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Indigenous and scientific knowledge: the choice and management of cultivation sites by bedouin in Upper Egypt

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Abstract. This paper investigates the ways in which some bedouin in the Nubian Desert of southeastern Egypt take decisions about both the choice of site for cultivation and the subsequent management of their soils. It explores the complementarity of formal and informal sciences and how each might profitably inform the other. Results show that the bedouin understand the physical limitations and nutrient supply properties of soils, but not aspects such as pH. Decisions on the choice of cultivation site are often made with regard to other perceived risks, such as soil loss and intermittent inundation, rather than just soil quality. It is also apparent that there exists among bedouin a plurality of indigenous knowledge mediated by factors such as experience, wealth levels, household circumstances and production priorities. Understanding indigenous knowledge is essential in helping to develop better use of the soil in this area, about which little is known and which has only a short history of small scale cropping.

Keywords: Indigenous knowledge, arid soils, site selection, soil management, Egypt

INTRODUCTION

Recent interest in the value of farmers' indigenous knowledge in Less-Developed Countries (LDCs) has largely stemmed from a dissatisfaction with diffusionist and modernization approaches in dealing with poverty, a situation exacerbated by the seeming inability of science and technology to improve living standards significantly for the majority of people in LDCs (Blaikie & Brookfield, 1987; Peet & Watts, 1993; Escobar, 1995). As a consequence, there is considerable interest in understanding indigenous knowledge in LDCs, and how this might be incorporated into development discourses (e.g. Richards, 1985; Chambers *et al*, 1989; Okali *et al.*, 1994; Osunade, 1994; Leach & Mearns, 1996; Reij *et al.*, 1996; Sillitoe, 1998).

With specific reference to soils, work on indigenous knowledge across a range of cultural and ecological regions has demonstrated the importance of soil colour and texture (or 'feel') as key attributes identifying soil quality for LDC farmers (Lamers & Feil, 1995; Sandor & Furbee, 1996; Kundiri *et al.*, 1997). Ostberg (1995), in his excellent study in central Tanzania, talks about farmers seeing land as 'cooled', and therefore at its best for cultivation. But as land is used, it becomes 'tired', and eventually 'hot', at which point it can no longer be cultivated. Other work has adopted a rather more traditional approach by identifying soil types based on chemical and/or morphological properties. De Queiroz & Norton (1992), for example, frame local soil knowledge within a western pedologist's conceptualization. Others are rather more sympathetic in the sense of recognising that the criteria used by western-trained pedologists may be of only limited relevance to the needs of farmers in the rural areas of LDCs (Sillitoe, 1996; Habarurema & Steiner, 1997).

Currently, there appears to be some tension between the contributions of indigenous knowledge and formal science. Maddox *et al.* (1996) have usefully captured this in their conceptualization of a 'Merrie Africa' and a 'Primitive Africa'. The former is characterized as dominated by indigenous knowledge operating in harmony with nature, whilst the latter suggests a condition of hostile, threatening environments, a condition which, of course, can only be successfully treated by the application of capital and technology. Both views, however, seriously underestimate the capacity for constructive transformation from within rural communities themselves; both, to a greater or lesser extent, are dismissive of the utility of indigenous knowledge (Tiffen *et al.*, 1994). However, it is increasingly clear that such polar extremes are untenable, and there is greater sympathy for the view that indigenous knowledge represents a complementary, not competing, set of knowledge, and that it somehow represents a sense of additionality (Reij *et al.*, 1996).

This study aims to investigate the ways in which some bedouin in the Nubian Desert of southeastern Egypt take decisions about both the choice of site for cultivation and the subsequent management of such soils. Whereas most work so far has focused on well-established cultivators, this study investigates soil knowledge of people who have only recently started cultivating, and for whom cultivation is a relatively minor activity.

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STUDY SITE AND METHODS

Background to study site

Wadi Allaqi is the largest wadi in the Eastern Desert of Egypt, situated on the eastern shore of Lake Nasser about 180 km south of Aswan (Fig. 1). Lake water has penetrated into the wadi up to about 80 km from the pre-inundation Nile channel. At the moment, with the lake approaching its maximum level, the shoreline is in part of the wadi which is 1–2 km wide. It is here that the bedouin have settled and are undertaking small-scale cropping. Briggs *et al.* (1993) identified two major processes of water movement which cause movement of soil within the wadi: (a) infrequent and erratic torrential flows of surface water following heavy rains in the Red Sea Hills, and, more importantly, (b) movement of the Lake Nasser shoreline. The first process has resulted in a runnel of finer soil particles in the centre of the wadi, while the second has resulted in the deposition of lacustrine sediment over much of the downstream part of Wadi Allaqi.

The introduction of water into this hyperarid environment has had a major impact on the ecology and resource base of the region. As a result of the changes in vegetation and the availability of lake water and shallow seepage water, some 200–250 bedouin have settled in the wadi over the last 17 years. They come from two groups: the Ababda, who form the dominant group and had originally been resident in the southeastern Egyptian Desert, and the Bishari, who are originally from the Red Sea Hills of northeast Sudan (Briggs *et al.*, 1993; Hobbs, 1989). The livelihood system of the bedouin is based upon five activities: charcoal production, sheep herding, camel herding, medicinal plant collection and cultivation of crops (Briggs, 1995). All of these activities are strongly related to resource availability, and in the case of cultivation especially to the availability of water.

Methods

A survey of bedouin living in Wadi Allaqi was undertaken using a checklist-questionnaire to gain information about the best general locations of preferred cultivation sites. Scoring of the importance of factors which led to the selection of such locations was on a 5-point scale from 0 (very unimportant/irrelevant) to 4 (very important). This was designed to draw out the underlying rationale for such choices, and, in particular, the key decision factors. This was followed up by probing knowledge with regard to soil management, before concluding discussions with bedouin perceptions on soil quality in the area. The emphasis throughout was on bedouin knowledge, and although the checklist-questionnaire provided a structure to discussions, it was sufficiently flexible to allow the development of broader debates. A total of 28 interviews took place with heads of households, giving a full cover of all households present in Wadi Allaqi at the time of the survey. Of these, just over 78% of the interviews were with Ababda households, and the rest with Bishari, broadly in line with the ethnic division in Wadi Allaqi. Most interviews were completed in less than half an hour, although most discussions lasted significantly longer as many bedouin wished to talk further about soil use and management. A further method for gaining information involved group discussions, some of which predated the present survey as they formed part of the larger Wadi Allaqi Project (Briggs *et al.*, 1993). These discussions proved to be particularly valuable in that their unstructured nature encouraged bedouin to talk freely, and, in some cases, at length, about soil management.

Soil characteristics identified by the bedouin in the questionnaire survey and discussions were related to information from soil analyses carried out over the ten years of the Allaqi Project and described elsewhere (Pulford *et al.*, 1992; Briggs *et al.*, 1993). Where necessary, additional soil samples were taken to confirm data for specific soil types.

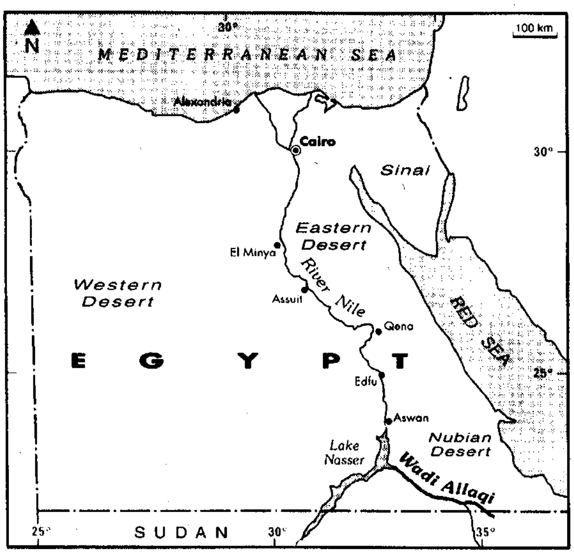

Fig. 1. Location of Wadi Allaqi.

RESULTS AND DISCUSSION

Over the last 10 years many bedouin have taken cultivation increasingly seriously, not as replacement for livestock herding, but rather as a complementary activity, and one which spreads risk somewhat more widely. A measure of this can be seen in Table 1. All 28 households now grow at least two crops per year, a significant increase on the early 1990s when only just over one-half of households in the area were growing crops. Moreover, the mode was six crops, and 17 different crops were being grown at the time of the survey. Watermelons, maize and wheat are easily the most popular, followed by sorghum and tomatoes. Some households are taking the opportunity to plant permanent tree crops.

Choice of cultivation site

There was some disagreement among bedouin as to the best site for cultivation (Table 1) with opinions split between three areas: (a) the runnel; (b) the edge of the wadi; or (c) the lakeshore. To some extent the choice of preferred site depended on the ethnic group of the respondent. Four out of the six Bishari respondents preferred the runnel, but the situation was far less clear with regard to Ababda respondents; of the 22, nine preferred the edge of the wadi, seven the runnel and six the lakeshore. It may be significant that the Bishari, as relatively recent arrivals in Wadi Allaqi, appear to have a rather greater consensus view of the best locations for cultivation. This may be due to the fact that Bishari experience of cultivation in the desert has been rather limited, a reflection of opportunity, and where it did take place, it was typically confined to runnels within wadis. The Bishari have, therefore, simply transferred previous experiences across differing

Table 1. Information on crops grown and siting of plots (number of bedouin interviewed = 28).

a) Number of crops grown on the plot

Number of crops	Number of bedouin	%
2	1	3.6
3	2	7.1
4	4	14.3
5	5	17.9
6	8	28.5
7	5	17.9
8	3	10.7

b) Number of bedouin growing each crop

Crop	Number of bedouin	%
watermelon	25	89.3
maize	23	82.1
wheat	20	71.4
sorghum	15	53.6
tomato	13	46.4
okra	9	32.1
hibiscus	8	28.6
Trifolium	7	25.0
onion	5	17.9
lemon	5	17.9
barley	4	14.3
moulikiya	4	14.3
lupins	3	10.7
lettuce	2	7.1
date palm	2	7.1
Acacia	2	7.1
lubia	1	3.6

c) Most favoured site for cultivation

	Number of bedouin	%
In the runnel	11	39.3
At the edge of the wadi	9	32.1
Near to the lake shore	7	25.0
Depends on the water source	1	3.6

environments, and come to the conclusion, based on limited Allaqi experience, that the runnel still affords the best potential. On the other hand, the Ababda, with a longer history of settlement in Wadi Allaqi, have had the time to develop experiences based on all three alternatives, and have developed strategies to suit particular needs under differing household circumstances.

Very clear advantages were perceived of a site in the runnel. Many talked about the soil being finer and hence more fertile, although some were well aware that the longer the time-periods between flow events, the drier the soil becomes and the more susceptible it is to wind erosion and removal. In this context, several respondents suggested that the runnels in tributary wadis, where flow events may be more infrequent and more spatially concentrated on the wadi floor, are preferable to those found in Wadi Allaqi itself. However, there was a clear division of opinion about the reliability of the runnels for cultivation, in the sense that water flow, which provides the rationale for cultivation, is also seen to be a major disincentive in that it can lead to loss and destruction of crops from flooding. Seven bedouin specifically mentioned the impact of torrents, and further suggested that this was the key reason why they chose sites away from the runnel. The strength of view on this may be a reflection of recent experiences, as a number of torrent events took place in the Allaqi region during the winter of 1996–97, and memories of crop loss and other destruction were still fresh in the minds of many. There was the further view that as the runnels support some vegetation, however scarce, dabuka (camel trains) tend to follow these paths in Wadi Allaqi, and hence any cultivation is somewhat vulnerable to opportunistic camel grazing.

Of the three areas identified, the runnel is physically the most distinct, with surface cracking of the sediment and trapping of sediment by vegetation. The finer texture of these soils was identified by the bedouin as being a positive feature for cultivation, an observation which may have been supported by the greater density of vegetation in the runnel, but emphasis was placed on physical factors, such as water retention, rather than nutrient supply, although this was recognised to some extent.

There is less clear cut evidence for the value of the soils at the edge of the wadi. Deposits of wind-blown soil have collected here, but, even though these soils had a somewhat elevated content of fine sand, silt and clay size particles, they tended to be less stable and prone to dispersal by wind. There is also the disadvantage that rocks and stones may fall down from the hills at the side of the wadi into these areas, a feature clearly identified as being a disincentive to cultivation. Such areas are not, however, in danger of inundation by lake water or subject to the effects of flowing water in torrents, unless situated at the mouth of a tributary wadi. It appears that this security is rated more highly by some bedouin than soil quality in the choice of cultivation site.

Lakeshore sites attracted a number of bedouin, with virtually all respondents acknowledging the high quality of lake-derived soils and recognising that annual inundation by Lake Nasser maintains fertility. In addition, the lake provides a reliable source of water for irrigation. However, most took the view that this is not a preferred site because of the annual, and unpredictable, flooding by Lake Nasser during the autumn and the first part of the winter. An interesting view was provided by one bedouin who said that 'for an experimental farm the best location is the lake shore, but for a longer-term productive farm it is better to be in the runnel'. The reasoning used was that the experiments were best carried out under conditions of water reliability, whereas once a rather longer-term perspective was being used, then investments would be less frequently threatened by torrents in the runnel than by inundation by Lake Nasser. There may be a view, held by some, that in any case access to water is a more important determinant of cultivation site than soil quality.

Inundation by lake water, in addition to depositing a layer of lacustrine sediment, has a considerable influence on soil properties, especially on the content of soluble salts. Briggs *et al.* (1993) showed that soils and vegetation changed markedly with distance from the lake shore and this is supported by data for the soils collected in this study (Table 2). Very recently-inundated soil has a low conductivity and total dissolved solids content as a result of dissolution and dispersal by lake water. After a short time of exposure following inundation, evaporation from the soil results in the concentration of salts at the surface, giving the soil a white colour. Without doubt, soils with a white colour were perceived by bedouin in a highly negative way, a view which can be supported by the high conductivity of the soil. Bedouin are well aware of the problems of salinity in the area, with some considering it to be their biggest challenge. Salinity is further exacerbated by the growth of *Tamarix*, which concentrates salt in the leaves, resulting in high soluble salt content of

Table 2. Properties of soils from Wadi Allaqi.

a) Soils from lake edge collected for this study

Soil	gravel (%)	pH	EC ($dS\ m^{-1}$)	TDS ($mg\ l^{-1}$)
Red sand, above high water line	0.5	6.60	4.89	3260
Red sand, damp, on border with dry sand	0.4	6.37	7.82	5230
Dry sand, 2 m above high water line	0.4	7.6	0.18	118
Light brown sand, recently inundated	14.7	7.71	0.15	104
White sand, recently inundated	26.8	6.88	1.72	1163
Brown sand, damp at surface, very recently inundated	36.5	7.55	0.26	174
Brown sand at lake shore, under mature *Tamarix*, very recently inundated	23.9	7.50	0.20	136
Brown sand at lake shore, under dead *Tamarix* but with litter layer, very recently inundated	7.1	7.23	0.32	210

† Total dissolved solids

b) Summary of properties of topsoils of Wadi Allaqi

	Minimum	Maximum	Median
pH	7.00	9.09	8.05
Conductivity ($dS\ m^{-1}$)	0.11	16.4	0.81
Coarse sand (%)	5.7	98	56
Fine sand (%)	0.2	80	31
Silt (%)	0.05	33	4.3
Clay (%)	0.20	29	5.2
NH_4OAc ext Ca ($mg\ kg^{-1}$)	103	2180	600
NH_4OAc ext Mg ($mg\ kg^{-1}$)	nd	560	24
NH_4OAc ext K ($mg\ kg^{-1}$)	36	9062	229
NH_4OAc ext Na ($mg\ kg^{-1}$)	40	18791	459

the surface layers of soil when the leaves die and are shed. The link between *Tamarix* cover, found especially in the lake-shore area, and high levels of salinity in the soils is well understood; eight bedouin specifically made mention of the fact that they prefer sites in which there is no *Tamarix* present.

With regard to the choice of specific site, it appears that the colour of the soil and the ease of clearing vegetation are the two key factors (Table 3). Soil colour was raised and discussed, sometimes at length, by virtually all respondents. As mentioned above, white soils were clearly recognised as unsuitable for cultivation. The preferred colour was invariably described as yellow with perhaps a reddish-brown tinge, although some mention was made by three respondents to darker red soils sometimes being better, especially if found relatively near the lake shore. This latter comment is not supported by soil analysis, as high conductivity values were measured for the red soils found around the high water line, which are visually very distinct and do not support vegetation naturally; this highlights the highly subjective nature of soil colour. Either the lack of vegetation, especially *Tamarix* due to the salinization problem outlined above, or if there is vegetation present its ease of clearance, are important location decision factors. Dense vegetation can be dangerous due to the presence of snakes and scorpions. It requires considerable effort to clear dense vegetation; even following burning there may be thick stems and roots of *Tamarix* which need to be removed.

From discussion, even though it is not immediately apparent from Table 3, the feel of the soil is probably as important as the colour. The best soils were considered to be 'smooth' with a 'sandy/clay' combination. Indeed, the importance of a fine sand content was widely acknowledged as 'it helps drainage'. Interestingly, it was the drainage which was widely seen to be important in maintaining fertility, rather than the ability of the soil to supply nutrients. This is helped by the soil being 'loose'. Coarse sand is to be avoided if at all possible, and soils which contain significant amounts of gravels and/or stones are definitely to be avoided; eight respondents specifically mentioned this without prompting. The reasons for such avoidance include the difficulty of working such soils, as well as their limited fertility. Even in areas where finer soil particle are found in higher amounts, such as the runnel, the sand fractions dominated. There did, however, appear to be a trade off between silt plus clay and the combined sand fractions, whereas coarse sand increased at the expense of fine sand and *vice versa*.

Management of soils

The overwhelming view expressed was that although the soils are high quality, they are fragile and in need of careful management. This was manifested in a number of ways, but particularly with regard to fertilizer use (Table 3). Although most recognised the need for less fertilizer on clay-rich soils, nonetheless every respondent considered that fertilizer use is necessary to a greater or lesser extent on Allaqi soils. Indeed, some respondents talked about bringing clay from other areas, such as the wadi edge, to increase the clay content of cultivated soils to improve fertility. The most common fertilizer source is sheep or goat dung obtained from grazing animals on land which is to be subsequently cultivated. However, this was also considered to be a less than satisfactory source, especially in terms of volume but also in terms of

Table 3. Information on soil and management factors.

a) Importance of location factors in site choice

	4	3	2	1	0	Score	%
Colour of the soil	25	2	0	0	1	106	94.6
Ease of clearing vegetation	21	7	0	0	0	105	93.8
Site has no vegetation on it	20	6	0	0	2	98	87.5
Feel of the soil	20	4	3	0	1	98	87.5
Previous use of the site	16	3	7	0	2	87	77.7

b) Importance of different sources of fertilizer

	4	3	2	1	0	Score	%
Goat/sheep dung (*in situ*)	15	2	2	7	2	77	68.8
Burnt vegetation	8	4	4	1	11	53	47.3
Goat/sheep dung (carried)	7	4	4	2	11	50	44.6
Bagged chemical fertilizer	7	1	3	2	15	39	34.8
Household waste	0	2	0	2	24	8	7.1

c) Importance of physical operations for successful cultivation

	4	3	2	1	0	Score	%
Clearing	23	3	2	0	0	105	93.8
Fencing	25	0	1	0	2	102	91.1
Weeding	21	2	3	2	0	98	87.5
Irrigation channels	20	3	3	2	0	97	86.6
Levelling	17	7	4	0	0	97	86.6
Bird scaring	19	4	4	0	1	96	85.7
Preparation/tilling	18	6	1	2	1	94	83.9

The scale runs from 4 = very important to 0 = very unimportant/irrelevant.

quality; the generally poor quality of grazing material results in relatively poor quality dung in terms of fertility. Some supplemented this source of *in situ* dung by transporting in extra loads from other locations. Dung was seen as being particularly important for water melons and maize, as well as for some tree crops, particularly lemons. Burnt vegetation was valued as a realistic alternative, with the advantage that it gives greater control over volumes applied. Five bedouin raised this separately and without being solicited, and talked at length about the perceived advantages of burnt vegetation. It was considered to be a particularly effective fertilizer for tomatoes and watermelons, as well as being a preventative measure against insect damage, a particular problem for watermelons.

The use of chemical fertilizer generated considerable discussion and disagreement among respondents. Table 3 demonstrates, to an extent, a bipolar response; just over one-half of respondents considered chemical fertilizer to be very unimportant or irrelevant as far as they are concerned, but another seven (the second largest group) took the opposite view. The only points on which all appeared to be in agreement related to the expense of buying such fertilizer and a questioning of how cost-effective it is anyway in the context of their agriculture. A strong view expressed by those not using such a source was that the soils are sufficiently fertile in their present form and do not require extra inputs, at least not from such an expensive source. Moreover, there was the further view that the use of chemical fertilizer adds to salinity levels, an extra threat which cannot be tolerated. Two respondents were very firmly of this view, both Bishari. Interestingly, the decision as to whether to use chemical fertilizer was frequently determined by whether the crop is to be sold. This was especially the case for both watermelons and tomatoes. Most recognised that the use of chemical fertilizer produced larger fruits, but at the expense of taste.

There was also recognition that use of chemical fertilizer requires access to reliable and quite large amounts of water to be effective, and herein lies a further problem. Many, but not all, households have access to petrol-driven pumps, but only with limited capacities. Consequently, this is a key constraint on the area of land cultivated. More significant, however, is water reliability. The typical annual variation in the water level of Lake Nasser of between 6 and 8 metres translates to a lateral variation along the floor of Wadi Allaqi of up to 10 km between the high and low water levels. As a result, cultivated plots which start off being located within 1 km of the lake shore, and hence with few difficulties of water access, can find themselves three months later being 6–7 km away, with all the resultant problems for successful cultivation of a limited water supply, which frequently becomes brackish. For many of the bedouin this was the key issue, rather than soil fertility.

Most respondents took the physical management of the soil seriously (Table 3). Land clearing and fencing were the two most important tasks for most, and to a degree they are related. Vegetation that is cleared is then used as fencing material. This is crucial as growing crops need protecting from marauding sheep, goats and camels, all of which are seen as particular pests by bedouin. Bird scaring is another important task. Wadi Allaqi is an important bird flyway between East Africa and Europe, and crop losses from bird attack is a major issue among bedouin cultivators. This received 11 specific unsolicited citations, the most commonly reported complaint. Various measures are taken including covering crops with fishing nets or attaching old clothes, cans and even bits of dead birds to ropes which are then strung across the plots over the growing crops.

CONCLUSIONS

From responses to the questionnaire and subsequent discussions, it is possible to distinguish three broad areas of bedouin understanding of soil characteristics. There is a good understanding of physical characteristics of soils, especially in relation to aspects such as water retention, drainage and erosion risk. These are all factors which are readily observed visually and therefore can easily be absorbed into the indigenous knowledge of the bedouin. The results of this study support those of earlier work (e.g. Lamers & Feil, 1995; Sandor & Furbee, 1996; Kundiri *et al.*, 1997) in identifying soil colour and texture as key characteristics in soil quality for LDC farmers. Significantly, this study shows that this also applies to relatively recent adoptees of cultivation methods, as well as to the more experienced cultivators of earlier studies referred to above.

Less easily observable, but also understood by the bedouin, is soil fertility. Clearly understood is the value of natural materials such as animal dung and plant ash, possibly as a result of observing improved vegetation growth in soil to which these materials had been added as a result of grazing or burning of vegetation. They are equally aware of the use of synthetic fertilizers, but also of their cost and effects on food quality.

The third area is concerned with those soil characteristics about which the bedouin are apparently unaware. This is exemplified by pH, a factor argued by science as a major controlling parameter in many soils, and a soil measurement from which much other information about a soil can be inferred. Unsurprisingly, perhaps, pH *per se* was not raised in any of the discussions, but, more significantly, nor was there any mention by bedouin of acidity/alkalinity issues either. This may be because the soils of the area, although alkaline, show no extremes of acidity or alkalininty. It may be that what science understands as pH is simply not important for bedouin in this setting. Alternatively, pH is not a factor which is immediately apparent by visual observation, except in cases of pH extremes where vegetation is killed off or will not grow. It may well be that bedouin recognise that under such circumstances there is a soil problem, but it is attributed rather to high salt content rather than a high alkaline pH. Clearly, however, morphological parameters are more important in assessing soil quality than chemical ones in the context of indigenous knowledge.

A major factor in the decision of the choice of site for cultivation plot is the risk to the crops from their location, especially in relation to flowing water from infrequent torrents or the more predictable inundation by lake water. While not characteristics of the soil *per se*, these are factors which are central to the indigenous knowledge bases through observation or, very often, direct experience. Furthermore, they may have a much more direct and catastrophic effect on crops, and hence on the effort expended in growing the crops, than, for example, a marginal decrease in yield due to insufficient nutrient supply.

Despite relevant knowledge possessed by bedouin on soils, it has to be recognised that most are nonetheless using soils for cultivation only because grazing and charcoal resources alone do not provide sufficient levels of income to support household reproduction. There is, indeed, an ambivalent attitude towards cultivation, with many taking the view that cultivation does not represent an economically realistic alternative to livestock herding. A common view was that it was not worth committing scarce labour resources to cultivation, when greater levels of expertise are available for sheep herding and production. However, it would be misleading to suggest that the view that cultivation is irrelevant is universally held among bedouin; 13 (including 4 Bishari) out of the 28 in the survey talked about crops and livestock being complementary activities, recognising however that the soils need a significant amount of care if they are to satisfy needs and remain productive. There is a third, minority, view which suggests that cultivation is preferred to livestock herding, and especially so if water availability is not an issue, in that crop production is seen as being easier to manage than livestock. Moreover, there is the reward of 'soils responding to effort'.

Although this study clearly demonstrates the areas of common ground (and otherwise) between scientific and indigenous knowledge, it does raise a fundamental question relating to the extent to which formal (scientific) and people's (indigenous) sciences are complementary and, perhaps more importantly, conflicting. For example, both sets of knowledge see the clay content of soils as an important characteristic for successful cultivation. Bedouin determine the soil's suitability by touch and feel, and see the clay as being less to do with fertility and more with water retention capacities, a factor of crucial importance in arid environments. On the other hand, pH, a factor central to soil science, is largely irrelevant. Whether this is because there are no extremes of pH, and so it is irrelevant to these soils (but bedouin may be aware of it, although conceptualized in a different form), or whether this is a factor unknown to bedouin is worthy of further research. Indeed, although great emphasis is placed in development debates on soil fertility and its maintenance, knowledge about this is less important among the bedouin of the Eastern Desert than knowledge on access to reliable water, the water retention capacities of soils, and security from damaging floods. It is also apparent that there exists among bedouin a plurality of indigenous knowledge mediated by factors such as experience, wealth levels, household circumstances and production priorities. Understanding indigenous knowledge is essential in helping to develop better use of the soil in this area, about which little is known and which has only a short history of small scale cropping.

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