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RESEARCH PAPER

Developing a New Bisaliah Decomposition Model to Evaluate the Effect of Sustainable Economic Development of Irrigation Technology on Palm Production

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Abstract
Analyzing the response of crop yields to varying irrigation methods is a focal point to ensure sound water resource management and the reduction of water loss. This paper investigates palm yield in both drip and traditional irrigation methods. So, the Bisaliah model and the Logit model were applied in Saravan city to evaluate palm yield and the economic factors underpinning the adoption of the drip irrigation system by farmers in this region. The results of the Bisaliah model indicated that the production yield of palms would increase by up to 28.98% by using drip irrigation compared to traditional irrigation considering no change in the consumption of inputs and by up to 5.35% versus the status quo taking changes in the use of inputs into account. Using drip irrigation in orchards and vineyards may cause a 38.54% increase in yield. The results of the Logit model revealed that farmer age, the number of family laborers, and the availability of water had negative impacts on the adoption of drip irrigation. Therefore, it is recommended that the results of this study be taken into consideration by planners to improve date production using irrigation technology.

Keywords: Bisaliah Model, Drip Irrigation, Logit Model, Palm, Saravan.
JEL Classification: B22, B41, C51.

1. Introduction
Water has always been considered the main factor in the development of societies. Water is a scarce resource, with irrigated agriculture accounting for up to 85% of global water consumption (Schilfgarde, 1994; Farrokhzadeh et al., 2020). It is thus important to increase crop yields.

Achieving agricultural productivity growth will not be possible without developing and disseminating yield-increasing technologies because it is no longer possible to meet the needs of increasing numbers of people by expanding the area under cultivation (Asfaw et al., 2012). The selection of a proper irrigation system will help manage limited water resources and increase crop profitability.

Meeting the food requirement of a growing population needs increasing the exploitation of natural and agricultural resources and expanding technical knowledge (engineering) in the field of natural and agricultural resources. By applying appropriate technology, in addition to the significant growth in agricultural production, it is possible to reduce manufacturing and economic costs Promoting technical knowledge takes time and a lot of expense in the context of science and research (Sardar Shahraki et al., 2018).

Sistan and Baluchestan province is one of the fertile regions of Iran, cultivating 57000 hectares of palm and producing 147000 kg/ha. A great portion of this crop is cultivated in Saravan, and the palm is considered the most economic product in this region. Since agriculture in arid regions has special conditions, water and irrigation are the keys to crops in such regions. That is why all efforts and measures are applied to enhance productivity or water consumption efficiency programs. The area under the drip irrigation system in Sistan and Baluchestan province has been around 18724 hectares since the beginning of the project in 1994-2006 (the beginning of the ninth presidential period) and it increased to 36350 hectares by the end of 2013. The fields in this area were equipped with drip irrigation, sprinkler irrigation, and subsurface (tape) irrigation. It should be mentioned that among all these regions in the province, sprinkler irrigation is used on 2632 hectares in Saravan County.

The average rainfall in Sistan and Baluchistan province is much less than Iran's average rainfall of 250 mm. So, it shows that the province is facing a water shortage due to the recent drought. Some new plans are, therefore, required to supply water in this area. So, research and studies have been undertaken to investigate necessary strategies for on-farm water management.

The aim of this prospective study is to evaluate the impact of irrigation technology change on palm yield and other economic factors in the study area (Saravan city). Moreover, the management and environmental influence of applying drip irrigation among farmers are to be examined. Therefore, the main objectives of the present research are as follows:

- Determining palm yield under two methods of drip irrigation and traditional irrigation using the Bisaliah and Logit models
- Investigating the economic, managerial, and environmental factors affecting the acceptance of drip irrigation by farmers.

2. Literature Review

In many studies, modern irrigation methods have been considered an innovation in agricultural science. On the one hand, these methods should be consistent with the local conditions and technical issues; on the other hand, they need to be accepted by the farmers and field managers. Researchers have highlighted economic, social, and agricultural factors that affect the general acceptance of modern drip irrigation. Darusman et al. (1997) found out that the application of drip irrigation to supply 75% of the water demand of the corn plant can lead to more efficient performance and a decrease in the penetration of water beneath the roots of the corn in that area. In India, Randhir and Krishnamorthy (1999) used the Cobb–Douglas production function to examine the production efficiency within a group of farmers accessing irrigation equipment and a group of farmers with no access to irrigation equipment. They claimed that the use of irrigation equipment can significantly affect the production efficiency and the income of the farmers. Ascough and Kiker (2002) investigated circular-central and semi-fixed sprinkler irrigation for sugarcane. They concluded that the average efficiency for these irrigation systems was 83.6% and 73.5%, respectively.

Water consumption has always been a great concern for farmers. Lamm (2004) reviewed some studies and claimed that one can grow corn by consuming the least amount of water. However, he suggested that such irrigation systems may reduce the efficiency and some qualitative features of the corn. Noroozi and Chizari (2006) studied the factors affecting the acceptance of sprinkler irrigation in Nahavand County. The findings showed that the proposed diagnostic model could help classify the farmers who used sprinkler irrigation and surface irrigation. The findings could lead to an increase in the acceptance of sprinkler irrigation among the farmers, thereby improving the efficiency of irrigation and water use on farms. In a seminal study, Kohansal et al. (2009) investigated the effect of environmental and non-environmental factors on the acceptance of sprinkler irrigation in Razavi Khorasan province, Iran. The results showed that educating farmers, providing necessary conditions for the farmers to receive bank facilities, and increasing farm size through land integrity could improve the adoption of sprinkler irrigation. Shahzadi (2013) concluded that education, land possession, farm size, bank facilities, and annual income had significant effects on the acceptance of drip irrigation. The results suggested that bank facilities played the most important role. Therefore, the banks should lower their interest rate to increase the farmers' acceptance of such irrigation methods. The factors affecting the adoption of drip irrigation by farmers in Shoosh, Andimeshk, and Dezfool counties were investigated by Aghapoor et al. (2013). The results showed that the small farm size, the procedure of granting bank facilities, and lack of farm ownership were the most important factors impeding the use of drip irrigation by the farmers. Literacy, land possession, and cultivated farms can encourage the use of drip irrigation. Farm number and farmer age are considered to have negative effects on the farmers' attitudes towards the use of modern irrigation methods. Movahedi et al. (2017) examined the factors affecting farmers' acceptance of modern drip irrigation technology in Asadabad County. They claimed that perceived efficiency, perceived ease of use, and usage attitude had significant and positive effects on the adoption of drip irrigation and, consequently, on the acceptance of such irrigation methods.

However, few studies have looked at the impact of agricultural technologies on crop yields by decomposition analysis. Gawaria et al. (2010) evaluated wheat productivity by decomposition analysis. Production response functions for both modern and traditional technologies were estimated to understand the advantage of modern technology over traditional technology. The total difference in the productivity between modern and traditional wheat technology was estimated at about 62%. Ben-Ari and Makowski (2014) developed an analytical expression decomposing global crop yield inter-annual variability into three informative components that would quantify how evenly cropland was distributed in the world. According to the literature reviewed above, it can be concluded that the nature and effectiveness of the variables underpinning the acceptance of modern irrigation methods are different in various parts of the country. More importantly, though, the variety and the extent of such studies in Iran support the fact that irrigation has been considered a crucial issue among researchers. Palm is one of the most strategic products of Saravan that accounts for a great part of palm production in the whole province and plays an important role in the local economy. The Logit model has commonly been used in previous studies to form models and determine the effects of irrigation methods. However, for the present study, the Bisaliah model was investigated too. We can claim that the present study is the first work in which both Logit and Bisaliah models are used to investigate the effectiveness of irrigation technology and palm production in Saravan County.

3. Materials and Methods

3.1 Bisaliah Model

In this study, the effectiveness of drip irrigation technology was investigated in palm production. The study assumed that "any changes in production technology (using drip irrigation) can trigger changes in the production function (slope and intercept)”. The objectives of the present study were that the acceptance of technology should first cause a change in the intercept function of how much is produced; second the production function should show a slight stretch; the third objective includes the two above-mentioned changes in the production function and the use of inputs and what production has been created; and the fourth objective is to determine the yield per unit area (ha) and any possible increase in the amount of production. Initially, knowing what form of function would fit there, an adequate amount of data was collected and various production functions (Cobb-Douglas, Translog, and Transdntal) were estimated and compared using F and R^2. To determine the function of the independent variables, in the ones who were chosen in the pilot estimation, the means were significant. The overall logarithmic function used in the study is as follows:

$$LnY = Lnb_0 + b_1 LnL + b_2 LnP + b_3 LnF + b_4 lnH + b_5 lnW + b_6 lnK + U_i \quad (1)$$

where:

Y = Amount of product (kg)
L = Area under cultivation (ha)
P = Amount of toxin (Lt)
F = Amount of fertilizer (kg)
H = Human resources (people)
W = Amount of water (cubic meters)
K = Capital (thousand IRR)
Slope = Function (i, the partial elasticity function)
Ui = any residual.

Here, using the Bisaliah decomposition model to detect and measure the share of the resources in different functions, one can identify the distinctive parameters in the performance of the two functions. The general changes in these two functions can happen either based on the changes in the parameters or as a result of any change in the disposal of the input materials. Since performance functions are the easiest econometric models to distinguish between performances, they were used for both groups of farmers whether they applied drip irrigation or traditional irrigation (Kiresur and Ichangi, 2011):

$$Lny_1 = Lnb_{01} + b_{11} LnP_1 + b_{21} Ln\mathrm{F}_1 + b_{31} lnH_1 + b_{41} lnW_1 + b_{51} lnK_1 + U_i \quad (2)$$

$$Ln\, y_2 = Ln\, b_{02} + b_{12} Ln\, P_2 + b_{22} Ln\, \mathrm{F}_2 + b_{32} LnH_2 + b_{42} LnW_2 + b_{52} lnK_2 + U_i \quad (3)$$

$$Lny_1 - Lny_2 = \{Lnb_{01} - Lnb_{02}\} + \{(b_{11} - b_{12})Ln\,P_2 + ...$$

$$(b_{21} - b_{22})Ln\;F_2(b_{31} - b_{32})ln\;H_2(b_{41} - b_{42})lnW_2\;(b_{51} - b_{52})ln\,K_2\} + \{b_{11}ln\left(\frac{P_1}{P_2}\right) + ... \quad (4)$$

$$+b_{21}ln\left(\frac{F_1}{F_2}\right)+b_{31}ln\left(\frac{H_1}{H_2}\right)b_{41}ln\left(\frac{W_1}{W_2}\right)+b_{51}ln\left(\frac{K_1}{K_2}\right)\} + U_i$$

The left side of the above equation indicates the difference in performance due to the use of technology. The first part of the formula on the right includes the effects of neutral components of technology (the percentage of changes due to the change in the parameters), the second bracket reflects the effect of non-neutral components of technology being weighed based on the consumption of the input variables in the farms using traditional irrigation (the percentage of changes due to the change in the slope of the parameters), and the third bracket shows the difference in the performance caused by the change in the consumption of inputs weighed considering partial modification of each of the production factors in the drip irrigation function (Kiresur and Manjunath, 2011).

The data needed for the calculation and estimation of the model were related to the crop year 2016-2017 and were mostly visited by local farmers in Saravan a questionnaire was collected by random sampling. Having collected the information, the researchers used *Eviews*$_8$ software to estimate the studied pattern.

3.2 Logit Model

The Logit model is used when the dependent variable is not visible. The dependent variable appears in a dual selection. The Logistic model also follows the logistic curve, so the curve fitting is based on actual data. For the actual data related to the dependent variable, the two values 1 and 0 are assigned based on whether it has occurred or not, respectively. So, the top or the bottom of the chart was determined with respect to different levels of a linear combination of independent variables. Superior to that of logistic regression, to determine the values 0 and 1, it is only necessary to notice the occurrences in the question. Thus, the dependent variable can be used to estimate the occurrence or non-occurrence of the event (Abrishami, 2007):

$P_i = F(Z_i) = F(a + bX_i) = 1/_{1+e^{-Z_i}} = 1/_1 + e^{-(a+bX_i)}$	(5)
$1 - P_i = 1/_{1+e^{Z_i}} = 1/_1 + e^{(a+bX_i)}$	(6)

$$\frac{P_i}{1-P_i}=\frac{1+e^{Z_i}}{1+e^{-Z_i}}=e^{Z_i} \quad (7)$$

$$L_i=Ln\frac{P_i}{1-P_i}=a+bX_i \quad (8)$$

In this study, the dependent variable is farmers' decisions to accept or refuse the new system of drip irrigation. Therefore, the Logit model was applied as follows to determine and assess the factors affecting the acceptance of drip irrigation technology in Saravan County (Abrishami, 2007):

$$Y_{\mathrm{i}}=\mathrm{F}\left(\mathrm{Z_I}\right) \quad (9)$$

$$\mathrm{Z_i}=a+\sum_{J=1}^{N} b_j X_{ij} \quad (10)$$

$$\mathrm{Z_i}=a+b_1X_{i1}+b_2X_{i2}+b_3X_{i3}+\ldots+b_nX_{in}+u_i \quad (11)$$

$$\mathrm{Z_i}=a+\sum_{J=1}^{9} b_j X_i+u_i \quad (12)$$

where:

(Qualitative dependent variable) = probability of adopting irrigation technologies (1 for the adoption of irrigation technology and 0 for non-adoption).

α = intercept model

n = total number of observations

Bj = the estimated model parameters.

Xj =independent variables (explanatory) model, a set of economic, environmental, and management characteristics and the following tiller number is:

Table 1. Explanatory Variable Influencing the Adoption of Pressurized Irrigation

Variable	**Definition**
X_1	Farmer age
X_2	The number of family labor
X_3	Farm area

Source: Research finding.

Table 2. Dummy Variable Influencing the Adoption of Pressurized Irrigation

Variable	Definition	Value	
		1	0
D_1	Education	High school diploma	School education
D_2	Main occupation	Home jobs	Secondary jobs
D_3	Land slope	High	Low
D_4	Class educational and promotional level	Participation	Lack of participation

Source: Research finding.

The data needed for the calculation and estimation of the model were related to the crop year 2016-2017 and were mostly visited by local farmers in Saravan through questionnaires which were randomly distributed among the farmers. In this study, the statistical population included the farmers in Saravan County, Sistan and Baluchestan province.

4. Results and Discussion

In this study, the production functions were estimated for the group of farmers who used drip irrigation (90 farmers) and those who didn't (120 farmers) using function(1). Then, considering all the data (210 farmers), a function including the intercept and dummy slope was estimated. We considered a dummy variable whose value was 1 in the case of the use of drip irrigation and 0 in the case of the use of traditional irrigation. Furthermore, in this section, the production function was estimated using four different methods. The first function was estimated using a function where the farmers used drip irrigation, the second function was estimated using a function where the farmers didn't use drip irrigation, the third function was estimated using the parameters of all the fields, and the fourth function was estimated using the parameters of all the fields as well as the dummy parameters. The results are presented in Table (3).

Table 3. Estimation of Production Functions

Variable	Coefficients			
	The first function	The second function	The third function	The fourth function
Intercept	5.87***	5.23***	3.54***	3.54***
Dummy variable	8.87	1.78	0.144*	0.144*
Cultivation	8.547***	5.236***	2.325***	2.325***
Amount of pesticides	3.258*	0.874***	0.254***	0.254***
Amount of fertilizers	0.124**	0.213*	0.214*	0.214*
R^2	0.89	0.88	0.99	0.99
Number of samples (n)	101	202	125	125
Confidence level: ***: 99% ; **: 95% ; **: 90%				

Source: Research finding.

A significant percentage of the estimated value of *F* (p=0.01) is significant and R^2 is reported above 70 in all the equations, which indicates the value of the models. Minor tractions of the cultivated acreage, labor, and the amount of pesticides were greater where the farmers did not use drip irrigation. However, other elements were lower for the farmers who didn't use drip irrigation. The *F* value (p=0.01) for the third function in which all variables of farms were used and for the fourth function in which all those variables plus dummy variables were used was significant. The coefficient index reveals a significant difference between the two functions. Therefore, the use of drip irrigation may increase the intercept and change the partial elasticity of the production factors.

Table 4. Results of Estimating Functions in Terms of Performance per Unit Area (ha)

Explanatory variables	Regression Coefficient		
	The first function	The second function	The third function
Intercept	2.87***	3.78***	4.98***
Amount of pesticides	5.25*	0.02***	0.21***
Amount of fertilizer	0.25**	0.87*	0.25*
Human resources	0.054*	0.257***	0.217*
Amount of water (m^3)	0.254***	0.214***	0.214***
Investment (IRR)	0.258*	0.658*	0.687*
R^2	0.87	0.85	0.97
Number of samples(n)	101	120	202
Confidence level: ***: 99% ; **: 95% ; **: 90%			

Source: Research finding.

To distinguish between the effects of factors affecting the performance of the functions, the first step was to identify the functions of those farmers who used drip irrigation and those who didn't in terms of unit area (ha). For this purpose, functions (1), (2), and (3) were used. Table (4) shows the results of the estimated functions for the performance of inputs whose regression coefficients were statistically significant. Since the intercept for the first function is significantly higher than that of the second function, it is concluded that drip irrigation caused the function to improve. Minor tractions for the pesticide level, human workforce, and amount of fertilizers were higher in the second function. However, the first function showed greater traction for water and capital compared to the second function.

To identify the effect of drip irrigation on the production and consumption of inputs, we could also compare the average consumption of the inputs between the situation where drip irrigation was used and the situation where traditional irrigation was used. Table (5) presents the average inputs used in production considering different irrigation modes. Hence, the results indicated that the use of drip irrigation has led to an increase (38.54%) in the average yield rate.

Table 5. Factors Affecting Yield

Factors altering yield	Percent change	
	Components	Total
The actual change in average yield	-	38.54
Changes in performance due to changes in technology, including:	-	28.98
A) changes due to neutral technology	-	87
B) changes due to non-neutral technology	-	-87.25
Changes in performance due to changes in the level of consumer input, including:	-	5.35
A) labor	-0.87	-
B) fertilizer	2.87	-
C) pesticide	-	-
D) water	-	-
E) investment	-	-
The total estimated change in the performance category	-	32.23

Source: Research finding.

The change rate was calculated using function (4) (the procedure is explained in Table (5), and the results showed that there was a 32.23% change in the performance. This value was compared to the percentage of the change observed in Table (5), indicating little difference (0.62%). The difference between these two values can be related to the residual. Moreover, Table (5) shows that employing drip irrigation can cause direct and indirect changes in production technology (by changing the consumption of inputs). It is claimed that the change in the yield (kg/ha) has increased by 28.98% and 5.35%, respectively.

The maximum likelihood (MEL) model was used to estimate the Logit model. Multi co-linearity of the variables, asymmetrical variances for residual terms, and the specification of the model were taken into account before estimating the Logit model and after the initial estimates. There were no problems regarding these issues in the final model. The results of the estimation of the Logit model are shown in Table (6).

Table 6. The Logit Model Results by the Maximum Likelihood Method

Variable	Name	Coefficient	Standard error	T statistic	The ultimate effect of variable
Constant coefficient	*C*	-3.25***	2.87	-3.885	-0.253
Farmer age	*X1*	0.54***	0/023	-6/854	-0.254
The number of family labor	*X2*	-0.254	-0.254	-0.254	-0.254
Farm area	*X3*	0.2584***	0.214	0.254	0.214
Education level	D_1	0.254**	0.254	2.458	.897
Main occupation	D_2	2.235*	2.325	3.2145	0.2544
Land slope	D_3	0.254*	1.254	0.258	0.365
Class educational and promotional	D_4	0.254**	0.554	3.22	0.324
Factor for the calculation of marginal effects =0.2354					
Maximized value of the log-likelihood function = -87.60					
Goodness of fit =0.8795					
Confidence level: ***: 99% ; **: 95% ; **: 90%					

Source: Research finding.

According to Table (6), the efficiency of fit for this model is considered to be 0.87%, which indicates an acceptable fit index. The index for the ultimate effect of the model is 0.23, which was obtained by multiplying this index by the coefficients. All these indices suggest that the model can successfully explain the behavior of the variables.

The results in Table (6) showed a negative impact of farmer age (P = at least 99% confidence level), indicating an inverse relationship between age and their willingness to invest in drip irrigation. This negative effect of age was not unexpected because as people (farmers) get older, they become more conservative and less risk-taker. According to the index, the net effect of -0.254 shows that if a farmer gets one year older, the possibility of his investment in drip irrigation decreases by 2.5%.

The number of family members as the workforce for that family was claimed to have a negative effect on the acceptance of drip irrigation by the farmers. Although this is not considered a significant effect, it may impede the willingness of the farmers to invest in modern irrigation methods. It can be concluded that because the farmers should replace the workforce with capital, they are reluctant to invest in drip irrigation. The table suggests that their willingness decreases by 2.5% per each new member in their family.

The literacy and knowledge of the farmers were proved to influence the acceptance of drip irrigation by the farmers significantly. The results showed that the higher the farmers' educational status, the more willing they are to apply modern irrigation methods. The farmers holding a diploma or higher degrees are 8.9% more interested in applying drip irrigation compared to those who lack such degrees. Therefore, educating and training farmers may lead to their acceptance and exploitation of modern irrigation systems.

It is also claimed that the bigger the farm, the more eager the farmers are to use drip irrigation. According to the results of this study, an increase of a single hectare in the field leads to a 21% increase in the acceptance of drip irrigation by the farmers. However, it all depends on the fact that the farmers can equip their fields with such technologies. On the other hand, increasing the cultivated areas can encourage the farmers to adopt more cost-effective methods to save their workforce and improve their production efficiency. Using drip irrigation is an appropriate way to spend less but gain more, especially in wider and bigger fields.

The nature of farming as a major job can have a significantly positive effect on the acceptable of drip irrigation. The results indicated that it is 25% more probable for a farmer to use drip irrigation if farming is his/her main sole job, not an adjunct. The reason behind such an attitude is the farmers' honest effort to improve their cultivation.

The shape and the slope of a field can influence the farmers' decisions, too. It is claimed that the more steep the slope of a field is, the higher the possibility of using drip irrigation by the farmer will be. The results showed that for a field of an average or high slope, there is a 36.5% more probability of using drip irrigation. If a field is flat, the farmer can perform necessary agricultural activities and use traditional irrigation; however, for steeper fields, the farmers confronted with difficulty in performing routine cultivation activities use the traditional irrigation system.

Holding meetings or workshops is considered an effective approach to training and improving farmers' knowledge. The data indicated that the farmers who take part in such classes and programs will tend to use drip irrigation 32% more than those who don't.

5. Conclusion and Suggestion

In summary, we can claim that the adoption of modern irrigation technology can lead to 38% variations in yield performance (kg/ha). Thus, the application of drip irrigation can cause changes in the production function and in partial elasticity of the production variables. These changes can lead to an improvement in the production performance and changes in the consumption of some variables and inputs. It was also revealed that where farmers exploited drip irrigation, the performance was reported higher, but water inputs and labor were reported fewer. The government should develop and enforce appropriate and timely policies to provide farmers with the required capital and other inputs (irrigation equipment, fertilizers, seeds, etc.) to encourage them to use modern irrigation systems. According to the results and findings of the study and the existing conditions in the region under investigation, we will propose the following guidelines and suggestions to help develop and enhance investments and encourage the use of effective drip irrigation systems:

1. Given the significantly positive effect of agricultural loans on the adoption of drip irrigation, it is suggested to facilitate the conditions for agricultural loans. It is also necessary to determine pre-agricultural loans, the bank rules and regulations, as well as how to get the necessary knowledge to find the pre-requisites for training farmers .
2. The goal is to promote pressurized irrigation and train farmers with higher educational levels because they are much more likely to accept drip irrigation compared to other farmers.
3. It is recommended to hold briefings and proceedings concerning the introduction of more efficient and sustainable irrigation systems, especially in rural areas where less pressurized irrigation systems are used.

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