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Agricultural Resources Allocation and Field Crops Competition

Elgilany Ahmed, Jamalludin Sulaiman and Saidatulakmal Mohd
Department of Postgraduate Studies and Research, University Sains Malaysia,
School of Social Sciences, Pulau Pinang, Malaysia

Abstract: Problem statement: Field crops are considered as essential cash and food crops produced in River Nile State (RNS) of North Sudan include cereal, food-legumes, vegetables and fodders beside the perennial crops. They are the main source of household income and regarded as a major part of the daily diet for the Sudanese. In other words they play an important role in household food security and poverty alleviation. However, resources use efficiency for producing these crops is became critical due to high competition from high population pressure and chronic low and instable crop yields emanating from environmental stresses and poor use of improved technology pose challenges for resource management. Since resources are most essential economical inputs, the target should be when optimizing resources use to obtain maximum productivity per unit. The RNS is considered as one of the main supplier of these cereal and food-legume crops to the country. The crops are commonly produced under pump irrigation from the River Nile. The production of field crops in the State are faced by numerous constraints namely inefficiency of resources use, low level of productivity and high cost of production. The study aims to assess the allocation of the available resources use over the competitive field crops of the dominant crop combination. **Approach:** It was on this basis that a study was prepared out in RNS to establish resource combination levels that maximize gross margins from food and cash crops that commonly grown within the combination. Primary data was collected by using structured questionnaires for (70) randomly selected respondents from Elzeidab scheme public irrigated scheme of RNS as a case study. A linear programming technique through the General Algebraic Modeling System (GAMS) program was used to assess the optimally combining resources in the prevalent field crops. **Results:** The model results revealed that tenants would get higher returns by allocating more resources namely land, water, labor and capital to the food legume crops production. Higher net benefits would be from food legume crops production and least from exclusion them. **Conclusion:** The RNS tenants should therefore, be guided on how to optimally and efficiently utilize their resources and be encouraged to grow food legume crops that give production and yield advantages, earn high returns and contributed significantly to farm sustainability and alleviates malnutrition in RNS.

Key word: General Algebraic Modeling System (GAMS), International Fund for Agricultural Development (IFAD), Water Amount (WA), Marginal Value Product (MVP)

INTRODUCTION

Information on the cultivated areas of agricultural products is as basic tools in preparing import-export policies, pricing agricultural products, planning agricultural developments and other relevant issues (Ashourloo *et al*., 2008). The agricultural development potential is manifest in the large mass of productive land not yet utilized and in the favorable land/ man ratio. The magnitude of the arable land, water and vast pastures forests qualified the Sudan for large scale crops and livestock production. UNEP (2007) reported that Sudan with its large land expanses extending over about 2.5 million km2 is bestowed with diverse natural resources. Agricultural activities, forming the main source of livelihood in the country, are basically geared by the magnitude of natural resources. This is particularly so on account of the low level of use of modern agricultural inputs such as improved seeds, modern irrigation technologies. In Sudan, the tenants have embraced numerous field crops in order to intensify production in an attempt to improve home food security and income. In Sudan and some of the developing countries, the trend of the farmers towards diverse crop combination is a dominant practice as means of increasing efficiency of resources. This behavior might be earned by experience to avoid agricultural risk, such as pests and unfavorable climatic conditions (i.e., high temperature, low moisture). Many studies mentioned that the RNS has been assumed to have a comparative advantage with seasonal cash and food crops production namely, wheat, faba bean, chick pea, dry bean, onion,

Corresponding Author: Elgilany Ahmed, Department of Postgraduate Studies and Research, University Sains Malaysia, School of Social Sciences, Pulau Pinang, Malaysia

vegetables, spices, sorghum, maize, potato and fodder beside some perennial crops. The study focused on field crops as most important farm activity in the State because they have a significant role in the diets of the Sudanese people and contribute substantially to the economy of the country. All the mentioned seasonal crops are grown in both private and public irrigated schemes of the state, but the public ones are regarded the main suppliers for these crops according to its areas and the highly number of tenants. The production in the public schemes is based on payment of fixed water charges. The study undertook Elzeidab public irrigated scheme as a case study to implement the study. The farm management is fully under the tenants' control, while the government is considered as a water seller besides the preparing for agricultural policies. Although, the research work is important to assess and recommend for the ideal crop combination, but in RNS a limited research has been conducted to establish resources combination level that maximize the tenants net returns. The RNS witnessed in the last three decades numerous of research work, they carried out through many organization programs such as International Center for Agricultural Research in the Dry Area (ICARDA) and International Fund for Agricultural Development (IFAD) with collaboration with Agricultural Research and Technology Corporation (ARTC), but the majority of these studies stressed on cereal and legume crops as pure stands and they provided information on production, , breeding improvement, agronomy, microbiology, crop protection, technology transfer and others, but not on the resources scarcity for crop production. However, the optimum resource levels in the crop combinations that maximize the tenant' profits have not been adequately assessed. According to this fact, this study aimed to determine the optimal levels of farm resource combination namely, water, land, labor and capital to ease making of rational economic decision regarding efficient reallocation of the limited resources.

MATERIALS AND METHODS

This study was carried in Elzeidab public irrigated scheme of RNS. The crops are commonly produced under pump irrigation from the River Nile to some extent as well as from underground water. The farming system of the RNS is characterized mainly as not full-mechanized system, the winter season is considered the main season for producing cereal and legume crops, recently, the State enlarged animal production activities and oil crops. The study depend mainly on primary data which was collected by using structured questionnaires for (70) randomly selected respondents through probability proportional method from Elzeidab scheme public irrigated scheme of RNS as a case study. Integrated techniques and tools are used to assess resources use in Elzeidab scheme of RNS, GAMS, Crop Wat.4 and Excel and SPSS software programs have been employed to achieve the objectives of the study. The data collected consisted focused on the dominant crop combination and the available resources allocation. There are a number of tools that can be used to optimize resources use of which is Linear Programming technique (LP) through the General Algebraic Modeling System (GAMS) program was used to assess the optimally combining resources in seasonal legume crops. LP is a mathematical technique for finding the best uses of a firm's limited resources. The adjective "Linear" is used to describe a relationship, which is directly and precisely proportional "Programming" refers to the use of certain mathematical techniques so as to get the best solutions to a problem involving limited resources. In this study, LP technique was used to achieve the optimal solution for legume crops in the crop combination of Elzeidab farming system. From the collected data, the average farm resources, yield and gross margins by feddan were computed and entered in the General Algebraic Modeling System (GAMS) software program for optimization analysis. The model was specified with gross margins maximization as the objective function as:

$$\text{Max } Z = \sum_{j=1} CjXj \quad (1)$$

Such that:

$$\sum \alpha ijXj \le bi, \text{all} = \overset{n}{\underset{j=1}{1}} \text{ to } m \quad (2)$$

And:

$$Xj \ge 0, \text{all } j = 1 \text{to } n \quad (3)$$

Where:

Z = Objective function value
Xj = Level of the jth the farm activity, such as the acreage of wheat grown. Let n denote the number of possible activities; the j=1 to n
Cj = Objective value, in this case the forecasted feddan) gross margin of a unit of the jth activity (SDD per feddan)
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 i^{th} 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 X_j, 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 legumes crops and other seasonal crops. In 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 i^{th} activity (enterprise), calculated on per feddan basis.

RESULT AND DISCUSSION

Agricultural resources use efficiency: Natural resources of every society are the wealth of that society which not only belongs to the present generation, but also a heritage belongs to posterity. But we must admit that the role of natural resources have never been so vital and useful for human beings at no moment in history and their existence have never been threatened by human in such a broad scale (Ghaly *et al*., 2008 cited by Arayesh and Hosseini, 2010). As the crops reflection properties showed many variations, for precise classification many signatures are needed (Ashourloo *et al*., 2008). Crop production activities continue all the year-round in River Nile State of North Sudan, supplied irrigation water for the grown crops. In northern Sudan, there are mainly two distinct seasons, winter (October to March) and saifi (Summer) (May to September). 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, the sorghum crop is usually sown at the end of the summer season (September) to be harvested at the middle of the winter season (January). The harvested crops are used either for domestic consumption and/or as cash crops as shown in Fig. 1. From Fig. 1 the distribution of field crops in season 2005/06 was such that 25% of the total land was devoted to wheat, followed by 19% for sorghum and 14% for onion, while the lowest percentage (1%) was allocated to potato. The other crops were ranked as 2, 2, 4, 5, 8, 8 and 12% occupied by spices, dry bean, maize, fodder, vegetables, chick pea and faba bean, respectively.

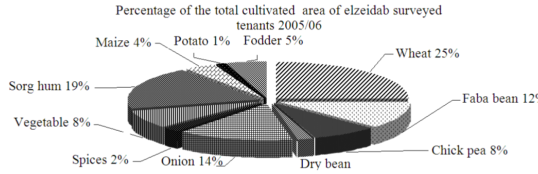

Fig. 1: Allocation of total cultivated area to different crops in the scheme

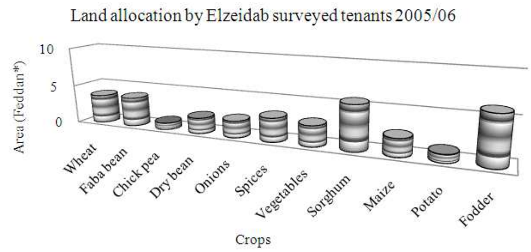

Fig. 2: Land allocations per farm for Elzeidab tenants 2005/06

Land resources use: A high crop competition recognized between crops of the dominant crop combination under the resources scarcity especially for winter season which is considered the season around the year. Figure 2 depicts the average land allocations per farm for Elzeidab tenants among the adopted crop combination in season 2005/06 and it is obvious that there are numerous choices for Elzeidab tenant to determine the best crop combination. Furthermore, the competition exceed the traditional field crops to the competition of the legumes each other.

The distribution of field crops areas within the farming system usually determined by several factors of which market-induced ones are the main.

Furthermore, the accumulated experiences of tenants enable them to distribute their available resources among the crop combination. As example, food-legume crops namely, faba bean, dry beans and chickpeas investigated clear variation, that the tenants of the scheme were devoted the greatest portion of their farm to faba bean crop, ranked by dry beans crop while chickpeas was occupied the smallest area within tenants' farm and so on. This result is not strange, because faba bean is the most important food legume overall the country, that it constitutes the main dish on the breakfast and dinner tables for a large sector of Sudanese people. Although, chickpeas is an important cash crop in Sudan and could achieve high profit for the State tenants but historically this crop faces a marketing problems. The production and consumption of this crop is fluctuated overall the country and during all the year except in the Holy month of Ramadan which witness the peak of its consumption by the faster Muslims. While dry beans used to be grown in small areas at the River Nile banks or islands as favourable options of land or/and high terrace land of the scheme.

Table 1: Assessment of FWUE per watering and per season for the seasonal crops of the surveyed tenants in Elzeidab scheme

Crop	Deficit in no of irrigations (%)	CWa (m^3/fed)	FWUE- watering	Over- irrigation (%)	FWUE-season	Over-irrigatio n(%)
Wheat	21	3756	0.41	59	0.64	36
Faba bean	16	3708	0.41	59	0.46	54
Chickpea	31	2411	0.43	57	0.72	28
Dry bean	25	3528	0.45	55	0.59	41
Onions	17	8820	0.37	63	0.30	70
Spices	25	3332	0.46	54	0.65	35
Vegetables	16	8820	0.34	66	0.23	77
Sorghum	27	3426	0.41	59	0.63	37
Maize	14	3822	0.46	54	0.68	32
Potato	17	5880	0.37	63	0.49	51
Abu 70	33	2352	0.38	62	0.72	28

Source: The field survey 2006

Water resources use: Numerous studies revealed that irrigation in agriculture represents about 70% of global water use. Yet experiences show that the number of countries where agricultural water is monitored with sufficient accuracy is limited. The obtained style of irrigation water in most cases is that, gross irrigation areas are multiplied by an average unit water use to obtain an estimation of the area's or district's water use in irrigation. While compilation of national statistics is necessary to benefit from local knowledge their use in global assessment has proved too unreliable to allow for meaningful analysis.

The approach developed in this study relies both on the State Ministry of Agriculture statistics and modeling to provide a more reliable dataset for districts and water use in irrigated schemes by combining as far as possible the data of the irrigated areas, cropping patterns, socioeconomic characteristics and irrigation system to assess the amount of water applied. The applied Water Amount (WA) in the study was calculated by the irrigation unit of the RNS Ministry of Agriculture and Irrigation for the State public irrigated schemes according to season 2005/06 as 588 m^3/fed per watering and it consisted of about 3% as losses for both seasonal and perennial crops. Surface irrigation is the dominant system in Elzeidab scheme, while ground water is main source for the small private schemes over all the RNS.

There are no impacts for rainfall in the study area on irrigated agriculture due to its small amount. FWUE of Elzeidab seasonal crops were estimated at two levels namely, FWUE per watering and per season as shown in Table 1. The average water application per season for seasonal crops' area was 8820 m^3 for onion and vegetables as the highest amounts, followed by 5880 m^3 for potatoes, while the water amounts for the other crops ranged between 3822 and 2352 m^3 as evident from Table 1. FWUE for some seasonal crops is relatively high given that onions, vegetables and potatoes crops are very water demanding through their growing season which took about 141, 130 and 110 days, respectively. The estimated FWUE of Elzeidab scheme indicated a wide technological gab between the required utilization and actual water application, as depicted in the above Table. According to Table 1 FWUE for the field crops per watering was found to be 0.46 for maize and spices as the highest FWUE, followed by 0.45and 0.43 for dry bean and chickpea, respectively. It was found to be similar for wheat, faba bean and sorghum at 0.41, while it was 0.34 for vegetables as the lowest one. This implies that farmers over-irrigated maize and spices by 54% and vegetable by 66%. On the other hand, FWUE amounted to as high as 0.72 for chick pea and Abu70, followed by 0.68, 0.64 and 0.63 for maize, wheat and sorghum, respectively, while it was as low as 0.23 and 0.30 for vegetables and onions respectively. This implies that farmers over-irrigate their crops by 28% as the case for both chick pea and Abu70 and by 77% for vegetable crops. The results revealed that all surveyed farmers over-irrigated entirely their seasonal crops. Generally in this study, the overall average FWUE was calculated as 0.40 per watering and 0.56 per season. The table shows that Elzeidab scheme tenants exceeded the seasonal crops water requirements per watering by 60% and by 46% for the entire season, suggesting high potential for irrigation water use, once FWUE is improved, as depicted in Table 1

Labor resource use: The research detected that farm labour force in Elzeidab scheme comprises both family and hired labours according to the production stage, size of cultivated area, financial abilities of tenants and the type of the crop. The tenants usually avoid hiring farm labours to reduce the cost of production, but sometimes and for some production stages that require large number of labours force, they found themselves compelled to hire labour (i.e., pre-sowing land cleaning, canal cleaning). The labour force is considered as an important resource to complete the production processes beside land and water. Hence, it is necessary to be aware the amount of these resources for better use efficiency. The estimation of the physical productivity of these resources at the farm level forms important indicators to assess issues such as land productivity, water productivity and labour productivity. The surveyed tenants reported that two family members contributed in the production stages as family labours and the hired labour for the seasonal crops varies from crop to another Table 2.

Table 2: Determination of productivity per unit labour for seasonal crops of the surveyed tenants in Elzeidab scheme

Crops	Yield (kg/fed)	Labor (man-days/fed)	Productivity per unit labor (kg/man-days)
Wheat	675.90	15	45.06
Faba bean	488.70	17	28.74
Chickpea	414.00	10	41.40
Dry bean	540.00	15	36.00
Onions	2880.00	25	115.20
Spices	630.00	13	48.46
Vegetables	1852.50	32	57.87
Sorghum	1005.30	16	62.83
Maize	855.00	14	61.07
Potato	4000.00	34	117.65

Source: The field survey 2006

Table 3: Average value by different financial sources in RNS

Source of finance	Average value '000'SDD	Time Received	Repayment time	No. of tenants	Tenants (%)
Self-finance	2.379	-	-	55	93.0
ABS	6000.000	Nov.	May	01	01.4
MAS	400.000	Dec.	April	01	01.4
Merchant	170.000	Nov.	April	02	02.8
Relatives	150.000	Oct.	April	01	01.4

Source: The field survey 2006

Table 4: Average farm area, yield and production of seasonal crops of surveyed tenants in the scheme as compared with ARC yields

Crops	Area (fed)	Yield (kg/fed)	Production (kg)	ARC yield (kg/fed)	Yield Gap (%)
Wheat	3.67	676	2481	2000	66
Faba bean	3.73	489	1823	1500	67
Chick pea	0.85	414	352	1250	67
Dry bean	2.00	54	1080	12000	55
Onions	2.12	2880	6106	1200	76
Spices	3.00	63	1890	Na	Na
Vegetables	2.60	1853	481	10000	81
Sorghum	5.57	1005	56	1700	41
Maize	2.20	855	1881	1700	50
Potato	1.00	4000	4000	10000	60
Fodder	6.00	4000	24000	2000	80

Source: field survey 2006, ARTC and MAS report for Investment Book 2006

Table 2 shows the field crops' labour requirements were estimated at 34 man-days/fed for potatoes as having the highest labour requirements, followed by vegetables at 32 man-day/fed and onion at 25 man-days, while 10 man-days applied to chickpea as the lowest crop labour requirements. The crop labour requirements for the remaining crops ranged between 10 and 34 man-days with the exclusion of Abu70 forage crop due to technical aspects (i.e., its usage is mainly before maturity as forage and that give unreliable results). The table also shows that potatoes crop achieved the highest labour productivity of 117.56 kg/man-day, followed by onion (115.2 kg/man-day) and sorghum and maize (62.83 and 61.07 kg/man-day, respectively). The lowest labour productivity was that of faba bean. Those of other crops ranged between 36 and 57 kg/man-days.

Financial resource use: 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. In the commercial segment a range of people like traders, agricultural and professional money lenders operate (Ijami, 1994).

The reduction of public funding for agricultural advisory services under structural adjustment programs aimed at limiting the inefficient use of public resources.

The study unveiled that 93% of surveyed tenants have to depend on their own resources of about SDD 2379 for a farm, while the other informal financing sources represented 2.8% from village merchants (about SDD 170000) and 1.4% for relatives (SDD 50000) as depicted in Table 3.

On the other hand, formal finance in the River Nile State usually comes from Agricultural Bank of Sudan (ABS) and State Ministry of Agriculture (MAS). The formal finance often in kind and to some extends in cash, but it is considered insufficient to meet the actual farm expenditures. The study revealed that both of the formal sources of finance mentioned earlier provided means for a very low percentage of the total respondents estimated at 1.4%. The average value provided by ABS and MAS were found to be SDD 600000 and SDD 400000, respectively Table 3.

Yield of field crops in the scheme: The profitability of adopting new irrigation technologies depends on the level of productivity improvement (Lin, 1994). The crop combination adopted by the scheme's tenants is as illustrated in Table 4. The average area distribution of the mentioned crops is shown by Table 4 Crop yields achieved by Elzeidab surveyed tenants were generally low when compared by research yields reported by the Agricultural Research Corporation (ARC).

Yield gaps of 47% and 81% apply for dry bean and vegetable crops, respectively, indicated that much potential gap exists to increase the scheme's yields of all field crops except for spices due to lack of information.

Cost of production of seasonal crops in the scheme: Cost recovery is an important reform strategy in agricultural advisory services. A number of different countries have contracted out advisory services to private providers or have diversified the funding of this activity (Ali *et al*., 2008). Production economics play a unique role in farm management (Doll and Orazem, 1992). The dominant conception of production cost in the area of study is known as the cost of material inputs, labor force, services and the management used in producing a certain goods or/and crops. Many studies showed that the cost of production overall the RNS has leaded to the low profit. The high cost of production attributed to high cost of numerous of production inputs, but absolutely, the irrigation water cost is considered as the most agricultural constraint and that might refer to the high cost pumping water from the River Nile and this is justified strict allocation among the different crops grown. The coming elaboration of the survey results in Fig. 3 discerned the cost items as the sequence of the seasonal crop production operations.

The study detected that mainly about 13 cost components as mentioned in the earlier Fig. they constitute the cost of production and they accounted SDD 70054.2 equal about US $ 300. Irrigation cost component achieved the highest cost item as 19% of total production cost. The wheat growers in Elzeidab scheme pay the cost of this item as a fixed rate for the scheme administration at the end of the season. The research also revealed that the average variable cost of potatoes was the highest one at 167800 SDD/fed, Followed by vegetables and onion at 156271 and 121212 SDD/fed, respectively, while Abu70 forage was found to be 30200 SDD/fed as the lowest average cost.

Gross margin: Gross margins as known reveals how much a firm (farm, company.) earns taking into consideration the costs that it incurs for producing its products and/or services and it could be expressed as a percentage. Gross margin is a good indicator of how profitable a firm is at the most fundamental level. Farms with higher gross margins will have more money left over to spend on other activities such as investment, improvement of production and marketing. The general mathematical form for the gross margin calculation per crop is as follow:

GM = GR-TVC

Where:

GM = Crop gross margin per fed in SD
GR = Crop gross revenue per fed in SDD
TVC = Crop total variable costs per fed in SDD

Gross margins for Elzeidab seasonal crops under the study were assessed individually per fed for season 2005/06. The Table also investigates that, although the gross margins of the mentioned seasonal crops were found to be positive, but they were very low. The gross margin of dry bean was SDD 97950 as the highest one, followed by onion and vegetable crops at SDD 65538 and 52478, respectively, while the gross margin of wheat of SDD 4295 was the lowest. The RNS experienced increasing input prices in the last decade and that might explain the high cost of production for the majority of the crops. According to this fact, some crops could be assessed as infeasible such as wheat and faba bean unless improvements are made.

Optimal field crops production obtained by Elzeidab model: The idea of offering leading services for agricultural and natural resources growth and development in the world can be traced back to the establishment of Agricultural Societies (Mohammadi and Mirbod, 2005). 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 productivities. The analysis also provided some other relevant results as shown in Table 5. It represents the actual and optimal cultivated area for the different crops under study and gives also the optimal allocation for the average area. The optimal solution reflects devoting land only for chickpea and dry bean as 8.62 and 1.38 feddans respectively, while the rest of the crops did not appear in the optimal plan. The actual returns from crop production are SDD 399487.28, while the optimal returns are SDD 891596.73 which is more than the actual returns by SDD 492109.45 or 123%.

Resources use and constraints: The most important season in the Northern Region of Sudan is winter, hence the tenants pursue the best crop combination to achieve satisfaction returns. According to the importance of the winter season, the resources use and availability might be described as fully utilized during this season. Introducing seasonality in the model as a known technique 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 5 per season; the total optimal area is 10 feddan, i.e., all available land. It is clear that the optimal plan resulted in all available land would be devoted to chickpea and dry bean due to their high returns when compared to other field crops. From Table 5 the optimal and actual water used are 15384.42 and 28573 m3, respectively. The Table also shows the optimal quantities of water used for the different field crops. It reflects that water use increased from October till January and decreased towards harvest. The period from October to January is known as the most demanding period that coincides with the growing of winter cash crops.

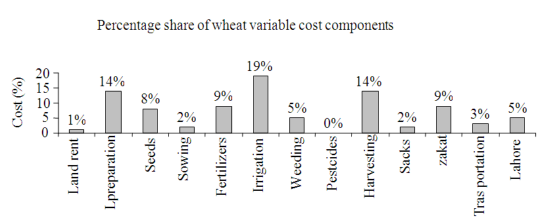

Fig. 3: Percentages share of the variable cost components for field crops in Elzeidab

Table 5: Optimal resources use and cropping pattern plan for Eleidab scheme tenancy

Item	Actual	Optimal	Units
Resources use:			
Total land	10	10	Feddan
Total irrigation water	28573	15384.4	Cubic meter (m^3)
Total labour	191	124	Man-day
Total capital	179532	122237	SDD
Returns: objfn value (Z)	399487	891597	SDD
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

Sou**rce:** Model results, 2008

Table 6: Shadow prices for essential resources in Elzeidab sheme

Resource	Shadow price in SDD
Land (per feddan)	67339.141
Capital of November (per SDD)	8.579

Source: Model results, 2008

Marginal productivities of the resources used in the scheme: Marginal Value Product (MVP) of a factor of production can be directly computed from its elasticity of production when output is measured in value terms. The MVP of a resource could be calculated from the equation:

$$MVP_{xi} = eiY/X_i$$

Where:

MVP_{xi} = Marginal value of resource X_i
Ei = Input elasticity of production for X_i
Y = Geometric mean of gross value of farm production
X_i = Geometric mean resource X_i

To find the efficiency index of a resource, MVP is related to its Marginal Factor Cost (MFC). Mathematically, the expression below gives the efficiency index (IEXi) of a particular resource:

$$IEXi = MVP_{xi}/MFC_{xi}$$

Efficient resource use is reached when the expected value of IEXi is positive, in other words, a resource can be expanded until its MVP is exactly equal to its MFC. A comparison will give an insight into the differences in efficiency of resource use within a district and between districts. Economically, MVP is the shadow price of the resource used.

Table 6 shows the shadow prices of land and capital in November in optimal plan. The shadow prices for both mentioned resources had a positive sign and this indicates the possibility of increasing the gross margin or the objective function value by increasing land and capital. The Table also shows that land has the greatest marginal value productivity (SDD 67339.141 per feddan); thus explaining land scarcity in the study area. The capital devoted for November was found to be SDD 8.579 per SDD, indicating limitation of financial resources particularly in November, which is regarded the peak period for capital requirements.

Scenarios of Elzeidab scheme model: Scenarios analysis is regarded as counter-factual analysis. The scenarios analysis tries to answer: "what happens if one or more elements in the model change". In the model scenarios analyses was applied to obtain new results by changing some parameter values of the model. The scenarios are considered here as one of the tools used to achieve the main objective of the study by exploring the optimal plan that might lead to efficiency of water use and high returns. Generally, some changes have been applied on the study constraints (water, land, labour and capital) and comparison is made between the basic solution and the scenarios. The model assumed that recommended crop water requirements might save valuable quantities of irrigation water.

First scenario: Recommended crop water requirements: The model assumed that instead of the actual quantities of the water used, we can use the recommended Crop Water Requirements (CWR) and that might save valuable quantities of irrigation water. Table 7 shows the new results of using the recommended CWR instead of the actual water used while the other parameters were constant. The Table illustrates that there would be no changes in any of the parameters values of the model except irrigation water. The total CWR used in the model was 13432.46 m^3, while the optimal water quantity was 9163.42 $m^{3,}$ which is less than the basic solution by 68% and that could be saved for area expansion. The optimal water quantity confirms that Elzeidab tenants over-irrigate their crops as mentioned early in this chapter.

Second scenario: Impact of low prices of chickpea and dry beans: The model was assumed the declining of both chickpea and dry beans prices as a dominant phenomenon in the RNS markets, while it was left faba bean to assess the impacts of their low returns. The model assumed that the decline of chickpea and dry bean prices down to 65 and 55%, respectively. It was detected that the decline of chick pea and dry beans product prices would expectedly lead to a fall in gross margins, but the margin would remain positive.

Table7: Impact of using CWR instead of actual one (first scenario)

Item	Actual	Optimal	Units
Resources use:			
Total land	10	10	Fed
Total CWR	13432.46	9163.42	Cubic meter (m^3)
Total labour	191	124	Man-day
Total capital	179532	122236.61	SDD
Returns: objfn value (Z)	399487.28	891596.73	SDD

Source: Model results, 2008

Table 8: Impact of low prices of chick pea and dry beans

Item	Actual	Optimal	Units
Resources use:			
Total land	10.0	8.254	Fed
Total irrigation water	28573.0	22399.100	Cubic meter (m^3)
Total labour	191.0	182.000	Man-day
Total capital	179532.0	163490.000	SDD
Returns: Objfn value (Z)	399487.0	254529.000	SDD
Cropping pattern:			
Wheat	1.1	-	Fed
Faba bean	1.1	3.11	Fed
Chick pea	0.3	-	Fed
Dry bean	0.6	-	Fed
Onions	0.6	1	Fed
Spices	0.9	0.044	Fed
Vegetables	0.8	1.048	Fed
Sorghum	1.7	1.750	Fed
Maize	0.7	-	Fed
Potato	0.4	1.302	Fed
Fodder	1.8	-	Fed

Source: Model results, 2008

Table 8 shows the results of the new model solution. The scenario analysis found that the effect of their prices change was influenced the tenants' returns, the gross margin and the allocation of the resources under the study. The optimal return was found to be SDD 254528.7457 which is less than the basic solution by 37%. The optimal levels of the resources used were found to be 8.254 fed, 22399.143 m^3, 182 Man-day and SDD 163490.002 of the total land, irrigation water, labour and capital, respectively. It is clear that the obtained results indicate to the importance of food legume crops within seasonal crop combination that their absence will affect the farm sustainability by reducing the tenants' returns by 37% compared with their actual returns and decreasing the cultivated area by 18%, thus the results are appointed to unemployed of other resources. The distribution of the cultivated area was found to be 3.110 fed for faba bean and 1.0, 0.044, 1.048, 1.750, 1.302 fed for onions, spices, vegetables, sorghum and potato, respectively as depicted in Table 8. This result indicated to faba bean as the most profitable crop as mentioned in the above applied scenario and it could be one of the best option for the RNS tenants due to it is high value.

No doubt the scientific research confirms that food legume crops are fix atmospheric nitrogen, which is made available to the non-legume crops resulting into higher yields of the non-legume crops if grown rotationally than if grown as pure stand consequently and that would assist farm sustainability.

CONCLUSION

Based on obtained results, the following policy implication can be made:

- There is high potential for improvement to save valuable amounts available resources especially irrigation water that can be used to stretch irrigated areas. Intervention of the State is needed to ease resources and agricultural inputs availability and improve resources-use efficiency either by changing or modernizing the existing farming system, adoption of the recommended resources use technologies and introduction of modern technologies ones
- Adoption of a participatory approach by the scheme administrators and tenants to manage agricultural resources and inputs is a big incentive for tenants to adopt modern resources-saving technologies
- Raising the tenant's awareness about the importance resources for agriculture, life and environment through efficient structure that can be applied by the extension system
- Most of the available resources water, land, labor and capital are used inefficiently at different levels. The resources use efficiency can be increased by implementing the optimal cropping plans resulting from the model calculations, specifically increasing the cultivated area of the seasonal food legume crops chickpea and dry bean and the perennial fodder legume alfalfa to increase farm returns
- The study unveiled the low value of most of the field crops particularly the strategic ones, wheat and faba beans. Incentives should be provided to make these crops more profitable due to their importance for food security. Relevant policies may include reducing production costs or interventions to purchase them at reasonable prices
- Improving finance institutions will enable the tenants to improve their resources use and significantly increase their farm returns

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