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Estimation of Impacts of Rainfall on Cereal Production in the Northern Region of Iraq for the Period 1992-2008

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Abstract

According to the average quantities of rainfall, Iraq's arable land is divided into three regions: rainfall, semi-rainfall and rain-fed. The total Iraq's regions are suffering from inefficient utilization of natural resources as a result of dis-maximization of agricultural production function.

The northern region on Ninava and Duhok Governorates is part of the northern region of Iraq which is located in the ensured rainfall zone and the figures of per donum yield of cereal crops are somewhat higher than the Iraqi figures, however, they are still less than the required figures. The average quantities of rainfall are annually fluctuated and, thus, considered the major determinant for producing cereal crops especially wheat and barley. The situation implies that an extensive efforts should be concentrated on administrating resources in order to increase per donum yield of cereals.

The main thrust of this research is to estimate the impacts of rainfall resource on producing wheat and barley in the region for the period 1992-2008. The library and historic data gathering has been used with the assistant of some administrative officials in the agricultural departments of the region. Production function analysis of different specifications are used to estimate the basic parameters in the agricultural sector of the region. The estimates are based on fitted the usual linear, semi-log, inverse semi-log and the double-log production function.

The results revealed that the double-log function was the more convenient function in presenting some important conclusions. Increasing of one unit of rainfall will increase per donum yields of wheat and barley by 0.956 and 0.611 kg/donum respectively. The annual increase of per donum yields of wheat and barley were about 0.250 and 0.214 kg/donum. Wheat production is carried on in first stage, while barley production is carried on in the second stage of production function. An additional unit of rainfall is added about 0.523 kg of

wheat and 0.264 kg of barley.

Introduction

Wheat and Barley are considered the very important and necessary cereal crops for the life of t he world societies especially Iraq. They are strategic crops planted in relatively large areas and their outputs are related to food security of almost all the developing countries including Iraq. In addition, wheat and barley are playing important role of international trade, where the world reports are indicated that food shortages are basically attributed to the lack of wheat and barely production (Mellor, 1973, 15). Both crops have low demand elasticities as an increase of their prices do not lead to decrease demand of each.

In fact, the total supply of water in Iraq is 74.640 billion m^3, about 70% of the quantity is utilized. While the Iraqi population is steadily growing and thus the demand for food is in turn increased, the country is suffering from recession of water supply of Euphrates and Tigres (the two major rivers in Iraq). In addition, Iraq as many other countries is influenced by global heating which has resulted in reduction of the rates of rainfall. During the last three years, about 600.000 donum of the total arable land, which were allocated for producing cereal crops become abandonment because of drought and desertification (Abdulrahman, 2010, 218). This implies that especial consideration must be paid to the areas that depend on rainfall in producing cereals, especially wheat and barley.

Problem statement

In Iraq, the total arable land is about 48 million donum (donum equals 0.4 hectare), while only about 23 million donum is exploited (48%). About 47% of the total exploited arable land is planted by the two cereal crops: wheat and barley. According to the means of irrigation, the total arable land is divided into three zones: ensured rainfall, semi-rainfall and the rain fed. The ensured rainfall zone is totally situated in northern region of the country, among them Ninava and Dohuk.

Almost all the Iraq's governorates are not effectively utilized natural agricultural resources and thus the country's output, especially of grains, is lower its utmost capability. Therefore, extensive efforts are needed to disposal this restriction. Regarding planning of agricultural sector, a greater effort should be made to determine the natural resources potential, especially the average quantities of rainfall, with view of generating practical recommendations on the optimum utilization of resource. The resource is considered the major determinant of cereal production and thus any attempt to increase output is often restricted by this factor. Therefore, efforts must be focused on conducting the rainfall factor efficiently in order to increase per donum yield of crops. Thus, this research could be considered as an appropriate solution this problem.

Importance and objective

The importance of research is derived from the importance of cereal crops, i.e., wheat and barley. These two crops are not only necessary for the life of people but also for the Iraqi economy . In the northern region, and because of the abnormal circumstances in the past period (the first Gulf-war on 1980, the events of 1990 and the UN-sanction on Iraq from

1990-1993), domestic demand for food has largely increased. The records of agricultural offices indicated that the total area cropped on (1988) which was about 223386 donum (18.7% of the total arable land in the region) increased to (900204) donum (75.2% of the total arable land in the region) on 2002. About 85% of the area has cropped by wheat, barley and lenses (GAD- Planning & Follow up).

In Iraq, and specially in the area studied, the output of cereals is fluctuated. The figures of area cropped of wheat which are relatively higher in the first five years (1992-96), started to decrease in the following years as can be seen in table (1). In contrary, the figures of area cropped of barley which are relatively lower during the period (1992-99), started to increase in the following years. Consequently, the figures of per donum yields of crops are fluctuated throughout the period of study. The average quantities of rainfall are also fluctuated and they ranged between 815.7 mm^3 in the season of (1992/93) and 233.8 mm^3 in the season of (1998/99). The figures are indicated that there have been two dry seasons in the period of study, i.e., the (1998/99) and (2007/08). Despite some good seasons, however, quantities of rainfall didn't take advantage of increasing per donum yield of crops.

Table 1. Total outputs, total area cropped, per donum yields of wheat and barley and quantities of rainfall in the area studied for the period (1993-2008)

Year	Output (tons)		Area (Donum)		Yield(Kg/donum)		Rainfall(mm^3)
	Wheat	Barley	Wheat	Barley	Wheat	Barley	
92/93	202631	6072	698730	31957	290	190	815.7
93/94	142325	12861	569300	71450	250	180	713.4
94/95	150417	13695	626741	70233	240	195	735.0
95/96	104333	14208	623700	65175	167	218	502.4
96/97	184895	22759	653340	72025	283	316	615.0
97/98	221793	3238	561500	11320	395	286	599.4
98/99	59142	15336	444680	108000	133	142	233.8
99/00	122020	17776	406735	88361	300	201	430.2
00/01	229090	58492	445700	146230	514	400	635.5
01/02	231814	58156	514000	134000	451	434	702.4
02/03	240284	41745	515750	156350	466	267	752.8
03/04	227843	31712	393240	109618	572	289	701.1
04/05	76707	30720	409108	146151	187	210	636.7
05/06	205883	52455	449472	193558	458	271	811.5
06/07	201643	76474	481250	200900	419	380	688.7
07/08	80986	23730	452158	146090	179	162	294.4

Source: Records of the State General Directory of Agriculture, Dohuk Governorate (1992-2008).

It is obvious that the figures of per donum yield of both crops are somewhat higher than the figures in Iraq as a whole which were 189.87 and 179.56 kg/donum of wheat and barley respectively for the same period (Al-Aswady, 2004, 52), however, they are still less than the

required figures.

Data for the period (1992-2008) of the total areas, total outputs of wheat and barley and the average quantities of rainfall were gathered and verified with the assistance of the officials in charge of the General Directory of Agriculture in Ninava and Dohuk cities. Thus, library and historic data gathering has been used.

Hypothesis

The impact of the quantities of rainfall in the northern region of Iraq on cereals production can be determined by estimating the functional relationship between the average quantities of rainfall and per donum yields of crops.

Analytical Approach

There have been quite a few quantitative investigations of production function in the northern region of the Iraqi agricultural sector, perhaps the studies made by (Al-Najafi, 1988) and (Al-Najafi and Hussain, 1993, 79-93) are the major leading contributions to the field of production in Iraq. The objectives of their empirical investigations were to measure the functional relationships between the agricultural inputs and can be considered as basic tools which may be allowed the rational uses of resources.

With the assistance of the economic theory assumptions, the statistical models were used to illustrate the variations of per donum yields of wheat and barley which are attributed to the variations of the average quantities of rainfall factor (R). All factors other than rainfall were grouped and represented by the time factor (T). Both factors were considered independent variables influencing wheat and barley productivities (Y1 and Y2 respectively) which are the dependent variables. Production function analysis with different specifications are used as analytical tools to estimate the basic parameters in the agricultural sector of Dohuk city. The estimates are based on fitted the usual linear, semi-log, inverse semi-log and double-log production functions. The mathematical formula of function is:

$$Y_i = F(R,T)$$

$$Y_i = b_o + b_1R + b_2T,$$

and by converting the model into the econometrical form, it will be:

$Y_i = b_o + b_1R + b_2 T + U_i$ where U_i is the random variable

The multiple linear regression analysis by means of the OLS method is used to estimate the production functions of both crops. The two functions are concluded by the application of the SPSS package which includes all the required tests. The parameters of production functions represent the elasticities of production with respect to the rainfall and time factors. Thus, t-test is used to examine the significance of each parameter separately (Al-Gadiri, 2006, 340). The coefficient of determination (R^2) is also used to examine the degree that the independent variables explaining variations of the dependent variable. The higher the R^2 value, the higher the degree that the rainfall and time are explaining variations of production. Comparison of explained and unexplained variations is examined by using F-testing. This test

is used to see the significance of estimated function (Al-Mousawi, 1990, 434-477). Also, Durbin Watson- test is used to examine whether there is an autocorrelation between the random variables, and the value of VIF is used to examine weather there is multicolinearity between the dependent and independent variables (Bakheet & Al-Rafaie, 2006, 403-427).

Discussion of Results

Wheat Crop

The results obtained by different functional forms for variables of wheat crop are presented in table (2).

Table 2. The results of the different functional forms for analyzing relation-ships between variables of wheat crop

The function	Estimated equation	R2 adj	F	DW	VIF
Linear	Y_1= -82.142 + 12.090T + 0.504R	0.428	6.609	1.636	1.016
	t = -0.702 2.132 3.192				
Semi-log	LinY_1=1.868 + 0.015T + 0.001R				
	t = 11.814 1.934 3.707	0.481	7.960	1.603	1.016
Inverse semi-log	Y_1=-534.481+202.143LinT+613.243LinR	0.518	9.057	1.939	1.051
	t = -3.280 2.750 3.774				
Double - log	LinY_1=lin-0.85532+0.250LinT+ 0.956LinR	0.568	10.880	1.777	1.051
	t = -0.592 2.534 4.378				

It can be seen from table (2) that the four specifications have passed the statistical tests and the values of coefficients are different than zero according to the values of t (0.05%, df=16). The estimated functions are all significant according to the values of (F). The values of DW indicate that there is no autocorrelation (dl<DW<4-du), and the values of VIF indicate that there is no multicolinearity (<5) between the dependent and the independent variables.

The theory of production function would predict that the relationship between productivity and factors of production should be positive. Although the four function forms give rather different results, however, double-log function (Cobb-douglas) give the best results among the others. In addition, the function is more convenient in producing some important economic conclusions. The mathematical formula of function is:

$$Y_1 = 0.425\ T^{0.250}\quad R^{0.956}$$

The figures of coefficients indicate that an increase of one unit of rainfall will increase productivity of wheat by about 0.956 kg/donum, which reflects the importance of rainfall in producing the crop. While the annual increase of productivity of wheat is about 0.250 kg/donum throughout the period of study. The function yields coefficients immediate elasticities of productivity with respect to the time factor and the quantities of rainfall. The elasticity indicates the percentage change in the dependent variable which would be, on

average, associated with percentage changes in the independent variables when other factors are held constant. The sum of these elasticities indicates return to scale. A sum of coefficients greater than unity, as the case with the function of wheat (1.206), indicates increasing return to scale which means that production is carried on the first stage of production function. This implies that the area cropped of wheat must be extended as long as per donum yield of wheat is increased until the second stage is reached.

Assuming that productivity , time and quantities of rainfall are at their geometric means (331.5kg/donum , (805) and 616.8 mm^3) and (b) is the elasticity of rainfall input, the marginal productivity (MP) of rainfall factor can be specified directly from the coefficients of Cobb-Douglas production function when all other inputs are held on their geometric mean. The MP value is given by the first partial derivative of function as follows:

$$MP = dY/dR = b\ (Y/R),$$

$$Y_1 = 0.425\ T^{0.250}\quad R^{0.956}$$

Thus, $MP_R = (0.4063)(8.5^{0.25})(616.8^{-0.044}) = 0.523$

This value implies that one extra unit of rainfall is added 0.523kg to wheat production. Such a result is important when the input-output prices and costs are taken into accounts.

Barley crop

The results obtained by different functional forms for variables of barley crop are presented in table (3).

Table 3. The results of the different functional forms for analyzing relationship between variables of barley crop

The function	Estimated equation	R2 adj	F	DW	VIF
Linear	Y_2= 57.186 + 6.573T + 0.236R	0.188	2.739	1.353	1.016
	t = (0.640) (1.518) (1.960)				
Semi-log	$LinY_2$= 4.66 + 0.025T + 0.00103R	0.26	3.68	1.267	1.016
	t = (4.66) (1.596) (2.38)				
Inverse semi-log	Y_2=-749.230 + 127.803LinT + 325.696LinR	0.363	5.374	1.513	1.051
	t = (-2.183) (2.369) (2.732)				
Double - log	$LinY_2$= 1.2004 + 0.214LinT + 0.611LinR	0.474	7.746	1.401	1.051
	t = (1.015) (2.646) (3.425)				

From table (3), it can be seen that the coefficients of variables for the linear and semi-log specifications reveal non-significance of time factor, while semi-log specification reveals highly significance for rainfall factor according to the values of (t). However, the inverse semi-log and double log specifications reveal significance for both rainfall and time factors (level 0.05, df=16). The figure of F of the double-log specification indicates that the function

is highly significant than the other. As the case with the four specifications, the value of DW of the double-log function has failed to discover the autocorrelation between variables, thus by estimating the value of (P^=1-DW/2), the result was 0.3. This means that a decision can be taken that there is no autocorrelation between variables as there is no autocorrelation between the random errors. The values of VIF indicate that there is no multicolinearity (<5) between the dependent and independent variables. The mathematical formula of function is:

$$Y_2 = 3.3213\ T^{0.214}\quad R^{0.611}$$

The figures of coefficients indicate that an increase of one unit of rainfall will increase productivity of barley by about 0.611 kg/donum, which reflects the importance of rainfall in producing the crop. While the annual increase of productivity of barley is about 0.214 kg/donum throughout the period of study. A sum of elasticities is less than unity (0.825), which indicates decreasing return to scale. This means that production is carried on the second stage of production function which implies that the area cropped of barley should continue to increase as long as productivity is increased until the maximum production is reached.

Assuming that productivity of barley crop , time and quantities of rainfall are at their geometric means (258.8kg/donum , 8.5 and 616.8mm^3) and (b) is the elasticity of rainfall, The MP value of rainfall will be:

$$MP_R = Y_2 = 3.3213\ T^{0.214}\quad R^{0.611} = (2.0293)(8.5^{0.214})(616.8^{-0.399}) = 0.264$$

The MP_R value implies that one extra unit of rainfall is added 0.247 kg to barley production.

Conclusions and Recommendations

1. The double-log production function is the best model to illustrate the functional relationships between the average quantities of rainfall and per donum yields of wheat and barley crops. The models have passed statistical tests and an increase of one unit of rainfall will increase productivities of crops by about 0.965 and 0.611 kg/donum of wheat and barley respectively.

2. In view of elasticity coefficients, wheat production is carried on in the first stage of production function which implies that the area of wheat must be extended as long as per donum yield is increased. While barley production is carried on in the second stage which implies that the area of barley must be extended until maximum output is reached.

3. The values of marginal productivities of rainfall indicate that one extra unit of rainfall is added about 0.523kg of wheat and 0.264kg of barley. In order to increase these figures, agricultural resources available especially the arable land must be reallocated on the basis of the quantities of rainfall dropped in the region.

4. As per donum output of crops are below their required levels, the following steps are suggested:

a. Planting new species of higher productivities and those appropriate to the regional conditions.

b. Following the accurate regulations for planting each crop.

c. Adapting the crop-rotations system in order not to reduce capability of the arable land.

5. The government must provide facilities to the farmers who are regularly cropping wheat and barley, support prices and give subsidies to encourage more production

6. It has been proved that, in order for extreme exploitation for the little attainable of water for irrigation either in the northern or in the middle regions of Iraq, there must be new technologies for irrigation adapted. Such technologies are regarded as complementary watering units, i.e. Spray Watering & Dropping Systems. These systems were used successfully on some regions in the country and which eventually resulted in permanent provision of water for irrigation, avoid drought and facing fluctuations of rainfall seasons.

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