Agricultural Resources Use for Sustainable Perennial Farms in North Region Sudan

ELGILANY A. AHMED  
Department Agribusiness  
Universiti Utara Malaysia (UUM)  
P.O. Box: 06010 UUM, Sintok, Krdah Darul Aman, MALAYSIA  
elgilanya@yahoo.com, Website: www.uum.edu.my

Abstract: This research examines resources-use optimization for agriculture development in North Sudan region. In the region, tenancies imply numerous field and perennial crops to intensify and diversify production aiming to maximize output and returns. Perennial crops such as palm, banana, guava, citrus fruits and mangoes are the most well-known fruit trees in the region. Furthermore, they are considered as essential food and cash crops within the dominant crop combination in the country. The research looked at River Nile State as a case study due to its high potential to produce food and cash crops. The perennial crops in the state are commonly produced under pump irrigation from the River Nile. The production of these crops in North Sudan faces numbers of shortcomings, namely low level of productivity, high cost of production and inefficiency in resource use. This research illustrates the poten for resources use efficiency in perennial crops in the State. Beside secondary data, primary data were collected using structured questionnaires for fifty randomly selected respondents’ tenants. Linear Programming was used to model the optimal use of resources in perennial crops. The model unveiled that farmers would benefit from increasing of resources use efficiency in perennial crops production compared to conventional ones. Therefore, they should be encouraged to adopt the recommended resources use package for better returns and contribute significantly to farm sustainability in the State.

Key-Words: - perennials, production, resources-use, north Sudan

1 Introduction
Agricultural resources are considered as fundamental economic inputs that why producer looks to obtain maximum production per unit. In North Sudan they are huge and properly management can promote food for the local consumption and exportation. Water from the River Nile and impressive rainfall in the centre and south meet cropping and herding requirements at different degrees. The available arable area of about 85 million ha, only 20% is currently under cultivation but with inter-seasonal variation (MAS, 2009). Given the country’s high dependence on crops and livestock for livelihoods, availability of and access to natural resources is paramount (De Pauw, 2009). In North Sudan, high competition for agricultural resources such as land and water resulting from high population explosion and problems of low crop yields (might emanated from climate change and poor use of technology) poses challenges for resource management. This calls for resource utilization efficiency. The research looks into other options to maximize Farmers’ profits and output under optimal and stable combination of the scarce resources. Thus, it addresses the issues resources use efficiency.

2 Methodology
The study was carried in Elketiab public irrigation scheme of the state, where annual perennial crops are grown. The research used mainly primary data collected in from 70 randomly selected farmers with probability proportional sampling techniques through structured questionnaire. Integrated analytical techniques comprised linear programming (LP) and resources-use efficiency models by using General Algebraic Modelling System (GAMS), CropWat4, Excel and SPSS software programs. Field survey included data collection on the prevalent crop manner and dominant resource allocation. The model was specified with gross margins maximization as the objective function as:

$$\text{Max } Z = \sum_{j=1}^{C} C_j X_j$$  \hspace{1cm} (1)
Such that:

$$\sum_{j=1}^{m} \alpha_{ij}x_j \leq b_i, \text{all } j = 1 \text{ to } m$$

... (2)

And:

$$x_j \geq 0, \text{ all } j = 1 \text{ to } n$$

... (3)

Where:

- Z = objective function value per year,
- Xj = Level of the jth the farm activity, such as the acreage of orang grown. Let n denote the number of possible activities; the j = 1 to n.
- Cj = Objective value, in this case the forecasted feddan (SDD/feddan) gross margin of a unit of the jth activity.
- Aij = quantity of the ith resource available (i.e., days of labour or other required quantities of inputs) required to produce one unit of the jth activity.
- M = Denote the number of resources; then i = 1 to m.
- Bi = Amount of the ith resource available (e.g. cubic meter of water, feddan of land, days of labour or other required quantities of inputs).

The objective is to find the cropping system (defined as a set of activities levels Xj, j = 1 to n) that has the highest possible total gross margin, Z, but doesn’t violate any of the fixed resource constraints or involve any negative activity levels.

Equation (1) is the objective function, which maximizes the gross margins from one feddan of perennial crops. Equation (2) shows the limits on the levels of the available resources (i.e., cubic meter of water, feddan of land, days of labour or other required quantities of inputs) that tenant can apply to produce the mentioned crops. Equation (3) which is a non-negativity condition, states that all resources used in the production process and output must be equal to or greater than zero, meaning that negative use of resources and negative of production is impossible. The coefficients represent the average requirement of the ith activity (enterprise), calculated per feddan basis. The calculation of the crop water requirements (CWR) of any crop requires estimation of its crop coefficient (Kc). Kc values could be used for estimation of CWR as a product of Kc * ETo in different regions of Sudan. Penman equation (1948) for calculating evapotranspiration from free water surfaces was used in the calculation of crop factors (CF by many scientists over the world. They were able to determine the CF of most filed and perennial crops in the world. Recently, FAO Penman-Monteith (PM) method was developed to estimate ETo values from a hypothetical reference crop that were more consistent with the actual CWR and has been recommended by FAO as the standard method for CWR calculation. The reference crop evapotranspiration ETo was calculated from the daily whether specifically the maximum and minimum temperature, relative humidity, wind speed at 2m height and sunshine duration by using Crop Wat4 windows program according to the recommended Penman-Monteith formula as shown in Equation (4).

$$ETo = C \left( WR_n + (I-W) f(u) (ea-ed) \right)$$

... (4)

Where:

- C = error factor
- W = weighting factors
- Rn = net radiation
- f(u) = function in wind speed
- ea = saturation pressure
- ed = perfumed water

3 Results and Discussion

3.1 Production of food and cash crops

In spite the majority of perennial crops grown in the State are mostly profitable, but limitations on essential resources namely, land, water, labour and capital constraint attainment of adequate yield and returns. The option of irrigation is mandatory in the scheme from the River Nile by pumps, as well as a little amount from ground water for supplementary irrigation. The study found the perennial crops in the River Nile district occupied only about 16% of the total cultivated area in 2006, while the prevalent perennial crop combination consist citruses, date palms, mangoes, guava and alfalfa (see Figure1). The research unveiled that the land devoted to perennial crops in the scheme was up to 53% occupied by citruses, followed by 15% for alfalfa, while date palms and guava were formed 13% and 11%, respectively. The lowest percentage (1%) was formed by mangoes.

According to Peter (2000), every 10% increase in crop yield reduces the number of income-poor by an average 7.2% in Sub-Saharan Africa. Variables cost of production play a unique role in producing annual crops where material-input costs largely influence earned profits (Doll and Orzem, 1984). The research
revealed that the land allocation at the farm level. It showed that citruses percentage formed 58% of respondent tenancies as the highest percentage over the perennial combination, while mango was the lowest one. The yield of perennial crop achieved by the surveyed tenants were generally low when compared by research yields attained by the Agricultural Research Corporation (ARC) in area of the study with minimum and maximum yield gap reaching 74% and 26% for date palms and alfalfa ‘Barseem’, respectively. The results indicate that there is high potential to increase yields of all perennial crops under study.

3.2 Cost of perennials production

Production economics play a unique role in farm management Doll and Orazem (1984). The dominant conception of production cost in the area of study is known as the cost of material inputs, labor, services, and the management used in producing a particular commodities or/and crops. Many studies revealed that the cost of production overall the state has decreased farmers’ returns. The high cost of production might emanating to high overall the state has decreased farmers’ returns. The cost of production might emanating to high cost of numerous production inputs. The farmers in North Sudan complain from high cost of production and they depend on self-finance totally to produce perennial crops by about 600 SDG/fed indicating shortcoming in formal financial system performance. Ijami (1994) mentioned that the formal financial system provides only small parts of credit used by farmers. Therefore, most of farmers seek other informal sources of finance. Loans extended by friends and relatives, mostly without interest, constitute the non-commercial segment.

The study unveiled that transportation cost component is absolutely considered as the most agricultural hindrance facing perennial crops production, having the highest cost item at 20% of total production cost. This might refer to the inadequate public investments. This followed by irrigation water cost, which is also regarded as one of the most important agricultural constraints that is caused by the high cost of water pumping; and justifies the need for strict allocation among the different crops grown. The perennials growers of the scheme pay the cost of this item as a fixed annual rate for the scheme administration.

3.3. Marketing of perennials in North Sudan

Farmers cultivating those food products will also get more income, which will be positively reflected on their standard of living. More national revenue means more money available for solving pertaining problems hindering Rural Development. Marketing such large amounts of organic foods will make Sudan a prominent figure in the international market of these products. It will also attract global investors to agricultural production of such crops Babiker (2003). Over the last decade North Sudan witnessed improvement in crop marketing due to some progress in public infrastructure. Although there is promotion, stretched linkages and options for marketing of perennials’ products, farmers still face some difficulties to take the right decision of where and when to trade their marketable surplus. The hesitancy of the State farmers might be attributed to the high cost of transportation, which forms the highest marketing cost item, in addition to the road fees inbetween big city markets. Furthermore, lack of some cold storage and other marketing infrastructures are considered as chronic problem facing perennials producers in Elketiab.

3.4. Contribution of perennial crops in household food security and income

Perennial crops are important sources of household food security and nutrition in many world countries as well as essential source of profit. They can yield as much food per acreage as most annual crops. They also offer great ecological and social benefits, and they can thus be productive and protective. Although North Sudan farmers exert tremendous efforts all over the growing seasons and dream of a successful harvest, they end up disappointed by unfavorable prices. Given limited infrastructure, this leads to the immediate post-harvest with low prices.

Decisions on marketable surplus quantities either to be sold immediately after harvest or/and for future sale depend on the crop perishability after devoting a certain amount for household consumption. The surveyed farmer reported that only two crops could be kept for future sale, namely palm dates and citruses. Elketiab farmers store citruses on trees for 3-5 months after maturity and they sell them when prices improve. It is derived that 2214 kg of dates and 3778 kg of citruses production are allocated either for storage or future sales. Also 81% of alfalfa production is considered for household-animal consumption while the rest is regarded as marketable surplus. For the other crops (mangoes and guava) the produce usually goes to market after devoting some quantities for household consumption. Numerous studies reported that although in most cases, staple food systems will remain dominant sources of food supply and off-farm activities are more dependable sources of income, organic diversification offers higher returns from land and labour investments. However, the
diversification start-up is often associated with high-price volatility which needs to be countered with improved marketing intelligence.

3.5 Optimal perennials production obtained by RNS model

Secured land and water-use rights are more important preconditions for investments in perennial diversification and commercialization compared to other forms of agriculture. The background of RNS tenants for growing perennials, annual crops and animal breeding offer a promising option for improving the farm system and livelihood of people both in rural and peri-urban areas. The competition for irrigation water and land increases resource management complexity. These inputs constitute the most important factors of agriculture in North Sudan, due to their scarcity and importance raised from population pressure on land when compared to the rest of the country and from the high cost of irrigation by pumps. They became common problems are aggravated even more by the diminution of the canals capacities and lead to low productivity of crops. Elsir et al (2004) summarized that the high cost of production coupled with low productivity and lack of a cheap source of power has made it difficult for farmers to realize the full potential of the State. Further, development is considered serious affected by the limitation of these two basic resources of land and water.

This situation led to an important fact that optimizing of the available resources should achieve food security, poverty alleviation and improve the livelihood of the farmers of the scheme. Yet, the potential of resources for raising both food production and living standards of the rural poor has since long been recognized. Generally, a third of the current crop production comes from one-sixth of the irrigated arable land. This necessitates improved reliability of crop production under greater intensity of land-use with removal of seasonal water supply constraints. Then the problem is how to balance demand and supply of resources under these conditions. The solution lies in resources use optimization.

The received information from the model run is the objective function value (returns), the optimal crop combination, and utilized resources accompanied by their respective marginal value productivities. The analysis also provided some other relevant results as shown in Table 1. The Table also presents the actual and optimal cultivated area for the different perennial crops and gives also the optimal allocation for the average area. The farmer’s trend in RNS towards diverse crop combination is a dominant practice as means of increasing efficiency of resources. This behavior might be acquired by experience to avoid agricultural risks such as pests and unfavorable climatic conditions (i.e. high temperature, low moisture and others). The optimal solution reflects devoting land only for citruses, mangoes and alfalfa as 4, 2, and 4 fed respectively, while the rest of the crops didn’t appear in the optimal plan. The actual returns from crop production are SDD 134998, while the optimal returns are SDD 427050 which is more than the actual returns by 68%.

3.6 Resource use and constraints

The last decades witnessed increased interest to grow perennial crops overall the state, and that might be due to the higher prices or the low operation costs of those crops when compared to the annual crops according to their duration on land. Many studies mentioned that the higher prices for perennial crops have enhanced incentives to grow them. Moreover, growing of perennial crops allows intercropping with some crops, particularly alfalfa. According to the mentioned characteristics of the perennial crops, resources use and availability might be under competition. Stan (2008) stated that perennial plants are highly efficient and responsive micromanagers of soil, nutrients, and water.
Table 1 Proposed scenario of cropping pattern plan perennial crops in RNS

<table>
<thead>
<tr>
<th>Item</th>
<th>Actual</th>
<th>Optimal</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Resources use:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total land</td>
<td>10</td>
<td>10</td>
<td>Fed</td>
</tr>
<tr>
<td>Total irrigation water</td>
<td>131256</td>
<td>122976</td>
<td>Cubic meter (m³)</td>
</tr>
<tr>
<td>Total labour</td>
<td>106</td>
<td>84</td>
<td>Man-day</td>
</tr>
<tr>
<td>Total capital</td>
<td>1675200</td>
<td>1675200</td>
<td>SDD</td>
</tr>
<tr>
<td><strong>Cropping pattern:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic Date</td>
<td>1</td>
<td>-</td>
<td>Fed</td>
</tr>
<tr>
<td>Organic Citrus</td>
<td>1</td>
<td>4</td>
<td>Fed</td>
</tr>
<tr>
<td>Organic Mango</td>
<td>1</td>
<td>2</td>
<td>Fed</td>
</tr>
<tr>
<td>Organic Guava</td>
<td>1</td>
<td>-</td>
<td>Fed</td>
</tr>
<tr>
<td>Organic Alfalfa</td>
<td>1</td>
<td>4</td>
<td>Fed</td>
</tr>
</tbody>
</table>

Source: Field survey

Annual crops are not; they require churning of the soil, precisely timed inputs and management, and favorable weather at just the right time. With shorter growing seasons and ephemeral, often small root systems, annual crops provide less protection against soil erosion, wasting water and nutrients, storing less carbon below ground, and are less tolerant to pests than are perennial plant communities (see Table 1). Table (1) depicts that the optimal and actual quantities of capital used for the different perennial crops under the study are SDD 1675200 and SDD 1675200. It is clear that the optimal plan resulted in all available land and cash to be devoted to some of the perennial crops namely, citruses, mangoes and alfalfa, while the optimal and actual water used are 122976 m³ and 131256 m³ respectively. The optimal level of hired labour amounted to 84, forming 79% of the total available labour. In the optimal plan, 122976 m³ of the total water would be used, which is 94% of total available water. The monthly distribution of labour in the optimal plan is 7 man-days, forming 78% of total available labour. At the optimal crop combination, the monthly distribution of actual available cash to finance the perennial crops was SDD 13960 allocated annually over the months, forming to 100% of the total available capital.

4 Conclusion

Our results show that there are promising opportunities for the production of perennials in River Nile State of North Sudan. However, a major obstacle expanding and realizing the potential of perennial crops is the high cost of establishing new plantations and the recurrent cost of financing crops for four to five years before any significant production can be realized. Finance provision for these crops is absent in the area of study. The study unveils the low productivity of the perennial crops that form promising strategic crops. Encouraging policies imply reducing the cost of production or providing incentives to the perennials growers of the State by subsidizing or and buying their products at reasonable prices. Based on these facts and the obtained results, the study concludes that:

- The potential for perennial farms production in the River Nile State is quite promising on account of the tremendous natural resources and the wide range of biodiversity available with high relative advantages.
- Establishment of organizing and certification bodies and development of national regulation for certified organic perennial crops production, handling, processing and marketing can be useful for implementation and sustainability of perennials farms in the RNS.
- Encouragement of some international companies with good history and long experience in production and marketing of proposed perennial products to shoulder the responsibility and foster perennial farms in the State.
- Because basic services are regarded as one of the chronic constraint facing agricultural production in area of the study, intervention is needed to establish public infrastructures.
- Spreading perennial culture among producers, processors and exporters of the State is important, and here extension will be of fundamental importance to build agro-
ecological knowledge. The fact that perennial farms emphasizes multi-, rather than mono-cropping is also important in terms of food security, which can be jeopardized when farmers produce a single commodity and have no safety net to fall back on.

- Relevant stakeholders’ interventions are needed to transfer improved technologies to increase farm productivity; in addition, the River Nile State tenants also need to be encouraged to produce organic perennial crops as high value crops when designing crop combination.
- Improving finance institutions will enable the River Nile State tenants to improve their resources use and significantly increase their farm returns.
- Appropriate combination of land, water, labour and capital resources for producing perennial crops in the River Nile State is very important and should be well designed and applied.

References:


