Tropentag 2014, Prague, Czech Republic
September 17-19, 2014

Conference on International Research on Food Security, Natural Resource Management and Rural Development
organised by the Czech University of Life Sciences Prague

Valuation of Environmental Role of *Acacia senegal* Tree in the Gum Belt of Kordofan and the Blue Nile Sectors, Sudan

Jürgen Pretzsch[a], Mohamed E. Taha[b], Muneer E. Siddig[c], Taisser H. H. Deafalla[d], Hatim M. A. Elamin[c]

a Professur für Tropische Forstwirtschaft, TU Dresden, Germany – pretzsch@forst.tu-dresden.de
b Faculty of Natural Res. & Environ. Studies, Kordofan University, Sudan – nour.54321@hotmail.com
c Gum Arabic Research Centre, University of Kordofan, Sudan/
d Institute of Photogrammetry and Remote Sensing, TU Dresden, Germany.
Corresponding author: Assoc. Prof. Mohamed El Nour Taha, nour.54321@hotmail.com

Keywords: *gum belt, gum arabic, sedentary farming systems, environmental benefits, anti-desertification insurance, nitrogen fixation, contingent valuation method, replacement cost technique.*

Abstract

Cultivation of *Acacia senegal* is a key component of sedentary farming systems across the gum belt in Sudan, which comprises in addition to forestry component, crop farming and livestock raising. Gum arabic from *Acacia senegal* tree is a major product of rainfed agricultural sector; it is well perceived for its significant contribution to household income of gum farmers and to foreign exchange earnings of the country. Gum trees provide in addition, a wide range of valuable environmental benefits in form of anti-desertification insurance. They provide also fodder and fuel wood and contribute to increase in crop yield through nitrogen fixation. The study focused on environmental benefits of gum trees within most important producing areas of the gum belt in Kordofan and the Blue Nile Sectors aiming mainly to finding out values for non-marketable goods and services provided by such a tree in terms of soil protection and restoration of soil fertility. Contingent valuation method, hedonic price and replacement cost technique using market-oriented prices were chosen to value environmental effects of gum trees on land quality and to determine share of the tree in carbon sequestration. The valuation process was based on estimating cost of the fertiliser equivalent to the amount of nitrogen provided by gum stands. The internal rate of return (IRR) for a 16-year rotation gum stand was calculated to be approximately 15.2 percent. It was found that gum stands can save considerable cost of supplying ammonia nitrate fertilizer equals to approximately US$ 78 per hectare annually. When ecological benefits and social values associated with gum tree cultivation were considered, the recalculated IRR for 16-year rotation gum stands jumped from 15.2% to approximately 61 percent.

Introduction

Having been acknowledged as the world dominant leader in gum arabic production; Sudan contributes to about 95% of the total world gum arabic production (Abdulgadir, 2013). It effectively controls almost over 80% of the world market (Anderson, 1993; GAC, 1996; Forman, 2012; Abdulgadir, 2013). Gum arabic provides an average of 12 percent of the gross domestic product (GDP) of the country. Gum production accounts for about 15.3 percent and 10 percent of the household income of gum producers and other farmers in the gum belt in Sudan, respectively (Elamin and Ballal, 1989; Taha, 1999 & Mahmoud, 2004).

Besides accommodating one-fifth of the population of Sudan and two-thirds of its livestock population, the gum belt is of immense agricultural importance to the country (IIES/IES, 1990). The gum belt area is also important because of its geographical position; it lies directly south of densely populated states whose wood requirements are largely derived from the gum belt area and it is the first and last defence line protecting the agricultural and livestock production areas to the south against imminent encroachment by the Sahara Desert (Badi, 1989; IIED/IES, 1990). The gum tree has an important role in supplying household wood energy and fodder demands, besides enriching the soil fertility (Sahni, 1968; Barbier, 1992). The tree is also used in the traditional *Acacia senegal*-based agro-forestry system, which is recognized and considered as one of the most successful forms of natural forest management in the tropical dry lands (Fries, 1992). Furthermore; the gum tree is regarded as sustainable in terms of its environmental, social and ecological benefits to a large area of the Sudan (Eisa, *et al*, 2008, Ballal, 2002; NEF, 2010). Moreover, the *Acacia senegal* stands offer protection to soils against desertification, which is a phenomenon of a perpetual declining soil productivity hazard resulting from climate variation and human use of the land.

The Sudan is aware of *Acacia senegal* tree as a national wealth, which needs to be conserved, improved and developed; not only to provide a sustained yield of gum, but also for other important socio-economic benefits of protection and production.

The overall objective of the study was to identifying environmental benefits of *Acacia senegal* trees within most important producing areas of gum belt in Kordofan and Blue Nile Regions. The study aimed specifically to finding out values for non marketable goods and services provided by gum tree in terms of soil protection and restoration of soil fertility.

The study area description

The study covered some selected areas in great Kordofan Sector-Western Sudan and in the Blue Nile Sector-South-eastern Sudan. Administratively, the existing Kordofan Sector comprises North Kordofan, South Kordofan and West Kordofan States. Whereas, the Blue Nile Sector constitutes now both Sennar and Damazin States. The whole area of study lies within the gum belt. It covers different climatic and ecological zones according to the variation of rainfall intensities, relative humidity, temperature and edaphic factors. The study area exemplifies the potentials and problems of gum arabic production under both sand (qoz) and clay soils in the two most important gum-producing regions of the Sudan. Almost more than half of gum arabic produced in Sudan comes from Kordofan Sector and a considerable part comes from the Blue Nile Sector (Abdulgadir, 2013). The main economic activity of the inhabitants in the study area is based on integration of agriculture, animal production and forestry and gum arabic is a component of the household farm system in the study area (Taha, 1999; IFAD, 2002; Ramly, 2002; Mahmoud, 2004).

Methodology

The valuation process made to estimate the environmental effects of *Acacia senegal* trees on land quality was based on two considerations: 1) the ability to fix atmospheric nitrogen and maintain soil fertility, therefore improving agricultural production, 2) provision of a considerable amount of nitrogen estimated as 7.7 Kilograms per hectare annually (Hussein, 1983). The amounts of nitrogen provided by *Hashab* trees were valued using current market prices of the reasonable substitute; most important is the *Urea* (ammonia nitrate fertiliser. The replacement cost approach (Saastamoinen, 1992) that uses market-oriented prices was chosen to value the environmental benefits of *Acacia senegal* trees; the on-site costs of soil erosion were valued by calculating the costs of physically replacing the lost soil fertility.

Results

According to Hussein (1983), *Acacia senegal* trees provide an amount of nitrogen estimated as 770 part per million, i.e. every million measuring units of area contain 770 nitrogen units by weight. This amount of nitrogen is equivalent to 7.7 Kilograms per hectare. It could be concluded that such trees provide the per hectare soil annually with 7.7 Kilograms of nitrogen element. The *Urea* (ammonia nitrate) fertiliser, the most important fertiliser used to compensate for the loss in nitrogen in the irrigated sector in Sudan, was considered as the reasonable substitute and its current market prices were used for valuing the amounts of nitrogen provided by *Acacia senegal* trees The ammonia nitrate fertiliser contains, in addition to other elements 46% nitrogen. Therefore, the amount of nitrogen provided by *Acacia senegal* trees (7.7 Kg/hectare) could be available if 16.74 Kilograms of ammonia nitrate were supplied. The total cost of ammonia nitrate equivalent to the nitrogen provided annually by *Acacia senegal* trees per one hectare was computed as 86,638.37 *L.s*. In other words, the presence of *Acacia senegal* trees can save a cost of supplying fertiliser equals to 86,638.37 Sudanese pounds per hectare, which responds to approximately US$ 78 per hectare annually.

As a widely used indicator/measure of financial and economic efficiency, the internal rate of return (IRR) of cultivating *Acacia senegal* stands was calculated. The absolute IRR for a 16-year rotation *Acacia senegal* stand was calculated to be approximately 15.2 percent. That means, the average rate of return on funds invested on gum trees is expected to be around 15.2%. In other words, this estimated internal rate of return constitutes the ceiling rate and permits to support gum producers up to this point. The estimated IRR of gum stands is relatively small when compared to that figure of IRR estimated by Pearce (1988). He calculated the private (financial) internal rate of return from *Acacia senegal* stands, taking into account production of gum and fodder as well as fuelwood, based on a 16-year rotation to be around 36 percent. The general conclusion that could be drawn was that the total financial benefits from gum cultivation were positive. In other words, there were real financial benefits to farmers from growing *Acacia senegal* stands in many diverse systems across the gum belt even when current market prices are used to calculate the financial profitability of such stands. Such a situation would improve more particularly if the announced producer price of gum has been maintained in real terms.

One important result of the study, in addition to others, was the identification of smallholder farmers' problems that affect their decision on different components of the farm system. The income deficit was the most important problem that has the top priority among others. One achievable measure proposed to remedy the economic situation of farm households was provision of extra financial support, whose amount could be calculated based on the IRR of cultivating *Acacia senegal* stands and the estimated environmental values from gum trees, and it

should be enough to cover the imbalance between household income and expenditure. When the ecological benefits and social values associated with cultivation of *Acacia senegal* stands were considered, the recalculated IRR for 16-year rotation gum stands jumped to approximately 61 percent.

The gap between total household family income and expenditure reduced when the environmental effects of *Acacia senegal* trees on soil quality have been taken into consideration. Both the overall household economic situation and consequently its real annual performance improved by subsidising the total household family income with some financial support (compensation payment) under predetermined requisites.

References

Abdulgadir, Abdulmajid, 2013. Secretary General of the Gum Arabic Council. Google Earth, http://news.sudanvisiondaily.com/details.html?rsnpid=219702. Accessed in November 2013.

Anderson, D. M. W., 1993. Some Factors Influencing the Demand for Gum Arabic (*Acacia senegal* (L.) Willd.) and other Water-Soluble Tree Exudates. In: Forest Ecology and Management 58: 1-18.

Ballal, M. E. 2002. Yield trends of gum arabic from *Acacia senegal* as related to some environmental and managerial factors. PhD. Thesis, University of Khartoum, Sduan, pp 105.

Badi, Kamal Hassan, 1989. " The Natural Forests". In: 'The Forests of the Sudan'. Khartoum, 1989. pp 147. books.google.com.tr/sitemap/Sitemap/Unclassified/1989/T_20.html.

Barbier, E. B., 1992. Rehabilitating Gum Arabic Systems in Sudan. Economic and Environmental Implications. In: Environmental and Resource Economics, Vol.2, 341-358.

Eisa, M.A., M. Roth and G. Sama, 2008. *Acacia Senegal* (Gum Arabic Tree): Present role and need for future conservation/Sudan. Paper presented on Deutscher Tropentag, Germany.

Elamin, E. M. and Ballal, M . E. (1989): Paper on Land Tenure and Usufructuary Rights in the Traditional Gum Belt Agroforestry System in Western Sudan. Elobeid Research Station, Sudan, pp 12.

Forman, Stephane, 2102. Revitalizing the Sudan Gum Arabic Production and Marketing: P110588 - Report on Implementation Status and Results. Report Number ISR8088. http://documents.worldbank.org/curated/en/2012/11/16910481/sudan-revitalizing-sudan-gum-arabic-production-marketing-p110588-implementation-status-results-report-sequence-04. Accessed in Oct. 2013.

Fries, J., 1992. Management of Natural Forests in the semi-arid Areas of Africa, Present Knowledge and Research Needs, Seminar in June 1990. Swedish University of Agricultural Sciences. International Rural Development Centre. Uppsala 1992. Earth and Environmental Sciences. ISBN: 91-576-4610-4, pp 47-68.

GAC, Gum Arabic Company, 1996. Paper Presented on Problems and Constraints of Marketing Gum Arabic. Gum Arabic Conference, Friendship Hall (19 October 1996), Department of Research and Statistics, Gum Arabic Company, Paper No. 9/96, Khartoum, Sudan, pp 8.

Hussein, S. Goda, 1983. A Preliminary Study of Soils Under *Acacia senegal* (L) Wild. In: Sudan Silva No. 25 Vol. V. Khartoum, Sudan.

IFAD, 2002. Evaluating Cooperative Societies of Gum Arabic Producers. Seminar Paper, Records of Forests National Corporation, Om Rowaba Locality, North Kordofan State, Sudan, pp8

IIES & IES (1990): Gum Arabic Rehabilitation in the Republic of the Sudan (1990). Stage 1 Report. Volume 2. Main Report and Recommendations for Action. By: International Institute for Environment and Development, London, England and Institute of Environmental Studies, University of Khartoum, Sudan.

Mohmoud, Tarig Elsheik, 2004. The Adequacy of Price Incentives on Production, Processing and Marketing of Gum Arabic in Sudan. A Case of North and West Kordofan. Ph.D Dissertation. TU Dresden, Germany. ISBN 3-9809816-4-9.

NEF, Near East Foundation, 2010. NEF Launches Gum Arabic Project in Central Sudan. http://www.neareast.org/newsupdates/page/nef_launches_gum_arabic_project_in_central_sudan. Accessed in Oct. 2013.

Pearce, D. W.,1988. Natural Resource Management and Anti-Desertification Policy in the Sahel-Sudan Zone: A Case Study of Gum Arabic". In: Geojournal 17, pp. 349-355.

Ramly, Fatima Mohamed Ahmed, 2002. Evaluating Cooperative Societies of Gum Arabic Producers. Seminar Paper No. 1, Records of Forests National Corporation, Om Rowaba Locality, North Kordofan State, Sudan, pp 8.

Saastamoinen, O., 1992. Economic Evaluation of Soil Erosion: A Survey of Methods and Approaches. In: Scandin.For.Econ. 33: 486-509.

Sahni, K. C., 1968. Important Trees of the Northern Sudan, UNDP and FAO of the United Nations. Forestry Research and Education Centre Khartoum, Sudan, Pp. 1-7.

Taha, Mohamed El Nour, 1999. The Socio-Economic Role of Acacia senegal in Sustainable Development of Rural Areas in the Gum Belt of the Sudan. PhD Thesis, TU Dresden, Germany, ISBN 3-9809816-6-6.