

# Grazing Intensity and Socioeconomic Activities in Wadi Allaqi Biosphere Reserve, South Egypt

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# Abstract

Natural resources, human and socioeconomic activities data were collected directly from human beings at the downstream and upstream parts of Wadi Allaqi. A survey of Bedouin living in this wadi was undertaken using an open-ended questionnaire to gain information about the best general critical factors that controlling the natural recourses of economic activities and their type, only for men bediouns, furthermore, grazing intensity was estimated. Domestic and wild animals can graze and browse on 58.8% of the total recorded species in Wadi Allaqi. As well as the highly palatable species, some camels can graze over 20 plant species that are usually avoided by other animals. About 38% species in the study area have low palatability, 16.5% species are unpalatable and 13.4% are known to be browsed by camels with some exception (*Crotalaria aegyptiaca* which is poisonous to goats and sheep). Sheep and camel herding, charcoal production, small-scale cultivation, and medicinal plant collections developed a system by Bedouin near Nasser Lake. Out of 93.3% of Bedouin reported that Lake Nasser fluctuation affected their production. Some 13.3% of Ababda and 26.8% Bishari Bedouins agree that the second key which effect their life is the rainfall incidence.

**Key words:** Wadi Allaqi, grazing intensity, sustainable uses, Socioeconomic activities, palatability

## Introduction

There has been much debate on the impact of livestock grazing on plant communities. Some researchers suggest positive impacts due to light grazing intensity with reported increases in plant diversity (Ayyad and El-Kady 1982; Pulungan 2019; Mohamed et al. 2020), while others reported significant negative impacts (Shaltout et al. 1996; Herrero-Jáuregui and Oesterheld 2017). The properties of these impacts, ranging from simple losses in cover (Shaltout et al. 1996; Eccard et al. 2000; Kurtz et al. 2018), to variations in general vegetation diversity (Ayyad and El-Kady 1982; Herrero-Jáuregui and Oesterheld 2017). Loss of perennial cover is associated with increased geophyte cover and dominance of less palatable species in response to the selective grazing pressure (Todd and Hoffman 2000; Wang and Tang 2019).

Nowadays considerable attention has been paid in Africa to the inter-relationship between human activity and natural resource use and management (Harrison 1991; Lewis and Berry 1988; Anderson and Hoffman 2006; United Nations 2019). Possibly triggered by the Sahel drought of the 1970s, the debate has since broadened to take issues such as population growth (World Bank 1993) and sustainable development (Smith 1993). Nevertheless, the central principle has remained the human natural environment interface; much of the debate has been concerned with resource overuse and abuse, and with the understanding and alleviation of stress conditions. Consequently, the human-natural resource relationship has frequently been portraying in antagonistic terms, dominated by negative and even hostile perceptions, in which the players may be interpreted as passive victims or even worse.

Living in extremely arid conditions with very limited resources and completely depending on these resources, local inhabitants (Bedouins) have developed their own means of managing sustainable yields of benefits. In south-east Egypt, the livelihood of the two nomadic tribes in Wadi Allaqi (Ababda and Bishariin) is slightly different from that of the Khushmaan tribe from the Eastern Desert (Warren 1984; Hobbs 1985; Watts 1987). But in general, individual perennial biota, spaces that occupy, and human benifaction of resources are the central components of environmental management for nomadic groups.

The main aim of this work is evaluating the grazing potentiality and grazing intensity in Wadi Allaqi Biosphere Reserve (WABR) as a rangeland area for the local inhabitants. In addition, natural resources survey of human and socioeconomic activities was done to assess their sustainable uses and provide basis for their conservation.

## MATERIAL AND METHODS

### Study area

Wadi Allaqi Biosphere Reserve is situated in the Egyptian Nubian Desert (i.e. Egyptian South-Eastern Desert). It is located south of Aswan for about 180 km, on the eastern bank of Nasser Lake (between latitude 22° and 23° N, and longitude 33° and 35° E), comprises an area of about 22,600 km<sup>2</sup>. It creates one of the largest drainage networks in the Egyptian Eastern Desert. Some of the mountains that separate the Nile Valley from the Red Sea coastal plain are drained by its upstream tributaries. This wadi is around 350 km long and 1 km width; it is narrower upstream and significantly wider downstream as it gets closer to Nasser Lake (**Fig. 1**). Water resources of this area are rare and represented mainly by some important wells that carry good potable water, but in limited quantities. Its lower part is now inundated by water of Nasser Lake (Springuel and Sheded 1991; Pulford et al. 1992). The upstream part is elevated; however the surrounding mountains are high such as Gebel Eiqat that rises up to 1148 m asl (Springuel and Sheded 1991). Some of the mountains that serve as a natural barrier between the Eastern Desert and the Red Sea coastal region are drained by the wadi's upstream tributaries.

Data from Wadi Allaqi Meteorological Station show a mean annual temperature of 25.8 °C, minimum of 18.0 °C, and maximum 33.6 °C. On the other hand, the mean annual relative humidity is 45.9% (**Table 1**); while the annual rainfall is highly variable in both time and space with trace values. The amount of retained water will depend on the texture and depth of the surface deposits (Kassas 1955).

### Optional and Actual Uses of Plants

The potential and actual economic uses of plants in the study area were assessed based on three approaches: 1- literature review (e.g. Tachkolm 1974; Boulos 1983; Boulos and El Hadidi 1994; Belal and Springuel 1997; Shaltout 1997; Boulos 1999-2005), 2- direct observation of the life styles of nomads and their livestock and 3- use of informal interviews and questionnaires with the nomads.

The economic uses of the desert vegetation were classified into seven major indigenous uses (i.e. goods): grazing (feed for livestock), medicinal use, human food, timber, fuel, charcoal production and other uses (e.g. making mats, baskets, ropes, chairs, extraction of oils, dyes, fibers). An importance value has been attributed for each species for each of the seven categories. The sum of the values for all uses importance is further expressed as relative percentages of maximum possible score. This total importance value (TIV) can be taken as the measure of the potential importance use for local economy as follows:  $TIV \% = [(U_1 + U_2 + U_3 + \dots + U_n) / 56] \times 100$ ; where  $U$  is the importance value for a particular use and  $n$  is the total number of uses.

### Grazing Intensity

For each plant species present within a site, the following data were recorded: the species concerned, percentage cover, and total number of individuals, plant stage, and overall health, level of grazing, and the presence of vehicle tracks. This scale was recorded depended on the subsequent criteria: 1- amount of reproduction of individuals (flowering and fruiting), 2- overall vigour and vitality of individuals, and 3- plant height and cover. On the other hand, palatability was recorded based on animal behavior and informal interview with Bedouins over several years of recording notes. Within each site, grazing intensity was evaluated visually and classified into five category: 1 (no evidence of grazed), 2 (low grazed - LG), 3 (moderate grazed - MG), 4 (heavily grazed - HG) and 5 (severe grazed - SG) (**Table 2**); based on the grazing intensity and amount of dung, grazing-damaged shrubs and extent of livestock footpaths (Moustafa 2000; Abd El-Wahab 2003; Guenther et al. 2005).

Mammal excrement was visually inspected by counting the number of droppings, the species involved (mostly camel, donkey, rabbit, sheep, ibex, fox, and gazelle), the number of droppings, and the age category of the droppings scaled into five categories: 1- fresh, 2- less than one week old, 3- over one week old, 4- less than one year old, and 5- over one year old (see Al-Qamy 2005; Guenther et al. 2005). The dung of ibex and goats are hard to tell apart, and discrimination is likely to be uneasy; others are very characteristic, and easy to identify (**Table 2**): 1- number of grazing animals and their types (goats, sheep, donkeys, and camels), 2- percentage of browsed branches, 3- number of visits by animals, and 4- rate of cutting and uprooting (number of individual uproots and cut due to human activities (Tarek et al. 2013).

### Natural Resources, Human and Socioeconomic Activities

Data and information about natural resources, human and socioeconomic activities were collected directly from the Bedouins at the downstream and upstream parts of Wadi Allaqi. A survey of Bedouin living in the study area was undertaken using an open-ended questionnaire to gain information about the best general critical factors that controlling the natural recourses of economic activities and their type, only for men Bedouins (**Table 3**). It was sufficiently flexible to allow the development of broader debates (Sharp et al. 2003; Briggs 1995). Thirty interviews were taken place with the heads of households, giving slightly full cover of all households during the time of the survey. Of these, just over 73.3% of them were with Ababda households, and 26.7% with Bishari (the broad of ethnic divisions in Wadi Allaqi). 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).

## RESULTS

### Optional and Actual Uses of Plants

Among the 97 species recorded in the current study, 20 species have unknown uses by nomads, while 44 species (45%) have a medicinal value (**Table 4**). However, only a proportion of this considerable number is currently collected by the nomads. Among the regularly collected are: *Citrullus colocynthis*, *Senna alexandrina*, *Solenostemma arghel*, *Salvadora persica*, *Balanites aegyptiaca*, *Cleome droserifolia* and *Cymbopogon proximus*. There is some evidence that *Hyoscyamus muticus*, which has recently spread along Lake Nasser shores, could be included in the list of important plants for commercial use. The major uses of plant species in this study are grazing (60 %) and medicinal use (45%). About 8 % are used for fuel, 25 % are edible, and 19 % have different uses. Other uses are timber and production of charcoal (phanerophytes) (**Fig. 2**).

## Grazing intensity and palatability pressure

The results indicated that the domestic and wild animals can graze and browse 58 plant species (60.0% of the recorded species). Among the most palatable are the leguminous plants, (expect: *Indigofera argentea* and *Senna alexandrina*). Selective use of plants by animals provides an example of resource portioning among grazing animals. On the other hand, the field investigation indicated that the camels' diet is of a wider variety than other domestic animals as well as camels can graze over 20 species that are usually avoided by other animals (e.g. *Fagonia* spp., *Leptadenia pyrotechnica*, *Morettia philaeana*, *Zygophyllum simplex* and *Caylusea hexagyna*), while sheep prefer *Cotula cineria* and *Psoralea plicata* (**Fig. 3, Table 4**). Observation indicated that *Crotalaria aegyptiaca* is grazed by camels and gazelles. *Tamarix nilotica* is apparently good for camels and goats, but not for sheep. *Aerva javanica* and *Salsola imbricata* are the favorable food for gazelles, but not for the domestic animals.

Thirteen species are known to be browsed by camels and goats (e.g. *Farsetia aegyptiaca*, *Leptadenia pyrotechnica*, *Lotononis platycarpa*, *Aerva javanica*, *Balanites aegyptiaca*, *Tamarix nilotica*, *Acacia ehrenbergiana* and *Senecio flavus*). Nine species are known to be very good for camels and sheep and sometime goats (*Astragalus eremophilus*, *Astragalus vogelii* and *Phragmites australis*, *Psoralea plicata*, *Cynodon dactylon*, *Cyperus laevigatus*, *Heliotropium arbainense*, *Heliotropium pterocarpum* and *Heliotropium supinum*). Four Legume trees are browsed by camels, and their seedlings are eaten by all animals (*Faidherbia albida*, *Acacia nilotica*, *Acacia tortilis* subsp. *tortilis* and *Acacia tortilis* subsp. *raddiana*). Eight species (*Dichanthium foevulatum*, *Dipterygium glaucum*, *Eragrostis aegyptiaca*, *Euphorbia forsskalii*, *Euphorbia granulate*, *Fimbristylis bis-umbellata*, *Lotus* sp and *Lotus deserti*) are known as palatable herbs for all stocks. Three species are eaten by all animal species, but are particularly good for sheep (*Aristida adscensionis*, *Aristida mutabilis* and *Arnebia hispidissima*). Finally seven species are good for all stock animals (*Zea mays*, *Alhagi graecorum*, *Panicum turgidum*, *Caylusea hexagyna*, *Crypsis schoenoides*, *Stipagrostis plumosa* and *Sesbania sesban*).

## Plant health and grazing pressure

Grazing intensity is used as an indicator upon the grazing pressure. The most affected part by grazing animals, is the lower part of tree canopy, this part sometimes reach 3-4 m height depending upon animals tall, and in some cases considered the damaged part of tree. This can be clear to recognize in *Acacia tortilis* subsp. *raddiana*, *Tamarix nilotica*, *Balanites aegyptiaca*, *Faidherbia albida*, *Acacia nilotica* and *Acacia tortilis* subsp. *tortilis* (**Figs. 4 and 5**).

## Range to be Overused

In the upstream part, the grazing intensity varied from moderate to high. The results suggest that if the grazing intensity is high to severe, the resulting disturbance pressure on the vegetation may be an important factor contributing to the observed plant diversity (**Figs. 6 and 7**). In midstream part, the vegetation cover steadily decreases with moisture decrease. Absence of drinking water sources is probably the reason why the vegetation here is slightly utilized for grazing. Based on felid work, low to moderate grazing intensity; was observed close to area of wells. In the downstream part, the vegetation cover steadily increases with moisture increase, vegetation

is slightly sparse to high dense toward Lake Nasser shoreline. The grazing intensity varied from low to high of most the downstream sites.

### **Natural Resources Availability**

Thirty interviews were done using an open-ended questionnaire to represent the heads of households, in Wadi Allaqi at the time of survey. Twenty-two of them were Ababda tribe (73.3%) and 8 were Bishari tribe (26.8%). Twenty eight of the total samples (93.3%) agreed that Lake Nasser fluctuation affected their production (Table 5). Furthermore, the whole samples agreed that the water is the critical factor of natural resource of economic activity. Its availability varies all over the year which in turn controls the Bedouin production. Twelve interviews (4 of Ababda and 8 of Bishari) agreed that the second key is the rainfall incidence. Those who dependent upon collection of medicinal plant are mostly Bishari, while the main activities of Ababda are camel and sheep herding. Although rainfall is negligible around Wadi Allaqi, and southern Nile Valley, there is slightly regular rainfall during the winter period (December - February) in the hill areas to the east, and especially towards the Red Sea coast. Although only low rainfall totals are experienced (around 50 mm), it is sufficient to stimulate the growth of potential grazing resources. The area in almost months of the year is practically rainless and consequently offers a difficult environment, apart from one or two basin areas. Seventeen of the total interviews (56.7%) agreed that sheep-herding and small-scale cultivation are important for them, while 19 interviews (63.3%) expressed that camel-herding is the main activities.

Livestock transhumance, particularly sheep herding and charcoal making are considered as primary winter activities (**Fig. 8**). This is associated with the availability of ephemeral grazing in the hills of south and east. In these areas there are also relatively abundant resources of acacia trees, which are the preferred species for charcoal production. While Bedouin are away with the sheep in the hills, they take the opportunity to make charcoal at the same time. The two economic activities are, therefore, very closely related to each other as far as Wadi Allaqi Bedouin are concerned. But in fact, charcoal production as economic activities disappeared by time especially in the down and the midstream parts, and restricted nowadays at the upstream part that was resulted by 23 of total interviews and free debates (76.7%).

Seventy percent of the Bedouin interviews and debates pointed out that cultivation is mainly a summer activity, although since the late 1990s it has extended throughout the year among some households. This reflects the fact that during the summer, most Allaqi Bedouins are back living in the Wadi itself, because the desert beyond is too hot and uncomfortable for long periods in comparison. The timing of planting is crucial because Bedouin have to make prediction about lake water retreats and advances. Otherwise, 23 of the total sample (76.7%) expressed that the collection of medicinal plant becomes not important for them, while 7 Bedouins still work with this activity (21%).

## **DISCUSSION**

The present results suggested that if the grazing intensity is high to severe, the resulting disturbance pressure on the vegetation may be an important factor contributing to the observed plant diversity close to nomadic settlements and their animals. A special note should be taken into account that the moderate grazing intensity was close to area famous with wells (such as W. Murra and Wadi Ungat); where grazing intensity was high, close to Lake Nasser in the downstream part of Wadi Allaqi resulting in disturbance pressure on the vegetation

may be an important factor contributing to the observed low to moderate plant diversity. The salinization and dominance of *Tamarix nilotica* may also be significant in downstream locations.

Grazing had negative significant effects on reproductive structures. Flower and seed production were significantly lower under grazing, and their reduction correlated with grazing intensity where animals feed on inflorescences and seeds (Sternberg et al. 2003). The present results show that the increasing grazing intensity and the history of previous grazing affected the performance of plants. Plant biomass, height, as well as flower and seed production were reduced when the plant was exposed to animal grazing. Moreover, the plant cover remained largely steady at moderate grazing intensities, indicating that it is potentially tolerant of grazing under these stocking rates (Sternberg et al. 2000; Salem 2006; Shaltout et al. 2009)

In the present study, 37 species were less palatable (e.g. *Aizoon canariense*, *Capparis decidua*, *Senna italica*, *Senna alexandrina* *Chenopodium album* and *Chenopodium murale*). *Chrozophora obongifolia* is potentially toxic to all grazing animals. Furthermore, 16 species were unpalatable, although their seedlings are eaten by goats and sheep (e.g. *Forsskalea tenacissima*, *Hyoscyamus muticus*, *Ziziphus spina-christi* and *Glinus lotoides*). In addition, *Ziziphus spina-christi* is unpalatable, but its fruits are eaten by all stock. Palatability refers to the plant attributes which determines its acceptability by grazing animals. Characteristics of plant species such as chemical composition, growth stage, external plant form and kinds of plant affect the acceptability, and may stimulate selective responses by animals (Hussain and Durrani 2009). Otherwise, palatability of plants depends upon dietary need and energy of animals (Ginane et al. 2015). The favorites for grazing species were grasses by sheep and woody plants by goat and camel. These results are in accordance with the study of Angassa and Baars (2000) in Borana and Ethiopia and Hussain and Durrani (2007) in Harboi arid rangeland (Kalat - Pakistan).

In the current study, domestic and wild animals, can graze and browse on 57 of the recently recorded species in Wadi Allaqi (58.8%). Among the most palatable of these are some Legumes (e.g. *Acacia tortilis* subsp. *raddiana*, *Acacia nilotica*, *Lotus deserti* and *Acacia tortilis* subsp. *Tortilis*) as well as the camels can graze over 20 species that are usually avoided by other animals (e.g. *Fagonia* spp., *Leptadenia pyrotechnica*, *Morettia phillaeana*, *Zygophyllum simplex* and *Caylusea hexagyna*). Selective use of plants by animals is described by several workers and provides an example of resource portioning among grazing animals. The camels' diet is of a wider variety than other domestic animals. The green *Crotalaria aegyptiaca* is grazed by camels and gazelles, but is poisonous to sheep and goats, thus its use by grazing animals should be avoided, due to its toxicity and carcinogenicity (Yacoub 2018). *Tamarix nilotica* is apparently good for camels and goats, but not for sheep; while *Aerva javanica* and *Salsola imbricata* are the main food for gazelles, but not for the domestic animals (Kandal et al. 2016).

Some morphological attributes of the plants act as physical defenses (such as spines, hairs, stickiness, severity, coarse texture, unfavorable odor or chemical natures and toxicity) to reduce their palatability. These results are in accordance with the study of Hussain and Durrani (2009), who stated that intensive browsing often lead the plants to produce long thorn against browsing. Palatability is a relative factor and depends upon the availability and nature of forage and kinds of animals. The chemical nature, such as nutritive value and mineral contents, cause variation in selection of the parts of the same plant by the grazing animals. The plant parts with low nutrition or containing harmful or toxic chemicals is generally avoided by most animals. The choice of dried plant material declines due to taste, odor and feel (Holechek and Galt 2000). Moreover, Shaltout et al. (2021)

indicated that the protection process led to an improvement in the vegetation and its individual populations, in relation to the plant cover, diversity indices, and biovolume. Many of the plant populations are either endemic or threatened species of high conservational value.

It might be possible that poor health and bad performance of livestock in the study area are partially due to toxic, salty and carcinogenic species such as *Tamarix nilotica* and *Crotalaria aegyptiaca*. Since there is always shortage of the livestock feed, therefore the less to non-palatable species are grazed under pressure, as no other choice is available. Towhidi and Zhandi (2007) in Iran reported that due to lack of fodder, non-palatable plants like *Salsola*, *Alhagi* and *Tamarix* species are grazed under pressure; the same is true in our study area. *Calotropis procera*, *Tamarix aphylla* and *Tamarix nilotica* are non-palatable in other parts of the world, but they grazed under compulsions in the study area. Although, 3 species (*Aristida adscensionis*, *Aristida mutabilis* and *Arnebia hispidissima*) are eaten by all animals, but are particularly good for sheep. In addition, 4 species (*Caylusea hexagyna*, *Crypsis schoenoides*, *Stipagrostis plumosa* and *Sesbania sesban*) are grazed by all stock animals. This findings are in agreement with the study of White (1995). Hirata et al. (2005) evaluated that the amount of forage available at the end of the growing season was reduced due to higher grazing impacts on herbaceous vegetation with a higher cover. On contrary, light grazing impact would occur with a higher cover of shrub vegetation types. The plant cover over the rangeland is maintained by simulated grazing. The ratio of most palatable species decreased in response to overgrazing, while that of unpalatable species increased (e.g. *Calotropis procera*) in the upstream part. Camels and wild animals (such as Dorcas gazelle) are of a wider variety than other domestic animals.

Grazing intensity in this study depends upon morphometric characteristics as well as nature and animal type (whether domestic or wild). For instance, sheep, goats and gazelles are not tall enough to reach the higher trees; therefore, their effects seem to be slightly moderate on most of Allaqi trees and shrubs (Salem 2006). On the other hand, Camels can feed upon higher trees and shrubs that resemble camel's height (e.g. 3–4 m height), therefore the most lower parts of some plant canopies are more affected by camel grazing (e.g. *Balanites aegyptiaca* and *Acacia tortilis* subsp. *raddiana*). Grazing intensity can provide a rapid indication of the biodiversity support capacity of desert plants. As grazing intensity increased, vegetation structural values decreased. Thus, overgrazing by stock, especially camels, is a likely cause of this severe degradation. In addition, the second core area in the upstream part (Wadi Eiqat), had high plant diversity (Ali et al. 1997). Grazing pressure varied from moderate to high at Eiqat core area. On the other hand, some sites (e.g. west Wadi Eigayib and south Halafway) suffer from severe grazing intensity. These sites were close to nomadic settlements and their animals. The results suggest that if the grazing intensity is high to severe, the disturbance pressure on the vegetation may be an important factor contributing to the observed plant diversity.

The data from the open ended questionnaire indicated that Ababda and Bishari societies still remain highly sex isolated, concerning the nature resources and socioeconomic activities. This can explain why the questionnaire carried out on a sample of men rather than women or the two together. During the years of this study, a recognizable comfortable or said-observed a relaxing of gender relations during the worked years in the desert. This may reflect the fact that women are now comfortable with the team of Allaqi protectorate, or male in some restricted condition (Belal et al. 2008; Briggs et al. 1993). Although, the entire studied interviewers were out of educational level, but the data collected explain that most of them have a great knowledge of life and issues of their life, such as water level of Nasser Lake and inundation effect.

There is a vertical difference of 6–8 m between minimum and maximum water levels in any year. This can result in around 10 to 12 km of wadi floor being seasonally exposed, this was agreed by 86.7% of the Bedouins especially those by/around the lake. Significantly, the soils in the exposed area are resulted and well flooded annually, contributing to their continued relative fertility. Furthermore, even after the surface water has retreated, associated groundwater can still be found, ensuring the regeneration and maintenance of vegetation such as *Tamarix nilotica*, Acacias and some grasses, as well as being available for small-scale irrigation from the hand-dug wells of depths of 4–6 m. Although it was the former long-term changes which were responsible for generating the new resource opportunity for attracting Bedouin to Wadi Allaqi in the first place, it is the latter short term changes which form the underlying basis of the present Bedouin livelihood systems.

The 30 interviews were compatible that Bedouin in Wadi Allaqi have developed a livelihood system; each of its elements makes use of the available resource opportunities, but does so in a managed and sustainable manner. The water availability and economic activity are closely related. This relationship is strongest regarding the sheep-herding, charcoal production and small-scale cultivation. Camel-herding and medicinal plant collections are less constrained by seasonal water availability. Generally, sheep-camel herding and small-scale cultivation characterized the Bedouins in downstream part. On contrast, medicinal plant collections, charcoal production, sheep-camel herding characterized the Bedouins in upstream part. It is useful to reiterate some of the significant long and short-term changes in livelihood strategies that have occurred in the study area. Camels, once prominent in the local economic system, have declined in importance in the past two decades as new and faster forms of transport emerged. A similar and more extreme pattern has been observed in other Arab countries, where camels have been neglected, and in some instances, have returned to a feral state (FAO 2017). Small stocks, both for subsistence and commercial exchange, are now increasingly important, where they require different fodder and husbanding-labour arrangements than camels.

Nineteen of Bedouins (63.3%) expressed that camel herding constitutes an important activity. For those households with significant numbers of camels, they represent a stock of savings that can be drawn upon as capital when needed. Within Wadi Allaqi community, the numbers of camels owned by households varies between 2–1000 camel for one household, while the classic household had 10–15 camels at the most. Camels not only make up an economic investment in their own right, but also provide the means for further economic activity. The key mode of transport that allows households to participate in grazing in winter grazing and charcoal production, as well as transport for selling products in Aswan and elsewhere beyond Wadi Allaqi. Households with fewer than seven camels cannot afford to commit such scarce resources to these types of activities, because of the other economic demands exerted on the household.

## Declarations

### CONFLICT OF INTEREST

All of the authors confirm that there are no conflicts of interest.

### AUTHORS CONTRIBUTIONS

Kamal H. Shaltout: **involved in** conception and design, acquisition, analysis, statistical analysis and interpretation of results, revising the article and approved the final version to be submitted for publication.

Ashraf H. Salem: **involved in** conception and design, acquisition, analysis, statistic analysis and interpretation of results and drafting the article. Yassin M. Al-Sodany: **involved in** statistical analysis and interpretation of results, drafting the article and revising it, and approved the final version to be submitted for publication. Mohamed G. Sheddad: **involved in** conception and design, acquisition and interpretation of results.

## DATA AVAILABILITY STATEMENT

Please contact the authors for data requests.

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## Tables

**Table 1.** Annual climatic records of mean, minimum (min) and maximum (max) air temperature (°C), relative humidity (RH), rain-fall (RF), solar radiation (SR), baro- pressure (BP), wind speed (WS), wind direction (WD) and water evaporation (WE) , at Wadi Allaqi metrological station (1997).

| Year          | Temperature (°C ) |             |             | RH          | RF         | SR                   | BP           | WS                    | WD           |
|---------------|-------------------|-------------|-------------|-------------|------------|----------------------|--------------|-----------------------|--------------|
|               | Min               | Max         | Mean        | (%)         | (mm)       | (W m <sup>-2</sup> ) | (mm bar)     | (km h <sup>-1</sup> ) | (Deg)        |
| <b>1996</b>   | 21.6              | 35.3        | 28.4        | 38.4        | traces     | 254.5                | 990.7        | 8.9                   | 247.8        |
| <b>1997</b>   | 16.8              | 33.3        | 25.1        | 47.6        | -          | 221.0                | 992.0        | 8.1                   | 242.3        |
| <b>1998</b>   | 17.2              | 35.8        | 26.5        | 48.9        | traces     | 270.5                | 990.2        | 8.9                   | 248.5        |
| <b>2001</b>   | 18.8              | 36.8        | 27.8        | 40.0        | -          | 289.3                | 989.3        | 10.1                  | 165.1        |
| <b>2002</b>   | 16.7              | 35.8        | 26.2        | 46.1        | -          | 241.8                | 991.1        | 8.6                   | 133.9        |
| <b>2003</b>   | 18.4              | 32.7        | 25.6        | 47.1        | -          | 235.8                | 991.5        | 7.6                   | 140.8        |
| <b>2004</b>   | 17.5              | 35.4        | 26.5        | 46.6        | -          | 245.1                | 990.4        | 8.9                   | 112.7        |
| <b>2005</b>   | 16.9              | 24.0        | 20.5        | 52.3        | -          | 216.0                | 992.0        | 8.1                   | 95.7         |
| <b>Annual</b> | <b>18.0</b>       | <b>33.6</b> | <b>25.8</b> | <b>45.9</b> | <b>0.0</b> | <b>246.8</b>         | <b>990.9</b> | <b>7.9</b>            | <b>173.4</b> |
| <b>SD</b>     | <b>1.6</b>        | <b>4.1</b>  | <b>2.4</b>  | <b>4.6</b>  | <b>-</b>   | <b>24.5</b>          | <b>0.9</b>   | <b>0.8</b>            | <b>63.6</b>  |

**Table 2.** Visual measurement of grazing intensity (after Guenther 2005; Abd El-Wahab 2003 and Moustafa 2000); and age categories of the mammal dungs (after Alqamy 2005 and Guenther 2005).

| Score | Grazing Intensity      | Dung Age       |
|-------|------------------------|----------------|
| 1     | No evidence of grazing | Fresh          |
| 2     | Low grazing            | < one-old week |
| 3     | Moderate grazing       | > one-old week |
| 4     | Heavy grazing          | < one-year old |
| 5     | Severe grazing         | > one-old week |

**Table 3.** Open ended questionnaire to gain information about the critical factors that controlling the natural resources in Wadi Allaqi.

| No | Question                                                                                                                                | Answer |
|----|-----------------------------------------------------------------------------------------------------------------------------------------|--------|
| 1  | What is the critical factors controlling the natural recourses of economic activities?                                                  |        |
| 2  | How the level of Lake Nasser or fluctuations influence the Bedouin production?                                                          |        |
| 3  | Have you developed your livelihoods system dependent upon the year, month, or during the year? identify                                 |        |
| 4  | How much type of your activities within the year?                                                                                       |        |
| 5  | Have you classified them into primary activities and secondary activities? Based on time interval (e.g. seasons, month) identify?       |        |
| 6  | Which one of your activities classified as winter activities and summer activities?                                                     |        |
| 7  | Which type of your activities considered the key factors of people wealth in the Bedouin tribes?                                        |        |
| 8  | In your opinion, do you think that medicinal plant collection, greater in the upstream or in the downstream, and which type of species? |        |
| 9  | Is the medicinal plant collection is an economically important activity for your life?                                                  |        |

**Table 4.** Economic importance of the recorded species and their palatability description in Wadi Allaqi. M: medicinal plant, T: Timber, G: Grazing, H, Human food, F: Fuel use, C: charcoal, O: other use, TIV: total economic importance value, 4 = minimum use, 8 = maximum use. The species are arranged according to their TIV values.

| Species                                                       | Palatability | Grazing Animal | Grazed part           | Economic importance |   |   |   |   |   | TIV |    |
|---------------------------------------------------------------|--------------|----------------|-----------------------|---------------------|---|---|---|---|---|-----|----|
|                                                               |              |                |                       | M                   | T | G | H | F | C |     | O  |
| <i>Balanites aegyptiaca</i> (L.) Delile                       |              | Camel          |                       | 8                   | 8 | 7 | 8 | 8 | 6 | 8   | 95 |
| <i>Acacia tortilis</i> subsp. <i>raddiana</i> (Savi) Brenan   | High         |                |                       | 7                   | 8 | 8 | - | 8 | 8 | 6   | 80 |
| <i>Acacia tortilis</i> (Forssk.) Hayne subsp. <i>tortilis</i> |              |                |                       | 8                   | 7 | 8 | - | 8 | 8 | 6   | 80 |
| <i>Salvadora persica</i> L.                                   |              |                |                       | 8                   | 6 | 6 | 6 | 6 | - | 6   | 68 |
| <i>Acacia nilotica</i> (L.) Delile                            |              |                |                       | 6                   | 6 | 6 | - | 6 | 6 | 6   | 64 |
| <i>Ziziphus spina-christi</i> (L.) Desf.                      |              |                | Fruit                 | 6                   | 6 | 6 | 6 | 6 | - | 6   | 64 |
| <i>Leptadenia pyrotechnica</i> (Forssk.) Decne                |              | Camel          |                       | 6                   | - | 6 | 6 | 7 | - | 6   | 55 |
| <i>Tamarix nilotica</i> (Ehrenb.) Bunge                       |              | Goat - Camel   |                       | 7                   | - | 7 | - | 8 | - | 7   | 52 |
| <i>Sesbania sesban</i> (L.) Merr.                             |              |                | Leaf - Stem - Others  | 6                   | 5 | 6 | - | 6 | - | 5   | 50 |
| <i>Ricinus communis</i> L.                                    |              |                |                       | 7                   | - | - | 5 | 7 | - | 7   | 46 |
| <i>Alhagi graecorum</i> Boiss.                                | Palatable    | All stock      | Leaf - Stem - Others  | 6                   | - | 7 | 6 | 6 | - | -   | 45 |
| <i>Phragmites australis</i> (Cav.) Trin. ex Steud.            |              |                |                       | 6                   | - | 6 | 6 | - | - | 6   | 43 |
| <i>Maerua crassifolia</i> Forssk.                             |              |                |                       | 5                   | 6 | 5 | - | 6 | - | -   | 39 |
| <i>Calotropis procera</i> (Aiton) W.T. Aiton                  |              |                | -                     | 7                   | - | - | - | 7 | - | 7   | 38 |
| <i>Panicum turgidum</i> Forssk.                               |              | All stock      |                       | 6                   | - | 8 | 7 | - | - | -   | 38 |
| <i>Acacia ehrenbergiana</i> Hayne                             |              | Camel - Goat   | Seedling, -Veg. parts | -                   | - | 8 | - | 6 | 6 | -   | 36 |

| Species                                                                          | Palatability      | Grazing Animal | Grazed part          | Economic importance |   |   |   |   |   | TIV |    |
|----------------------------------------------------------------------------------|-------------------|----------------|----------------------|---------------------|---|---|---|---|---|-----|----|
|                                                                                  |                   |                |                      | M                   | T | G | H | F | C |     | O  |
| <i>Cymbopogon schoenanthus</i> subsp. <i>proximus</i> (A. Rich.) Maire & Weiller |                   |                |                      | 7                   | - | 6 | 7 | - | - | -   | 36 |
| <i>Capparis decidua</i> (Forssk.) Edgew.                                         |                   |                |                      | 7                   | - | - | 5 | 6 | - | -   | 32 |
| <i>Faidherbia albida</i> (Delile) A. Chev.                                       |                   |                | Seedling             | 6                   | 5 | 6 | - | 6 | - | -   | 32 |
| <i>Medemia argun</i> (Mart.) Württemb. ex H. Wendl.                              |                   |                | -                    | 6                   | - | - | - | 6 | - | 6   | 32 |
| <i>Pulicaria crispa</i> (Forssk.) Oliv.                                          |                   |                |                      | 6                   | - | 6 | - | 6 | - | -   | 32 |
| <i>Imperata cylindrica</i> (L.) Raeusch.                                         |                   |                |                      | 6                   | - | 4 | - | - | - | 6   | 29 |
| <i>Lupinus digitatus</i> Forssk.                                                 |                   |                |                      | -                   | - | 5 | 6 | - | - | 6   | 29 |
| <i>Zilla spinosa</i> (L.) Prantl                                                 |                   | Camel - Goat   |                      | 5                   | - | 6 | - | 5 | - | -   | 29 |
| <i>Cocculus pendulus</i> (J.R. & G. Forst.) Diels                                |                   |                |                      | 5                   | - | - | 5 | 5 | - | -   | 27 |
| <i>Cotula cinerea</i> Delile                                                     |                   |                |                      | 5                   | - | 6 | - | - | - | 5   | 27 |
| <i>Senna alexandrina</i> Mill.                                                   |                   |                |                      | 6                   | - | - | - | 5 | - | 4   | 27 |
| <i>Senna italica</i> Mill.                                                       |                   |                |                      | 6                   | - | - | - | 5 | - | 4   | 25 |
| <i>Pulicaria incisa</i> (Lam.) DC.                                               |                   |                |                      | 7                   | - | 5 | 7 | - | - | -   | 23 |
| <i>Cynodon dactylon</i> (L.) Pers.                                               |                   |                |                      | 6                   | - | 6 | - | - | - | -   | 21 |
| <i>Pergularia tomentosa</i> L.                                                   | Unpalatable - Low | All stock      | Leaf - Stem - Others | 6                   | - | - | 6 | - | - | -   | 21 |
| <i>Cullen plicatum</i> (Delile) C.H. Stirt.                                      |                   | Sheep - Goat   |                      | 5                   | - | 8 | - | - | - | -   | 21 |
| <i>Arnebia hispidissima</i> (Lehm.) DC.                                          |                   |                |                      | 4                   | - | 7 | - | - | - | -   | 20 |

| Species                                               | Palatability | Grazing Animal | Grazed part            | Economic importance |   |   |   |   |   |   | TIV |
|-------------------------------------------------------|--------------|----------------|------------------------|---------------------|---|---|---|---|---|---|-----|
|                                                       |              |                |                        | M                   | T | G | H | F | C | O |     |
| <i>Aerva javanica</i> (Burm.f.) Juss. ex Schult.      | Low          | Camel - Goat   | Leaf - Stem - Others   | 5                   | - | 5 | - | - | - | - | 18  |
| <i>Asphodelus tenuifolius</i> Cav.                    |              |                | -                      | 5                   | - | - | 5 | - | - | - | 18  |
| <i>Polycarpaea repens</i> (Forssk.) Asch. & Schweinf. |              |                |                        | 5                   | - | 6 | - | - | - | - | 18  |
| <i>Zea mays</i> L.                                    |              | All stock      |                        | -                   | - | 5 | - | 5 | - | - | 18  |
| <i>Crotalaria aegyptiaca</i> Benth.                   |              | Camel          |                        | 5                   | - | 5 | - | - | - | - | 16  |
| <i>Citrullus colocynthis</i> (L.) Schard.             | Low          |                |                        | 8                   | - | - | - | - | - | - | 14  |
| <i>Glinus lotoides</i> L.                             |              |                | Seedling - Dried plant | 5                   | - | 4 | - | - | - | - | 14  |
| <i>Hyoscyamus muticus</i> L.                          |              |                | Seedling               | 8                   | - | 6 | - | - | - | - | 14  |
| <i>Solenostemma argel</i> (Delile) Hayne              |              |                | -                      | 8                   | - | - | - | - | - | - | 14  |
| <i>Lotononis platycarpa</i> (Viv.) Pic. Serm.         |              | Camel          |                        | -                   | - | 7 | - | - | - | - | 13  |
| <i>Aristida adscensionis</i> L.                       |              |                |                        | -                   | - | 6 | - | - | - | - | 11  |
| <i>Aristida mutabilis</i> Trin. & Rupr.               |              |                |                        | -                   | - | 6 | - | - | - | - | 11  |
| <i>Astragalus eremophilus</i> Boiss.                  |              | Camel-Sheep    |                        | -                   | - | 6 | - | - | - | - | 11  |
| <i>Astragalus vogelii</i> (Webb) Bornm.               | High         |                | Leaf - Stem - Others   | -                   | - | 6 | - | - | - | - | 11  |
| <i>Caylusea hexagyna</i> (Forssk.) M.L. Green         |              |                |                        | -                   | - | 6 | - | - | - | - | 11  |
| <i>Cleome droserifolia</i> (Forssk.) Delile           | Unpalatable  | All stock      | -                      | -                   | - | 6 | - | - | - | - | 11  |

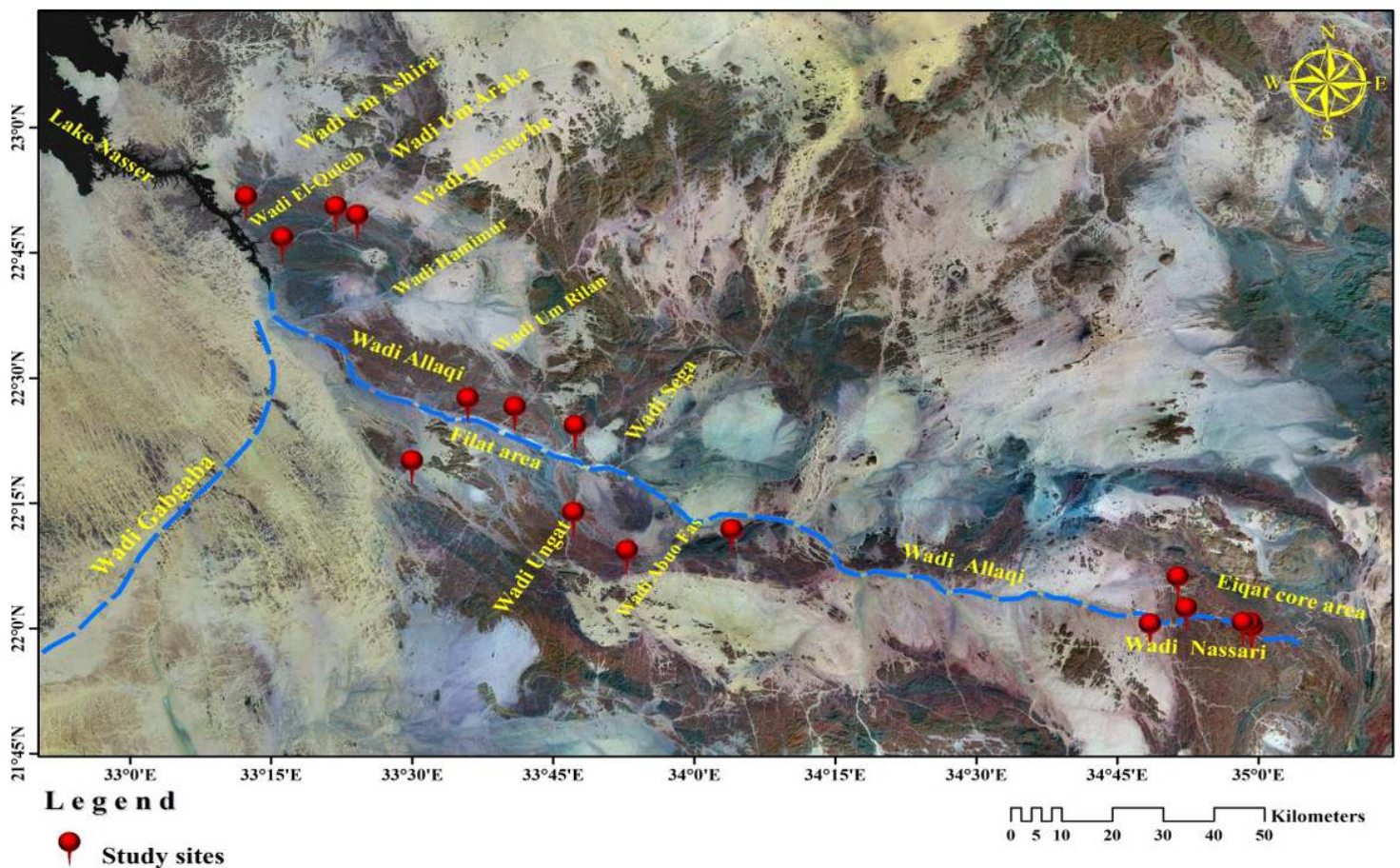
| Species                                               | Palatability | Grazing Animal | Grazed part                | Economic importance |   |   |   |   |   | TIV |    |
|-------------------------------------------------------|--------------|----------------|----------------------------|---------------------|---|---|---|---|---|-----|----|
|                                                       |              |                |                            | M                   | T | G | H | F | C |     | O  |
| <i>Crypsis schoenoides</i> (L.) Lam.                  |              |                |                            | -                   | - | 6 | - | - | - | -   | 11 |
| <i>Eragrostis aegyptiaca</i> .(Willd.) Delile         | Palatable    | All stock      |                            | -                   | - | 6 | - | - | - | -   | 11 |
| <i>Fagonia indica</i> Burm.                           |              |                |                            | -                   | - | 6 | - | - | - | -   | 11 |
| <i>Indigofera argentea</i> Burm.                      |              |                |                            | -                   | - | 6 | - | - | - | -   | 11 |
| <i>Morettia philaeana</i> (Delile) DC.                |              |                |                            | -                   | - | 6 | - | - | - | -   | 11 |
| <i>Salsola imbricata</i> Forssk.                      |              |                |                            | -                   | - | 6 | - | 6 | - | -   | 11 |
| <i>Stipagrostis plumosa</i> (L.) Munro ex T. Anderson |              |                |                            | -                   | - | 6 | - | - | - | -   | 11 |
| <i>Trianthema triquetra</i> Willd.                    |              |                |                            | -                   | - | 6 | - | - | - | -   | 11 |
| <i>Crotalaria microphylla</i> Vahl.                   |              |                |                            | -                   | - | 6 | - | - | - | -   | 9  |
| <i>Dichanthium foevulatum</i> (Delile) Roberty        |              |                | Leaf -<br>Stem -<br>Others | -                   | - | 5 | - | - | - | -   | 9  |
| <i>Dipterygium glaucum</i> Decne                      |              |                |                            | -                   | - | - | - | 5 | - | -   | 9  |
| <i>Farsetia aegyptiaca</i> Turra                      |              | Camel          |                            | -                   | - | 5 | - | - | - | -   | 9  |
| <i>Fimbristylis bisumbellata</i> (Forssk.) Bubani     |              |                |                            | -                   | - | 5 | - | - | - | -   | 9  |
| <i>Lotus deserti</i> Täck. & Boulos                   |              |                |                            | -                   | - | 6 | - | - | - | -   | 9  |
| <i>Lotus</i> sp                                       | High         |                |                            | -                   | - | 6 | - | - | - | -   | 9  |
| <i>Aizoon canariense</i> L.                           |              | All stock      | Leaf -<br>Stem -<br>Others | -                   | - | - | 4 | - | - | -   | 7  |
| <i>Chenopodium murale</i> L.                          |              |                |                            | -                   | - | 4 | - | - | - | -   | 7  |
| <i>Chrozophora obongifolia</i> (Delile) Spreng.       |              |                |                            | -                   | - | - | - | - | - | 4   | 7  |

| Species                                             | Palatability | Grazing Animal  | Grazed part | Economic importance |   |    |    |    |   | TIV |   |
|-----------------------------------------------------|--------------|-----------------|-------------|---------------------|---|----|----|----|---|-----|---|
|                                                     |              |                 |             | M                   | T | G  | H  | F  | C |     | O |
| <i>Cistanche phelypaea</i> (L.) Cout.               |              |                 |             | 4                   | - | -  | -  | -  | - | -   | 7 |
| <i>Euphorbia granulata</i> Forssk.                  |              |                 |             | 4                   | - | -  | -  | -  | - | -   | 7 |
| <i>Haplophyllum tuberculatum</i> (Forssk.) Juss.    |              |                 | -           | 5                   | - | -  | -  | -  | - | -   | 7 |
| <i>Heliotropium supinum</i> L.                      |              |                 |             | 4                   | - | -  | -  | -  | - | -   | 7 |
| <i>Senecio flavus</i> (Decne) Sch.Bip.              |              | Camel - Gazelle |             | -                   | - | 5  | -  | -  | - | -   | 7 |
| <i>Sonchus oleraceus</i> L.                         |              |                 | -           | -                   | - | 5  | -  | -  | - | -   | 7 |
| <i>Tephrosia purpurea</i> (L.) Pers.                |              |                 |             | -                   | - | 5  | -  | -  | - | -   | 7 |
| <i>Tribulus ochroleucus</i> (Maire) Ozenda & Quézel |              |                 |             | -                   | - | 5  | -  | -  | - | -   | 7 |
| <i>Tribulus pentandrus</i> Forssk.                  |              |                 |             | -                   | - | 4  | -  | -  | - | -   | 7 |
| <i>Zygophyllum simplex</i> L.                       |              |                 |             | -                   | - | 4  | -  | -  | - | -   | 7 |
| Total                                               |              |                 |             | 44                  | 8 | 58 | 17 | 25 | 5 | 18  |   |
| Percentage                                          |              |                 |             | 45                  | 8 | 60 | 18 | 26 | 5 | 19  |   |

Table 5. Livelihood system and their activities in Wadi Allaqi.

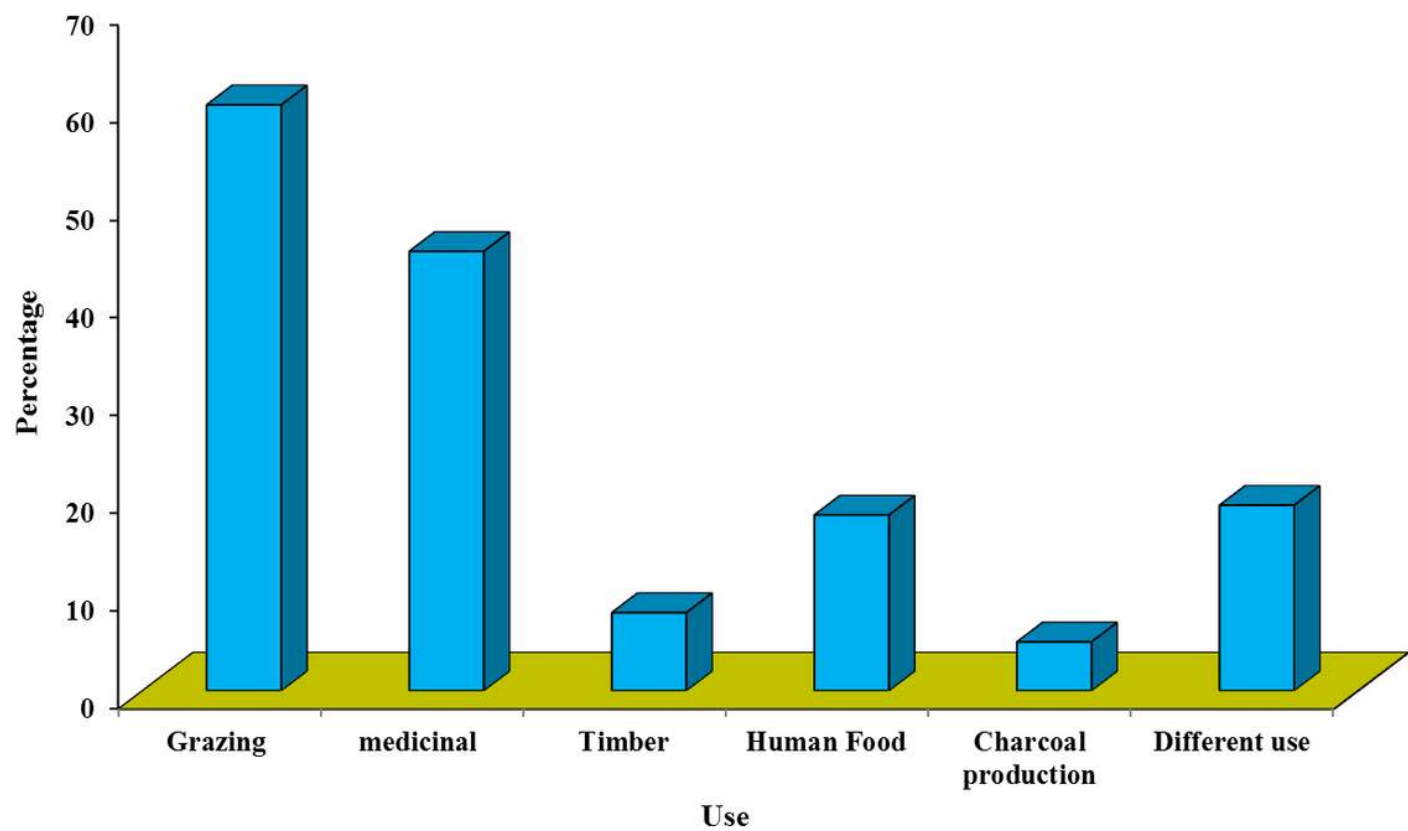
| Character                                                 | No. of interviews | %     |
|-----------------------------------------------------------|-------------------|-------|
| Ababda                                                    | 22                | 73.3  |
| Bishari                                                   | 8                 | 26.8  |
| <b>Activity</b>                                           |                   |       |
| Charcoal production                                       | 23                | 76.7  |
| Cultivation                                               | 21                | 70.0  |
| Camel-herding                                             | 19                | 63.3  |
| Sheep-herding                                             | 17                | 56.7  |
| Medicinal plant collection                                | 7                 | 23.3  |
| <b>Critical factors controlling the natural resources</b> |                   |       |
| Water                                                     | 30                | 100.0 |
| Lake Nasser fluctuation                                   | 28                | 93.3  |
| Rainfall incidence                                        | 12                | 40.0  |

## Figures



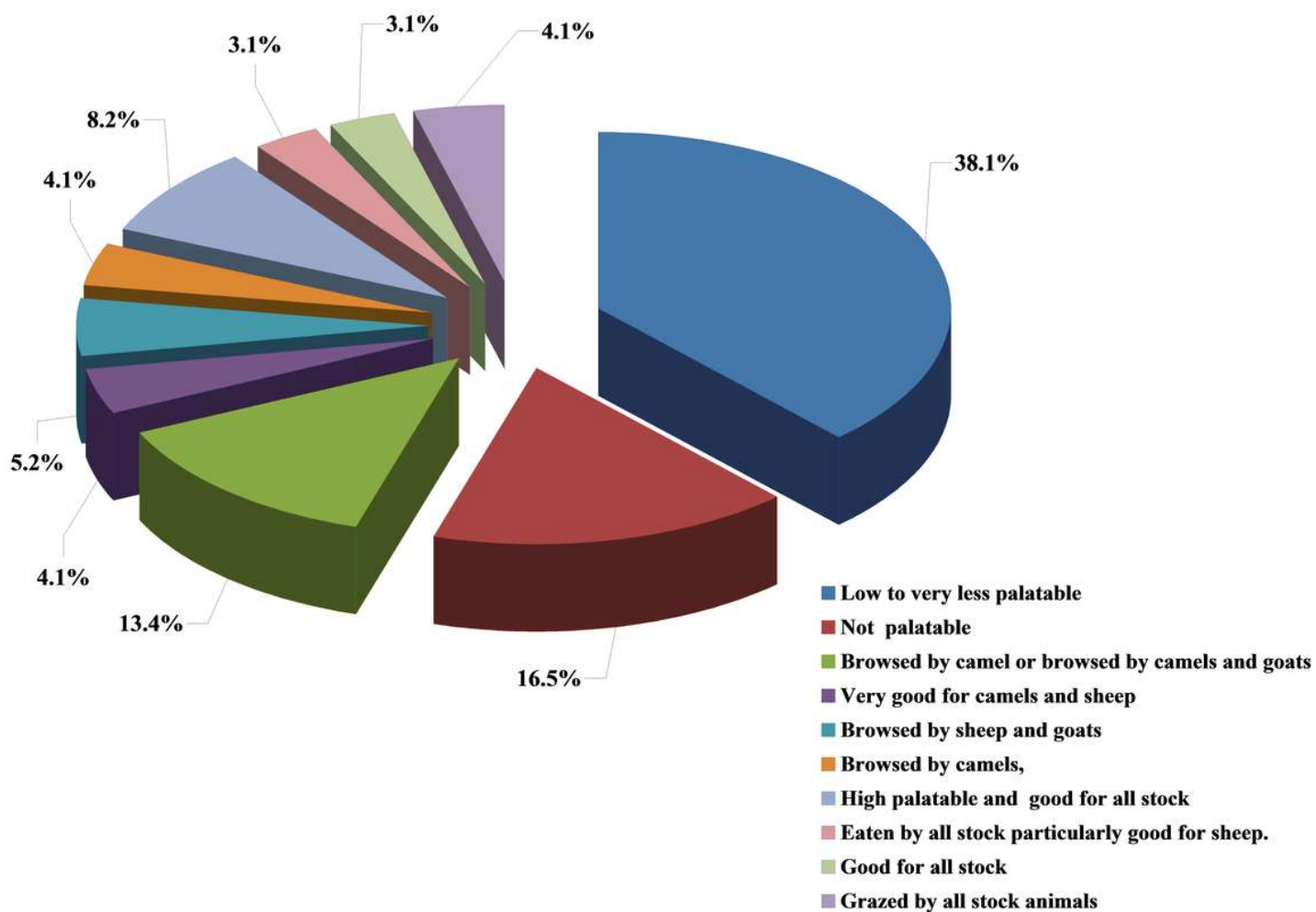
**Figure 1**

General map of south Egypt showing the location of Wadi Allaqi.



**Figure 2**

Actual uses of the plants in the present study.



**Figure 3**

Palatability chart of grazing and browsing species by domestic and wild animals in Wadi Allaqi.



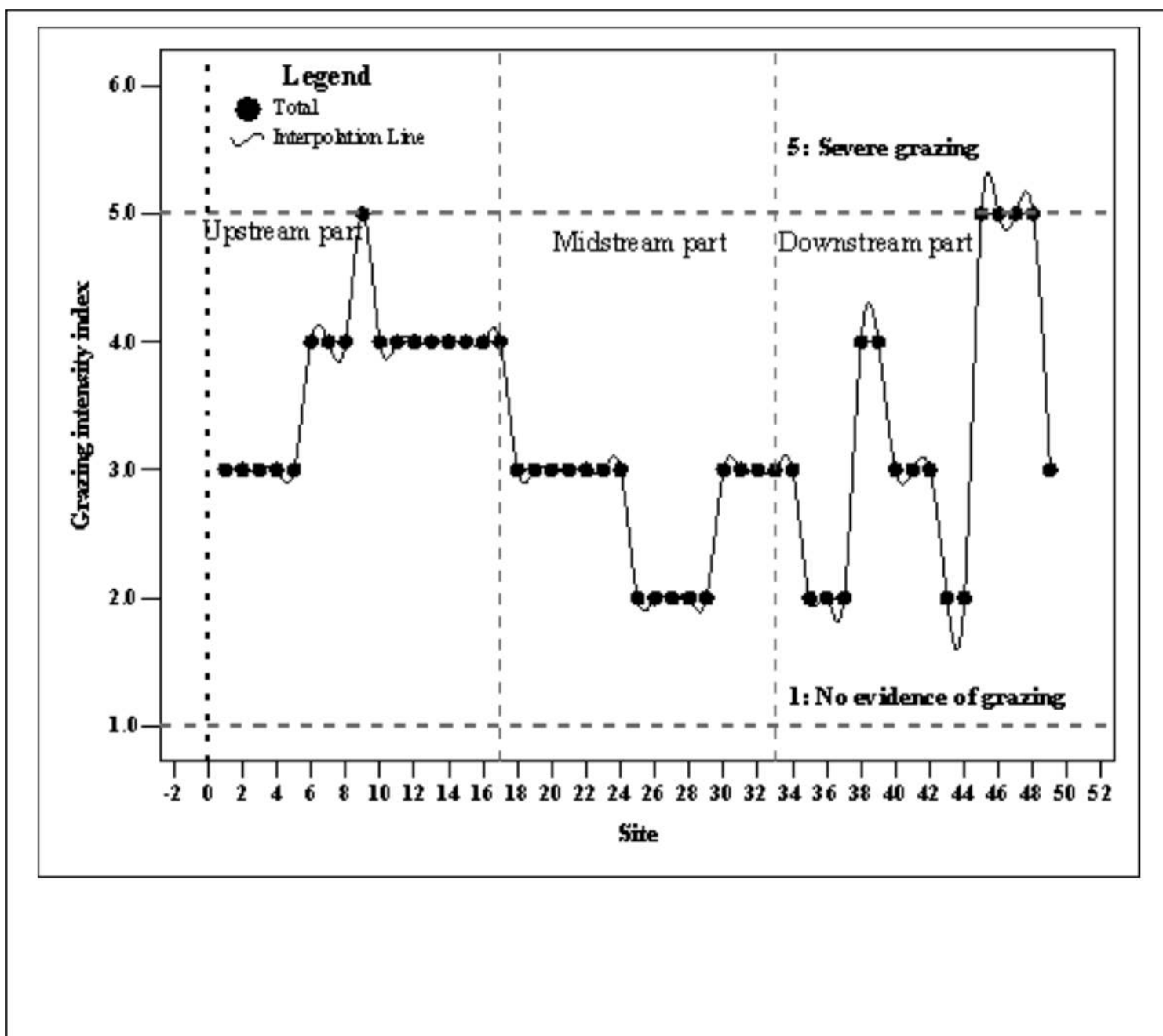
**Figure 4**

Prominent browse-line on moderate-high preferred browse species (e.g. *Acacia tortilis* subsp. *raddiana*). It's an indication of the past (left) and continuous overuses (right).



**Figure 5**

Prominent browse-line on a low-preferred plant (e.g. *Tamarix nilotica*). It is an indication of severe overuse of the browse resource.



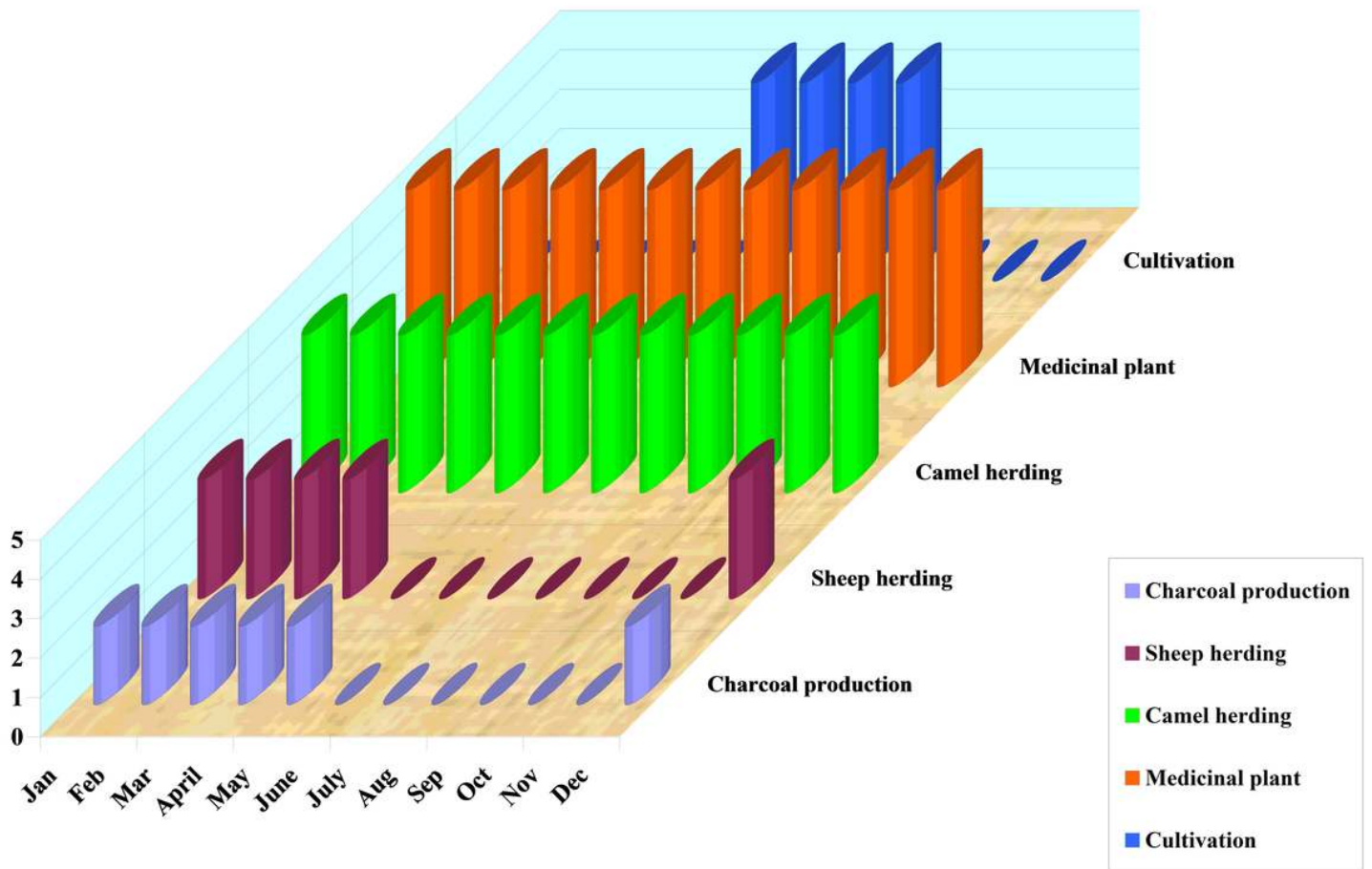
**Figure 6**

Grazing intensity index in Wadi Allaqi Biosphere Reserve. This index is classified into five categories: 1: no evidence of grazing, 2: low, 3: moderate, 4: high and 5: severe grazing.



**Figure 7**

Grazing and browsing by domestic and wild animal at Wadi Allaqi.



**Figure 8**

Calendar of socio-economic activities throughout Wadi Allaqi