

*Forests* **2011**, *2*, 948–960; doi:10.3390/f2040948

OPEN ACCESS

*forests*

ISSN 1999-4907

[www.mdpi.com/journal/forests](http://www.mdpi.com/journal/forests)

*Communication*

## **Making the National Adaptation Programme of Action (NAPA) More Responsive to the Livelihood Needs of Tree Planting Farmers, Drawing on Previous Experience in Dryland Sudan**

**Fobissie Blese Kalame \***, **Olavi Luukkanen** and **Markku Kanninen**

Viikki Tropical Resources Institute (VITRI), Department of Forest Sciences, University of Helsinki, P.O. Box 27, Helsinki, FIN-00014, Finland; E-Mails: [olavi.luukkanen@helsinki.fi](mailto:olavi.luukkanen@helsinki.fi) (O.L.); [markku.kanninen@helsinki.fi](mailto:markku.kanninen@helsinki.fi) (M.K.)

\* Author to whom correspondence should be addressed; E-Mail: [fobissie.kalame@helsinki.fi](mailto:fobissie.kalame@helsinki.fi); Tel.: +358-9-19158639; Fax: +358-9-19158100.

*Received: 21 September 2011; in revised form: 21 October 2011 / Accepted: 3 November 2011 / Published: 9 November 2011*

---

**Abstract:** Recently, tree planting has become popular under NAPA. For decades, many tree planting projects were implemented to reduce the vulnerability of ecosystems and societies. Despite all of these, tree-dependent livelihoods remain vulnerable, which leaves doubt on the benefit of tree planting to enhance the resilience of livelihoods to climatic shocks. This suggests that much can be learned from the past to improve future tree planting adaptation projects. This paper draws on the experience of farmers involved in gum arabic agroforestry in Sudan in order to understand the needs of tree-related adaptation projects that should be addressed. Surveyed farmers appreciated the different environmental services rendered by trees. Their priority areas for an adaptation project however, remain issues tied to gum producer price, rainfall pattern, and locust attacks as well as extension services and to a lesser extent access to micro credits. Moreover, Sudan's Gum Arabic Company (GAC) and Forests National Corporation play key roles in governance but are not yet considered as key adaptation players particularly the unsupportive role of the monopoly of gum exportation by GAC to tree planting as an adaptation activity. By focusing the design and implementation on tree related livelihood obstacles, adaptation projects are likely to be more responsive to the needs of vulnerable groups.

**Keywords:** adaptation; Africa; climate change impacts; governance; reforestation

---

## 1. Introduction

Tree planting is assumed to play a role at the national and local levels in helping vulnerable poor communities to adapt to the impacts of climate change [1,2]. This is true especially in many National Adaptation Programmes of Action (NAPAs) of the Climate Convention (UNFCCC). The role of tree planting as an adaptation activity is widely acknowledged in many NAPAs designed by governments of Least Developed Countries (LDC) such as Burkina Faso, Niger, Senegal, Sudan, and Gambia [3-5]. NAPAs identify and address the most urgent and priority needs of groups of people most vulnerable to climate risks [3]. The Least Developed Countries' Fund (LDCF) of the UNFCCC has been mobilized to assist LDC parties prepare and implement their NAPAs. A majority of the NAPA priority projects, in order of importance, are in the areas of agriculture, forestry, fisheries, water resources and disaster risk reduction [3]. Tree planting activities are not new although the concept and projects in NAPA might be [6]. In these NAPAs, tree planting is (or will be) implemented through agroforestry, rehabilitation/reforestation of degraded lands, stabilization of sand dune movement and the protection and restoration of watersheds. In Sudan, where this study focuses, "rehabilitation of the gum arabic belt for poverty reduction, combating desertification and conservation of biodiversity" are mentioned, for example, as tree planting adaptation projects ([7], p. 17).

Just like other NAPA priority activities, tree planting merits critical attention. In general there is much less known about when, where and how tree related projects can help communities adapt to impacts of climate change. This is crucial in relation to enhancing the capacity of vulnerable poor communities to adapt to impacts of climate change. Although recently during the UNFCCC Conference of the Parties in Cancun 2010, the design of a huge sum of USD100 billion per year was confirmed for long-term finance of adaptation and mitigation projects [8], current funds to sponsor adaptation projects remain limited [9]. Moreover, a wrongly focused and poorly conducted project can actually increase vulnerability or have little or no positive effect. This suggests that lessons learned from past tree planting activities may be useful for effective design and implementation of NAPA's tree-related adaptation projects. Furthermore, there is an increasing recognition to understand and integrate local experience in efforts aiming at strengthening the resilience of communities and ecosystems [10].

Prior to the creation of the Climate Convention (UNFCCC) in 1992, many multimillion (in US \$) tree planting projects in Africa were implemented to combat the effects of the great Sahelian drought of the 1970s, involving land degradation and desertification processes [11]. Major tree planting projects in Sudan were implemented in the gum belt by the United Nations Development Programme—UNSO (1981–1997), SOS Sahel (1985–2000) and the Governments of: Denmark—DANIDA (1978–1993), Finland—FINNIDA (1979–2005), Canada—CIDA (1986–1990), and Ireland (1986–1997).

Being the world's largest producers (80%) of gum arabic—a complex polysaccharide gum from *Acacia senegal* that has food, pharmaceutical and technical applications [12], most of the forestry projects in the gum belt of Sudan focused on restocking the gum belt. The restocking was intended to improve the gum yields, stabilize the supply [13], and provide a natural buffer zone to the desert in the North and the more fertile agricultural lands in the South [14] as a way to improving the livelihoods of the local population. A case in point was the ca Eur 30 million FINNIDA project aimed at improving the living conditions of the local population and reducing their poverty by combating desertification, rehabilitation of the gum (*Acacia senegal*) belt of Sudan as well as the training and exchange of

forestry experts between Sudan and Finland [15]. Despite all these projects, smallholder farmers remain one of the most vulnerable groups in Sudan [7] and Africa at large [16]. This leaves doubts on the effectiveness of tree planting projects, which is often only felt many years after, to reduce the vulnerability of poor communities.

This paper attempts to fill this gap by exploring the relevance of climate change adaptation projects to farmers' concerns and seeks to understand farmers' perspectives on the issues which adaptation projects should be focusing on to reduce their vulnerability. It draws from many years of farmers' experience in gum arabic (*Acacia senegal*) tree planting projects in Sudan. This experience can arguably act as a proxy to guide or improve the design and implementation of tree related adaptation activities in the NAPA.

In this paper, vulnerability is the degree to which farmers are susceptible to, or unable to cope with adverse effects of climate change, including other drivers of natural resources and environmental degradation [16]. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed (E), its sensitivity (S), and its adaptive capacity (AC). Adaptation on the other hand is an adjustment of natural or human systems to the actual or expected climate risk or their effects, which moderates harm or exploits beneficial opportunities' [16].

The structure of the paper is such that the next section highlights the theoretical background to the expectations of responsive adaptation projects. Thereafter in Section 3, the study sites and data collection methods are presented. The results are then presented in Section 4 where their implications for the design of tree-planting adaptation projects are discussed. Concluding remarks are presented in Section 6.

## 2. Theoretical Background: Responsive Adaptation

We acknowledge the fact that criteria for assessing the success of adaptation projects are context specific, and vary from project to project, and from place to place. These criteria can also be constrained by spatial and temporal scales of analysis. The criteria include elements of the following: project effectiveness and efficiency, equity and institutional flexibility [17,18]. According to Adger *et al.* [17], an effective adaptation project is required to reduce both short and long term vulnerabilities without producing negative unintended impacts to the adapting agent. The economic efficiency of an adaptation project is determined by the relationship of the cost and benefits (market and non-market value) and the timing of the project in relation to the climate change impact. Equity issues however relate to the distribution of benefits and costs among people and stakeholders of adaptation projects. Other studies [19,20] have pointed out that "present-day adaptation projects reinforce existing inequalities and do little to alleviate underlying vulnerabilities". Furthermore, institutional flexibility takes into account future uncertainties and also learns from experience and to incorporate lessons into climate change projects to facilitate successful adaptation.

In this study, we argue that a responsive adaptation process should assist socio-ecological systems to adapt to the impacts of climate change. The goals of responsive adaptations projects can be categorized into three broad aspects: projects or activities aiming at creating or enhancing (i) resilient and improved livelihood, (ii) resilient and productive ecosystems/environment, and (iii) supportive governance systems [21-23]. The results of this study will be discussed in terms of how they relate to these three categories of responsive adaptation projects. However, an adaptation project, depending on

the priority needs of the target vulnerable group or ecosystem, may address one or more of the issues outlined in each of the three categories.

The first category of adaptation process centred on vulnerable poor people is likely to have an impact on reduction of poverty and improving their capacity to respond to climatic and non climatic stresses. Such potential impacts on vulnerable poor groups could be realized by improved economic opportunities for vulnerable poor groups, provision of water supply, education and health, diversity of food source and livelihood activities, processing and marketing of local products and subsistence utilization of natural resources, *etc.* [24]. The second category of adaptation projects is centred on the vulnerable environment or ecosystems. Such projects are most likely to improve the resilience and provision of ecosystem goods and services. Potential activities could involve but not be limited to, risk planning: in natural resource management, early warning systems, co-management and climate impact defence systems against flood, storms, drought and desertification, *etc.* [23]. The third category is centred on promoting good governance: it is likely to support livelihood improvement and environmental management. The governance perspective may involve society, state and market perspectives [25]. This aim should be met through the following mechanisms: increased and improved access to ownership and viability of communal resources, extension services, decentralized management of natural resources, policies that enhance marketing and profits of local products for vulnerable groups, linkage between local informal and formal institutions and integration of local knowledge and climate change into development activities [24].

### 3. Methods

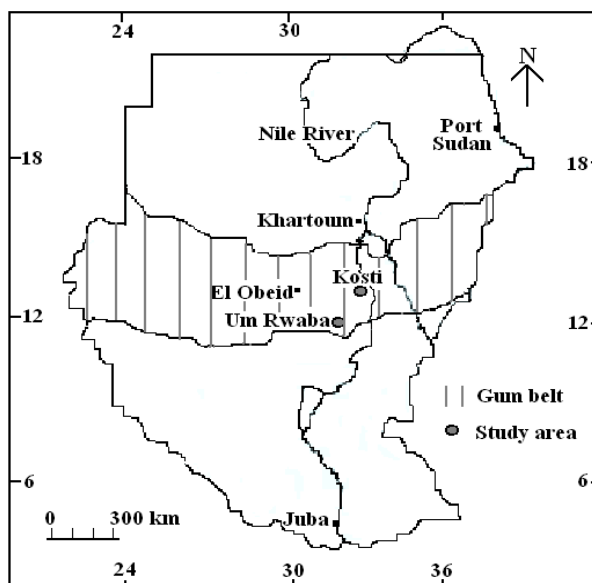
#### 3.1. Study Sites

The study was carried out in the gum arabic belt of Sudan (Figure 1) during the months of February and March 2010. The gum arabic belt as shown in Figure 1 represents one of the most important forest types in the Sudan. The belt lies within the low-rain savanna and indicates a zone of 520,000 km<sup>2</sup> in area that extends across Central Sudan between latitudes 10° and 14° N. *Acacia senegal* grows in this belt both naturally and through planting. The commercial gum arabic is exuded from the *A. senegal* tree in the form of nodules, after making incisions into the branches and stripping away the bark [26]. The belt accounts for one fifth of the country's total area, one fifth of the country's population and two thirds of the livestock population [26]. It should be noted however that Figure 1 is based on the map of old Sudan at the time when the study was conducted in 2010. Today, the Sudan is divided into two countries, North and South Sudan states.

Four sites were selected for this study: three from communities in Um Rwaba locality of North Kodofan State and one from a community in Kosti locality of White Nile State (Table 1). The selection was based on consultation with the National Forestry Corporation of Sudan (FNC), gum arabic experts and researchers. Table 1 clearly shows that gum arabic is not a key source of income for farmers in Jogup. For this reason, Jogup community was selected in Kosti locality as a control for other gum producing communities in North Kodofan. This control community enables this study to explore potentially different perspectives of tree planting. Farmers practice gum arabic agroforestry as the dominant and repeated farming system in all the study sites. Farmers cultivate crops with gum tree

(*A. senegal*) for about 4–6 successive years before *A. senegal* starts producing gum for harvest. This system takes about 15–25 years for a complete rotation period after which the trees become non-productive and are cut and used for fuel wood while the land is cultivated.

**Figure 1.** Map of Sudan showing the approximate boundaries of the gum belt and the study areas.



**Table 1.** Key characteristics of the study communities.

Um Gazira, Um Seriha, Amanala (Um Rwaba locality)	Jogup (Kosti locality)
Main income: gum arabic, groundnut and sesame	Main income: sesame and off-farm jobs
Sandy soil	Clay soil
Major gum-producing area	Minor gum-producing area
Strong gum association: 111–500 members / association	Weak or no gum association
Drought, deforestation and land degradation	Drought, deforestation and land degradation
Major tree project: UNSO-FNC	Major tree project: FINNIDA-FNC

The four sites represent a classic example of the tree planting experience in acutely vulnerable areas in Sudan. They were the major focus of about ten internationally financed projects in the 1980s and 1990s addressing, through reforestation of *Acacia senegal*, the vulnerability of societies and ecosystems [27]. Frequent drought (since the 1970s) coupled with desertification, deforestation, land degradation and decreasing soil and agricultural productivity impacts and leaves many smallholder farmers and ecosystems (especially the gum belt) with persistent vulnerability [28–31]. Climate projections for Sudan indicate that by 2060, temperatures will have increased in the range of 1.1 °C to 3.1 °C while rainfall will reduce by 6 mm/month in the rainy seasons with huge negative impacts on sustainable development [7].

### 3.2. Data Collection

In the study sites, 137 smallholder farmers practising gum arabic agroforestry and who had participated in one or more tree planting projects in their locality were surveyed. Many reasons made

this study focus on smallholder farmers in the gum belt of Sudan. Firstly, Smallholder farmers depend on rain-fed land and constitute one of the groups most vulnerable (in Sudan) to and disproportionately affected by climate change impacts [7]. Secondly, their views in the NAPA process in many developing countries were marginalized [3]. Thirdly, adaptation needs to be understood in a specific context. Fourthly, Smallholder farmers are in many cases involved in tree planting projects and activities are thus assumed to have a better understanding on where a tree related adaptation activity should focus.

Data was collected using a pre-tested semi-structured questionnaire. A survey was conducted in English and Arabic. Trained field research assistants conducted interviews in Arabic. Detailed information on household characteristics and farmers' opinions on tree planting projects and their role in reducing vulnerability to climatic and non-climatic stresses were obtained. Group and focus discussions were also held with farmers and local government officials in all the sites to further understand tree related issues affecting farmers' vulnerability. Discussions were held on the different expected livelihood, environmental and governance outcomes of successful climate change adaptation projects. Farmers were asked during these discussions, based on their tree-planting experience, to indicate the level of influence of factors affecting tree planting in relation to the three expected outcomes or goals of successful adaptation projects. The level of influence was rated from a high level of negative (--) to a high level of positive influence (++) .

Discussions aimed at validating and analyzing farmers' views were held with 15 other experts from relevant non-governmental organizations, and national and international institutions in Sudan. They included Forest National Corporation (FNC), Higher Council for Environment and Natural Resources, University of Khartoum, Gum Research Centre, Gum Arabic Association, Gum Arabic Company, United Nations Development Programme and Sudanese Social Forestry Society. Additional information was also obtained from literature while qualitative and quantitative (descriptive statistics) methods were used to analyze the data collected.

#### 4. Results: Farmers' Experience in Tree Planting

Table 2 presents the main issues influencing study area farmers to plant and maintain *Acacia senegal* trees on their farmlands. It provides a summary of the results section that is further expanded as subsections.

**Table 2.** Most important factors for tree planting and maintenance indicated by the farmers.

Factors	Study communities *				Total in % (n = 137)
	Um Gazira (n = 33)	Um Seriha (n = 45)	Amanala (n = 28)	Jogup (n = 31)	
<b>Producer price (%)</b>	90.9	91.1	89.3	71.0	86.1
<b>Rainfall pattern (%)</b>	72.2	55.5	60.7	93.5	69.3
<b>Extension services (%)</b>	54.5	75.5	75.0	32.3	60.6
<b>Locust attack (%)</b>	48.5	40.0	53.6	64.5	50.4
<b>Micro credits (%)</b>	39.4	22.2	54.5	-	29.9

\* Sample size for each study community does not sum up to 100% because farmers indicated more than one factor.

#### 4.1. Low Producer Price for Gum Arabic

Fluctuating producer price for gum over the years played an important role in discouraging farmers to engage in planting and maintaining *Acacia senegal* as a more attractive livelihood option over other sources of income (Table 3). Some farmers in Um Gazira and Amanala cut and stopped tapping *A. senegal* trees due to the low prices of gum arabic offered by “middle men” who buy for less than the floor price. Floor price is a government policy to ensure a minimum buying price to the farmer and it is announced annually. It is the amount left after deducting from the export price the estimated cost of cleaning, handling, preparing and transporting the gum for export, as well as taxes, insurance and Gum Arabic Company (GAC) profits [5]. Farmers sold a kilo of gum arabic in 2010, 2006 and 2002 at about SDG 60–70, SDG 250, and SDG 70 respectively (At the time of the research, US \$1 was about 2.28972 new Sudanese Pounds (SDG)). The high price in 2006 reflects the temporal liberalization decision taken by the government in 2003 and 2004 to issue licenses to Sudan-based gum processing companies that led to competition among buyers and translated into high gum producer prices. A major source of income for many farmers (47.6%) now comes from cultivation of sesame, groundnuts, and Roselle that have high market demands and prices with fast cash rewards.

**Table 3.** Income sources of farmers as of February 2010.

Source of income	Study communities				All sites (%) (n = 137)
	Um Gazira (n = 33)	Um Seriha (n = 45)	Amanala (n = 28)	Jogup (n = 31)	
<b>Agricultural crops (%)</b>	41.5	56	39.6	49	47.6
<b>Gum arabic (%)</b>	23	16.7	24.3	0	16
<b>Livestock (%)</b>	17	4.4	12.9	12	10.9
<b>Others * (%)</b>	18.5	22.9	23.2	39	25.5
<b>Total (%)</b>	100	100	100	100	100

\* Others include jobs such as gum tapping, driving, building, petit trading, tailoring, painting, land leasing, as well as working as guards, bakery workers, butchers, family support, etc.

#### 4.2. Rainfall Pattern Influence Tree Establishment

Poor and changing rainfall patterns, with uncertainty regarding their distribution, intensity and frequency are perceived by a majority (69.3%) of the farmers as increasing tree and seedling mortality rates that affect the growth and establishment of trees after planting. Farmers as well as forest officers relied on rain fed tree planting. Farmers perceived years with relatively good rainfall, as indicated in Table 4 (e.g., 2007, 2006), to be generally favourable for tree planting, growth and establishment, with a risk of flooding and water erosion while years with droughts (e.g., 1990) to be costly, in terms of irrigation, and to be unfavourable. Tree mortality and low gum production were attributed to recurrent droughts. In Jogup, farmers remember 1973–1974, 1984, 1992, 1998 and 2002 as major drought years while farmers in Um Gazira, Um Seriha and Amanala similarly indicated the early 1970s, mid 1980s, 1992 and 2002. Although there might be a mismatch in some years, there is generally a relationship between dryness and gum production. Most of the dry years mentioned by farmers show a declining trend in gum production and vice versa [32].

**Table 4.** Illustration of selected years with good and poor rainfall (Adapted from [33,34]).

Year	Annual mean precipitation (mm)		Gum production (in thousand metric tons)
	Kosti	El Obeid *	
1990	151	208	25.7
1992	196	440	9.0
2006	442	556	11.9
2007	686	647	20
1970–2009 (mean)	324	361	-

\* El Obeid is the closest meteorological station to Um Rwaba.

#### 4.3. Incentive-Based Forest Extension Service

Personnel from FNC, an autonomous state institution, play an important role in training farmers on how to plant trees and tap gum, and supplying them with tapping tools (sunki) and *Acacia senegal* seeds and seedlings. FNC is more supportive to farmers in gum-rich Um Rwaba than to gum-deficient Jogup. This supporting role is easily carried out through externally funded projects and the collection of taxes and royalties on gum marketing inside Sudan which partly generates income to pay FNC staff. By continuously providing extension services to farmers, FNC is in one way ensuring Sudan's future productivity of gum arabic and enhancing its influence over gum arabic issues-monopolized by the GAC. The main shortcomings of FNC include however short intervention at the initial phase of tree planting and insufficient extension personnel to reach a larger number of farmers.

#### 4.4. Locust Attacks are Threats to Gum Productivity

Anecdotal evidence by almost half of the farmers in both localities indicated that the Sahelian tree locust (*Anacridium melanorhodon melanorhodon*) attacks destroyed gum gardens (*A. senegal*), decreasing gum yields and income. These attacks occur almost on a yearly basis and FNC and the agricultural departments rarely provide insecticides to spray the infected plants or put in place an efficient response strategy including activities and research to combat locust attacks. These farmers use local, less efficient and labour intensive techniques to fight locust invasion. They dig trenches or tunnels in some areas around the trees and set fire in the tunnels. The wingless nymphs move on the ground by jumping and they fall into the tunnels and get burnt and killed.

#### 4.5. Micro Credits may Help Farmers Invest in Gum Arabic Production

Insufficient funds and lack of access to credits to invest in the intensive and expensive labour requirements during gum arabic planting, tapping and collection were identified by some farmers (38.7%) in Um Rwaba as a major obstacle to gum production. The cost of labour was estimated at about 25 SDG ( $\approx$ US \$10.9) for tapping 1 feddan ( $\approx$ 0.42 ha) which produces about 0.75 kinter ( $\approx$ 45 kg) of gum arabic. Not all farmers needed to hire labour however. Some of the gum arabic associations in UmRwaba have been able to get loans from the banks and donors. Amanala had the opportunity in 2003 to source loans or use a revolving fund aimed at hiring labour to tap the gum which was then repaid later in kind with gum arabic. Part of the loan was used to build stores for keeping gum arabic and other crops as well as to dig wells for water provision, which was identified as a priority and



expensive need during gum tapping and collection. Due to a poor gum harvest, farmers in Amalana in the second round of the loan could not repay which then led to the end of the revolving loan.

## 5. Discussion: Relevance of Farmers' Experience to Tree Planting Adaptation Projects

Using farmers' tree planting experience as a proxy to tree planting adaptation projects, we argue that a large focus should be laid on farmers' concerns particularly on highly negative factors impeding resilient livelihoods, and the resilient ecosystem/environment or supportive governance (see Table 5).

**Table 5.** Outcome of factors based on the past tree-planting experience of smallholders in relation to the goals of successful adaptation projects.

Factor	Relation to the goals of successful adaptation		
	Resilient livelihood	Supportive governance	Resilient environment
Gum producer price	---	---	0
Rainfall pattern	-	-	-
Extension services	+	+	+
Locust attacks	-	-	-
Micro credits situation	+	+	0

Note: --- = high level of negative influence; - = low level of negative influence; 0 = neutral influence; + = low level of positive influence; ++ = high level of positive influence; The level of influence is based on the judgement of knowledgeable local and national experts consulted during the study.

### 5.1. Livelihood and Pricing Perspective

Gum arabic provides farmers in Jogup with very little or no income. In contrast, gum productivity in Um Rwaba is one of the best in Sudan and provides farmers with income especially during the dry season when there is no income from other agricultural crops. It represents a way to diversify and improve livelihood while enhancing the capacity of farmers to absorb potential climatic shocks. Income generation according to study area farmers represents the most important priority related to the planting of *Acacia senegal* trees. The low gum prices however discourage farmers to plant more trees as they receive less than one fifth of the total export price of gum arabic. As one farmer in Um Gazira described: "Before, I hired labour and then we divided the benefit. It was not profitable so I decided not to plant and tap the trees for now". Improved gum prices for farmers can therefore be argued to reflect adaptation priority or entry point for tree related projects aiming at increasing the resilience of vulnerable farmers practicing gum agroforestry systems. Such market mechanism is partly and highly dependent on appropriate pro-farmer policy reforms and governance related influence over the gum arabic trade.

### 5.2. Governance and Marketing Perspective

Institutions involved in the study area that are supposed to support the capacity of farmers to adapt to shocks are rather more of an obstruction. Heads of gum arabic associations represent elite groups that are either educated or well connected to other powerful and influential actors. These elite groups

have higher chances to access microcredit for farmers but they rather use such credit opportunities to invest in activities that will enhance their own gum production and personal benefit. These elites have little or no influence on negotiating gum prices on behalf of farmers who are unfamiliar with market situations. Additionally, the generally low price of gum reflects Sudan's government policy to monopolize the export of gum arabic through GAC, hence restricting, to the detriment of farmers, other potential competing buyers and exporters with better prices. The political situation in Sudan (Darfur and Southern Sudan) further hurts the gum arabic trade. International sanctions for example were first imposed on gum arabic imports from Sudan to the USA in 1997, before exemptions were later granted. In this light, adaptation projects should strengthen the role of gum associations in negotiating better gum prices for the farmers; in creating innovative mechanisms to enable farmers access micro credits for gum production; and in helping the government to carefully review and maintain a stable liberalized gum export market that will benefit the farmers. This is a situation far from the role of the forest sector and implementers of NAPA; working with the Ministry of Trade and Presidency as key players influencing gum policies that affect the capacity of farmer to adapt to climate shocks.

### 5.3. Environmental and Extension Perspective

The numerous services provided by trees especially during and after the Sahelian drought, ranging from gum arabic, firewood, soil fertility, wind breaks, soil stabilization, *etc.* is well recognized by farmers in the two study localities and the government. This explains the protection, by farmers and FNC, of the less economic important species notably *Acacia tortilis* and *Leptadenia pyrotechnica*. Farmers in the gum-deficient Jogup prefer however to invest in the future in planting trees other than *Acacia senegal* that can provide other tangible livelihood benefits. This implies that the nature of provisional services of trees merits consideration in tree planting adaptation projects. The success of this project may partly depend on the ability of existing forest extension services taking a broader role in partnership with relevant institutions for timely communication and for making maximum use of weather forecast and early warning systems for drought, flood, locust attacks and other shocks. This information will likely direct resources allocation for example to water harvesting and storage, land rehabilitation techniques or organic pesticides to combat locust attacks.

## 6. Conclusions

The study uses the experience of farmers engaged in gum agroforestry in Sudan to provide an indicative guide to make tree planting adaptation projects more responsive to the needs of vulnerable groups. It may not have covered the full range of issues related to tree planting and does not suggest that all tree planting adaptation projects should focus on the issues highlighted in this study due to location-specific situations. Our analysis however shows that the design of tree related adaptation projects should, in the case of gum belt, primarily focus on factors with a negative trend such as governance issues related to policies and markets affecting producer gum price. In cases where the financial resources of tree planting adaptation projects are sufficient, emphasis can then cover other important areas such as rainfall forecast/ preparedness and issues of locust attacks before addressing activities such as extension and micro credits that already show a positive trend. Non-traditional

NAPA actors such as FNC and GAC play bigger roles while gum associations play minor roles in influencing governance of adaptation in the gum belt. FNC through extension services may act as a base to address broader issues linked to locust attacks, communication of weather forecast and other tree related adaptation implementation.

The government in the long term should liberalize the gum sector and promote a pro-poor gum policy. This policy is justified by the recognition, by farmers and the government, of the environmental services and livelihood improvement potentials of *Acacia senegal* tree planting. The focus of past tree planting projects aimed at increasing incomes and reducing poverty among other things still remains on tree planting-business as usual, while the major concerns of farmers related to gum price and marketing, locust attacks and rainfall pattern are overlooked. These concerns represent the core areas where the design of tree planting adaptation projects should focus in order to enhance the adaptive capacity and resilience of farmers to climate hazards and risks.

### Acknowledgements

Research for this article was supported by the Carbon Sequestration and Soil Fertility on African Dryland (CASFAD) Project funded by the Academy of Finland. We are grateful to those who participated in the research and to the anonymous reviewers for their valuable comments on earlier drafts of this manuscript.

### References

1. Verchot, L.V.; van Noordwijk, M.; Kandji, S.; Tomich, T.P.; Ong, C.K.; Albrecht, A.; Mackensen, J.; Bantilan, C.; Anupama, K.V.; Palm, C. Climate change: Linking adaptation and mitigation through agroforestry. *Mitig. Adapt. Strateg. Glob. Chang.* **2007**, *12*, 901-918.
2. Locatelli, B.; Kanninen, M.; Brockhaus, M.; Colfer, C.J.P.; Murdiyarto, D.; Santoso, H. *Facing Uncertain Future: How Forests and People can Adapt to Climate Change*; Forest Perspectives No. 5; Center for International Forestry Research (CIFOR): Bogor, Indonesia, 2008.
3. United Nations Framework Convention on Climate Change (UNFCCC). *The Least Developed Countries National Adaptation Programmes of Action: Overview of Preparation, Design of Implementation Strategies and Submission of Revised Project Lists and Profiles*; LDC Expert Group 2009, UNFCCC: Bonn, Germany, 2009.
4. Osman-Elasha, B.; Downing, T. *Lessons Learned in Preparing National Adaptation Programmes of Action in Eastern and Southern Africa*; Policy Analysis Report; European Capacity Building Initiative (ECBI): Oxford, UK, 2007.
5. Hardee, K.; Mutunga, C. Strengthening the link between climate change adaptation and national development plans: Lessons from the case of population in National Adaptation Programmes of Actions (NAPAs). *Mitig. Adapt. Strateg. Glob. Chang.* **2009**, *15*, 113-126.
6. Kalame, F.B. Modified taungya system in the transition zone of Ghana. In *Forests and Climate Change: Adaptation and Mitigation*; Bodegom, V., Jan, A., Savenije, H., Wit, M., Eds.; Tropenbos International: Wageningen, The Netherlands, 2009; pp. 101-106.

7. HCENR. *National Adaptation Programme of Action (NAPA)*; Higher Council for Environment and Natural Resource, Ministry of Environment and Physical Development: Khartoum, Republic of Sudan, 2007.
8. *The Cancun Agreement: Outcome of the Work of the Ad Hoc Working Group on Long-Term Cooperative Action Under the Convention (Decision 1/CP.16)*; UNFCCC: Cancun, Mexico, 2011. Available online: <http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=2> (accessed on 15 September 2011).
9. Flåm, K.H.; Skjærseth, J.B. Does adequate financing exist for adaptation in developing countries? *Clim. Policy* **2009**, *9*, 109-114.
10. McGuire, S.J.; Sperling, L. Leveraging farmers' strategies for coping with stress: Seed aid in Ethiopia. *Glob. Environ. Chang.* **2008**, *18*, 679-688.
11. Weber, F.R.; Stoney, C. *Reforestation in Arid Lands*, 2nd ed.; Volunteers in Technical Assistance (VITA): Arlington, VA, USA, 1986.
12. World Bank. *Export Marketing of Gum Arabic from Sudan*; Policy Note; Multi Donor Trust Fund-National, Technical Secretariat: Khartoum, Sudan; Juba, Sudan, 2007.
13. Ballal, M.E.; El Siddig, E.A.; Elfadle, M.A.; Luukkanen, O. Gum arabic yield in differently managed *Acacia senegal* stands in Western Sudan. *Agrofor. Forum* **2005**, *63*, 237-245.
14. Rahim, A.H.; van Ierland, E.C.; Wesseler, J. Economic incentives for abandoning or expanding gum Arabic production in Sudan. *For. Policy Econ.* **2007**, *10*, 36-47.
15. Ibrahim, A.M. Twenty eight years (1979–2007) of forestry cooperation between Finland and Sudan: A case study. In *Research Collaboration on Responsible Natural Resources Management, the 1st UniPID Workshop*, Hyytiälä, Finland, 16–17 October 2007; Hares, M., Luukkanen, O., Eds.; University of Helsinki: Helsinki, Finland, 2008; pp. 51-54.
16. IPCC. *Climate Change 2007, Impacts, Adaptation and Vulnerability*; Contribution of Working Group II to the Fourth Assessment Report of the Inter-governmental Panel on Climate Change; Cambridge University Press: Cambridge, UK, 2007.
17. Adger, W.N.; Arnell, N.W.; Tompkins, E.L. Successful adaptation to climate change across scales. *Glob. Environ. Chang.* **2005**, *15*, 77-86.
18. Hedger, M.; Mitchell, T.; Leavy, J.; Greeley, M.; Downie, A.; Horrocks, A. *Evaluation of Adaptation to Climate Change from a Development Perspective*; Institute of Development Studies: Brighton, UK, 2008.
19. Adger, W.N.; Huq, S.; Brown, K.; Conway, D.; Hulme, M. Adaptation to climate change in the developing world. *Prog. Dev. Stud.* **2003**, *3*, 179-195.
20. Thomas, D.S.G.; Twyman, C. Equity and justice in climate change adaptation amongst natural-resource-dependent societies. *Glob. Environ. Chang.* **2005**, *15*, 115-124.
21. Environmental Protection Agency. *Strategic Environmental Assessment of the Ghana Poverty Reduction Strategy Report*; EPA: Accra, Ghana, 2004.
22. Carlsson, L.; Berkes, F. Co-management: Concepts and methodological implications. *J. Environ. Manag.* **2005**, *75*, 65-76.
23. Plummer, R.; Armitage, D. A resilience-based framework for evaluating adaptive comanagement: Linking ecology, economics and society in a complex world. *Ecol. Econ.* **2007**, *61*, 62-74.

24. Eriksen, S.; Næss, L.O. *Pro-Poor Climate Adaptation: Norwegian Development Cooperation and Climate Change Adaptation: An Assessment of Issues, Strategies and Potential Entry Points*; CICERO Report 2003:2; Report prepared for the Norwegian Agency for Development Cooperation (NORAD): Oslo, Norway, 2003.
25. Lemos, M.C.; Agrawal, A. Environmental governance. *Annu. Rev. Environ. Resour.* **2006**, *31*, 297-325.
26. Gaafar, M. Improving Traditional Acacia Senegal Agroforestry: Ecophysiological Characteristics as Indicators for Tree-Crop Interaction in Western Sudan. Ph.D. Dissertation, University of Helsinki: Helsinki, Finland, 2005.
27. Keddeman, W. *Restocking of the Gum Belt for Desertification Control in Kordofan, Phase III*; Report of the evaluation mission (UNSO/SUD/89/X05); Netherlands Economic Institute, Agricultural and Rural Development Department: Rotterdam, The Netherlands, 1994.
28. Warren, A.; Khogali, M. *Assessment of Desertification and Drought in the Sudano-Sahelian Region 1985–1991*; UNSO: New York, NY, USA, 1992.
29. Olsson, L. On the causes of famine—Drought, desertification and market failure in the Sudan. *Ambio* **1993**, *22*, 395-403.
30. Elmqvist, B.; Olsson, L. Livelihood diversification: Continuity and change in the Sahel. *GeoJournal* **2006**, *67*, 167-180.
31. United Nations Environmental Programme (UNEP). *Sudan Post-Conflict Environmental Assessment*; UNEP: Nairobi, Kenya, 2007.
32. Tarig, E.M. Vulnerability of Gum Arabic Producing Farmers. Director of Gum Arabic Research Center, University of Kordofan: El Obeid, North Kurdufan, Sudan. Personal communication, 10 March 2010.
33. *El Obeid and Kosti Stations*; Sudan Meteorological Authority: Khartoum, Sudan, 2010.
34. *Gum Arabic Production*; Bank of Sudan: Khartoum, Sudan, 2007.

© 2011 by the authors; licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/3.0/>).