

# Local Peoples' Knowledge on Uses, Status, Threats and Conservation Measures of *Balanites aegyptiaca* (L.) Del. Heglig Tree in Sudan

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**Abstract**— The aim of this study was to evaluate the uses, current status and identify main threatening factors and conservation measures of *Balanites aegyptiaca* in Sudan. The study was carried out in South of Sinnar State (Abuhjar locality) and North the Blue Nile State (Aldamazin locality) where the tree was observed to be dense. Group discussion was carried out to tap local community knowledge about the potentials and threatening factors of the species. The structured interview was used to verify and check the information generated in group discussion. A total of 120 respondents from the two localities were interviewed. Results showed that *Balanites aegyptiaca* represents a useful tree for the whole community and almost all of the respondents were benefited from it. Results also showed that the gene pool of the species was severely affected by many deteriorating factors like lopping of branches, grazing, mechanized farming and gap in transfer of indigenous knowledge. These factors were combined with removal of associated trees and retaining *Balanites* which made it vulnerable. Protection, in situ conservation stands and conservation in use is the most suitable measures for this species in Sudan.

**Keywords**— *Balanites*, conservation measures, local knowledge, threats, uses.

## I. INTRODUCTION

*Balanites aegyptiaca*, commonly known as desert date, is an important food and medicinal tree found in most African countries, stretching from arid and semi-arid regions to sub-humid savanna. Its fruit has an edible mesocarp and a hard woody endocarp enclosing an edible oil- rich seed kernel. The leaves are eaten as a vegetable in the dry season in many countries throughout its range in dryland Africa. According to [1], *B. aegyptiaca* is a promising economic plant for both the arid and semi-arid regions of tropical Africa, the Middle East and India. As a multipurpose tree, *B. aegyptiaca* offers food, medicines, cosmetics, fodder, fuelwood and pesticides valued for subsistence living in the semi- arid areas where other options are few [2]. The fruit of *B. aegyptiaca* has been the basis of an active trade for many centuries in countries where the species grows [3]. The seed kernel oil is rich in saturated fatty acids and is used as cooking oil [4] and [2]. It also contains steroids (saponins, sapogenins, diosgenins) used as raw material for industrial production of contraceptive pills, corticoids, anabolisants and other sexual hormones [5]. [6]

Noted that the genetic resources of *B. aegyptiaca* are in danger of depletion due to destruction of habitat and over-exploitation of the species. The situation is compounded by the low rate of natural regeneration and a slow 'growth rate flowering after five to seven years [7] and [3]. There is, therefore, a need to conserve, develop and utilize the existing *B. aegyptiaca* germplasm.

For many tree species which are characteristic of the semi-arid Africa so far studied, it is believed that *B. aegyptiaca* has the most organised and specialised use that has been sustained for a long time [8], [9] and [10]. *B. aegyptiaca* has a long history of use as a resource throughout its range, especially in Africa. It has been cultivated in Egypt for over 4,000 years; stones of its fruits have been found in pharaohs' tombs (placed as votive offerings) dating back to at least the 12th dynasty in ancient Egypt [8], [10] and [2]. The tree is also reported to have biblical connections where it is believed to be the source of one of the ingredients of spikenard perfume [11]. Accounts of the earlier use of *B. aegyptiaca* in various parts of Africa have been given by several authors e. g., [12], [13], [14], [8], [9], [15], [16] and [17]. The feasibility of commercial exploitation of *B. aegyptiaca* for pharmaceutical and food industry in the Blue Nile Province of Sudan was shown in the early 1980s by [13]. In this region of Sudan, the species was reported to make up a third of the total tree population, estimated to have a million *B. aegyptiaca* trees.

In the study area *B. aegyptiaca* is one of the dominant trees and has potential to contribute towards environmental stability, food security and poverty alleviation. [18] Noted that utilisation of wild food plants (including *Balanites aegyptiaca*) in Sudan is inefficient due to lack of knowledge on appropriate post-harvest technologies and even where information is available, it is usually scattered and users are unaware of where to get it. Little attention was given to this species and its valuable information such as indigenous knowledge. However, the tree is also has good natural regeneration, sprout well and coppice freely [19]. It has been protected by native customs and retained on farms for non-timber product values and benefits that were essential for rural livelihood. However, substantial impacts were exerted on the tree that led to loss of large number of trees and populations. It

was believed that the gene pool was reduced and genetic erosion was occurring within and between natural populations [20]. Accordingly, it was declared as an endangered priority species and its cutting was banned [21]. The species was identified as over exploited in Africa, that needs prompt action in germplasm collection, provenance and progeny testing and establishment of ex situ and in situ conservation measures[21]. The current conservation status is not known. Conservation status refers to the present state of the tree and risk of depletion in the future [22] and [23]. To develop and implement effective genetic conservation strategies it is necessary to integrate information drawn from several areas, including local people’s knowledge [24]. Many techniques and tools are used for generating community knowledge about trees and their uses and values. These include semi-structured and key informant interviews, institutional analysis, transects walks, matrix scoring and ranking, participatory mapping and diagramming [25]. The aim of this study was to evaluate the current status and identify main uses, threatening factors and conservation measures of *Balanites aegyptiaca* in Sudan from local people’s perspectives.

Specifically,

To assess the tree uses, its present state, the factors causing its degradation and trends of change and measures needed to conserve the species.

## II. RESEARCH METHODOLOGY

The study was carried out in South of Sinnar State (Abuhjar locality) and North of the Blue Nile State (Aldamazin locality) between latitude (13.33-11.49) N and longitude (33.37-34.42) E where the tree was observed to be dense. The climate of the two areas is characterized by short rainy season from July to September with an average annual rain fall of about 500 mm increasing southwards. The temperature is high during the dry period between February and June with an average maximum of 40°C decreasing to 14°C during the winter (November to January). The two areas are inhabited by settled population; their economy is dominated by traditional rain fed agriculture and seasonal wages [19]. Six villages (three in each state) were chosen for data collection in the two study areas. The selection of villages was based on the existence of *Balanites* trees and their product use. Twenty resident households in each village were randomly selected. The total number of households interviewed was 120. The primary data were obtained through a questionnaire-based structured interview with the selected informants. Furthermore, checklist-based semi-structured interviews were carried out with Forest National Corporation staff and forestry researchers. The main purpose was to collect information about uses and management of *Balanites* tree. The secondary sources were institutions’ reports, records and papers. All interviews were accompanied by personal observations, which allowed the researchers to judge the reliability of the answers given. Finally, participatory rural appraisal sessions were held to clarify all the points and remove inconsistencies. The Data were processed and analyzed using the Statistical Package for Social Science (SPSS) software.

## III. RESULTS AND DISCUSSION

### A. Uses of *Balanites aegyptiaca*

*Balanites* has been used by local communities in the study area for generation. Almost all the respondents had at least used *Balanites* tree or its products in one way or another.

#### Main uses of *Balanites* Products

All household members in the study area utilized *Balanites* products. *Balanites* leaves are utilized by all while the fruits were more frequently consumed by children and women. Results presented in Table (1) revealed that one of the main uses of *Balanites* were snack food (fruit pulp) and leafy vegetables where *Balanites* product represent source of food for most of the respondents in the surveyed villages (43%).

Table 1. Main uses of *Balanites* Products.

| Main uses      | Frequency | Percent |
|----------------|-----------|---------|
| Food           | 52        | 43.4    |
| Medicine       | 30        | 25      |
| Fodder         | 25        | 20.8    |
| Building poles | 12        | 10.8    |
| Total          | 120       | 100     |

*Balanites* fruits were considered as one of the indigenous plant food with great potential to support and strengthen livelihoods of local people. In the focus group discussion respondents were also reported the use of the tree leaves as vegetable in both dry season and in the years of plentiful crop harvest. They argued that the intensity of use increases in years of food shortage or famine.

[26] Reported that in Nigeria fruits, leaves and nuts of *Balanites aegyptiaca* are widely used as food by the local people especially during the dry season and drought periods. [27] Also reported the importance of *Balanites aegyptiaca* tree (bedena in Amharic) among communities in southern Ethiopia where ripe fruits are eaten by children and as food after being mixed into porridge for nursing mothers. The new shoots, which continuously grow during the dry season, are commonly used as animal forage while newly grown succulent shoots and leaves are used by households for cooking [27]. It is clear that local people in the study area regarded *Balanites* as their dependable dry season vegetable and all community members appreciated its use. This presents an opportunity for participatory domestication and on-farm integration of *Balanites*. This has been achieved with the baobab tree (*Adansonia digitata*) in West Africa where the fruits and leaves are eaten [28].

The second main use of *Balanites* products is medicine this is mentioned by 25% of the respondents. The medicinal uses of *Balanites* were further inquired during the focus group discussions with the aim of documenting the purported ailments treated with the different products or parts of *Balanites*. The main parts/products used were the root and stem bark, oil, fruit pulp and kernel cake. Several ailments were reported to be treated with *Balanites* products included; body pains, stomach upsets, malfunctioning of internal body organs (liver and spleen), malaria, snake bites, skin diseases and de-worming children. Table (2) explains the current medicinal uses by the local people in the study area and the part of the tree used.

Table 2. Current medicinal uses of *Balanites aegyptiaca* in the study area.

| Use                   | Part used  |
|-----------------------|--|
| Anti-diabetic         | Fruit pulp   |
| Chest pains           | Gum from stem bark                                       |
| De-worming (children) | Oil and fruit pulp                                       |
| Joint pains           | Bark   |
| Malaria control       | Raw fruit kernel cake poured in mosquito breeding places |
| Malaria treatment     | Root bark extract  |
| Mosquito repellent    | Smoke from nut shells                                    |
| Stomach pains         | Stem and root bark                                       |

[29] Found that *Balanites* fruits have been used in the treatment of liver and spleen diseases. According to [10] and [30] most parts of *Balanites* have traditionally been used medicinally and although the efficacy of such treatments has rarely been proven, there is no doubt that the plant yields useful steroidal saponins from which, notably, the sapogenin and diosgenin can be extracted for use in the pharmaceutical industry. Extracts are also used as a pesticide, the active ingredient being a saponin which is very toxic to cold-blooded animals. According to [19] the Sudan supplied about 20% of the world demand of diosgenin from its natural resources. [31] found that the fruit mesocarp contains pregnant glycosides.

Communities' local use of *Balanites* for malaria treatment seems to be supported by [32] who reported that the aqueous extracts of root and bark of *B. aegyptiaca* are very effective against mosquito larvae. [33] Reported that *Balanites* features are prominently in Hausa (West Africa) ethnomedicine and are also very useful for other household purposes. The oil from the fruit kernel is used for dressing wounds and as embrocating in rheumatoid while the root is used for treatment of malaria, herpes zoster and venereal diseases. The saponins occurring in the roots, woodchips and fruits facilitate their use for washing clothes [33].

Respondents (20%) stated the importance of the tree as fodder for their animals. The tree is classified as good fodder of high protein value and withstands prolonged browsing and lopping [34] and [35]. In the study area *Balanites* tree among other tree species is the main source of building poles this is stated by 11% of the respondents.

*Other uses of Balanites products*

Households used *Balanites* tree or its products in other numerous ways, however, fuelwood (firewood and charcoal) were the other prominent uses. In the focus group discussion respondents stated that *Balanites* is a good firewood source and the wood is easy workable and has many other uses in furniture and agricultural tools. The increasing use of *Balanites* for fuel (firewood and charcoal) was reported to decrease the numbers of trees in the study area. *Balanites* is valued as a fuel because it burns with minimal smoke and produces more heat. [3] Reported a calorific value of 4600 kcal per kg for *Balanites* wood. The shells (stones) which are left after the kernel removal provide good fuel used by the communities the study area. The use of these materials and charcoal from *Balanites* has also been reported by women in Burkina Faso [36].

*Balanites* wood is also hard, durable, worked easily and smoothly which make it widely used for tool handles and made into yokes, wooden spoons, pestles, stools and combs,

bowls, posts mortars and many households and agricultural implements, the wood is also valued for furniture.

*B. Sources of Balanites Products*

The current source of *Balanites* was mainly the wild trees (68%) with fallow lands contributing only 22.5 (Table 3). Nine % get the products on- farm. Results presented in table (3) also revealed that the majority of the respondents (48%) said that they have to walk more than 10 km to obtain *Balanites* products where 27% of the respondents walked between 7 -10 km for these products and 22% need to travel 3 -6 km to get *Balanites* products. According to this result it's not easy to get *Balanites* products around homes. Only 1.7% said that they could obtain *Balanites* products one km away from their homes.

Table 3. Sources and current distances of the main sources from home (km) of *Balanites* Products in the study area.

| Source      | F   | %    | Current distance of source | F   | %     |
|-------------|-----|------|----------------------------|-----|-------|
| Wild        | 82  | 68.3 | >10km                      | 58  | 48.3  |
| Fallow land | 27  | 22.5 | 7-10 km                    | 33  | 27.5  |
| On farm     | 11  | 9.2  | 3-6 km                     | 27  | 22.5  |
|             |     |      | 1-2 km                     | 2   | 1.7   |
| Total       | 120 | 100  | Total                      | 120 | 100.0 |

The case was different ten years ago where 85% of the respondents easily obtained *Balanites* products around their homes (Table 4). The main reason for this change in the location of *Balanites* product was that; large areas occupied with *Balanites* trees were subjected to clearance for farming. This result was stated by 86% of the respondents (Table 4).

Table 4. Distances of the main source from home 10 years ago (km) and the main reasons for change in *Balanites* location

| Distance | F   | %    | Reasons                        | F   | %    |
|----------|-----|------|--------------------------------|-----|------|
| <1km     | 103 | 85.8 | Land clearance for farming     | 104 | 86.7 |
| 1-2 km   | 15  | 12.5 | Harvesting of <i>Balanites</i> | 8   | 6.7  |
| 3-6 km   | 2   | 1.7  | Increased demand               | 8   | 6.7  |
| Total    | 120 | 100. | Total                          | 120 | 100  |

The Food and Agriculture Organization of the United Nations (FAO) estimated that every year 130,000 km<sup>2</sup> of the world's forests are lost due to deforestation and conversion to agricultural land [36]. The main source of *Balanites* in the study area was the wild as stated earlier and the stocks are reported to be declining over the years due to land clearance for agricultural purposes. The destructive uses of *Balanites* such as, cutting of trees for fuelwood and poor harvesting techniques for the leaves in the study area pose a threat to the species. *Balanites* grows along swamps and rivers and in other well drained sites but with access to ground water. About a decade ago most of these areas were not used for human settlement but the current increase in both human and animal population has forced some people to move into such areas. This has resulted in the declining of *Balanites* population in addition to uncontrolled cutting for fuel wood and increased grazing pressure which hampers regeneration.

*C. Status of Balanites Tree*

Results of the study (Table 5) revealed that the majority of the interviewed respondents (84.2%) noticed the changes in

the presence of the tree now days compared to the past. The form of changes is represented in decline in the number of trees. This result was indicated by 78.3% of the respondents (Table 5). Declining in tree number is attributed to the cutting of trees for agricultural demands, or harvesting *Balanites* for timber [38]. Only 11% Of the respondents stated that the tree is spreading south where rates of rainfall are higher and new regeneration is quickly obtained.

Majority of the respondents (71%) in the study area believed that the tree is endangered (Table 6). However, the causes vary from cutting of *Balanites* trees for farming and other purposes (65.8%) to overgrazing which is mentioned by 9.2% (Table 6).

Table 5. Change in the presence of Balanite tree between the past and now days and the form the extent of *Balanite*

| Presence of change | F   | %    | Form of change                                  | F   | %    |
|--------------------|-----|------|---|-----|------|
| Yes                | 101 | 84.2 | Decline in number of trees                      | 94  | 78.3 |
| No                 | 19  | 15.8 | Decline in number of trees with spreading south | 14  | 11.7 |
|                    |     |      | Spreading south                                 | 12  | 10   |
| Total              | 120 | 100  | Total   | 120 | 100  |

Table 6. Respondents' views about whether the tree is endanger or not and the causes of tree depletion.

| Tree Endangered | F   | %     | Cause of depletion | F   | %     |
|-----------------|-----|-------|--------------------|-----|-------|
| Yes             | 86  | 71.7  | Cutting of trees   | 79  | 65.8  |
| No              | 34  | 28.3  | Effect of farming  | 30  | 25.0  |
|                 |     |       | Overgrazing        | 11  | 9.2   |
| Total           | 120 | 100.0 | Total              | 120 | 100.0 |

The negligence of the non-wood use of this tree combined with other factors like mechanized cropping, over grazing and lopping of branches led to threatening of this species in the study area. To bring back the situation and restore the condition for the species table (7) revealed that 63% of the respondents claim that combining both protection of natural regeneration of the tree with extension on current and potential value of the species will help in bringing back the situation, whereas 33% think that it's important to protect the natural regeneration of the species.

Table 7. Action required for restoring the favourable condition of the tree.

| Action required   | Frequency | Percent |
|---|-----------|---------|
| Protection of natural regeneration with extension on current and potential value of the species | 76        | 63.3    |
| Protection of natural regeneration  | 40        | 33.3    |
| Extension on current and potential value of the species   | 4         | 3.3     |
| Total   | 120       | 100.0   |

Generally *Balanites aegyptiaca* is ranked high by dryland communities in the Sudan [38]. Organized collection of fruits and products from *Balanites aegyptiaca* trees provide employment, particularly for women, children and the landless poor. This is because dryland fruits, like most wild food products, are usually free and easy to access by the local communities [39] and [40]. In addition to its fruit, *Balanites aegyptiaca* is an important source of vegetable, fodder and fuelwood, and has many medicinal and industrial uses. However, intensive and uncontrolled exploitation of the tree combined with low rate of natural regeneration is causing

drastic depletion of this important resource. This is further complicated by the long juvenile phase of *Balanites*, reported to be about five to seven years [3]. Since *Balanites aegyptiaca* is one of the most useful trees in the Sudan, there is an urgent need for improved management and utilization of the resource to restore its conditions.

#### D. Extent of Distribution of the Tree

All the interviewed respondents (100%) gave a positive answer when asked if there are natural *Balanites* trees in their area. About 40% of them said that these natural trees are found scattered and 38% said the trees are found mixed. Only 21% of the respondents stated that the tree is found in pure stands (Table 8).

Table 8. The form of *Balanites aegyptiaca* occurrence.

| State of occurrence    | Frequency | Percent |
|------------------------|-----------|---------|
| Scattered trees        | 48        | 40.3    |
| Mixed with other trees | 46        | 38.7    |
| Pure stands            | 26        | 21.6    |
| Total                  | 120       | 100.0   |

The people indicated the presence of the pure stands is mainly due to the removal of the tree associates. [8] and [9] reported that this tree is found in association with many tree species. Although retaining of *Balanites* accompanied with its good natural regeneration assisted in its distribution, it also has a negative effect. The tree was left alone to become stand vulnerable to many damaging factors like lopping of branches for browsing especially in the dry season and cutting of the tree for different purposes. The National Forest Inventory [41] estimated more than 93 million *Balanites. aegyptiaca* trees in northern, central, eastern and western Sudan. Taking into account the very high fruit production per tree [8], it further highlights the potential of this tree in Sudan. Therefore great efforts are needed to conserve this tree.

#### E. Planting and Management of *Balanites* Trees

##### Growing of *Balanites aegyptiaca*

*Balanites aegyptiaca* was reported to have been planted by a few (15.1%) households, however, many (43.7%) retained and protected natural regeneration on their farms and another 41.2% regarded it as God given, thus no need to plant it (Table 9).

Table 9. Establishment of *Balantines* trees.

| Variable                       | Frequency | Percent |
|--------------------------------|-----------|---------|
| Retaining natural regeneration | 52        | 43.7    |
| Do not plant or protect        | 49        | 41.2    |
| Planting                       | 18        | 15.1    |
| Total                          | 120       | 100.0   |

Decreasing levels of wild trees coupled with increasing dependence on the tree products was a driving incentive for on-farm retention of the species along with other useful indigenous fruit trees (IFTs). [42] Also observed that although many rural households rely on indigenous fruit trees (IFTs) as sources of cash and subsistence in Southern Africa, there has been little effort to cultivate, improve or add value to these fruits.

[43] Noted that wild harvested products can be very unreliable in the quantities and qualities due to the variation of the weather. Quantities may also be affected by the existence of competing opportunities for producers, for whom indigenous fruit production typically contributes just a small part of their income. [42] Noted that as a result of the dwindling access to forest products, an increasingly higher proportion of households are finding it necessary to explore options to plant trees for supplying household requirements. In this regard, IFTs are always among the first trees to be planted. *Balanites* was found to be planted or retained near homes, scattered on farm or along farm boundaries. Similar findings have been reported in the Miombo region of Southern Africa [42].

The main planting materials used is seed this is reported by almost all the respondents (100%). This result is supported by [44] who stated that the best way of establishing *Balanites* trees is by seeds which are collected from the wild forests. Among the respondents interviewed 46% stated that they retain *Balanites* trees on scattered places and *Balanites* trees were, however, more retained on farm boundaries (37%) than near homesteads or around villages (16.8%) (Table 10).

Table 10. Sites where naturally growing *Balanites* trees are normally retained.

| Site             | Frequency | Percent |
|------------------|-----------|---------|
| Scattered        | 55        | 46.2    |
| On farm boundary | 45        | 37.0    |
| Near home        | 20        | 16.8    |
| Total            | 120       | 100.0   |

In the group discussion respondents declared that retaining of *Balanites* plantation is done on marginal lands or where there is no possibility of using this land for agricultural purposes. This was true since the species in the study area is found dense in some valleys and high lands not in cultivable land.

Results of this study revealed that 38.7 % of the interviewed respondents stated that *Balanites* trees increase yield of associated agricultural crops although 31.1% reported decrease in yield and another 21.8% reported *Balanites* trees having no effect on associated agricultural crops (Table 11). *Balanites* trees were reported to have no effect on yield of cereals, especially, maize, sorghum and millet but with some negative effect on yield of pulses and tubers such as groundnuts and sweet potatoes and cassava [45].

On the other hand, results of the research showed that on average 5 trees were regarded suitable to be retained in one hectare this was stated by 52 % of the interviewed respondents and 22.5% stated that they will not leave even a single *Balanites* tree in their farm because they think that trees on farm may gather birds and destroy the crop yield.

Table 11. The effect of *Balanites* trees on yield of associated crops

| Effect            | Frequency | Percent |
|-------------------|-----------|---------|
| Increase in yield | 46        | 38.7    |
| Decrease in yield | 38        | 31.1    |
| No effect         | 26        | 21.8    |
| Do not Know       | 10        | 8.4     |
| Total             | 120       | 100.0   |

In the study area *Balanites* trees were among trees retained on farm. In some areas, this has created the impression that *Balanites* and other IFTs are dominant on farms. According to [42] the retention of a low density of valuable trees in parklands of the semi-arid areas is a common practice to improve the yield of understory crops. In southern Tanzania, [42] reported that farmers spare fruit trees such as *Uapaca kirkiana* and *Parinari curatellifolia* because of their importance to households. This process makes IFTs the dominant trees on farms. They also reported that IFTs constitute about 71% of the trees on farmers' fields. Planting of *Balanites* species should be encouraged and be addressed.

*Constraints on Ggrowing Balanites Trees*

As mentioned earlier the majority (41.2%) of the respondents in the surveyed villages thought that planting of *Balanites* was worthwhile, however, the major, reason for limited planting was the lack of knowledge and skills on its propagation (23.3%). This followed by the lack of seeds and seedlings as stated by 19.2% and 17.6% of the respondents, respectively (Table 12).

Table 12. Constraints on growing *Balanites* trees.

| Constraints                      | Frequency | Percent |
|----------------------------------|-----------|---------|
| Lack of knowledge on propagation | 28        | 23.3    |
| Lack of seedlings                | 23        | 19.2    |
| Lack of seed                     | 21        | 17.6    |
| Drought                          | 8         | 6.6     |
| Grazing                          | 24        | 20      |
| Lack of interest                 | 9         | 7.6     |
| Fire                             | 7         | 5.7     |
| Total                            | 120       | 100     |

In order to overcome these problems 33.3% of the interviewed respondents stated that conservation of new regeneration of *Balanites* is the key factor in retaining the species since the tree is said to be growing naturally, not planted, while 18.3% of the respondents' stated that supplying of seed will help in solving the problem and 17.5% thought that the solution is in providing enough seedlings. Moreover 16.7 % of the respondent considered the solution in regular planting by the authority and 14% mentioned raising local people awareness (Table 13).

Table 13. Possible solutions for growing *Balanites* tree

| Possible solutions                        | Frequency | Percent |
|---|-----------|---------|
| Conservation of new regeneration          | 40        | 33.3    |
| Supply of seeds                           | 22        | 18.3    |
| Supply of seedlings                       | 20        | 17.5    |
| Regular planting by authority             | 21        | 16.7    |
| Extension campaigns and raising awareness | 17        | 14.2    |
| Total                                     | 120       | 100     |

In developing countries a large amount of ecological knowledge is held by local people and has not yet been adequately integrated with formal scientific knowledge [45]. It is therefore likely, in some environments, that local people's knowledge could make a major contribution to the information needed for improved methods of forest restoration. Therefore one priority should be the recording of relevant local knowledge of forest regeneration and its integration with scientific knowledge. Constraints to growing *Balanites* such as

lack of seedlings, and lack of knowledge and skills on its propagation need to be addressed by building the agronomic capacity of these communities.

F. Management of *Balanites aegyptiaca*

All the interviewed respondents in this study (100%) declared that there is no management practices applied to the wild stands of *Balanites*. On farms trees (81.5%) of the respondents said that the *Balanites* trees benefited from weeding of associated crops where as 23% of the respondents carry spot weeding for the *Balanites* trees on farm. Around homes 55.5% of the interviewed respondents manage the trees by making spot weeding while 36.1% are pollarding the trees. Only 8.4% do not manage it (Table 14). These trees are considered home garden for some people.

Table 14. Indigenous /Local management practices applied to *Balanites* trees.

| On farm trees         |     |      | Around homes  |     |      |
|-----------------------|-----|------|---------------|-----|------|
|                       | F   | %    |               | F   | %    |
| Benefits from weeding | 97  | 81.5 | Spot weeding  | 66  | 55.5 |
| Spot weeding          | 22  | 18.5 | Pollarding    | 43  | 36.1 |
| Total                 | 120 | 100  | No management | 10  | 8.4  |
|                       |     |      | Total         | 120 | 100  |

Local communities were aware of tree management to minimize negative effects on associated crops, such as shoot pruning just before sowing. These practices can be built upon in efforts to improve agroforestry in these areas.

G. Constraints and Opportunities for Management and Conservation of *Balanites aegyptiaca*.

A number of constraints and opportunities for improved management and utilization of *Balanites* were identified Table (15) and Table (16). The key constraints were illicit felling and expansion of cultivation at the expense of *Balanites* growing areas. In the group discussions respondents stated that the main constrains to manage and conserve *Balanites* trees in the study area is the ignorance of the people about the importance of the tree and the danger of cutting trees since the main reason for cutting trees is for obtaining land for farming, absence of the authorities, the poverty that strike the people force them to cut trees which is the only source of income during the drought season. According to the respondents *Balanites* trees are found in marginal lands and outside the reserved forests which make these trees get little attention of forest authorities. However, several opportunities were also identified and they included; high local demand for *Balanites* products including their tradability, high density of *Balanites* trees found in the study areas, availability of local awareness and knowledge on some processing, and presence of some local institutions willing to play a role in improving the management of *Balanites* and other IFTs

Table 15. Constraints against improving management and conservation of *Balanites* trees.

| Constraint               | Frequency | Percent |
|--------------------------|-----------|---------|
| Illicit felling          | 42        | 35      |
| Expansion of cultivation | 38        | 32      |
| Overgrazing              | 20        | 17      |
| Forest fires             | 10        | 8       |
| Absence of Authorities   | 10        | 8       |
| Total                    | 120       | 100     |

Table 16. Opportunities for sustainable management and utilization of *Balanites* tree.

| Opportunity   | Frequency | Percent |
|---|-----------|---------|
| Benefits provided by the tree                             | 32        | 27      |
| Contribution to Family income                             | 30        | 25      |
| Local awareness   | 26        | 22      |
| Existence of dense stands of <i>Balanites</i> in the area | 18        | 15      |
| The divers utilization of <i>Balanites</i> tree           | 14        | 11      |
| Total   | 120       | 100     |

To overcome most of the constraints cited above, it is important for the researchers and development community to work with local communities, especially women groups to add value to *Balanites* products. In this regard, oil processing should be encouraged because it seems to offer greater promise given the high unsupplied market and its high market value. This could raise the status of *Balanites* leading to its protection. This would later lead to increased demand for planting and thus kick-start a participatory domestication process as it has been done with other IFTs such as *S. birrea* in southern Africa [46], [43] and [42] and *A. digitata* in Western Africa [28]. Participatory domestication would then solve the problem of long juvenile phase through vegetative propagation and also improve fruit characteristics [42].

In the short run, the method of leaf harvesting and control of bush fires in all the study sites need to be addressed to sustain the resource base. Furthermore, community sensitization is needed for raising awareness about the potential role of *Balanites* and other IFTs in the study area for livelihood improvement. According to [47] some socio-economic conditions need to be addressed for the potential of IFTs to be realized. Some of these include; a change in land use and forest policies to give farmers ownership of parkland trees and production incentives related to markets and technology.

IV. CONCLUSIONS

The study revealed that the species was recognized by local people as important multi-purpose tree. However, the tree was threatened by many deteriorating factors. The study identified a number of opportunities for improved management and utilisation of *Balanites* tree. In situ conservation is suitable measure for this species in Sudan.

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