# Charcoal making technology for livelihood for rural people

## Agricultural technology transfer society

## Executive summary

Poverty reduction and desertification are two major challenges facing the world that are often linked, especially in developing country contexts. Both issues are currently among the central themes of most international development programmes, such as the United Nations Convention to Combat Desertification (UNCCD) and the New Partnership for Africa's Development (NEPAD). The World Summit on Sustainable Development (WSSD) held in Johannesburg, South Africa, in September 2002 also had these topics as the most important cross-cutting issues. Such environmental challenges are diverse in character and include, for instance, the over-exploitation of vegetation; water and soil pollution problems; human and livestock population growth pressures on land use and tenure; and problems with various kinds of **invasive species**.

Mesquite has been introduced principally as a shelterbelt/wind break for Tokar Town in the mid 1980s but it invaded the cultivated land and posed a dangerous weed to the delta farmers occupying 33% of the total Tokar Delta as a whole and 37% of the arable land area. Mesquite is accused of impeding cultivation. Huge resources were allocated to eradicate it. The massive mesquite population tempted was exploited by charcoal traders. Mesquite wood and charcoal present livelihood for many unskilled local inhabitants and internal displaced population (IDPs) and contributed considerably to local government revenue. The stock of wood material in the Delta can fetch around SDG 120 million with an expected annual growth increment of 2%, with a 10% error is to cater for the heterogeneity of mesquite stands even within stands of same category.

The potential economic value of mesquite for small holders and IDPs with regard to charcoal, building material, fire wood and other uses is fairly bright. The estimated income of charcoal producers is satisfying which indicates that if it is well organised and properly managed could constitute a fairly good income for small holders and IDPs.

The bulk of the charcoal originates from the eastern and middle parts of the Delta. **Though there is no data as regards the number of people depending on it for their living but in general people depending on mesquite for their income are from various walks of life.** The onsite charcoal workers and their dependants who depend on charcoal production as the main livelihood means are said to be almost one thousand. The chain of those economically benefiting from mesquite charcoal business radiates from onsite charcoal producer to retail traders through lorry drivers, porters, **wholesalers and brokers whose number is not known**. Moreover, the approximately 30,000 delta landowners and sharecroppers depend mostly on charcoal as a cheap energy source. The daily production of charcoal in the Delta was informally reported to be 30 truck loads. When leaving the Delta the charcoal is being taxed. Pods utilisation could be as a cheap component of animal feed for camels, cattle, sheep and goats. It could be mixed with sugar cane bagasse and cotton seed cakes where it proved good for maintaining and gaining weight.

## Introduction

**A prosopis species, identified as *Prosopis juliflora*** was introduced in 1917 to Sudan simultaneously from both Egypt and South Africa by R.E. Massey, who worked at the Egyptian Department of Agriculture in Giza. In 1928, another plantation was established near the present Khartoum airport. The naturalised prosopis around these plantations was observed to grow best on crests of sand dunes and, therefore, the following plantations in the 1930s were made to stabilize sand dunes southwest of Khartoum. After this, prosopis seeds were distributed in various directions; near the Gezira Agricultural Irrigation Scheme, to Port Sudan, and to areas north of Khartoum along the Nile.

In the early 2000s prosopis had been introduced in about half of the total of 26 states which constitute Sudan. During the early 1990s a popular opinion in parts of central Sudan and within the Sudanese Government had begun to consider prosopis a noxious weed and a problematic tree species due to its aggressive ability to invade farmlands and pastures, especially in and around irrigated agricultural lands. As a consequence prosopis was deemed an invasive alien species, and on 26 February 1995, a **presidential decree** for

its eradication was issued, which was **followed by campaigning** to execute the eradication.

## Area of the project

The area of the project is located at the eastern part of Sudan within the Red Sea state which covers a large geographical area that has borders with both Egypt and Eritrea. The area of focus is a Delta known as Delta Toker which lies between longitudes $37^{o}50'$ and $38^{o}$ 17' E and latitudes $17^{o}80'$ and $18^{o}$ 79'N. The delta is a sandy triangle plain with the head of the triangle constituting a discharge point of a seasonal stream (Khor) named Baraka in the south west and the base parallel to the Red Sea in the northeast. The seasonal stream is a watercourse with a catchment area of 45,000 $K^2$ from two major water courses feeders arising from Eritrea and Sudan. The normal flood season is from mid July to mid September. There is enormous year to year variation in the volume of water discharged and the area covered by flood flowing to the seasonal stream. Main rains fall in winter (October to February) with insignificant showers in summer.

The total delta covers about 406,000 feddans distributed among the three parts, eastern (125,000), central (165,000) and western (116,000). Livestock keeping and subsistence cultivation constitute the main source of activity.

Mesquite was first introduced to the Delta in late 1970's as an effective green belt against sand encroachment to Tokar town. About 73% of the area is infested with Mesquite, with the western part 100% infested with Mesquite, eastern part, 96% and central part 37%. Causes of Mesquite invasion had various reasons: animals which are allowed to enter the crop fields after the crop harvest, people who cut and transport Mesquite branches to be used as fences for houses, farms, schools, mosques, army camps and animals enclosures, collection and carrying of branches to the houses, to be used as fire wood, charcoal producers cut Mesquite branches and throw them with their pods on the ground. Furthermore, the irregular flooding pattern catalyses the dispersal of Mesquite seeds.

## Environmental aspects

Mesquite is evidently extremely adapted to the Tokar environment. The trees are evergreen. They flower all the year round from the age of one year and are prolific seed producers. They have an indefinite inflorescence. It is not unusual to encounter several fruiting stages on the one branch ranging from

unopened buds through open ones, just pollinated, embryonic pod formation, fully developed green pods, yellow pods to dry pods.

The Mesquite in the area has flourished due to the existence of favorable and ideal conditions such as fertile soil, abundant water, lack of plant competition and natural enemies and presence of various agents of seed dispersal for spreading in the Delta. Cotton is the main crop cultivated, however, the productivity of the scheme is no longer cost-effective and so most of farmers abandoned the fields, pasture areas also shrank due to the thick canopy of Mesquite reducing the number of livestock raised by farmers. The canopy have become a host to some wild animals, like pigs, rabbits and rats which frequently attach the farm fields and eat the crops.

The Mesquite canopy poses other threats in the Delta such as possible hazards of vehicles passing by the paved roads to be hit by the trees as they now come too close to the road. Also they impede drivers from seeing vehicles coming on the opposite side of the road. Mesquite canopy prevents livestock to reach pasture because of its thorny nature.

Extended Mesquite root systems allow tapping deep water underlying the water tables, causing the water tables to recede, diminishing the possibility for replenishment during the next rainy season. Receding water tables led to drying up of streams, reducing the ability of existing water supply schemes to deliver sufficient water to meet human needs.

Mechanically cleared areas that become re-infested produce impenetrable thickets of mesquite of a stocking density in the range of 700-1000 stems per fed. Two year thickets have attained diameters in the range of 5-8 cm. and a height of 2-3 meters. Virgin areas, not cleared since first infestation 18-20 years ago, have a stocking density of some 600 stems per fed, a diameter of 12-20 cm and a height of 4-7 meters. Re-infested mechanically cleared areas have impenetrable thickets of mesquite of a stocking density in the range of 700-1000 stems per feddan. Two year thickets have attained diameters in the range of 5-8 cm. and a height of 2-3 meters. Virgin areas not cleared since first infestation 18-20 years ago have a stocking density of some 600 stems per feddan, a diameter of 12-20 cm and a height of 4-7 meters.

Besides the mesquite utility as fuelwood (firewood and charcoal) and building poles, it has undisputed environmental roles:

- It is nitrogen fixing and as such helps to maintain soil fertility,
- It stabilizes sand-dunes permanently or temporarily,
- It stabilizes the banks of Khor Baraka. One of the eternal problems with KB is that the waters flow in no really permanent channels and that large changes in course may occur during a single flood or even a single spate. Mesquite trees and the ones that existed before mesquite came must have played a good role in the Khor maintaining its course in the upper reaches.

**Policy issues**

Based on land reclamation by farmers and under the pressure of farmer union of Toker Delta agricultural scheme, the central government declared the year 1995 as the "Mesquite Eradication Year". All public authorities concerned with agriculture, animal production and environment, joined hand with the agro and pastoral communities to uproot and burn Mesquite trees in their area. The role of the national forest cooperation was to coordinate the national efforts and to provide the extension packages on the best option to eradicate the tree. Oxfam launched an eradication scheme project during the year 2001 – 2003, under the title "food for work". 17 billion pounds were allocated to eradicated 20,000 feddans of the Mesquite trees. A contract was signed between Red Sea government and a private sector. The activity was stopped due to flooding of the plain. After flood, the area was heavily infested by the tree. People now are convinced that the current eradication programmes will not bring back their lands. Local people are now willing to participate in charcoal industry.

**Economy of Charcoal Production in the Delta**

Presently charcoal burning is a significant activity on mesquite in Tokar. According to locality authorities and TDAS about 25-30 lorries daily leave the delta with a 7500- 9000 charcoal sacs load. With the onsite price of 8 SDG per sac it means that 60,000-72,000 SDG is the daily income of the charcoal producers! It is noteworthy that food for charcoal producers is provided by charcoal buyers and is subtracted from their dues.

The taxation authorities in Ashat station (some 50 km from Tokar on the way to Port Sudan) gave a smaller number of 5,000 sacs per day, adding that many loaded trucks smuggle their way through. This lowers the daily income of charcoal producers to 40,000 SDG. Given the estimated number of 1000 charcoal producers; the daily income for each one is 40 SDG at least! The charcoal production season extends for 8 months which means

the annual income of the individual charcoal producer is SDG 6400-8000 assuming he works 25-20 days per month.

**Livelihood for rural people**

Charcoal still remains an important energy source for domestic cooking. Biomass Charcoal technology should be permitted in rural area so as to conserve and optimize the use of inefficient fuel wood. The biomass charcoal technology will be led to significant increase in the income of rural people (women).

***Economy of Pod Production:***

Pods are eaten by camels, cattle, sheep and goats. Mesquite pods provide a highly nutritive livestock feed that is cheaper than other available feeds. Some studies recommend mixing it with sugar cane bagasse. When mixed with cotton seed cake for goats and sheep it proved to be a good feed for maintaining weight and gaining weight (ARC, FRC, Pamphlet no.2 1986). Dry pods composition as reported by Vimal and Tyagi (India, 1986) contain: protein, 16.5%; fat, 4.2%; carbohydrate, 57%; fibre, 16.8%; ash, 5.4%; calcium, 0.33%; and phosphorus, 0.44%. Pods utilisation would add to the economy of Tokar and help control the spread of mesquite trees in arable land if processed as powdered livestock feed. Ripe legumes may be stripped from trees by hand or picked up from the ground. The whole pod dried and cleaned then running them through mechanical scarifiers or hammer mills, and then screening out or blowing away the trash.

**Emissions and controls**

The wood burns evenly and hot, as it has a high density and **a calorific value estimated at 4,220 kcal/kg** in young trees that increases as the trees mature. The wood burns well even when fresh and green, although the calorific value is then reduced due to the moisture content. Approximately **3-6 kg of prosopis wood is required to produce one kilogram** of charcoal, depending on the production method.

Charcoal, as differentiated from coal, is obtained by heating wood in the absence of oxygen and is considered to be a relatively better source of energy than wood.

The conversion of wood into charcoal is described by following chemical equation-

**Wood** **Heat strongly in absence of Air** Charcoal + Volatile matter + Moisture (Black residue)

Charcoal has higher calorific value (33 kjg-1) than wood (17kjg-1). Charcoal are classified in various category as lump charcoal, briquette charcoal, and extruded charcoal.

There are **five types of products and byproducts** from charcoal production operations: charcoal, Non-condensable gases as-
**Carbon monoxide** (CO),
**Carbon dioxide** (CO2),
**Methane, and ethane**)
**Pyroacids (primarily acetic acid and methanol**)
**Tars and heavy oils**, and water. With the exception of charcoal, all of these materials are emitted with the kiln exhaust. Constituents vary, depending on raw materials and carbonization parameters. **Organics and CO** are naturally combusted to CO2 and water before leaving the **retort.**

Particulate matter emissions from **briquetting** operations can be controlled with a centrifugal collector (65 percent control) or fabric filter (99 percent control).

Methane avoidance
There is at the moment no „good and simple“ methodology to calculate the emission reductions from charcoal. The methodology AMS-III.K is the only one which is appropriate and has been approved:
http://cdm.unfccc.int/methodologies/DB/5S7G7PZRR5A01LTMMIQMLVN2BSHCIR

If no external source of energy can be found, I would recommend the "Adam kiln" which cost only 800 EUROS per unit and **can produce 50 tonnes** of charcoal per year.

**As you can see, producing 1,460 tCO2e from renewable biomass or invasive plants would yield 6,143 CERs per year – with a value of €5/CER.**

*Charcoal production through the development of* ***improved kilns****; could help manage the expansion of mesquite trees and turn it into a resource in areas which are unsuitable for pastoral and agricultural production. Such initiatives could be started* ***as small scale, village based interventions and scaled up with appropriate market analysis and financial and marketing skills support in order to become more reliable income sources***.

Charcoal are classified in various category as lump charcoal, briquette charcoal, and extruded charcoal.

Mesquite has been introduced to Tokar area in the early 1960s, was later primarily used as a shelterbelt/wind break for Tokar Town in the mid 1980s and was satisfactorily to purpose. But later mesquite, a naturally invasive tree, encroached over the cultivated land and posed a dangerous weed to the delta farmers. Mesquite spread was exacerbated by many factors. These factors include spread of seeds by wind, flood, animals and human beings.

The Baraka stream waters, which never follow stable channels, added to reasons for farmers to abandon their lands when the water flow misses them as the stream change in course may occur during a single flood or even a single spate. Not only unpredictability of flood irrigation but also the uncertainty of the scarce irregular winter rains added extra reasons to farmers to leave their lands for mesquite. By now mesquite has occupied 33% of the total Tokar Delta as a whole and 37% of the arable land area.

Mesquite is evidently extremely adapted to the Tokar environment. The trees are evergreen. They flower all the year round from the age of one year and are prolific seed producers. They have an indefinite inflorescence. It is not unusual to encounter several fruiting stages on the one branch ranging from

unopened buds through open ones, just pollinated, embryonic pod formation, fully developed green pods, yellow pods to dry pods. Referring to local information compared with GTZ satellite imagery and SPCRP-MP-TDRP the area subject to flood spates fluctuated between 100,000 and 50,000 feddans during past decade whereas in 2009 it was about 7000 feddans only. Of the 100,000 feddans area around 20,000 are covered with scattered and new mesquite generations.

Mesquite is accused of hampering cultivation by its density and depletion of soil nutrients and thus its eradication became the number one concern of the government. Efforts to eradicate mesquite have had only limited success. The problem is to upkeep the cleared areas free from new infestation – after all, there are still the reasons mentioned before for farmers not to put forth efforts and resources with the uncertainty of the opportunity to make a living from cultivating their lands. During this period abandoned areas get easily re-dominated again from coppicing stumps and seeds.

Give an indication of the potential of Mesquite production in the Delta, its potential economic value for small holders and IDPs with regard to charcoal, building material, fire wood and other uses.

Environmental and Other Roles of Mesquite

*Another possible area of engagement could be that of charcoal production through the development of* ***improved kilns****; this could help manage the expansion of mesquite trees and turn it into a resource in areas which are unsuitable for pastoral and agricultural production. Such initiatives could be started* ***as small scale, village based interventions and scaled up with appropriate market analysis and financial and marketing skills support in order to become more reliable income sources***.

## Charcoal making

Toker Delta produce about 50,000, (35Kg/sack). Earth kiln is the most common practice of making charcoal, tow methods are used; one is that earth is excavated and wood is put in the pit which is then covered with the excavated earth, the second is that the mound or pile of wood is put on the ground and covered with earth. The capacity of the mound kilns used in the area varies between 5 sacks usually used in subsistence production and 30 sacks used be traders who sell small portion locally and exporting the rest to other nearby towns. The traders in the area are willing to organize themselves as a co-operative or to be registered as a company. The aim is to encourage charcoal production, increase marketing opportunities and increase employment opportunities. Reduction of cultivated lands turned people to casual labors working in charcoal making but a very low rate; costs of provision of food, tools, and empty sacs by the trader are usually deducted from labors' payment.

Mesquite provides a wide range of positive attributes that makes the species useful and promising for multi purposes in the semi arid dry lands. It provides sawn timber, fuel wood, charcoal, fodder, food, gum, tannin and medicine. It provides shade, stabilizes dunes, protects against erosion, improved degraded soils, and many other benefits. However, mesquite is becoming a nuisance on agricultural lands, irrigation canals, drainage lines and bridge inlets.

The massive Mesquite cover of the delta can provide high quality honey on sustainable basis. It can increase farmers' income by 40 – 60%, other products than honey is bee wax and bee venom. Genuine natural bee honey is now sold at 70 – 100 US$ per kilogram. Most of the respondents in the area are willing to participate in furniture industry or pods processing for animal and human consumption.

*P. juliflora* is currently stated to be the species common over large parts of Sudan, it landraces often have multi-stemmed and prostate habits with long branches and a crown that even touches the ground. The wood burns evenly and hot, as it has a high density and **a calorific value estimated at 4,220 kcal/kg** in young trees that increases as the trees mature. The wood burns well even when fresh and green, although the calorific value is then reduced due to the moisture content. Approximately **3-6 kg of prosopis wood is**

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**A metal kiln** is designed for carbonization of Mesquite with **efficiency around 25 %.** The metal kilns have additional advantage over the normally used earth-mound kiln is that it enables fine charcoal to be made from the **small branches of the Mesquite shrub**. **Twenty charcoal producers were trained** to use two identical metal kilns that were used for burning. The trainees participated with great enthusiasm and within a couple of hours of training they were comfortable with the kilns operation. Due to the fact that the wood originally put in the kiln was a little wet the carbonization process took four days, however this was reduced to one day after further testing. The output is **very good producing 6 sacks of good quality coal.**