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Contribution of Agro-silvo-pastoral System in the Livelihood of Rural Households in
Central-west of Sudan

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1. Introduction

Agro-silvo-pastoral Systems (ASPS) is a collective name for the land use systems implying
the combination of trees/shrubs with husbandry and/or crops. In Sudan, the Gum tree (*Acacia
senegal*), animal components and crops are presented simultaneous in time and space with
mandate to achieve sustainable production. The system has remained an important source of
income for millions of smallholders in areas where other income-generating activities are not
available (ABDELATEIF, 2012). According to RECARDO, (1996) economic benefits and
stability of land use were the direct advantage of ASPS. Similarly, ISAAC (2008) argues that
ASPS provides more than 43 products, and contribute essentially to the sustainability of food
security. Although ASPS plays a significant role in various biological and economical
aspects, the environment hazards was rapidly increased in North Kordofan where this study
was conducted. Therefore, one can reasonably assume that, any future strategy neglecting
ASPS in Sudan, may have an ambiguous effect on farmer's income and consequently their
livelihood. Particularly, small-scale farmers and pastoralists who were heavily dependent on
the environmental assets embodied in various agroforestry systems.

2. Statement of the Problem

In spite the vital role of the ASPS in Sudan with respect to household income and ecological
aspects, the deforestation and desertification of environment and land degradation remained
drastically high. According to ADB, (1994) more than 60 percent of the total area of Sudan is
seriously affected by desertification. During 1990-2005 Sudan had lost about 8.8 million
hectares of forests, which represents 11 percent, of its forests mainly because of subsistence
activities such as overgrazing, trees cutting and expansion of traditional agriculture
(RAINFORESTS, 2007). Although, central-west of Sudan is the main areas where *Acacia
senegal* trees (gum arabic trees), are found, the contribution of trees to the household income
is still relatively small. This is because farmers do not view the trees as direct means of
raising their income; rather he/she has removed and replaced the large areas of natural
woodlands by mono-cropping. It has been reported that farmers have responded to declining
land productivity by abandoning their existing degraded cropland and moving to new lands
for cultivation of their rainfed agricultural crops (ABDELATEIF, 2012). Moreover, the
dramatic increase in the animal and human population has led to increased pressure on the
available natural resources, particularly land and the woody vegetation. Similarly, the

intensive cultivation, overgrazing and tree cutting has led to land degradation and, consequently, decreased the land productivity. These factors have resulted in food shortage, poverty, and lack of fodder and fuelwood (EL-AMIN, 2006). In addition to that, new challenges such as lack of marketing facilities and institutional support and weak infrastructure were considered to be the major obstacles that constrained the sustainability of ASPS in the area. As result, the people in the area depend highly on resource-based subsistence economy, living in highly degraded lands and vulnerable environments which make them struggle to maintain their basic needs. Based on such background, this study was aimed to determine the income generated by the best land use alternative mixtures of agro-silvo-pastoral system and tries to estimate the profitability of the system components taking into account the contribution of forest products to the livelihood of farm households. This, however, raises a fundamental set of the following research questions:

1. What are the best land use alternative mixtures that make the agro-silvo-pastoral system more profitable?
2. How do the ongoing practices influence the livelihood of farm households in long run?

3. Data Collection and Analytical Techniques

The data were derived from field survey that is carried out in 2014 in three localities in North Kordofan, namely Wad Banda, Elkhawei and Enuhud, central-west of Sudan. Structured questionnaire was distributed to 250 farm households. A cluster random sampling technique was used for the selection of sampling. Subsequently, focus group discussions with the key informants in the village communities were also conducted. Descriptive statistical analysis, partial budget and benefit cost analysis were used to analyze the data. Partial budget was used to explain and clarify in detail to what extend are cost and revenues have been investigated in the different activities. However, the exploration of the model items, such as income sheet was used to calculate the revenues and costs under hypothetical assumptions of sensitivity analysis. Mathematically, we employed the following formulae:

GM = TR –TVC

$$GM (\Pi) = \sum (TR-TVC) = \sum (PQ-WX_i)$$

$$\frac{\Pi}{P}(P, Z) = \frac{\sum (PQ - WX_i)}{P} = \frac{Q - WX_i}{P} = f(X_i, Z) - \sum P_i X_i$$

Where:
R = revenue in SDG
P = market price in SDG
Q = output in sack/ SDG
TC = Total cost in SDG
Π = Profit in SDG

4. Results and Discussion

4.1 Descriptive results

The results of descriptive analysis show that 17% of rural households had a preference to mix crops with trees and/or animals, while 25% of rural households are more likely to mix animals and trees (see Table 1). Typically, about 41% of rural households predominately practice all components of agro-silvo-pastoral system (crops, trees, and animals). This result implies that households in North Kordofan had a substantial awareness in practicing of agro-

silvo-pastoral system and consequently, mixing of trees growing activities contributes significantly to production when compared with other components.

Table 1: Preference of practiced mix by farmers

Preferences	Frequency	Percentage
Crops and trees	18	17
Crops and animals	18	17
Animals and trees	26	25
Animals + trees + crops	43	41

Source: depicted from own data, 2014

On the components basis, the mean gross margins of livestock for all areas (Wad Banda, Elkhawei and Enuhud) were calculated as (50, 169.197 and 45 SDG) respectively. Similarly, livestock activities in all areas under study are the most important and most profitable. However, crops are considered to be the second source of income followed by animals in all mentioned areas. On the other hand, the analysis of gross margin for tree products show that the mean gross margins of trees are lowest in all the three zones with amount of (7.549, 5.240 and 3.579 SDG) respectively. Further analysis concluded that, among the three areas Elkhawei recorded the highest gross margin of livestock followed by crops and trees.

Table 2: Actual mix of agro-silvo-pastoral components SDG/hectare

Area	Crops/sack	Animals/head	Trees/quintal/sack	Total
Wad Banda	45	50	7.549	58
Area	0.04%	86%	13%	≈ 100%
Elkhawei	900	169.197	5.240	175
Area	0.01%	96%	3%	≈ 100%
Enuhud	3.489	45.293	3.579	52
Area	0.17%	91%	7%	≈ 100%

Source: depicted from own data, 2014

The results obviously, showed that the best alternative mix of land use in Wad Banda area includes millet, sheep beside non-timber forest products mainly (*Adansonia digitata (Ganglis), Balanites aegyptiaca (Lalob), Grewia tanix (Godium), and Ziziphus spina-christi (Nabag)*). However, in Elkhawei area the best land use alternative mix consist of groundnut, sheep and gum Arabic. While in Enuhud area it includes groundnut, cattle and gum Arabic.

Table 3: Best land use alternative mixture of agro-silvo pastoral components/hectare

Components	Crops/sack/ha	Animals/head	Trees/quintal/sack/ha
Wad Banda area			
Land use alternative	Millet	Sheep	NFTPs
Net revenue/SD	56	161	76
Amount unit	25	268	80
El-khawei area			
Land use alternative	Groundnuts	Sheep	Gum Arabic
Net revenue/SD	39	301	47
Amount unit	10	532	7
Enuhud area			
Land use alternative	Groundnuts	Cattle	Gum Arabic
Net revenue/SD	97	128	93
Amount unit	22	27	8

Source: depicted from own data, 2014

5. Conclusion and Recommendations

The potential services introduced by agro-silvo-pastoral system are considered a crucial factor for enhancing household income and food security, since they determine whether the farmers benefit from the services offered or whether the services themselves respond to the needs and standard conditions of such households. In this paper, we analyzed the contribution of agro-silvo-pastoral system in the livelihood of rural households in North Kordofan State of Sudan. The result of descriptive statistics reveals that the farm households prefer to practice the different components of agro-silvo-pastoral system in all areas under study. In spite of, positive contribution of the actual mixes agro-silvo-pastoral system in livelihood of households in all areas under study, urgent improvement in institutional arrangements, promotion of community-based natural resources management, marketing opportunities, and provision of better veterinary services are required to ease the profitability of the system in the long term future. The findings have also come to conclude that gum Arabic, sheep and groundnut are dominant in the study area followed by millet, cattle and non- timber forest products.

Considering the previous results, one can reasonably assume that, if rural households keep practicing in the ways shown in table 2, practicing of agro-silvo-pastoral system will improve to the point of becoming significant and positive, not only in income source, but also in sustainability of food security. To promote sustainable practice of ASPS, the policies that encourage the adoption of ASPS components should be improved. This could be possible through lunching a sustainable education program on ASPS practices and supporting farmers and organizations interested to invest in Agroforestry.

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