An Examination of Technical, Economic, Allocative Efficiency and Economic Impacts of Salinity on Livelihoods: The Case of Al-Musayyeb Farms in Iraq

Boubaker Dhehibi[1, *], Roberto Telleria[1], Aden Aw-Hassan[1], Saad Hatem Mohamed[2], Feras Ziadat[3] and Weicheng Wu[4]

[1]Social, Economics and Policy Research Program (SEPRP) - International Center for Agricultural Research in the Dry Areas (ICARDA). B. O. Box 950764 – Amman 11195, Jordan ([*] Corresponding author E-mail: b.dhehibi@cgiar.org)
[2]Iraq Ministry of Agriculture – Iraq
[3]Integrated Water and Land Management Program (IWLMP) - International Center for Agricultural Research in the Dry Areas (ICARDA). B. O. Box 950764 – Amman 11195, Jordan
[4]Geographic Information System Unit (GIS) - International Center for Agricultural Research in the Dry Areas (ICARDA). B. O. Box 950764 – Amman 11195, Jordan

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Abstract - The objective of the study was to investigate how farmers could sustain an economically viable agricultural production on salt affected areas of Al-Musayyeb area in Central Iraq. It aims to assess the impacts of salinity on crop productivity, resource use and profitability under different soil salinity levels. Earlier research could not provide the causal relationship between soil salinity and the loss of crop production, resource use and the technical efficiency (TE), allocative (cost) efficiency (AE), economic efficiency (EE) and income.

Stratified random samples of 220 households were interviewed based on severity of salinity indicators. The scores and determinants of both the TE and AE were identified using stochastic frontier *translog* cost and production functions. Empirical findings show that the estimated AE of the farms in the Al- Musayyeb area varied widely from 56 to 94%, with a mean value of 59%. This suggests that the average farmer needs a cost saving of 41% to attain the status of the most allocatively efficient farmer. Findings show that technical efficiency indices varied from 57 to 98%, with a mean of 89%; and economic efficiency varied from 32 to 84%, with a mean of 52%. These widely varying indices of efficiency among Al-Musayyeb farmers in a similar agro-ecological locality indicate great potential to achieve productivity growth through improved efficiency, using existing technologies and the available resource base in the study area. Results of the estimated coefficients indicated that family labor and land tenure are significant and positively correlated to technical and allocative efficiencies, while off farm income contributed significantly to technical efficiencies. These results suggest that land tenure in this farming system and increased investment in extension services could jointly contribute to an improvement in efficiency of Al-Musayyeb farmers.

The assessment of the profitability between farmers in soil salinity-affected and salinity-free areas was also conducted using the production function decomposition analysis. The estimated model accounts for more than 54% percent of the difference in gross margin between salinity-free and salinity-affected areas. The problem of salinity accounted for 41.8%. This value indicates that with the same level of resource use, compared to salinity-free area, gross margin would decline by 41.8% in soil-affected areas of Al-Musayyeb. However, about 13% percent of the gross margin difference could be attributed to change in input use in the salinity-affected areas.

Keywords— Frontier production and cost function, technical efficiency, allocative efficiency, economic efficiency, inefficiency determinants, profitability, living with salinity, Iraq.

1. Introduction

Salinity has emerged as one of the major factor responsible for low crop production in Iraq. During the last many years, various agricultural regions have significantly lost their productivity due to soil salinity. This situation is very alarming especially for the Al-Musayyeb region which is producing an important share of crops for the whole country (Reference). Additionally, Iraqi economy is heavily dependent on agriculture through the exports of agricultural goods and the dependence of textile sector upon cotton crop.

According to an estimate, an annual loss of cultivated lands in Iraq is about 5 percent due to salinization and water logging. It is estimated also that 28 million acres in Iraq are cultivable or 26 percent of the total area of the country. The total area estimated to be used for agriculture is 19 million acres, which is almost 93 percent of the cultivable area. According to FAO estimates, more than 2 million hectares are irrigated and it is estimated that approximately 75 per cent of this area is moderately saline and another 25 per cent has levels of salinity that prevent farming. However, due to soil salinity-fallow practices, and the unstable political situation, it is estimated that only 7 to 12 million acres are actually cultivated annually.

Soil salinity leads to reduce agricultural productivity of affected lands, but there are no published estimates of the relationships between the level of agricultural productivity and the severity of salinity. There are useful published relationships between agricultural productivity and the concentration of salt in irrigation water, but no such relationships between agricultural productivity and soil salinity levels or water table depths have been determined for salinity in Iraq. It was concluded that no such relationships were available.

However, agricultural productivity suffered from different factors; lack of fertilizers, agricultural machinery, management practices and the means of spraying planted areas with pesticides as well as salinity. Intensity of problem is large which has made it very difficult for most farmers to combat with the situation. In addition, not much has been done so far to explore the impact of salinity on the socio-economic conditions of small farmers. To determine the relation between crop production and salinity in an agricultural area and to assess the extent and degree of salinity problems, it deserve recommendation to implement field surveys sampling crop yield and soil salinity at random, and perform an appropriate statistical regression analysis of the data obtained. Thus, this paper specifically investigates how farmers could sustain an economically viable agricultural production on salt affected areas of Al-Musayyeb area in Central Iraq. It aims to assess the impacts of salinity on crop productivity, resource use and profitability under different soil salinity levels.

Moreover, this study focused on the measurement of the level of technical and allocative efficiencies and their determinants in Al-Musayyeb region, Iraq using stochastic frontier *translog* cost and production functions. Allocative efficiency is the ratio between total cost of producing one unit of output using actual factor proportions in a technically efficient manner and total cost of producing one unit using optimal factor proportions in a technically efficient manner.

The plan of the study is as follows: Introduction, background information and objectives of the study are described in section I. Section 2 describes conceptual framework to measure both technical and allocative efficiency using production and cost function framework plus model specification. Study area and data used are outlined in section 3. Section 4 deals with the presentation and discussion of our empirical results. In the last section, conclusion and policy implications from the result are drawn.

2. Conceptual Framework: Efficiency and Frontier Production Functions

The concept of efficiency is concerned with the relative performance of the processes used in transforming given inputs into outputs. Economic theory identifies at least three types of efficiency. These are technical, allocative and economic efficiencies. Allocative efficiency refers to the choice of an optimum combination of inputs consistent with the relative factor prices. Technical efficiency shows the ability of firms to employ the 'best practice' in an industry, so that no more than the necessary amount of a given sets of inputs is used in producing the best level of output. Economic efficiency is the product of technical and allocative efficiencies.

Efficiency is a very important factor of productivity growth, especially in developing agricultural economies where resources are insufficient and opportunities for developing and adopting better technologies are dwindling. Such economies can benefit greatly by determining the extent to which it is possible to raise productivity or increase efficiency, at the existing resource base or technology. For efficient production, non-physical inputs, such as experience, information and supervision, might influence the ability of a producer to use the available technology efficiently. Each type of inefficiency is costly to a firm or production unit (e.g., a farm household) in the sense that each type of inefficiency causes a reduction in profit below the maximum value attainable under full efficiency.

In the empirical literature, two techniques of estimating a firm's relative position to the frontier are used in the empirical studies: Data Envelopment Analysis (DEA) and Stochastic Frontier Production Function (SFPF). Parametric and non-parametric methods are the two main approaches used to quantify efficiency. Choosing between DEA and SFA methods is a delicate matter (Johansson, 2005). There are a lot of controversies about the choice of a method for estimating efficiency. In fact, each method has its advantages and disadvantages. In parametric approaches such as Corrected Ordinary Least Square (COLS) and Stochastic Frontier Analysis (SFA), a functional form is needed to estimate the production frontier. Using SFA cost or profit function approaches are possible via production function. This matter is argued on the basis of duality on such functions. In addition, cost and profit functions have the advantage to allow with different outputs on which the case of our research. Consequently, if the wrong functional form is chosen, the efficiency scores are incorrect. In contrast, non- parametric techniques such as DEA do not require predetermined production functions to relate inputs and outputs. They however implicitly suppose that stochastic errors are absent. In this latter case, if measurement errors exist, the calculated efficiency is also biased because stochastic deviations from the frontiers are regarded as inefficiencies. Nevertheless, several studies comparing both methodologies have shown, that results from both methods are highly correlated (Wadud and White, 2000; Thiam *et al.,* 2001; Alene and Zeller, 2005), indicating that both methods are valuable and that the choice can be based on the authors' preference.

Since the stochastic production frontier model was first, and nearly simultaneously, published by Meeusen and van den Broeck (1977) and Aigner *et al.,* (1977), there has been considerable research to extend the model and explore exogenous influences on producer performance. Early empirical contributions investigating the role of exogenous variables in explaining inefficiency effects adopted a two-stage formulation, which suffered from a serious econometric problem[1]. Kumbhakar *et al.,* (1991), Reifschneider and Stevenson (1991) and Huang and Liu (1994) proposed stochastic production models that simultaneously estimate the parameters of both the stochastic frontier and the inefficiency functions. While the formulated models differ somewhat in the specification of the second error component, they all used a cross section data. Battese and Coelli (1995) formulated a stochastic frontier production model similar to that of Huang and Liu (1994) and specified for panel data. In methodological note, we adopt the Battese and Coelli (1995) model for a general framework considering data in a cross section data context. The model consists of two equations (1) and (2). The first equation specifies the stochastic frontier production function. The second equation, which captures the effects of technical inefficiency, has a systematic component $\delta' z_i$ associated with the exogenous variables and a random component ε_i :

$$LnY_i = Ln f(x_i ; \beta) + v_i - u_i \tag{1}$$

$$u_i = \delta' z_i + \varepsilon_i \tag{2}$$

Where Y_i denotes the production of the i-th firm; x_i is a vector of input quantities of the i-th firm. β is a vector of unknown parameters to be estimated. The parameters of the stochastic frontier production function in (1) and the model for technical inefficiency effects in (2) may simultaneously be estimated by the maximum likelihood method. The technical efficiency of production for the i-th farm in the t-th period of time can be defined as follows:

$$TE_i = \exp(-u_i) = \exp(-\delta' z_i - \varepsilon_i) \tag{3}$$

Finally, v_i represents the random errors and are assumed to be independent and identically distributed N (0, σ_v^2). The non-negativity condition on u_i is modeled as ε_i ~ N (0,σ_ε^2) with the distribution of ε_i being bounded below by the truncation point $-\delta' z_i$. Thus technical efficiency is allowed to change over time. This model does not impose any firm specific effects, which means that it doesn't account for possible heterogeneity between farms in the sample. Maximum likelihood estimation of equation (1) provides estimates of β parameters and the variance parameters, $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \frac{\sigma_u^2}{\sigma_u^2}$. Thus, mean technical efficiency is redefined as:

$$TE_i = E(\exp(-U_i)) \tag{4}$$

A predictor for which is provided by its conditional expectation[2]:

$$E\left[\exp\{-u_i\} \middle| (v_i - u_i)\right] = \left[\exp\left\{-\mu_{*i} + \frac{1}{2}\sigma_*^2\right\}\right] \cdot \left[\frac{\Phi\left[(\mu_{*i}/\sigma_*) - \sigma_*\right]}{\Phi(\mu_{*i}/\sigma_*)}\right] \tag{4a}$$

Where,

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[1] In the first stage of this formulation, the stochastic frontier model is estimated and the residuals are decomposed using the Jondrow *et al.* (1982) technique. The estimated inefficiency scores are then regressed, in a second stage, against the exogenous variables contradicting the assumption of identically distributed inefficiency of the first stage.

[2] For the derivation of the likelihood function, its partial derivatives with respect to the parameters of the model and an expression for the predictor of technical efficiency see Battese and Coelli (1995).

$$\mu_{*i} = \frac{\sigma_v^2(\delta^{'} z_i) - \sigma_u^2(\varepsilon_i)}{\sigma_v^2 + \sigma_u^2} \tag{4b}$$

$$\sigma_*^2 = \frac{\sigma_v^2\ \sigma_u^2}{\sigma_v^2 + \sigma_u^2} \tag{4c}$$

On the other hand, Bravo-Ureta and Rieger (1991) and Sharma *et al.,* (1999) have used the cost decomposition procedure developed by Kopp and Diwert (1982) which yield measures of economic efficiency and allocative efficiency. In this way, we subtract v_{it} from both sides of equation (1), we obtains:

$$LnY_i^* = LnY_i - v_i = Ln f(x_i ; \beta) - u_i \tag{5}$$

Where LnY_i^* is the observed output of firm i, adjusted for the white noise, v_i. The technically efficient input vector (X_i^{TE}) for a given level of output Y_i^*, is obtained by solving simultaneously equation (5) and the input ratios $\frac{X_1}{X_i} = k_i (i > 1)$, where k_i is the ratio of the observed inputs at the output level Y_i^* in period t.

To obtain estimates of TE_i , we first need to specify the functional form $Ln f(x_i ; \beta)$ in (1) prior to estimation. In this context, we assume that the production function is Cobb-Douglas, thus the corresponding cost function can be derived algebraically as follows:

$$C_i = f(W_{hi}; y_i^*) \tag{6}$$

In this equation, C_i is the cost called "minimum" associated with the level of production Y_i^* of firm i and W_h is considered as the price of the h-th input. Applying Shephard' lemma for the equation (6), we obtain the following system:

$$\frac{\delta C_{it}}{\delta W_{hit}} = X_{hit}(W_{it} ; Y_{it}^*), \qquad h = 1,2,...h \text{ inputs} \tag{7}$$

The general expressed form in (7) is a system of minimum cost input demand equations.

Substituting the firm's input prices and output level equation (5) into equation (7), we obtains the economically efficient input demand vector (X_i^{ee}). This parameter is used to calculate both technical and economic efficient input combination of firm i, $w_i^{'} x_i^{e}$ and $w_i^{'} x_i^{ee}$, respectively. On the basis of the observed cost $w_i\ x_i$, the economic efficiency measures can be computed as follows:

$$EE_i = \frac{w_i^{'} x_i^{ee}}{w_i^{'} x_i} \tag{8}$$

Taking into account that technical efficiency can be describes in terms of technical and economic costs,

$$TE_i = \frac{w_i^{'} x_i^{te}}{w_i^{'} x_i} \tag{9}$$

These measures can be combined to yield a measure of allocative efficiency using Farrel (1957) decomposition:

$$AE_i = \frac{EE_i}{TE_i} = \frac{w_i^{'} x_i^{ee}}{w_i^{'} x_i^{te}} \qquad (10)$$

3. Study Area and Data Analysis

3.1. Study area

Al-Musayyeb area is considered one of the most important agricultural areas, which located in the north-east of the Babel Governorate, Iraq. It is one of four main districts compounds Babel, with total area of 80,000 ha out of 516,000 ha as the total area of the governorate. About 45000 ha out of the district area is cultivable. The total number of farmers is estimated at 3745 that control three types of land tenures: private, leased and rented. The topography of the district is 100% foothills and the agriculture sector depends mainly on irrigation. The total population is estimated to be 150,000 with 7 persons as the average family size. The majority of the people are predominantly farmers with a relatively small holding with an average of 8ha. The annual temperature in the district is ranged between 0 and 50. Wide range of crops is cultivated in Al-Musayyeb along the year. Around 700 ha are devoted for date palm orchards and controlled by 534 farmers. Orchards of citrus, figs, apricot, olive and grapes are also available in the district. In addition to that, cereal crops, vegetables and forages are regularly cultivated by farmers. Some of vegetables are grown under about 135 green houses that run by 40 farmers in addition to 253760 tunnels. Livestock production in Al-Musayyeb is reflected by the number of animals and livestock projects. Hundreds of sheep heads, goats, buffalo and cows are owned by Al-Musayyeb farmers.

3.2. Data collection and descriptive analysis

The data used in this study were cross-sectional survey collected from 220 farmers selected from 10 villages. The summary of statistics variable used for the stochastic production and cost function analyses is presented in Table 1. Average age of interviewed farmers who have the responsibility of farms management is 57 years old. Average family household is about 13 person, about 6 of them are working in agriculture. In addition, more than 68 percent of the households have a certain level of education. The analysis of the surveyed farmers indicated that 31.6 percent of households are illiterate, 23.3 percent, 22.3 percent, 21.9 percent and 0.9 percent of the households are read and write, primary, secondary and university educated, respectively. Indeed, descriptive statistics showed a good percent of education –although it is not high as the other regions of the country, but they reflect a good potential for transferring or adoption of new technologies. The analysis of land tenure in Al-Musayyeb region indicates that two types of land tenure have been recorded. The first one called private ownership represents 16 percent of the interviewed households and the rent from State, which represents 84 percent.

In Iraq, one of the main land tenure systems known is the rent of land from the State. It is originated from the law of agriculture reform which is issued by the government during late of fifties of the last century. This law has revised many times by the successive Iraqis' governments since its implementation. This law is targeted to organize agricultural activities and to insure a certain level of equity in land and income distribution. Land have taken from the biggest owners and redistributed among the marginal farmers or farmers who have no lands –mainly who are working with the biggest farmers. The application of that law has kept almost half of the lands to the biggest owners.

Table 1: Summary statistics of variables for stochastic production and cost functions analysis

Notation	Variables	Mean	Standard Deviation	Min	Max
S	Area (ha)	13.1	14.33	1.00	97.75
TGMC	Total Gross Margin (ID/ha)	4032592	4921351	53000.00	26666667
TVC	Total Variable Cost (ID/ha)	652379.4	832210.8	77599.47	8619933
L	Cost of Labor (ID/ha)	13966.06	77406.57	0.00	720000.0
M	Cost of Machinery (ID/ha)	229318.1	306548.6	0.00	2140000
SE	Cost of Seeds(ID/ha)	111991.0	150153.0	0.00	1565467
F	Cost of Fertilizer (ID/ha)	185888.6	408542.7	0.00	4666667
IC	Cost of Irrigation (ID/ha)	109542.3	226146.7	0.00	2116667
CC	Cost of Chemical (ID/ha)	116828.1	448491.9	0.00	3500000
OC	Other Costs (ID/ha)	348180.7	1238386.	800.00	10000031
NDVI	Normalized Difference Vegetation Index	0.435	0.100	0.129	0.643
EC	Electrical Conductivity (dS/M)	8.92	10.55	5.46	75.67
OFI	Off Farm Income (%)	3.4	8.7	0.00	50
AGE	Farmer Age (years)	56.39	11.83	24.00	100.00
EL	Education Level (*Dummy variable: 1 secondary to high; 0 otherwise)*	0.23	0.42	0.00	1.00
LT	Land Tenure (*Dummy variable: 1 private ownership; 0 otherwise*)	0.21	0.41	0.00	1.00
FSL	Income From Livestock Sector (%)	29	16	0.00	75
FLTL	Family Labor with respect to Total Labor (%)	94	21	0.00	100

Source: Own elaboration from survey data (2012).

Note: ID – Iraqi Dinars (1000 ID= 0.85 US$ - Average 2012).

The average total gross margin per farmer per annum was 4032592 Iraqi Dinars with large variability of 4921351 ID. This implies there are large inequalities in gross margin among the sampled farmers. Farm size ranged between 1ha and 97.75ha with average size of 13.1ha. The average cost of labor used shows that Al-Musayyeb Farms used relatively small amount of labor. The mean cost per hectare is around 13966.06 ID. This is so because farmers in the study area depends heavily on family labor to do the most of the farming operations as this is also reflected in the percentage show of family labor of 94 percent out of total labor. In addition, the analysis of the variables shows that the percentage share of cost of machinery, cost of seeds, cost of fertilizer, cost of irrigation, cost of chemical and other costs accounted for 20.55%, 10.03%, 16.66%, 9.81%, 10.47% and 31.20% of the total variable production cost respectively. Regarding the household's income sources for households in Al-Mussayeb Area, it appears that farming or plant production represents the main source of income (67.2 percent). Out-farm income represents only 3.4 percent in comparison with other resources which indicates that farmer's income is mainly from agricultural activities. Indeed, the analysis of variables shows that livestock represents an important source of income for Al-Musayyeb farmers. On average it contributes for about 30% for the farmer income. Finally, the Normalized Difference Vegetation Index (NDVI) is ranging between 0.13 and

0.64 with an average of 0.43. This implies there are large variability in vegetation covers and biomass and consequently yield among the sampled farmers. The analysis of soil salinity indicator (EC) indicates that 20% of farms are considered with high salinity level (EC>8dS/M) and the remained 80% are considered low soil salinity (EC<8dS/M).

4. Empirical Model

4.1. Efficiency and frontier production functions

The model, which is proposed for the analysis of farm-level data, involves a stochastic frontier production function, in which the parameters of the production function are specified. According to Kopp and Smith (1980), functional forms have a limited effect on empirical efficiency measurement. A Cobb-Cobb-Douglas form has been used in many empirical studies, particularly in those relating to developing agriculture (Battese, 1992). The Cobb-Douglas functional form also meets the requirement of being self-dual, allowing an examination of economic efficiency. In this study, the following Cobb-Douglas functional form was selected to model Iraqi's farmer's production technology. The Cobb-Douglas functional form for Al-Musayyeb farms in the study area is specified as follows for the production functions:

$$\text{Log } Y_i = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + \beta_6 \log X_6 + \beta_7 \log X_7 + \beta_8 \log X_8 + (v_i - u_i) \quad (11)$$

Whereby Y_i total output approximated by the NDVI index; β_0 is the intercept; X_1 represents land; X_2 represents labor cost per hectare in Iraqi Dinars; X_3 represents mechanization cost per hectare in Iraqi Dinars; X_3 represents seed cost per hectare in Iraqi Dinars; X_5 represents fertilizer cost per hectare in Iraqi Dinars; X_6 represents irrigation cost per hectare in Iraqi Dinars; X_7 represents chemical costs per hectare in Iraqi Dinars; X_8 represents other costs per hectare in Iraqi Dinars; u_i represents the specific technical efficiency factor for farm i; and v_i represents a random variable for farm i.

Also, Cobb-Douglas cost frontier function for Al-Musayyeb farms in the study area is specified as:

$$\text{Log } TVC_i = \alpha_0 + \alpha_1 \log W_1 + \alpha_2 \log W_2 + \alpha_3 \log W_3 + \alpha_4 \log W_4 + \alpha_5 \log W_5 + \alpha_6 \log W_6 + \alpha_7 \log W_7 + (V_i - U_i) \quad (12)$$

Whereby TVC_i is total variable production cost per hectare; α_0 is the intercept; W_1 represents labor cost per hectare in Iraqi Dinars; W_2 represents mechanization cost per hectare in Iraqi Dinars; W_3 represents seed cost per hectare in Iraqi Dinars; W_4 represents fertilizer cost per hectare in Iraqi Dinars; W_5 represents irrigation cost per hectare in Iraqi Dinars; W_6 represents chemical costs per hectare in Iraqi Dinars; W_7 represents other costs per hectare in Iraqi Dinars; U_i represents the specific allocative efficiency factor for farm i; and V_i represents a random variable for farm i.

The technical, allocative and economic inefficiencies are explained by:

$$\mu_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} \quad (13)$$

Whereby μ_i represents inefficiency effects; δ_0 represents the intercept; Z_{1i} represents the percentage of source income generated by livestock production; Z_{2i} represents the percentage of the off farm income; Z_{3i} represents age of farmers (years); Z_{4i} represents the farmers education level (1 if education level of farmer is secondary to high school, university and higher and Zero otherwise); Z_{5i} represents the percentage of family labor with respect to total farm labor; Z_{6i} represents the land tenure (1 for private ownership; Zero otherwise) and Z_{7i} represents the electrical conductivity (EC) level (measured in dS/m). The frontier functions (production and cost) are estimated through maximum likelihood methods. In addition, for this study, the computer programme FRONTIER version 4.1 (Coelli, 1996) was used. However, it should be noted that this computer programme estimate the cost efficiency (CE) which is computed originally as inverse of the farm -level economic efficiency (EE).

4.2. Salinity impacts on resource use and productivity

In addition to the production and cost function analysis, a decomposition analysis was used to discern the true impact of soil salinity on the gross margin. Decomposition analysis is a mathematical technique that could disaggregate and quantify a difference in an observable quantitative variable into its components. More simply, the technique provides a method to quantify the intervening factors of a difference such as before and after the situation. Production function decomposition analysis can be used to decompose the difference in the changes in gross margin output between salinity-free soils and salinity-affected soils. Bisaliah (1977), Joshi and Dayanantha (1992) and Joshi *et al.,* (1994) and Thiruchelvam and Pathmarajah (2003) used a similar technique for wheat and other crops. The change in gross margin output between normal and salinity-affected soils will be decomposed into: (i) changes due to salinity effect and (ii) changes due to reallocation of inputs. The land use pattern, resource use pattern and crop productivity can be also analyzed for different soil salinity levels.

For production function decomposition analysis, separate production functions are estimated for different soil salinity levels. As mentioned above, in this analysis, we differentiate farms on the basis of the electrical conductivity level. We will consider the salinity-free soil for farmers where the EC is less than 8dS/m and the salinity affected soil for farmers where EC is more than 8dS/m. In the last case salinity represents a severe problem for their land. These are specified in a log-linear form as follows:

Salinity-free soil - SFS

$$\text{Log } GM_{ni} = \text{Log } A_{ni} + b_{ni} \text{ Log } L_{ni} + c_{ni} \text{ Log } M_{ni} + d_{ni} \text{ Log } S_{ni} + e_{ni} \text{ Log } FR_{ni} + f_{ni} \text{ Log } IR_{ni} + g_{ni} \text{ Log } CH_{ni} + h_{ni} \text{ Log } OC_{ni} \tag{14}$$

Salinity-affected soil - SAS

$$\text{Log } GM_{si} = \text{Log } A_{si} + b_{si} \text{ Log } L_{si} + c_{si} \text{ Log } M_{si} + d_{si} \text{ Log } S_{si} + e_{si} \text{ Log } FR_{si} + f_{si} \text{ Log } IR_{si} + g_{si} \text{ Log } CH_{si} + h_{si} \text{ Log } OC_{si} \tag{15}$$

Where GM is gross margin per hectare (Iraqi Dinars/ha), (L), (M), (S), (FR), (IR), (CH), (OC) are cost per hectare (Iraqi Dinars/ha). A is a scale parameter. Others are the same as in the previous production function. Taking the difference between (14) and (15) and adding some terms and subtracting the same terms yield the following:

$$\begin{aligned}\text{Log } GM_{si} - \text{Log}GM_{ni} = {} & (\text{Log } A_{si} - \text{Log } A_{ni}) + (b_{si} \text{ Log } L_{si} - b_{ni} \text{ Log } L_{ni} + b_{si} \text{ Log } L_{ni} - b_{si} \text{ Log } L_{ni}) \\ & + (c_{si} \text{ Log } M_{si} - c_{ni} \text{ Log } M_{ni} + c_{si} \text{ Log } M_{ni} - c_{si} \text{ Log } M_{ni}) \\ & + (d_{si} \text{ Log } S_{si} - d_{ni} \text{ Log } S_{ni} + d_{si} \text{ Log } S_{ni} - d_{si} \text{ Log } S_{ni}) \\ & + (e_{si} \text{ Log } FR_{si} - e_{ni} \text{ Log } FR_{ni} + e_{si} \text{ Log } FR_{ni} - e_{si} \text{ Log } FR_{ni}) \\ & + (f_{si} \text{ Log } IR_{si} - f_{ni} \text{ Log } IR_{ni} + f_{si} \text{ Log } IR_{ni} - f_{si} \text{ Log } IR_{ni})\end{aligned}$$

$$+ (g_{si} \text{ Log } CH_{si} - g_{ni} \text{ Log } CH_{ni} + g_{si} \text{ Log } CH_{ni} - g_{si} \text{ Log } CH_{ni})$$
$$+ (h_{si} \text{ Log } OC_{si} - h_{ni} \text{ Log } OC_{ni} + h_{si} \text{ Log } OC_{ni} - h_{si} \text{ Log } OC_{ni}) \quad (16)$$

Rearranging terms in equation (16) yields the following:

$$\text{Log}(GM_{si}/GM_{ni}) = \text{Log } (A_{si}/A_{ni})$$
$$+[(b_{si}-b_{ni})\text{Log } L_{ni} +(c_{si}-c_{ni}) \text{ Log } M_{ni} +(d_{si}-d_{ni}) \text{ Log } S_{ni} + (e_{si}-e_{ni})\text{Log } FR_{ni}+ (f_{si}-f_{ni})\text{Log } IR_{ni}+ (g_{si}-g_{ni})\text{Log } CH_{ni}+ (h_{si}-h_{ni})\text{Log } OC_{ni}]$$
$$+ [b_{si} \text{ Log } (L_{si}/L_{ni}) + c_{si} \text{ Log } (M_{si}/M_{ni}) + d_{si}\text{Log } (S_{si}/S_{ni}) + e_{si} \text{ Log } (FR_{si}/FR_{ni}) + f_{si} \text{ Log } (IR_{si}/IR_{ni}) + g_{si} \text{ Log } (CH_{si}/CH_{ni}) + h_{si} \text{ Log } (OC_{si}/OC_{ni})] \quad (17)$$

Equation (17) apportions approximately the differences in gross margin per hectare between salinity-free and salinity-affected soils of farms into two components. The sum of the first two bracketed components on the right hand side indicates the land degradation effect. The third bracketed term measures the contribution of changes in input levels between the two situations.

5. Results and Discussion

<u>Maximum Likelihood Estimates of the Production and Cost Production Functions</u>

The maximum likelihood estimates for parameters of the Cobb-Douglas production and cost frontier models (equations 11 & 12) are obtained using the computer package FRONTIER version 4.1. Parameters estimates, along with the standard errors of the ML estimators of Al-Musayyeb producing farms production and cost frontier models are presented in Table 2. These parameters represent percentage change in the dependent variable as a result of percentage change in the independent variables, and as such show the relative importance of these variables to agriculture output/total variable costs in Al-Musayyeb region.

The estimates of the parameters of the stochastic frontier production model (equation 11), revealed that all the estimated coefficients of the variables of the production function were positive except that of fertilizers and chemicals. All the variables in the model with positive coefficients, implying that any increase in such variable would lead to an increase in output in the crop production. Mechanization and farm size have the highest coefficient, indicating that it is they are the most important variables in the production system in the region. This could imply that agriculture production is mechanization intensive, i.e. few improved technologies (chemical and mechanical inputs) are employed. As a result of family planning advocacy, people are cautious of the number of children they raise and this affects the availability of family labor. While the negative coefficient of fertilizers shows that as the farmers uses no recommended quantity and quality of fertilizers, agricultural output decreases.

This finding is in conformity with the descriptive analysis where the quantity of fertilizers used is less than the recommended. Seeds, irrigation and other costs are non-significantly which their impact on the production is neutral. In addition, the ratio of farm specific variability to total variability γ is positive and significant at 5% level, implying that farm specific technical efficiency is important in explaining the total variability of agricultural output produced. This affirmation confirms that stochastic production function is justified from empirical point of view.

The elasticities of production (farm size, labor, mechanization, seeds, fertilizers, irrigation, chemical and other costs) were positive decreasing function to the factors indicating the variables allocation of the production region, meaning that these variables were inefficiently utilized in course of agricultural production. The return to scale (RTS) analysis is given also in Table 2. The RTS of 0.092 implies that resources and agricultural production were inefficient.

The estimates of the stochastic frontier cost function are also presented in Table 2. The result revealed that all the independent variables conform with the a prior, expectation as all the estimated coefficients (cost of mechanization, cost of seeds, cost of fertilizers, cost of irrigation cost and cost of agro-chemicals) gave positive coefficients, meaning as these factors increased, total production cost increased ceteris paribus. The result of t - ratio test shows that all these positive variables are statistically different from zero at 5 percent level of significance. Hence, these variables are important determinant of agricultural production in the study area. While the negative and significant coefficient of labor shows that agricultural production in Al-Musayyeb region is family intensive labor. The ratio of farm specific variability to total variability γ is positive and significant at 5% level, implying that farm specific technical efficiency is important in explaining the total variability of agricultural cost for the production process. This affirmation confirms also that stochastic cost function is justified from empirical point of view.

Marginal products indicated that except labor all elasticties are positive and decreasing for the whole inputs. Moreover, empirical results showed that, an average, the mechanization impact factor is greater than the fertilizers, seeds, irrigation and agro-chemicals inputs factors. The values of these elasticities for mechanization, fertilizers, seeds, irrigation costs and agro-chemicals are 0.70, 0.21, 0.15, 0.11 and 0.09, respectively. These results indicated that mechanization has contributed the most to the agricultural production followed by fertilizers and irrigation costs.

Table 2: Maximum Likelihood Estimates of the Stochastic Frontier Production and Cost Functions in Al-Musayyeb Producing Farms

Production Function Estimates			**Cost Function Estimates**		
Variables	***Parameters***	***Coefficients***	***Variables***	***Parameters***	***Coefficients***
Stochastic Frontier Model					
Dependant Variable: NDVI (Proxy of Total Yield)			***Dependant Variable: TVC (Total Variable Cost)***		
Intercept	β_0	-0.27** (0.013)	Intercept	α_0	-0.43*** (0.09)
Ln(LA)	β_1	0.039* (0.026)	Ln(L)	α_1	-0.32* (0.18)
Ln(L)	β_2	0.011 (0.032)	Ln(M)	α_2	0.70*** (0.08)
Ln(M)	β_3	0.045** (0.021)	Ln(SE)	α_3	0.15** (0.06)
Ln(SE)	β_4	0.002 (0.015)	Ln(F)	α_4	0.21*** (0.04)
Ln(F)	β_5	-0.022** (0.011)	Ln(IC)	α_5	0.11* (0.07)
Ln(IC)	β_6	0.016 (0.002)	Ln(CC)	α_6	0.09** (0.03)
Ln(CC)	β_7	-0.007 (0.01)	Ln(OC)	α_7	0.037 (0.04)

Ln(OC)	β_8	0.008 (0.015)	-	-	-
		Partial Production / Cost Elasticities			
$E_{Y/LA}$	β_1	0.039	$E_{TVC/L}$	α_1	-0.32
$E_{Y/L}$	β_2	0.011	$E_{TVC/M}$	α_2	0.7
$E_{Y/M}$	β_3	0.045	$E_{TVC/SE}$	α_3	0.15
$E_{Y/SE}$	β_4	0.002	$E_{TVC/F}$	α_4	0.21
$E_{Y/F}$	β_5	-0.022	$E_{TVC/IC}$	α_5	0.11
$E_{Y/IC}$	β_6	0.016	$E_{TVC/CC}$	α_6	0.09
$E_{Y/CC}$	β_7	-0.007	$E_{TVC/OC}$	α_7	0.037
$E_{Y/OC}$	β_8	0.008	-	-	-
Returns to Scale	*RTS*	*0.092*	*Returns to Scale*	*RTS*	*0.97*
		Inefficiency Effects Model			
Intercept	δ_0	-0,014 (0.01)	Intercept	δ_0	0.86* (0.48)
Age	δ_1	0.009* (0.005)	Age	δ_1	0.004 (0.008)
EL	δ_2	0.11 (0.09)	EL	δ_2	0.085 (0.3)
FLTL	δ_3	-1.35* (0.103)	FLTL	δ_3	-1.93*** (0.46)
OFI	δ_4	-3.41* (2.42)	OFI	δ_4	0.58 (1.06)
LT	δ_5	-1.92** (0.096)	LT	δ_5	-1.22* (1.06)
EC	δ_6	0.02** (0.009)	EC	δ_6	0.01** (0.006)
		Variance Parameters			
Sigma-squared	σ^2	0.11* (0.06)	Sigma-squared	σ^2	0.14** (0.068)
Gamma	γ	0.97*** (0.015)	Gamma	γ	0.42* (0.33)
Log-Likelihood	LL	203.94	Log-Likelihood	LL	-45.34
N (# farms)		220	N (# farms)		220

Source: Own elaboration from survey data (2012).

Notes: 1. ***. Significant at the 1% level. **. Significant at the 5% level, *. Significant at the 10% level.
2. Standard error is in parenthesis

Analysis of Productive Efficiency

a. *Technical Efficiency Analysis*

The technical efficiency analysis of Al-Musayyeb production farms revealed that there was presence of technical inefficiency effects in Al-Musayyeb production farms in the study area as confirmed by the gamma value of 0.97 that was significance at 5 percent level (Table 2). The gamma (γ) value of 0.97 implies that about 79 percent variation in the output of Al-Musayyeb production farmers was due to differences in their technical efficiencies. The predicted technical efficiencies (TE) ranges between 0.57 and 0.98 with the mean TE of 0.89 as presented in Table 3. This means if the average farmer in the sample was to achieve the TE level of its most efficient counterpart, then the average farmer could realize a 9.18 percent cost saving [i.e., 1-(89.0/98.0) x100]. A similar calculation for the most technically inefficient farmer reveals cost saving of 41.8 percent [i.e., 1-(57.0/98.0) x100].

Table 3: Deciles Range of Frequency Distribution of Technical, Allocative and Economic Efficiency in Al-Musayyeb Producing Farms

Efficiency Level (%)	Technical Efficiency		Allocative Efficiency		Economic Efficiency	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
0.10 – 0.20	0.00	0.00	0.00	0.00	0.00	0.00
0.20 – 0.29	0.00	0.00	0.00	0.00	0.00	0.00
0.30 – 0.39	0.00	0.00	0.00	0.00	9	4.1
0.40 – 0.49	0.00	0.00	0.00	0.00	44	20
0.50 – 0.59	2	0.91	187	85	150	68.2
0.60 – 0.69	6	2.72	22	10	10	4.6
0.70 – 0.79	18	8.18	1	0.45	3	1.3
0.80 – 0.89	56	25.45	8	3.63	4	1.8
0.90 – 0.99	138	62.72	2	0.91	0.00	0.00
N	220	100	220	100	220	100
Mean Efficiency	0.89		0.59		0.52	
Std. Deviation	0.082		0.068		0.074	
Min.	0.57		0.56		0.32	
Max.	0.98		0.94		0.84	

Source: Own elaboration from survey data (2012).

In another development to give a better indication of the distribution of the technical efficiencies, a frequency distribution of the predicted technical efficiencies is presented in Table 3. The frequencies of occurrences of the predicted technical efficiencies in decile range indicate that the highest number of farmers have technical efficiencies between 0.90 - 0.99. The sample frequency distribution indicates a clustering of technical efficiencies in the region 0.90 - 0.99 efficiency ranges, representing 62.72 percent of the respondents. This implies that the farmers are fairly efficient. That is, the farmers are efficient in deriving maximum output from input, given the available resources.

b. Economic Efficiency Analysis

The economic efficiency analysis of Al-Musayyeb farmers revealed that there was presence of cost inefficiency effects in agricultural production as confirmed by the significance gamma value of 0.42 at 5 percent level (Table 3). This implies that about 42 percent variation in the total production cost is due to differences in their cost efficiencies. The predicted economic efficiencies (EE) estimated as inverse of cost of efficiencies differs substantially among the farmers, ranging between 0.32 and 0.94 with a mean

EE of 0.52 as presented in Table 4. This means that if the average farmer in the sample area were to reach the EE level of its most efficient counterpart, then the average farmer could experience a cost saving of 38.1 percent [i.e. 1-(52.0/84.0) x100].The same computation for the most economically inefficient farmer suggests a gain in economic efficiency of 61.9 percent [i.e. 1-(32.0/84.0x100]. And to give a better indication of the distribution of the economic efficiencies, a frequency distribution of the predicted economic efficiencies is presented in Table 3. The frequencies of occurrence of the predicted economic efficiencies in decile range indicate that the highest number of farmers have economic efficiencies between 0.50 -0.59, representing about 68.2 percent of the respondents while 7.7 percent of the respondents have EE of 0.60 and above which is an indication that farmers are fairly efficient. That is, the farmers are fairly efficient in producing a pre - determined quantity of agricultural products at a minimum cost for a given level of technology.

c. Allocative Efficiency Analysis

The predicted allocative efficiencies differ substantially among the farmers ranging between value 0.56 and 0.94 with the mean AE of 0.59. This implies that if the average farmer in the sample was to achieve AE level of its most efficient counterpart, then the average farmer could realize 37.23 percent cost saving [i.e. 1-(59.0/94.0) x100]. A similar calculation for the most allocative inefficient farmer reveals cost saving of 40.42 percent [i.e. 1-(56.0/94.0) x100]. And to give a better indication of the distribution of the allocative efficiencies, a frequency distribution of the predicted allocative efficiencies is presented in Table 3. The table reveals that the frequency of occurrence of the predicted allocative efficiencies in decile ranges indicate that a clustering of allocative efficiencies in the region of 0.50 - 0.59 efficiencies range. This implies that the farmers are fairly efficient. That is, the farmers are fairly efficient in producing at a given level of output using the cost minimizing input ratio as about 15 percent of the respondents have AE of 0.60 and above. The implication of these findings (TE, EE and AE) is that given the production resources at the disposal of the farmers, who are mainly small - scale resource poor farmers are fairly efficient in the use of their resources. And judged by the result of the frequency of occurrence of the predicted efficiencies presented in Table 3, it is evident that variation in economics efficiency largely comes from difference in allocative efficiency.

Salinity Impacts on Resource Use and Productivity

The estimated regression results (equations 14 & 15) for affected and free salinity areas in Al-Mussayeb farms are presented in Table 4.

It's important to remind that the empirical analysis in Al-Mussayeb area was conducted for salinity affected and salinity free areas using the salinity level (electrical conductivity) of 8dS/m as a breakpoint reference between the salinity free and salinity affected soils. In Al- Mussayeb salinity free areas, the variables namely seeds, fertilization, irrigation and other costs (harvesting and marketing costs) were positive and statistically significant in the equation for salinity affected soils. However, the rest of variables (labor, mechanization and chemicals inputs) were statistically non-significant. This indicates that an increase on the costs of variables such as seeds, fertilization, irrigation and other costs will increase the total gross margin. In contrast, an increase on the cost of mechanization, labor and chemicals has a neutral impact on the total gross margin.

In the free soil areas, the same magnitude and sign of variables was observed in Mussayeb farms. The positive and significant coefficients of seeds, fertilization and other costs (harvesting and marketing costs) implies that as each of these variables are increased, the total gross margin of the corresponding farms increased. While, the rest of the explanatory variables were statistically non-significant, showing their neutral impact on the total gross margin. In summary, these empirical findings indicates that the behavior of farmers with respect to inputs changed significantly as soil salinity increased in this study area.

Table 4: Log Linear Production Function for Free and High Salinity Soils in Al-Musayyeb Producing Farms

Variables	**Farms with Salinity Affected Soil Area (EC > 8dS/m)**	**Farms with Salinity Free Soil Area (EC < 8dS/m)**
Intercept	0.197	0.064
	(0.16)	(0.09)
Labour	0.0041	0.012
	(0.04)	(0.02)
Mechanisation	0.169	0.015
	(0.23)	(0.05)
Seeds	0.251*	0.601***
	(0.08)	(0.07)
Fertilisation	0.068*	0.134***
	(0.046)	(0.02)
Irrigation	0.132**	0.044
	(0.065)	(0.03)
Chemicals	-0.0009	0.001
	(0.041)	(0.02)
Others costs	0.25**	0.203***
	(0.11)	(0.06)
R^2	0.55	0.48
F-statistics	6.29	22.42
Log likelihood	-16.61	-69.84
N	43	177

Source: Own elaboration from survey data (2012).

Notes: 1. Dependent variable: Log Linear Gross Margin.

2. ***. Significant at the 1% level. **. Significant at the 5% level, *. Significant at the 10% level;

3. Standard error is in parenthesis

The assessment of the profitability between farmers in soil salinity-affected and salinity-free areas was also conducted using the production function decomposition analysis. Results are indicated in Table 5. The estimated model accounts for more than 54% percent of the difference in gross margin between salinity-free and salinity-affected areas.

The problem of salinity accounted for 41.76%. This value indicates that with the same level of resource use, compared to salinity-free area, gross margin would decline by 41.76% in soil-affected areas of Al-Musayyeb. However, about 13% percent of the gross margin difference could be attributed to change in input use in the salinity-affected areas.

Table 5: Decomposition of Output Differences into Soil Salinity and Input Changes in Al-Musayyeb Producing Farms

Variables	**Percentage Attributable** **Salinity Free Soil Area *vs* Salinity Affected Soil Area**
Source of Change	
1. Salinity	-41.76
2. Changes in input	-12.99
Labour	0.22
Mechanisation	-13.09
Seeds	-5.24
Fertilisation	-0.28
Irrigation	1.047
Chemicals	0.02
Others costs	4.34
Total difference explained	-54.75

Source: Own elaboration from survey data (2012).

6. Concluding Remarks and Policy Implications

Soil salinity has emerged as a problem which is not only reducing the agricultural productivity but is also putting far reaching impacts on the livelihood strategies of small farmers. Intensity of problem is large which has made it very difficult for the farmers to adapt with the situation. The temporary solutions being adopted by the farmers seem to have adverse effects in the long run. These will not only put more pressure on the small farmers who are already at the cutting edge but will also spoil the soil and ultimately the whole agricultural set up. Given this, the objective of the study was to investigate how farmers could sustain an economically viable agricultural production on salt affected areas of Al-Musayyeb area in Central Iraq. It aims to assess the impacts of salinity on crop productivity, resource use and profitability under different soil salinity levels. Earlier research could not provide the causal relationship between soil salinity and the loss of crop production, resource use and the technical efficiency (TE), allocative (cost) efficiency (AE), economic efficiency (EE) and income.

In order to attempt the above objective, this paper used a stochastic production and cost frontier models to estimate and analyze the technical, economic and allocative efficiencies of small holder producing farmers in Al-Musayyeb region. The analysis reveals an average level of technical, allocative and economic efficiency equal to 89 percent, 59 percent and 52 percent respectively. The results of this study are consistent with "Shultz poor - but - efficient hypothesis" that peasant farmers in traditional agricultural setting are efficient in their resources allocation behavior giving their operating circumstances (Shultz, 1964) when considering the relative size of TE, AE and EE obtained from the analysis, which is a clear indication that average farms in the sample area are technically, allocatively and economically efficient. The results also point to the importance of examining not only TE, but also AE and EE when measuring productivity. An important conclusion stemming from the analysis is that overall economic efficiency (EE) of Al-Musayyeb producing farms could be improved substantially and that allocative efficiency constitutes a more serious problem than technical inefficiency as TE appears to be more significant than AE as a source of gains in EE.

Hence, it is of this view that one would like to point out that despite the role higher efficiency level can have on output, productivity gains stemming from technological innovations remain critical importance in agriculture sector of the Iraqi economy. Therefore, efforts directed to generation of new technology should not be neglected specially on agronomic practices, drainage and water management related to the soil salinity affected areas.

The assessment of the profitability between farmers in soil salinity-affected and salinity-free areas was also conducted using the production function decomposition analysis. Empirical findings accounts for more than 54% percent of the difference in gross margin between salinity-free and salinity-affected areas. The problem of salinity accounted for 41.76%. This value indicates that with the same level of resource use, compared to salinity-free area, gross margin would decline by 41.76% in soil-affected areas of Al-Musayyeb. However, about 13% percent of the gross margin difference could be attributed to change in input use in the salinity-affected areas. The soil salinity problems are significantly high in this region and the major causes of soil salinity development in are poor drainage, waterlogging and dry conditions. Crop management under these conditions basically involves control of water table and maintaining favorable salt balance over the root zone. Since 21% of the farmers' fields are affected by moderate salinity, it is important to prevent their lands from turning into high salinity areas. At the same time, improvement of high salinity areas also needs more attention. Farmers change input use as soil salinity increases. The incidence of salinity will result in an increase in cost and reduced production. It will also not be economically viable to cultivate in the high and severe saline areas. Therefore, soil salinity should be controlled to realize the benefit from any increase in crop production.

Finally it is important to indicate that the role of institutions in soil salinity control activity was not investigated. Research regarding the role of institutions in salinity control is needed. Thus, more technically sound data are needed to establish statistically sound relationships among soil salinity, water table depth and crops yield. A continuous monitoring of data on the changes in hydro physical, chemical, economic, social and environmental status of the farmers in the salinity affected areas soil is needed for the said analysis. Further efforts are needed to improve this study on the effect of salinity on crop production. This knowledge is important to recommend the appropriate technologies and methods to control soil salinity.

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