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Research paper

Potentials of Wheat Production and Competitiveness of Prevalent Crops in the Irrigated Farming System of the River Nile State, Sudan

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Abstract

In the River Nile State of Sudan, farmland and irrigation water are the main resources to attain sound crop combinations and sustainable farming systems, whereby resources use efficiency and optimization of available fundamental resources is needed. The broad aim of this research, based on competition indicators with respect to the available agricultural resources use (i.e. land and water) was to determine the promising crop combination taking on board alfalfa and wheat in terms of sustainability of farming system. The analysis depended on structured survey questionnaires and field observations in the area of the study where surface irrigation by pumps from the River Nile is predominant forming the major water supply choice. Integrated techniques comprising economic and hydrologic techniques are applied to assess land and irrigation water use in the State. Descriptive statistics including quantile analysis of the crop water applied and crop water requirements were applied. GAMS, CropWat4 and SPSS have been used to assess the irrigation water performance. The study findings represent the suitable cropping systems for exploiting the available agricultural resources where alfalfa was more competitive than wheat.

Keywords: Alfalfa, wheat, multi-cropping, competitiveness

إمكانيات إنتاج القمح والقدرة التنافسية للمحاصيل السائدة في نظام الزراعة المروية في ولاية نهر النيل، السودان

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المستخلص

في ولاية نهر النيل بالسودان، تعد الأراضي الزراعية ومياه الري هي الموارد الرئيسية لتحقيق التركيبة المحصولية السليمة في نظام الزراعة المستدامة، حيث يلزم استخدام الموارد بكفاءة وتحسين الموارد الأساسية المتاحة. كان الهدف العام من هذا البحث، استنادًا إلى مؤشرات المنافسة فيما يتعلق باستخدام الموارد الزراعية المتاحة (أي الأرض والمياه)، هو تحديد تركيبة من المحاصيل الواعدة التي تحتوي على البرسيم والقمح من حيث استدامة نظام الزراعة. اعتمد التحليل على استبيانات المسح الحقلي والملاحظات الميدانية في منطقة الدراسة حيث يسود الري السطحي بالمضخات من نهر النيل والذي يشكل الاختيار الرئيسي لإمدادات المياه. تم تطبيق حزمة متكاملة للتحليل تشتمل على طرق اقتصادية وهيدرولوجية لتقييم استخدامات الأراضي ومياه الري في الولاية. تم استخدام الإحصاء الوصفي بما في ذلك التحليل الكمي لمياه المحصول المطبقة والمتطلبات المائية للمحاصيل قيد الدراسة. تم استخدام برنامج الكمبيوتر للنماذج الجبرية GAMS وبرنامج الكمبيوتر لتقييم المتطلبات المائية للمحاصيل من مياه الري CropWat4 وكذلك برنامج التحليل الإحصائي SPSS. تشير نتائج الدراسة الى النظم المحصولية المناسبة لاستغلال الموارد الزراعية المتاحة حيث كان البرسيم أكثر قدرة على المنافسة من القمح.

***كلمات مفتاحية*:** البرسيم، القمح، المحاصيل المتعددة، التنافسية

Introduction

In Sudan, the assessment of winter field crops combination is considered crucial. The Winter season is ranked as the top and principle season for the River Nile State' farmers in terms of agricultural production. The summer and autumn “*demira*” seasons come thereafter due to some environmental aspects that give high advantages for the winter crops. An evaluation of competitiveness between alfalfa (*Medicago sativa L.*) and wheat (*Triticum aestivum*) was carried out to assess farm resources use as well as productivities of the crops under study. Alfalfa is a perennial legume crop and often used in crop rotations of farming system throughout north and middle regions of Sudan to supply fodder and thereby also provides nitrogen for subsequent cereal field crops. It has a significant contribution to the farm sustainability, household food security and income; that is why it called “Queen of the Forages". Among the dominant crop combinations in North Sudan, alfalfa is usually grown for three to five production years and harvested mechanically or manually according to the farm size. While wheat is considered as one of the main strategic crops in the country, it ranks after sorghum and before millet, contributing to rural and urban livelihoods and food security. Over the past two decades, wheat production, which is almost entirely irrigated, has been fluctuating and declining due to declining yields and soaring input costs. Since the end of 1990s, the government liberalized agriculture and removed all support programs. These new policies have affected a lot of wheat growers to consider wheat as a secondary crop and extend the lucrative cash crops areas, such as legumes, pulses and vegetables.

The overall average area under wheat for the period 2013 to 2017 was about 454,000 feddan allocated among the main supplier states namely, Gezira (256,000 fed), Northern State (84,000 fed), River Nile (39,000 fed), New Halfa (38,000 fed) and White Nile (37,000 fed). This research was carried out in the River Nile State (RNS) at the northern part of the country. The RNS is considered as one of the most promising states in the country as it enjoys relatively cooler winter season "*Shetwi*" and is endowed with fertile alluvial soils. It also has a comparative advantages compared to other parts of Sudan in producing relatively high-value field and perennial crops (citrus, mangos, dates, wheat, faba beans, certain spices and medicinal plants). The State accommodates numerous types of irrigated schemes such as the public irrigated schemes, foreign investmet schemes, agricultural companies, private and cooperative schemes with different production relationship systems. These schemes are regarded as main potential ones for developing agriculture in general and winter season crops in particular due to their high acreage share, capital availability and machineries while hosting high numbers of farmers.

The research sellected El-Zeidab Public Irrigated Scheme as one of the study cases representing the conventional irrigation systems in the state. It is the oldest and biggest one belonging to the State Ministry of Agriculture. The total area of the scheme is about 22,000 feddans.

Beside El-Zeidab scheme, the study has choosen Elkafaa-Al-Rajhi Scheme representing the modern irrigation systems in Berber locality of the RNS. The location of Elkafaa-Al-Rajhi scheme is considered as an appropriate site to apply modern farming system and advanced irrigation technologies (i.e. pivot sprinkler irrigation system) and holds potential to develop agricultural production. The scheme is one of the recent foreign investment schemes in the RNS located at about 350 km north of Khartoum. It was established in 2012 by Al-Rajhi International Group for Investment of Saudi Arabia. The total area of the scheme was originally about 100,000 fed devoted for grain and fodder production. The scheme is applying international experience of agricultural development and advanced irrigation technologies for agricultural production.

These problems that contribute mainly to the low levels and fluctuations of winter crops yield include inadequate practices forming the crops technical packages used by farmers, misuse of agricultural resources, stress caused and inflicted by changing environmental and climatic conditions especially temperature, beside the widespread of different diseases, insects, pests, weeds and power failure caused by lack and high cost of fuel and spare parts to operate the pumps. Numerous research mentioned that the high cost of production coupled with low levels of crop yields and instable source of power has contributed to difficulties faced by growers to realize the full potential in the State. In addition, development is constrained by serious limitations in two basic resources namely, land and water. Regarding irrigation water in the State, there are many hindrances contributing to inefficiency of irrigation water use and affecting crop production in the irrigated schemes in RNS such as inadequate supply of irrigation inputs at the proper time and right prices.

Generally, improvement of the farming systems in the State considering climatic change and food security and farming system sustainability of the local populations is regarded as a great challenge for researchers, policy makers, scientists, agricultural administrators in public and private sectors, related organizations and investors. Finally, this study looks to determine the promising crop combination including alfalfa and wheat in terms of resources use advantages in the form of economic returns and crop yields.

Methodology

This research was carried in the River Nile State. The climatic conditions of the State allow the production of a wide range of perennial and seasonal crops. The farming system in RNS includes mainly four types of agricultural schemes namely, private or individual, cooperative, public pump and foreign investment irrigated schemes. Tropical and sub-tropical fruits grown include dates, citruses, mango, banana and guava. Soils are alluvial, which are generally fertile, are made up of loamy and silt deposits, generally well drained non-saline and non-sodic (Ahmed, 2004). Many studies mentioned that the RNS has been assumed to have a comparative advantage in field cash and food crops production namely, legumes, vegetables, cereal and spices beside perennial crops including alfalfa. This assumption is based on the State's favorable climatic conditions, vast endowments such as land, permanent sources of irrigation and accumulated experiences of skilled farmers. Beside the River Nile, Atbara River and underground water are other important direct resources of irrigation water in the agricultural sector of RNS. Although the RNS is characterized by past comparative advantages, but the last decade witnessed frequent debates about the deterioration of agricultural production, which might manifest itself in numerous indicators such as low crop productivity, high cost of production, inadequate credit, and markets and prices instability. This situation raises the conviction that the stability of the irrigation sub-sector forms a major driver for achieving food security, poverty alleviation and improving the livelihood of the farmers of the scheme.

The study has been based on two case studies namely, El-Zeidab public irrigated scheme and Elkafaa foreign investment irrigated scheme. Elkafaa scheme is characterized as a modern scheme applying modern and full-mechanized systems. Its production system is based mainly on annual field crops such as grains, pulses, fodder and other agricultural activities, while the farming system of El-zeidab scheme is distinguished mainly as semi-mechanized system.

The prevalent crop combination in the RNS often includes field crops, perennials and animal production activities. This research depends mainly on primary data from areas of the study, beside secondary data from relevant official sources. The method selected for primary data collection was direct personal interviewing of the sampled respondents by using structured questionnaires. The primary and secondary data were collected for season 2015/2016 to compile information concerning the operation of the schemes under study.

Sample size

In order to secure reasonable precision, stratified random sampling techniques was applied based on sample size proportional to the relative sizes of the targeted groups in the public irrigated scheme, where primary data was collected through direct personal interviewing by using structured questionnaires for (70) randomly selected respondents through probability proportional method, taking into consideration limitations in survey budgets, the time factor and other available facilities. On the other hand, a comprehensive secondary data set was obtained from Al-

Rajhi-Kafaa irrigated scheme. A few hindrances were faced in the two case studies; firstly, in El-Zeidab public scheme which was still lagging behind with inadequate infrastructure made the movement and the field work implementation over the study area rather difficult.

The tenants of the scheme, often skeptic about the research work, the information flow from them needed patience and smart enumerators. Some of the tenants were uncertain about, and had mistrust in the aims of research work, thinking that it aims to raise taxes so their response was sometimes very poor. Some others reported that numerous research work had been done in their tenancies without tangible returns in the scheme.

Secondly, Elkafaa scheme is regarded as new scheme in the area of study when compared to the public ones. However, the accessibility for the required information and other technical data is not reported in a proper manner.

Analytical techniques

Numerous techniques were applied to achieve the goals of the study. Descriptive statistical analysis was used. In this part of the analysis, graphical, frequency distribution and statistical analysis was applied. The computation of the crop water requirements (CWR) of any crop requires estimation of its crop coefficient values. The Food and Agriculture Organization's (FAO) Penman-Monteith (PM) method was recently developed to assess ETO values from a hypothetical reference crop that were more consistent with the actual CWR and has been recommended by the FAO as the standard method for CWR calculation designed in the software program CROPWAT4. For the on-farm water-use efficiency (FWUE), the research has adopted ICARDA's (2005) concept to evaluate the efficiency of on-farm water use. The concept of ICARDA concerning FWUE has been developed to address farm levels where complexity exists. The definition of FWUE by ICARDA is a ratio of required irrigation water to produce a specific output level to the actual amount of water applied by farmers. Linear programming (LP) analytical technique also was employed using GAMS (General Algebraic Modeling System). LP is a mathematical programming technique useful for detecting the best allocation of the farm scarce resources. The model seeks the maximization of gross margins as the underlying objective function:

$$Max\ \pi = \sum_{j=1}^{n} Z_jX_j \quad \ldots\ldots (1)$$

Such that:

$$\sum_{j=1}^{n} \alpha_{ij}X_j \leq b_i,\ \text{all } 1 \text{ to } m \quad \ldots\ldots (2)$$

And:

$$X_j \geq 0,\ \text{all } j = 1 \text{ to } n \quad \ldots\ldots (3)$$

Where:

π = is objective function value per year;

Xj = Level of the j^{th} the farm activity, such as the acreage of wheat grown and n denotes the number of possible activities; the j=1 to n;

Zj = gross margin of a unit of the j^{th} activity (SDD/feddan) ;

Aij = quantity of the i^{th} resource available (i.e., days of labour or other required quantities of inputs) required to produce one unit of the j^{th} activity;
M = Denotes the number of resources; then i = 1 to m;
Bi = Amount of the i^{th} resource available (e.g. cubic meter of irrigation water, land area in feddans, 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 ton) that has the highest possible total gross margin π, 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 field 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 the 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 production is not allowed.

The research adapted the regression model of Heady and Dillon 1961 adopted by Ahmed (2009). The model is based on Cobb- Doughas production function and others. For Multiple Regressions; according to Ahmed (2009), that multiple regression is measuring the change in one variable while holding the effects of other variables constant. It consists of two or more independents variable. The multiple regression model contains several explanatory variables, is considered as a logical extension of simple regression model. According to Mohammed (2013), that the production function in theory, would include inputs of sources such as variable soil nutrient, pest and disease that might influence yield and because impossibility of specifying all of their variables separately, some may be lumped together into a broad category, such as land and labor. Other variables which are considered unimportant can be ignored. Production function can be represented by Table (s), schedule (s), all mathematical equations, to determine maximum output that can be produced from specified combination of inputs given in the existing state of technology, and the output will change when the quantity of inputs changed. Mathematically the production function can be represented as follows:

$$Qi = f(x_1, x_2, \ldots x_n).$$

Where:

Qi = Output of the product;

x_1 = Inputs used i = 1 ton

The study also applied partial budget analysis to assess the cost and returns of the crops under the study. Statistical tools were used to analyze the main cost items of potato production to determine the significant variables. According to Abbas and Elamin (1997), there are three broad types of situation in which budgeting may be called for:

i. A comparatively minor change in practice.
ii. A drastic change in farming.
iii. Starting up on a new farm.

Partial budget analysis was used to analyze field data survey and the economic evaluation of the effect of new recommended package. It organized data and information on yield, costs of inputs, husbandry practices and resultant benefit of crop output. Table 2 shows the calculation of partial budget analysis according to the following criteria:

1. The gross revenue (GR); was calculated by multiplying the farm gate price of the crop by the crop yield,
2. Total variable costs (TVC); is calculated by multiplying the quantity of input (material or practice) used by its price,
3. Gross marginal revenue (GMR); was calculated by subtracting the gross revenues minus the total variable costs. The difference in gross marginal revenues of adopters and non-adopters indicated the net monetary return that resulted from use of the technology. The general mathematic expression is:

   Gross marginal return = Gross revenue - total variable costs

$$GMR = GR - TVC \qquad (1)$$

Where:

GMR Gross marginal return (revenue),

GR Gross revenue,

TVC Total variable cost

The study also applied partial budget analysis to assess the cost and returns of the crops under the study. The basic data used to compute gross returns per fed are output values, while gross margin per fed was calculated by subtracting the average total operation cost (variable costs) from the average total returns. The general mathematical form for the gross margin calculation per crop is as follow:

$$GM = GR - TVC$$

Where:

GM= Crop gross margin per feddan in SDG,

GR= Crop gross revenue per feddan in SDG, and

TVC= Crop total variable costs per feddan in SDG.

Results and discussion

The design of a comprehensive crop combination for each season especially the winter season in River Nile State (RNS) is considered as a key factor to obtain a successful production and sustainable farming system. The winter season crop combination in RNS implies mainly cereal and legumes crops. In general, non-legume crop is considered a suppressing crop in annual legume/non-legume intercrop system (Guiguo *et al.*, 2011). However, the performance of perennial legume and annual cereal intercropping varied by intercrop pattern (Abdel Magid, 1991). The competition between alfalfa and wheat crops in northern Sudan is not inter-specific competition; it is not concerning above-below ground competition, the competition here is known as the interaction between two crops in one crop combination that affect the decision of producers to allocate their available agricultural resources to each crop of the targeted crop combination. The competitive abilities of component crops can be defined in terms of crop yield and returns; hence, the dominant crop directly influences the apparent performance of the crop combination communities. Thus, the crop combination competitive behavior is essential to the structural stability of the cropping pattern and farming system. Further, knowledge of competitiveness can predict yields and returns of crop combination.

The tenants in the agricultural schemes of RNS seek every season to adopt a relevant crop rotation that contributes to irrigation water and land use efficiency as well as soil conservation. They look to manage a reliable crop combination comprising cereal or grains such as wheat and beans or legumes crop like faba bean and alfalfa. However, a successful winter season with high yield for grains and legumes might attain many goals, at least may achieve maximization of resources use which leads to poverty alleviation and food security in the agricultural rural areas of Sudan.

Agricultural resources management in River Nile State (RNS)

Agricultural resources are essential components for crop production. In a world of limited resources, limited sympathy and limited rationality, competition leading to tensions and conflict can arise. In such circumstances, a key responsibility of any society is to ensure the security of its citizens (Richard, 2009). Due to natural resources management complexity and scarcity, rationalizing and optimizing resources use becomes crucial to maximize the benefit from them. The scarcity of agricultural resources is exacerbated by limited agricultural land and limited water available for irrigation in case of expansion in new reclaimed land. Thus, the optimum crop combination should be considered to achieve more than one goal to reach the most efficient crop combination to achieve and rationalize resources consumption in order to increase farm income and save a large amount of irrigation water for expansion. The River Nile State is considered as one of the main suppliers for agricultural production in Sudan. The total area of the state is about 129.744 km^2 (30 million feddans) out of which about 3,249,000 fed is certified land for investment and suitable for multi agricultural activities and production **(**Table 1**).**

However, this research revealed that the performance of resources management for agricultural production in the state is indicated by low efficiency as shown in Figure (1).

Table (1): Distribution of land resources in RNS

Land resource	Area (feddan)
Agricultural Arable land	9,500,000 feddan
Certified land for investment	3,249,000 feddan
Agricultural cultivated land	1,200,000 feddan
Forest land	209,000 feddan
Natural pasture land	48,000 km^3

Source: Ministry of Agriculture in RNS 2017

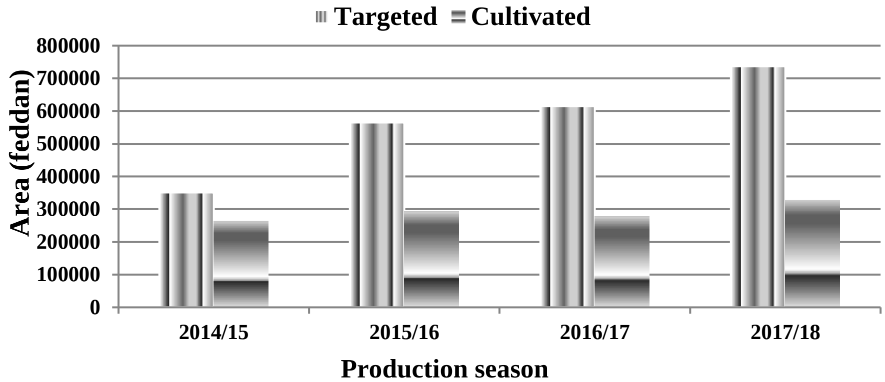


Figure (1): Area gaps between the targeted and cultivated areas in RNS for the winter seasons 2014/15 to 2017/18

No doubt water resources represent one of the essential inputs for agricultural production. Sudan also is endowed with a sizeable amount of surface water resources. The utilization of this water under the umbrella of the Nile Waters Agreement (1959) signed between Sudan and Egypt is based on the average annual flow of 84 billion m^3 measured at Aswan shared as follows: the Sudanese share 18.5 bm^3, Egyptian share 55.5 bm^3, and the losses in Aswan 10 bm^3. In addition, the State has underground water in the Nubian Sand Stone. The River Nile State is one of the relatively rich states in the country in water resources. The main direct resources of irrigation water in RNS are the River Nile, Atbara River, underground water and rains (Table 2).

Table (2): The main direct resources of irrigation water in RNS

Water source	Water amount
River Nile along the RNS	670 km^3
Atbara River	200 km^3
Underground water aquiver	3,16 bm^3
Surface water and valleys from rains	1, 490 bm^3 and 57 valleys

Source: Ministry of Agriculture in RNS (2017)

Cultivated area in River Nile State

The distribution of field crops in the River Nile State season 2016/17 was such that the majority of the total land was devoted to onions, followed by wheat and faba bean, while the lowest percentage was allocated to chickpea. The other crops were ranked as illustrated in Table (3).

Table (3): Cultivated area of crops in the RNS in season 2016/17

Crop	Area (fed)	Production (ton)	Price (SDG/ton)
Wheat	38,281	49766	5500
Faba bean	30,611	10408	17500
Kidney bean	10,875	4133	27500
Chickpea	3,728	1492	19000
Potatoes	14,773	92332	28000
Onions	54,184	915710	3250
Vegetables	17,315	110555	22200
Fodders	26,086	42816	900
Spices	6,086	59244	85575
Sorghum	12,917	30799	3830

Source: Ministry of Agriculture in RNS 2017

On the other hand, available information unveils that the total cultivated area of Al-Rajhi-Kafaa scheme is about 19,500 feddans distributed among 156 pivot sprikiler units. The allocation of the field crops in the scheme was such that 40% of the total cultivated land was occupied by wheat, followed by 30% for alfalfa, while 20 and 8% went for maize and sunflower, respectively. The paper observes that most of the cultivated area was covered by cereal crops which are very exhaustive to soil fertility, while legumes and vegetable crops formed a limited area of the scheme indicating negligence of land improvement to produce food security products and of soil conservation.

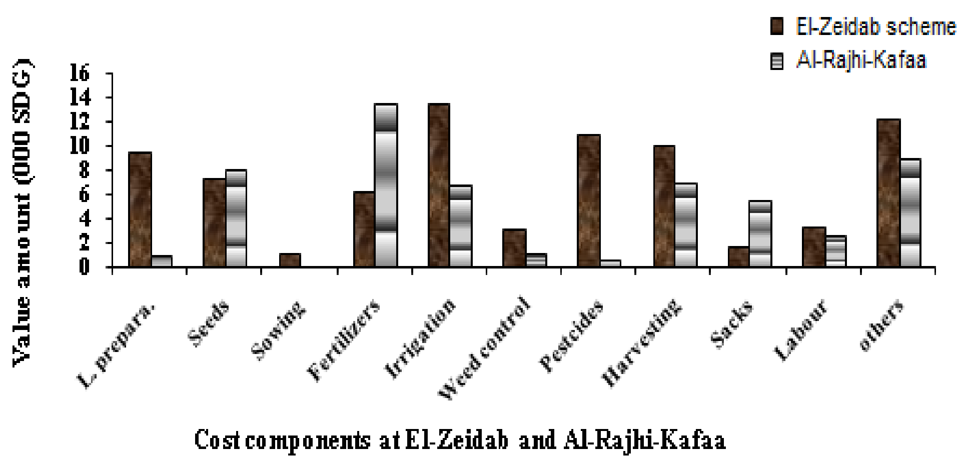
The majority of these crops are cultivated as winter crops with exceptional cases for some crops that could be produced in winter and summer seasons, namely maize, fodder, and vegetables. Furthermore, sorghum in El-Zeidab scheme is usually sown at the end of the summer season (September) to be harvested in the middle of the winter season (January), while sorghum and onions are grown in April after wheat harvest and continue to be irrigated with wheat. The harvested crops are used either for domestic consumption and/or as cash crops.

Wheat and alfalfa crops production in RNS

Agricultural production relations in River Nile State are variable. Those in the private pump schemes are unique. The small farmers there have to pay part of their produce in return for irrigation water alone, or in some cases, irrigation plus other services provided by the owner of water pump. The share of the small farmer should pay usually differs according to the crop grown, land ownership, soil quality and obligations agreed upon between the two partners (Ijami, 1994). The public schemes in RNS include holdings of various sizes whose operators may be owners or tenants. Water is delivered to the land by the administration of the scheme which owns the pumps and canals of these schemes, and the farmers are billed the cost of water. In RNS the most dominant procedure is allocation of one seventh of the crop output for the land, while the remaining output is shared equally between the pump owner and the small farmer. Based on this agreement, and according to whether the crop grown is a low or a high value crop, the pump owner may pay or share the cost of inputs with the farmer such as fertilizer and pesticides (Ijami, 1994). The production relations in the schemes of the study are absolutely different. In El-Zeidab scheme the relation has been based on a water rate system subject to an agreement between farmers and scheme administration. The scheme water charges differ between field and perennial crops. In Al-Rajhi-Kafaa scheme the situation is different as mentioned early; however, the crop production operations and processing has been are managed by the scheme administration as mentioned before.

Analysis of wheat and alfalfa costs and returns

Generally, economics of production is regarded as fundamental role in enterprise and farm management. Production costs are known as the cost of inputs, labour, services, and the management used in producing a particular commodity or crops. Numerous researches indicated that the high cost of crop production in the River Nile State has contributed to low profit (Ahmed, 2009). The research observed that that most of the tenancy operations in El-Zeidab scheme were handled by the scheme's farmers and/or their relatives, while hired labours were usually needed for labour intensive operations such as land preparation and harvest. In large scale private schemes, the situation is different. In this study case of Al-Rajhi-Kafaa scheme farm machineries are used for most of production operations with low numbers of labours. Figure (2) illustrates the cost components within the sequence of production operations of annual crops in the two study schemes. It is clear that the majority of the variable cost components of producing annual crops in El-Zeidab scheme exceeded those at Al-Rajhi-Kafaa. The high cost in the public scheme of RNS could be justified with such as lack of application of advance technologies as well as the large scale of production. Generally, Al-Rajhi-Kafaa scheme is characterized by being fully mechanized with large scale production, contributing significantly in decreasing the operation cost of the scheme in contrast to the case of El-Zeidab scheme.



Source: Field Survey 2017

Figure (2): Average cost components for field crops in El-Zeidab and Al-Rajhi-Kafaa

The research employed gross margin analysis technique to assess wheat and alfalfa returns. Gross margin is considered as one of the good indicators of how profitable a farm or a firm at the most fundamental level. Farms or enterprises with high gross margins will have abundant resources to invest in future activities such as production and marketing promotion.

The past few decades have witnessed the increase of global demand for alfalfa fodders and wheat grains with increasing awareness of their value and benefits. Gross margins for alfalfa and wheat under study were assessed in Table (4).

Table (4): **Gross margin analysis for wheat and alfalfa at Al-Rajhi-Kafaa and El-Zeidab**

Budget component	Alfalfa budget analysis Al-Rajhi-Kafaa (SDG/year)	Alfalfa budget analysis El-Zeidab (SDG/year)	Wheat budget analysis Al-Rajhi-Kafaa (SDG/season)	Wheat budget analysis El-Zeidab (SDG/season)
Production cost (SDG/fed)	4,200	3,800	3,626	3000
Average yield (kg/fed)	7,560	6,206	2,300	1,080
Average price (SDG/kg)	3.00	3.0	5.0	5.0
Gross returns (SDG)	22,680	18618	11,500	5,400
Gross margins (SDG)	18,480	14,818	7,874	2,400

Source: The field survey 2017

Gross margins of the two crops were positive in the schemes of the study as depicted in Table (4), but with variation. Al-Rajhi-Kafaa could attain the highest gross margins for alfalfa reaching about SDG 18,480 compared to SDG 14,818 obtained by El-Zeidab tenants. The gross margins for wheat reached about SDG 7,874 and 2,400 for Al-Rajhi-Kafaa and El-Zeidab, respectively. The differences in gross margins of wheat and alfalfa are mainly due to variation in the crops productivities. Furthermore, with yield improvement of wheat and alfalfa crops grown in El-Zeidab public scheme, still higher gross margins can be obtained in case they introduce advanced technology and effective agricultural management.

In general, farm income in the public irrigated schemes of RNS is low. Wheat and alfalfa growers in these schemes need more awareness regarding modern technologies, farming system management and market promotion within marketing issues. The research revealed that, on one hand the alfalfa growers in the River Nile State may replace low income crops to expand alfalfa cultivated area due to its high returns. On the other hand, the government considers wheat as strategic crop and encourages the crop growers to produce it.

Irrigation water management in El-Zeidab and Al-Rajhi-Kafaa

The demand for good-quality water is continuously rising owing to the rise in the population, intensive agricultural practices, industrialization and overall rise in living standards (Srinivas *et al*, 2009). Many researches unveiled that irrigation water in agriculture represents about 70% of global fresh water use. The method developed in this research utilizes the statistics obtained from Ministry of Agriculture of RNS, Al-Rajhi-Kafaa scheme reports and economic modeling to design a more reliable data set for RNS and resources use in its irrigated schemes by combining as far as possible the obtained data from the areas of the studies, prevalent cropping patterns and irrigation systems to evaluate the amount of cultivated land and water applied.

Crop water requirements in the area of study

Extensive researches were carried out in the field of irrigation water use for a range of perennials and field crops to facilitate the accurate estimate of irrigation requirements of the mentioned crops on the basis of climatic and standardized crop data. Combined with soil water balance calculation, a range of computer programs such as the FAO CropWat4 program exist to determine irrigation schedules, assuring accurate and efficient water supply. The predominant conception of irrigation requirements (IR) refers to the water that must be supplied through the irrigation system to ensure that the crop receives its full crop water requirements. This research adopted the Food and Agriculture Organization (FAO) method for computing crop water requirements (CWR); from the calculation of crop coefficient (kc) to the estimation of irrigation diversion requirements. Using the CropWat4 associated database of climatic data for key stations around the world for the main annual crops namely, wheat, maize and alfalfa in the area of the study. The obtained results (Table 5) showed that the CWR for the field crops in the areas of the study vary according to the prevalent climatic factors.

Table (5): Determination of CWR/ha in area of the study

Crop	ETo (m^3)	Kc	CWR (m^3/ha)
Wheat	1.81	1.82	5,750
Alfalfa	6.00	1.7	17,460

Source: calculated by the authors (2018)

Irrigation water supply in the schemes of the study

The amount of on-farm supplied water was already computed by specialists working at the Ministry of Agriculture and Irrigation in the State. This quantity is estimated as 588 mm /fed per watering for the public irrigated schemes in the State including about 3% losses for both seasonal and perennial crops. On the other hand, the applied irrigation water amount was adjusted according to type of crop and hence was calibrated for the crop combination in Al-Rajhi-Kafaa scheme. The main source of irrigation for El-Zeidab and Al-Rajhi-Kafaa schemes is mainly the River Nile. Irrigation water supply at Al-Rajhi-Kafaa scheme is characterized as a daily application and the watering period was in the range of 16 – 20 hr/day for the crops grown in the scheme namely, wheat, maize and alfalfa. The research revealed that the computed irrigation water charge in the Al-Rajhi-Kafaa scheme in season 2016/2017 was 200 SDG for wheat and 1000 SDG for alfalfa, while the impact of rainfall is neglected due to its small amount. The general characteristics of the crops under study are summarized as average quantities (Table 6).

Table (6): Wheat and alfalfa crops basic data in Al-Zeidab public scheme

Crops	Growing Period (days)	No. of Irrigations	Term of irrigation (hours/fed)	Irrigation Interval (days)	Water charge (SDG/fed)
Alfalfa	1460	24	5.5	15	1000
Wheat	114	7	4	15	200

Source: field survey 2017

Wheat stays 114 days while alfalfa stays 1460 days as the longest duration among the dominant crop combination in El-Zeidab scheme. The number of watering varied among the field crops, being about 7 watering for wheat while alfalfa received about 24 watering. The average irrigation interval was 15 days for each of the two crops. The annual water charge was fixed by the scheme administration at 200 SDG for wheat and 1000 SDG for alfalfa. In assessing the on-farm water use efficiency (FWUE) of alfalfa and wheat, the calculated FWUE covered mainly two levels of irrigation: per watering and per season. The annual average water application in Zeidab was 3,756 mm for wheat and 9,023 mm for alfalfa (alfalfa is a perennial crop). The study found that the average water application for the other field crops per season was 8820 mm, 3426 mm and 2,352 mm for onion, sorghum and Abu sabein forage crop, respectively (Table 7).

Table (7): FWUE per watering and season for wheat and alfalfa in El-Zeidab

Crop	CWA (m^3/fed)	FWUE per watering	Over-irrigation (%)	FWUE per season	Over-irrigation (%)
Alfalfa	9023	0.46	54	0.81	19
Wheat	3756	0.41	59	0.64	36

Source: The field survey 2017

Table (7) shows that the FWUE for El-Zeidab field crops are relatively high and indicating increased water demand per watering throughout their growing season. Further, the estimated FWUE of El-Zeidab scheme indicated a wide technical gap between the required amount of water and the actual water supply. Results also unveiled that the FWUEs per watering were 0.46 for alfalfa and 0.41 for wheat, while the FWUE per season amounted to as high as 0.81 for alfalfa and 0.64 for wheat. This shows clearly that the tenants within El-Zeidab surveyed sample over-irrigated their field crops. On the other hand, FWUE in Al-Rajhi-Kafaa scheme was shown in Table (8). The distribution of crop growing periods revealed that wheat stays for 114 days while alfalfa stays for 290 days with a longer duration compared to wheat and other field crops.

Table (8): On-farm irrigation water-use efficiency at Al-Rajhi-Kafaa

Crop	Growing period (day)	Supplied water (m^3/ ha)/year	Annual CWR (m^3/ha)	FWUE /year	% Over irrigation
Wheat	114	8,721	5,750	0.66	34
Alfalfa	290	22,185	17,460	0.79	21

Source: The field survey 2017

The annual average water application for alfalfa in Al-Rajhi-Kafaa was about 8,050 mm exceeding those of all the grown field crops in the scheme due to the same justification in El-Zeidab scheme where the average water application was 2,275 mm for onion as the highest amount, followed by 1.925, 1.750 and 1.225 mm for wheat, sorghum and Abu sabein forage crop, respectively.

Table (9): FWUE per watering and season for the schemes' crops of the study

Scheme	FWUE/ watering	Over/under irrigation %	FWUE/ season	Over/under irrigation%
FWUE El-Zeidab	0.41	(+) 59	0.62	(+) 38
FWUE Al-Rajhi-Kafaa	1.1	(-) 10	1.1	(-) 10

Source: The field survey (RNS) 2017

The FWUE for Al-Rajhi-Kafaa field crops are relatively low when compared to El-Zeidab field crops and also to their water requirements except the case of alfalfa indicating water shortage through their growing season. Further, the estimated FWUE of Al-Rajhi-Kafaa scheme indicated negative technological gaps between the required utilization and actual water application for most of field crops, while FWUE for Al-Rajhi-Kafaa per watering was found to be 0.89 for alfalfa as the lowest FWUE, while it was 1.4 for abu70 forage as the highest FWUE, followed by 1.3, 1.2 and 1.1 for wheat, sorghum and onions, respectively. On the other hand, FWUE per season amounted to as high as 1.3 for abu70 forage; followed by 1.2 for each of wheat and sorghum and 1.1 for onions, while it was as low as 0.9 for alfalfa. This implies that the administration of Al-Rajhi-Kafaa scheme under-irrigated its field crops by 20% as the cases of wheat and sorghum and by 30% for Abu sabein forage, while alfalfa was over-irrigated by 10%. These results showed fundamental policies implications such that, improving FWUE for the annual crops under the schemes of the study to contribute to the overall FWUE in region. The estimated surplus water at Al-Zeidab public irrigated scheme would be sufficient for expansion in new irrigated area in the scheme. The irrigation water supply in Al-Rajhi-Kafaa is, on the other hand, characterized by irrigation shortages for most annual crops.

Water productivity for wheat and alfalfa crops in RNS

Yield and water productivity can be sustainably improved with the application of supplemental irrigation in the rain–fed areas, the adoption of water harvesting in the steppe areas, and the use of improved irrigation systems and schedules in irrigated areas (Shideed *et al.*, 2005). ICARDA (2005) defines water productivity as the ratio of crop production (kg) to the unit of water used (mm) or as the amount of food produced per unit volume of water used, while economic productivity is defined as the net present value of the product divided by the net present value of the amount of water diverted or depleted (defined in terms of its value or opportunity cost in highest alternative use). Generally, ICARDA reports that there are several different ways for expressing water productivity (WP) such as pure physical productivity or combined physical and economic productivity, but the majority of the researchers frequently use the term water productivity as the ratio of physical crop yield and the amount of water consumed. Productivity is expressed as a mass (kg or ton) and the amount of irrigation water as a volume (m^3). The determination of productivity per unit water (WP) for Al-Zeidab and Al-Rajhi-Kafaa annual crops of the study was based on physical water productivity as presented in Table (10). As research facts, numerous techniques can be used to achieve high water productivity, this can be through promoting water use efficiency (WUE) techniques, adopting advanced irrigation technologies for an effective on-farm water use, selection of proper crop combination, cultural practices and adopting suitable crop varieties.

From Table (10) the technical method for assessing physical water productivity derived as kg of output per m^3 of water was generally low for Al-Zeidab field crops while it is high in Al-Rajhi-Kafaa scheme.

Table (10): Yield and WP for wheat and alfalfa in physical and monetary terms

Crops	Yield (kg/fed)	Research yield (kg/fed)	Yield Gap %	WP (kg/m^3)	Water price (SDG)	WP (SDG/m^3)
Wheat (Zeidab)	1,080	2,000	46%	0.29	200	0.05
Alfalfa (Zeidab)	6,206	8,500	26%	0.69	1000	0.1
Wheat (Kafaa)	2,300	2,000	15% (-)	1.1	110	0.05
Alfalfa (Kafaa)	7,560	8,500	11%	11.9	480	0.1

Source: The field survey (RNS)-2017/2018
47.5 SDG[2]= 1 US$

Table (10) shows that the water productivity was high for Al-Rajhi-Kafaa wheat and alfalfa crops and low for Al-Zeidab ones indicating very high irrigation water use efficiency under Al-Rajhi-Kafaa modern irrigation systems represented by pivot sprinkler system. This may confirm the ability of advanced irrigation technology to manage irrigation water efficiently.

The main factors affecting wheat and alfalfa production in RNS

a. **Factors affecting wheat production in in El-Zeidab scheme**

Analysis of resource allocation efficiency can be accomplished by estimating input response or production functions for various crops and examining resources use through production economics analysis. The data were statistically fitted to several algebraic forms of production functions, a few of which were the linear model, the Cobb- Douglas, the Quadratic and the Cubic forms (Ahmed, 2009). One of the models used in this study is based on Cobb-Douglas production function using the primary data of the field survey in the area of study. The model satisfies some of the specific aims of the research as far as the factors affecting wheat and alfalfa production in Al-Rajhi-Kafaa and El-Zeidab schemes are concerned.

In the first model wheat was taken as one of the important and strategic crops in the Northern Region of Sudan due to it is importance in food security, cash and its big area share. Wheat productivity (kg/fed) was taken as dependent variable in this model, while the average of tenants' age, family labour (man-day/fed), field location (km), hired labour (man-day/fed), distance of farm to source of irrigation (km), number of watering (per season), period of watering (hour/fed).

All the variables had the expected signs with their coefficients passing the t-test at different significant levels. The F-statistics of 15.11 was significant. The model is specified in a linear-linear form; hence, the coefficients of the variables represent the corresponding elasticities that indicate the relative change in wheat yield (kg/fed) relative to the change in independent variables. The variables included in the model were found to be significant at different levels as shown in Table (11). From Table (11) the age of tenants has got coefficient of -0.26 indicating a one percent increase in tenants' age will decrease the yield by 0.26%, while the numbers of hired and family labours represent a relative increase of 1 % in hired and family labour will cause a relative increase of 0.94% and 0.40% in yield of wheat, respectively.

Table (11): Regression equation results for wheat in El-Zeidab scheme

Variables	Coefficients	Standard errors	t-values	Level of Significance (*)
Intercept	-13.482	6.220	-3.169	*
Age	-0.264	0.629	-2.7	*
Family labours (man-day/fed)	0.4	0.694	4.013	**
Hired labours (man-day/fed)	0.942	0.509	5.303	***
Farm to source of irrigation (km)	1.12	0.929	8.096	***
distance from source of irrigation to a farm (km)	-0.819	0.000	-7.903	***
No. of watering (per season)	0.421	0.419	2.533	*
Period of watering (hour/fed)	-1.446	0.765	-5.875	***

Source: Computed from the field survey data

R-square = 0.93, Adjusted R-square = 0.88, F-value = 17.87

* = Significant at 90% level of probability.

** = Significant at 95% level of probability.

*** = Significant at 99% level of probability.

The results show that the coefficient of distance from source of irrigation to a farm (km) variable has got a positive sign explaining an increase of yield by 1.120% and the coefficient for the distance from source of irrigation to a farm was found as 0.819 indicating a decrease of yield by 0.819%. Relative increase of 1% in number of watering will cause a relative increase of 0.42% in yield of wheat. While the period of watering per hour/fed has got a negative coefficient indicating a decrease in wheat productivity by 1.446%. The regression analysis concluded that, the mentioned variables in Table (11) represent factors affecting wheat productivity and give impressive indicator to assess the management component and resources use efficiency for field crops in the public and private schemes of River Nile State.

b. Factors affecting alfalfa production in RNS in El-Zeidab scheme

The analysis showed that there are some factors affecting the production of wheat and alfalfa crops in El-Zeidab and Al-Rajhi-Kafaa schemes, by considering the productivity of alfalfa and wheat crops (kg/fed) as dependent variables. In the model alfalfa legume crop was taken as an important and promising fodder crop among the dominant crop combination in the northern region of the country. In addition, a scientific fact is that the crop is considered as essential for farm sustainability and conserving soil fertility due to its ability of nitrogen fixation. As mentioned before, alfalfa productivity (kg/fed) was taken as dependent variable, while the average of tenants' age, family labour (man-day/fed), family size, total farm area, alfalfa area, distance of farm to source of irrigation, citrus area, number of watering (per season), alfalfa seed rate (kg/fed), irrigation interval formed the independent variables. All the variables had the expected signs with their coefficients passing the t-test at different significant levels. The F-statistics was significant. The model is specified in a linear-linear form; hence, the coefficients of the variables represent the corresponding elasticities that indicate the relative change in alfalfa yield (kg/fed) to the change in independent variables. The variables included in the model were found to be significant at different levels as illustrated in Table (12).

Table (12): Factors affecting alfalfa crop production-regression equation results in El-Zeidab scheme

Variables	Coefficients	Standard errors	t-values	Level of Significant (*)
Intercept	28.931	6.065	4,770	**
Average age of tenants	-1.589	0.570	-4.660	**
Family labours (man-day/fed)	-0.453	0.372	-2.409	**
Family size	0.688	0.530	3.321	*
Total farm area (fed)	0.910	0.876	3.086	*
Distance of farm to irrigation source (km)	-0.642	0.048	-3.448	*
Alfalfa area (fed)	-1.235	0.510	-4.299	**
Citrus area (fed)	0.456	0.046	2.251	*
Alfalfa seed rate (kg/fed)	-0.511	0.053	-4.231	**
No. of watering (season)	-1.147	0.097	-2.608	*
Irrigation interval (day)	-0.846	0.190	-2.031	*

Source: Computed from the field survey data (RNS)

R-square = 0.86, Adjusted R-square = 0.68, F-value = 4.638

* = Significant at 90% level of probability, ** = Significant at 95% level of probability, and *** = Significant at 99% level of probability.

From Table (12) the age of tenants has got coefficient of -1.589 indicating a one percent increase on tenants' age will decrease the yield by 1.6%, while the increase in the number of family labour gave a relative increase of 1 % while an increase in family labour will cause a relative decrease of 0.453% in yield of alfalfa. The coefficient of farm area per fed variable has got a positive sign which means a relative yield increase of 0.910% in the yield of alfalfa and the coefficient for the distance of source of irrigation to a farm recorded -0.642 indicating a decrease in yield by 0.6%. The number of watering (per season) variable for alfalfa reflects that a relative increase of 1 % in number of irrigations will cause a relative yield decrease of 1.147%. The change in alfalfa area variable in feddans showed a negative coefficient indicating a decrease in alfalfa productivity by 1.235%. The citruses area variable showed that it's a relative area increase by 1 % will cause a relative increase of 0.456% in the yield of alfalfa. The amount of seed rate (kg/fed) has got a negative coefficient indicating a decrease in alfalfa productivity by 0.511 %. Similarly, the irrigation interval for alfalfa in days was associated with a negative coefficient indicating a decrease in alfalfa productivity by 0.846 %. It can be drawn from the regression analysis that the included variables (Table 12) are the main factors affecting alfalfa productivity and can provide a reliable indicator to assess alfalfa production among the crop combination in River Nile State.

Assessment of resources use for wheat and alfalfa production

Availability of agricultural resources, especially land and irrigation water form essential preconditions for successful agricultural investment in different cash, food products and their commercialization. The long history of an experience in perennials and annual crop production in the country have provided a broad and strong background for Sudanese farmers to manage their farming system to produce various food and cash crops. The combination of annual crops and livestock herding offers promising options for promoting the farming system and improving livelihoods of rural people. Yet, the high competition for fresh water and fertile land increases the complexity of natural resource use and management. 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 region. In fact, agricultural resources are available for increasing agricultural production and raising the living standards of the rural poor. Generally, in River Nile State crop productivity potential within the agricultural sector come from the irrigated sub-sector. Then the important question here is how to balance the use of available agricultural resources in the area of study. Thus, agricultural resource-use efficiency might be an appropriate indicator to build on within the existing circumstances.

Alfalfa and optimal cropping pattern and returns in RNS

This research provides information and results on the objective function value under optimal crop combination and resources used accompanied by their respective marginal value productivities. The actual and optimal cultivated land for the dominant perennial crops combination is presented in Table (13). From the table, the optimal solution reflects devoting land only for alfalfa (at 5 fed), while the rest of the crops including fruits didn't appear in the optimal plan. Thus, policy makers should design the right policies that include how to maximize the available resources. The actual returns from crops production amounted to SD 134998 compared to SD 255215 under the optimal solution; an increase of 89%. The last decades witnessed increased interest to grow perennial crops overall the RNS as well as Northern State, and that might be due to their higher prices and/or the low operation costs when compared to the annual crops according to their time occupation of land. In fact, the higher prices for perennial crops have provided incentives and justifications to grow them. Moreover, growing of perennial crops allows their intercropping by some crops particularly alfalfa according to the mentioned characteristics of the perennials, the resources use and availability might be under competition. The actual and optimal levels of the resources depicted in Table (13) reflect that 50% of the available land should be used for alfalfa apparently due to its high returns compared to other perennial crops.

Table (13): Resources use and cropping pattern plan for Alfalfa in RNS

Item	Actual	Optimal	Units
Resources use:			
Total land	10	5	Fed
Total irrigation water	65613.75	45120	Cubic meter
Total labor	101	60	Man-day
Total capital	960108	737760	SDG
Returns: objfn value (Z)	134998	255215	SDG
Cropping pattern:			
Date	1.23	-	Fed
Citrus	5.01	-	Fed
Alfalfa	**1.72**	**5**	**Fed**
Mango	0.75	-	Fed
Guava	1.29	-	Fed

Source: Model results (RNS)

Resources use and constraints for alfalfa crop

The disappearance of the other perennials in the optimal solution raises concerns about the need for efforts, including appropriate policies, to improve their productivity, as justified by research results, and set their market prices right. This is justified by the fore-mentioned advantages of the other perennials (date palm, citruses, mangoes and guava) in people's livelihood and the actual expansion in their areas. On the other hand, the simplified model – due to lack of information – did not capture issues that would have raised the other perennials gross margins such as their by-products and the expected notable value of crops that can actually be grown underneath the trees. Furthermore, the other perennials are associated with low risks of perishability, long storage potential and low transport costs compared with other fruit plantations.

The model also assumes that the demand for alfalfa is highly inelastic and that there are no constraints on its markets.

Wheat and optimal cropping pattern and returns in RNS

As with the case of alfalfa, the model results for wheat-based system comprise the objective function value (returns), the optimal crop combination, and utilized resources accompanied by their respective marginal productivities. The analysis also provided some other relevant results as shown in Table (14). The Table represents the actual and optimal cultivated area for the different field crops and gives also the optimal average area allocation. The optimal solution indicates land occupation only for chickpea and dry bean at 8.62 and 1.38 fed respectively, while the rest of the crops did not appear in the optimal plan. The actual returns from crop production were SDG 399487, while the optimal returns amounted to SD 891597, which is more than the actual returns by about 123%.

Resources use and constraints

The most important season in RNS is winter; hence the farmers pursue the best crop combination to achieve satisfactory returns. According to the importance of the winter season, the resources use and availability might be described as fully utilized during this season. Norton and Hazell (1986) reported that, introducing seasonality in the model would further restrict the model solution and will likely lead to lower value of the objective function. The actual and optimal levels of the resources are depicted in Table **(**14) per season; the total optimal area is 10 fed, i.e. all available land would be used. It is clear that the optimal plan resulted in all available land to be devoted to chickpea and dry bean due to their high returns when compared to other seasonal crops.

From Table (14) the optimal and actual resources used are illustrated. The Table also depicts the optimal amount of resources used for the different annual crops in the area of study. It reflects that the utilization of agricultural resources for producing the mentioned crop combination increased from October till January the same period of growing winter crops in area of the study. This situation revealed that the period from October to January is considered as the most demanding period that coincides with the growing of winter food and cash crops in northern region of Sudan.

Table (14): **Optimal resources use and cropping pattern plan for El Zeidab scheme tenancy**

Item	Actual	Optimal	Units
Resources use:			
Total land	10	10	Feddan
Total irrigation water	28573	15384.42	Cubic meter
Total labour	191	124	Man-day
Total capital	179532	122236.61	SDG
Returns: objfn value (Z)	399487.28	891596.73	SDG
Cropping pattern:			
Wheat	1.1	-	Fed
Faba bean	1.1	-	Fed
Chick pea	0.3	8.62	Fed
Dry bean	0.6	1.38	Fed
Onions	0.6	-	Fed
Spices	0.9	-	Fed
Vegetables	0.8	-	Fed
Sorghum	1.7	-	Fed
Maize	0.7	-	Fed
Potato	0.4	-	Fed
Fodder	1.8	-	Fed

Source: Model results, 2008

Conclusion and policy implications

This research presents some of the findings of the field survey for public and private schemes surveyed in the RNS of the Northern Region, describing the alfalfa/wheat competitiveness in RNS farming systems and emphasizes the importance of agricultural resources for producing main food and cash crops Conclusion that can be drawn from numerous analytical tools are:

1. Wheat is still a fairly dominant crop and strong competitor in the prevalent crop combination in the River Nile State of north Sudan. In the conventional sub-sector represented by El-Zeidab scheme, wheat ranked after onions by occupying the second highest percentage of land over all the area of the public irrigated schemes. In the modern sub-sector such as Al-Rajhi-Kafaa scheme on the other hand, the allocation of field crops in the scheme was recorded 40% of the total cultivated land occupied by wheat, followed by 30% for all alfalfa, while 20% and 8% were under maize and sunflower, respectively.
2. Alfalfa legume is considered as one of the main competitors in the dominant crop combination of the modern investment and private schemes in RNS. The findings of the study indicate that alfalfa and other fodders had higher opportunity to occupy the available agricultural land within field crops and farming systems in the RNS in particular and the Northern Region in general compared to cereal crops including wheat. The higher annual alfalfa yield and returns resulted in the higher total cultivated areas in absolute and relative terms occupied by alfalfa in the RNS' farming systems and suggest that alfalfa

would be the superior dominant crop enjoying greater competitiveness within the field crop combination in the State.

3. Although wheat is not as profitable as alfalfa, it is enjoying large cultivated areas in the RNS. This due to it is importance as one of the main strategic crops in the country where the national policies usually encourage wheat growers to extend its areas compared to other crops. This also clarifies why most of the cultivated area was covered by cereal strategic crops despite that they are described as very exhaustive crops to the soil fertility. Legumes and vegetable crops formed a limited acreage in the Northern Region. Generally, the crop combination in the state is mainly determined by the nature of season, tenants' experiences, market conditions and others, but in case of wheat its production is mostly determined by national and state agricultural policies.
4. Thus, it is evident that alfalfa fodder crop has ability to utilize and absorb more agricultural resources than wheat due to its importance in the farming system's sustainability. In other words, the yearly increase in alfalfa areas and returns contributed significantly to the increase in annual farm investment and improves the stability of agricultural production.
5. The study revealed that the performance of resources management for agricultural production in the state is bound with low efficiency as reflected in area gaps between the estimated optimal areas that can be cultivated and the actual cultivated areas.

References

Abbas, E. and Elamin, M. (1997). Study of the comparative advantage of potato crop in Sudan. Agricultural Research Corporation, Wad Medani, Sudan.

Abdel Magid, H.M. (1991). Productivity of wheat and alfalfa under intercropping. Exp. Agr. 27, 391–395.

Ahmed, E.A. (2004). Economics of Faba bean Production and Marketing in River Nile State. A Case Study Elddamer District. M.Sc. Thesis, University of Khartoum.

Ahmed, E.A. (2009). Economic Aspects and Water Use Efficiency in Public Pump Irrigated Schemes of the River Nile State. PhD. thesis, University of Khartoum.

Guiguo, Zhanga B.; Zaibin, Yangb; Shuting, Donga (2011). Interspecific competitiveness affects the total biomass yield in an alfalfa and corn intercropping system.

ICARDA (2005). Assessing On-Farm Water-Use Efficiency: A New Approach A report on collaborative research undertaken by: The International Center for Agricultural Research in the dry Areas (ICARDA) and The United Nations Economic and Social Commission for Western Asia (ESCWA).

Ijami, A.A. (1994). Efficiency and equity Effects of Market Access on Agricultural productivity in Sudan. A Case Study Small Holder Along the River Nile State.

Mohammed A.H. (2013). A Production Function Explanation of Saudi Economic Growth (1984-2011). International Journal of Economics and Finance; Vol. 5, No. 5; 2013. ISSN 1916-971X E-ISSN 1916-9728 Published by Canadian Center of Science and Education.

Norton, R. D. and Hazell, P.B. (1986). Mathmatical Programming for Economic Analysis in Agriculture. Collier Macmillan, London

Richard, B. W. (2009). Water engineering for the promotion of peace. 1944-3994 / 1944-3986 © 2009. Desalination Publications. doi: 10.5004/dwt.2009.170. 1 (2009) 1–6. 2009.

Shideed, K.T.; Oweis, T.Y.; Gabr, M. and Osman, M. (2005). Assessing On-Farm Water-Use Efficiency: A new Approach. Methodology and Six Case Study. In A report on Collaborative research undertaken by KARDA and ESCWA, Aleppo, Syria.

Srinivas, G.; Sekar, S.; Saravanan, R. and Renganaray-anan, S. (2009). Studies on a water-based absorption heat transformer for desalination using MED´´. 1944-3994/1944-3986 © 2009 Desalination Publications.1 (2009) 75–81. 2009.