meadows, practices that have nearly disappeared since the Bedouins abandoned the pastoral lifestyle (Belal *et al.* 2009). Gender-based differences concerning rangeland topics may have to do with traditional gender roles, as grazing and charcoal activities have typically been the responsibility of males (Briggs *et al.* 1993; Belal *et al.* 2009).

In addition to the changing environmental conditions following the formation of Lake Nasser and the subsequent drought in the last decade, the younger generation's tendency to prefer a more modern life in permanent homes established by the Aswan governorate in order to develop the Wadi Allaqi region has played a role in the developments addressed in this study (Belal *et al.* 2009). In this context, the formation of Lake Nasser and the accompanying presence of both governmental and private-sector institutions and companies have been accompanied by the construction of a paved road and the use of cars instead of camels for transport in Wadi Allaqi. Our results illustrate the loss of traditional knowledge concerning rangeland that occurs as rural societies modernize (see also Godoy *et al.* 2009; Gomez-Baggethun *et al.* 2010; Reyes-García *et al.* 2005).

Settlement issues

Our findings indicate several significant differences between age groups with regard to settlement-related knowledge (Figures 2 and 3). For example, traditional knowledge concerning medicines and handcrafts is disappearing in younger age groups. According to informal discussions during our interviews, however, the medical skills possessed by older Wadi Allaqi Bedouins (often women) are generally still regarded as valuable or important. Younger people are no longer interested in such knowledge, however, and they often prefer to go to the city of Aswan for their health services. These findings support those of Belal and colleagues (2009), who reported a generation gap between older and younger Bedouins in Wadi Allaqi with regard to a wide range of environmental knowledge. More generally, several studies have indicated a decrease in traditional medicinal knowledge among younger generations in traditional communities (see e.g., Kala, 2005; Reyes-García *et al.* 2013; Ahmed and Akhtar, 2016).

Taking all settlement-related topics together (Figures 2 and 3), and in contrast to knowledge relating to rangeland, we found no significant differences between women and men, despite significant differences on several individual issues relating to settlement (see Tables 3 and 4). We

could speculatively attribute this finding to the fact that Bedouin men are currently at home more often, which may reduce knowledge differences with respect to issues that had previously been more specific to women. Nevertheless, some issues (e.g., traditional medicine, handcrafts, and care for newborn babies) are the distinctive domains of women, while men are more skilled in such matters as treating camel scabies.

Community resilience in Wadi Allaqi

Kandal and colleagues (2016) reported a decrease in knowledge of plant species in Wadi Allaqi among younger people (less than 50 years). As demonstrated by the results of our study, this decrease is embedded in the decrease in knowledge concerning a wider array of topics relating to both rangeland and settlement. Despite the decline in traditional knowledge that is reflected in our findings, however, the results reported in Tables 3 and 4 indicate continued high scores for several knowledge items. These items relate to knowledge possessed by most of the Bedouins, regardless of age, gender, or location. Examples include the best season and species for charcoal making and the best current places and plant species for grazing. Our results also indicate high scores for certain new items of knowledge that emerged after the formation of Lake Nasser: the use of aquatic species for animal feed and agriculture (Topics 3 and 5, respectively, in Table 4) and the best places for grazing since Lake Nasser was established (Item 8 in Table 3).

Despite a loss of knowledge with respect to some items, our results also reflect the development of new knowledge and skills, including the replacement of desert plants with aquatic species (e.g., *Najas* spp. and *Tamarix nilotica*) as animal feed (Topic 3 in Table 4) and the development of new agricultural practices (Topic 5 in Table 4) (see also Pulford *et al.* 1992; Belal *et al.* 1998; Briggs *et al.* 1999, 2003; Yacoub 2009). Our respondents have thus developed new sets of knowledge and skills in order to utilize the new resources that have emerged in the wadi. These findings are in line with several studies indicating that changes in traditional knowledge systems are closely related to changes in livelihood (Berkes *et al.* 2001; Ross, 2002; Reyes-García *et al.* 2013).

In contrast to these findings, our results for several topics (see Tables 3 and 4) reveal no loss of knowledge over the generations. This is in accordance with literature that indicates the persistence of traditional knowledge even as societies undergo cultural, economic, and ecological changes (Byg and Balslev, 2001; Lykke *et al.* 2004; Godoy *et al.* 2009). The tendencies toward both the persistence and loss of traditional knowledge are consistent with the claim advanced by Carpenter and colleagues (2001), Folke (2006), and Holling (1973) that the resilience of a social-ecological system emphasizes its capacity to absorb disturbance and maintain the state of the system in response to changing environmental and socio-economic conditions. This implies the capacity to develop and update knowledge through self-reorganization.

In conclusion, both capacities are reflected in developments in the knowledge of the Bedouin community in response to the disturbance caused by the formation of Lake Nasser and the construction of the Aswan High Dam in the 1960s. As such, the dynamics of the Wadi Allaqi socio-ecological system in response to these new conditions may be regarded as an example of community resilience.

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Appendix 1: Predefined knowledge statements questionnaire I. Legends: EBK: experienced based knowledge, InK: indirect knowledge, NK: no knowledge. Questions were asked and answered in the local Arabic language.

No	Question	Answer pre-defined knowledge statements	Degree of knowledge
Topic1: Charcoal production			
1	What are the favored plant species for making charcoal?	Best: <i>Acacia raddiana</i> (Sayaal) Then: <i>Acacia ehrenbergiana</i> (Salam) Least: <i>Balanites aegyptiaca</i> (Higlig)	• EBK • InK • NK
2	What are the best places for making charcoal?	Haimur, Urn Qareiyat and Ungat	• EBK • InK • NK
3	How do you make charcoal?	Dead trees are burned in a shallow hole and covered with sand for several days	• EBK • InK • NK
4	What is the best season for making charcoal?	Winter time	• EBK • InK • NK
Topic 2: Grazing			
5	Which species are best for livestock grazing (goats & sheep)?	For goats: <i>Acacias</i> , <i>Glinus lotoides</i> , <i>Najas</i> spp. For sheep: <i>Glinus lotoides</i> , <i>Tamarix nilotica</i> , <i>Najas</i> spp.	• EBK • InK • NK
6	Which species are best for camel grazing?	Acacias	• EBK • InK • NK
7	What were the grazing areas for goats and sheep before the formation of Lake Nasser formation?	Upstream: Wadi Eiqat, Wadi Seiga, Wadi Defeit Midstream: Wadi Ungat, Wadi Abu Fas, Wadi Haimur Downstream: Wadi Quelib, Wadi Umm Ashira	• EBK • InK • NK
8	What are the new grazing areas for goats and sheep after the formation of Lake Nasser?	Rod Abu Hambol, Ras el-Mayya	• EBK • InK • NK
Topic 3: Plants used as medicine for people and domestic animals			
9	How do treat you eye diseases?	An extract from Acacia leaves (soaked in water) is used as eye drops	• EBK • InK • NK
10	How do you treat measles?	<i>Cleome droserifolia</i> is applied as an incense	• EBK • InK • NK
11	How do you treat skin diseases?	Using ointment made from succulent plant leaves e.g. <i>Calotropis procera</i> .	• EBK • InK • NK
12	How do you treat gynecological diseases?	The legume <i>Acacia nilotica</i> is burned and used as incense to treat inflammations and other postnatal problems; Extracts from this plants (soaked in water) are used as vaginal lotion.	• EBK • InK • NK
13	How do you treat camel scabies?	Oil from <i>Citrullus colocynthis</i> (El-gar) is applied to the infected places	• EBK • InK • NK
Topic 4: Bedouin's handcrafts related to vegetation.			
14	Do you have the skills to make handmade pots? *	EBK: I did or do it by myself InK: know how to do it, but I have no experience myself	• EBK • InK • NK

		NK: I do not know	
15	Do you know how to make goat skin-made handbags? **	EBK: I did or do it by myself InK: know how to do it, but I have no experience myself NK: I do not know	<ul style="list-style-type: none"> • EBK • InK • NK

* so-called “el kapota”, often used for storing coffee and perfumes

** so-called “el gerba”