Wheat Production Improvement Program in Iraq: Cost-benefit and Adoption Analysis with Case Study from Babylon Region. By Aymen M. Daham *

Forward

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Abstract

The National Program for the Development of Wheat Crop Production aims to adopt and use modern technologies, including laser leveling, certified and high-quality seed, recommended fertilizers, pest and disease control and management as well as the introduction of new high yielding, diseases resistance and salinity tolerant varieties. The ultimate objective is to increase the productivity per unit area and ensure food security and self-sufficiency and to reduce the large yield gap in the of main grain crops, and to cease the reliance on import of major cereal crops. The duration of the implementation of the National Program for Development of Wheat in Iraq is ten years, subject to renewal, to reach a total area of five million donum (donum =0.25 ha) to adopt the technology package.

This study aims to present economic analysis of wheat improvement program on the farm level using cost-benefit analysis CBA of adopter and non- adopters of the technology package. The research examines the main determinants that affect and influence the famer decision to adopt the technology package using logistic regression

model. The results of the cost-benefit analysis (CBA) shows that the net returns of the adoption of the technologies amounted to (393,932) dinars / dunum, which is 64% higher than the net returns of non-adoption of which estimated at (239,760) dinar / dunum, and thus indicates the adoption of the technology package is profitable and the estimated internal rate (IRR) of return was 16.5% in comparison with capital in banks and the benefit-cost ratio of 2.25 indicates that one dinar investment in the technology returns 2.25 dinar. The logistic regression model shows that farm type (luminous and traditional farms) and productivity influence the farmer decision to adopt the technology package. The logistic regression of several household attributes were not statistically significant and indicated that they don't influence the adoption decision.
Further research is required to expand the survey sample to attain more representative sample data and to include adopters and non-adopters from several governorates and should include policy variables.

Highlights

- Adoption of wheat improvement technology resulted in 64% higher return for adopters than nonadopters.
- Productivity and type of farms (traditional farms, modern farms) influence the farmers decision to adopt the wheat improvement technology package.
- Farmers with small land holding allocated higher proportion of their land to apply the new technology compared with farmers with large land holding.

Keywords: Wheat, Technology Package, Adoption, CBA, Logistic Regression

1. Introduction

Wheat crop is one of the strategic and important cereals crops in the world in general, and equally important crops for Iraq in particular. The per capita consumption of wheat is inversely related to the level of income, that is, the higher the income, the lower the consumption rate of the crop, as it is necessity commodity i.e. wheat income elasticity of demand is between zero and one. Wheat covers the largest agricultural area compared to any crop on the surface of the globe, as it represents about 28% of the global production of grain, and for Iraq, where the natural, financial, and human resources should transform the country to self-sufficient in the production of wheat provided the country adopt modern technology of production, storage and marketing.
It should be noted that, farmers in Iraq lagged behind their counterpart in the neighboring countries in terms of the production level and to keep pace with progress, education and food gap has emerged due to wars and economic embargo and has been reflected by low long-term average of wheat yield per hectare and was estimated for the period from 1960 to 2019 at about 1.16 tons / hectare $^{-1}$, with a standard deviation of 0.61 tons/ha, and this indicates that the instability of annual production levels, where the coefficient of variation was 72% for the same time period. When measuring the cumulative coefficient of variation for a period of 10 years, the coefficient of variation was 18% for the period 2011-2019, which indicates an improvement in the production stability compared to the period 2000-2010, where the coefficient of variation was 38%.

The steady growth in the population of Iraq, which is considered one of the highest rates of population growth in the world, where estimates of growth amounted to more than 2.6%, and the continuous rise in wheat consumption, indicates the importance of the wheat crop in Iraqi economy. Where the total consumption of wheat in Iraq is estimated at about (4.5-5) million tons annually, according to (United Nation Food Program UN-WFP and the General Company for Grain Trade statistics, 2019). Iraqi per capita consumption of wheat flour is about 9 kg per month, at 108 kg annually, according to Iraq public distribution system (PDS). Moreover, wheat and rice crop accounts for the largest share of government subsidy allocations provided to the agricultural sector during the past decade, as government allocations to support the two crops for the year 2021 were estimated at about 3.7 trillion Iraqi dinars[1], equivalent to 2.5 billion US dollars (The Federal Ministry of Finance, Budget Department, 2016-2021).

Governmental plans and agricultural policies in Iraq have considered wheat as one of the strategic food security crops and one of the attempts to bridge the food gap as well as diversify the Iraqi economy, which is dependent on oil export revenues, as oil revenue constitutes 60% of the gross domestic product (GDP), which is subject to instability as a result of fluctuating international oil prices.

Accordingly, the Ministry of Agriculture has develop wheat improvement program to improve wheat productivity through adoption of technology package which includes high yielding varieties and are resistant to climatic conditions, provide support for famers and most notably the National Program for the Development of Wheat farming, which represents the main pillar by introducing group of modern agricultural techniques and the adoption of modern technology in production. The program began in 2011 in five governorates (Wasit, Kirkuk, Qadisiyah, Nineveh, Anbar) with an area of 113 thousand donum (.25 ha), then increased accordingly to 5 million donum in 2020. The program also includes laser leveling, Fertilizer, potassium fertilizers, microelements, chemical pesticides.

Extensive research have been conducted to evaluate the technological packages for wheat production improvement on the world level and in Iraq, as well as trying to measure the indicators of adoption by farmers, as well as and the economic impact on the farm level or on the agricultural sector level. The cost-benefit analysis is one of the economic evaluation tools to assess the costs and benefits of different alternatives for applying or adopting new techniques or planning to establish new projects or evaluating existing projects. It is widely used in public decision-making and is considered one of the successful methods in analyzing public policies and programs.

[1] USD =1450 Iraqi Dinar (IQD)

In a study conducted in Saudi Arabia (Al-Yami, (2005) emphasized that cost benefit analysis has important implication in reducing the uncertainty in the estimation of benefits and costs in adopting public projects. The benefit-cost approach was also adopted to estimate the economic and financial consequences of increasing the use of commercial inputs and its impact on improving corn production in Uganda (Leung & Jenkins, 2011), and whether farmers are able to obtain and use commercial inputs accurately, and the results revealed a number of challenges facing maize cultivation in Uganda, including the limited use of good quality inputs, slow rates of adoption of techniques and practices to improve benefits.

The CBA is also used as a general framework to clarify the economic tools and how they can be utilized in the context of focusing on stakeholders of water use and in climate change situations for planning and evaluating adaptation to climate change in Morocco (Chambwera et.al, 2013), where the study recommended that stakeholders are part of the decision-making process before action is taken or funded, providing a useful basis on how to use the CBA method for its applicability in different settings. CBA was applied to conduct economic evaluation of the adoption rice varieties (Amber, Jasmine, Amber al-Baraka), and estimated the effect of profitability on the farmers' tendencies to adopt the new varieties of the crop according to ADOPT analysis in Iraq, Karbala Governorate (Khairy, 2017), and it was found that higher profitability induced higher adoption of the new rice varieties. Consequently, the study's identified the importance of publishing the findings of the research centers for farmers.

In a similar study on an economic analysis to compare the cases of adoption and non-adoption of modern irrigation techniques by farmers in the study sample, to predict the rates of adoption of this modern technology in the future, and farmers' adoption of the technology using the logistic regression method, the result of the cost-benefit analysis (CBA) (Farhan, 2017) in Iraq, indicated that it was economically feasible to use subsurface irrigation technology. The ADOPT analysis indicated that the time period in which adoption reaches 95% of farmers, and thus the study showed the importance of developing and implementing intensive extension programs related to the use of modern irrigation methods.

Predicting the rates of farmers' adoption of water harvesting technologies using the results of the ADOPT program is an essential aid for policy makers and decision makers, as well as the agricultural extension system to distinguish between farmers regarding their likelihood of adopting technology on the basis of the forecasting method (Akrouch, 2019), the study area is Badia Jordan, where it identified four categories of effects on adoption, namely, innovation characteristics, target population characteristics, and the comparative advantage of using innovation and education from the comparative advantage of innovation.

In a study on the demand for available production resources and the productivity of these resources, the rate of productive wheat crop yield in Iraq, the possibility of increasing the technical and economic efficiency of irrigation water, reducing losses , rationalizing water used for irrigation and reducing labor costs in irrigation (Al-Amri, 2017), results showed that the use of laser leveling technology increases the total production of the crop, which led to an increase in the average wheat crop yield of 1127.4 kg / dunum compared with the traditional methods of grading which was 889.5 kg / per dunum, which constituted 27% of the crop yield.

In a study on the change in the harvested area and productivity to identify specific weight for each on the production on the country level in Iraq (Al-Hijami, 2018), it was shown that there is a decline in horizontal expansion and an increase in vertical expansion in wheat production at country level and the most important conclusions was that modern technology has positive effects on production and economic efficiency and profitability, depending on the technology used, but it is recommended that a method for distributing subsidized productive inputs should be based on achieving a specific rate of productivity and not on the basis of the cultivated area.

A research study on the impact of modern technologies in improving wheat productivity in Iraq, Babil Governorate (Daham, 2020) , included an analysis of the comparison between the cases of adoption and non-adoption of the techniques provided by the National Program for Wheat Development, using cost-benefit analysis and measuring the degree of adoption using ADOPT analysis, the results of ADOPT indicted that the prevailing level of education among the adopting farmers is secondary education, and their percentage reached 48%, and that 95% of the farmers adopting these technologies may extend to 11 years. The cost-benefit analysis also showed that the net present value when using the program's techniques was higher than the net present value in the case of traditional agriculture.

This study is an economic analysis to examine the cost and benefit of the Iraqi government wheat improvement program and to determine the main factors influence the adoption and non-adoption of the technology package in Babylon area with reflection of the adoption of the technology package by the farmers on the country level using ADOP methodology. In this study CBA is used to determine the rule of profitability of wheat production under adoption of the technology and we also present the effect of different farm and farmer attributes on adoption and non-adoption of the technology using logistic regression analysis.

2. Theoretical framework and research methods

There has been extensive theoretical examination of the adoption of new technologies and there were separate adoption theories in education, rural sociology, medicine, marketing and other disciplines. In agriculture and resource management, for example, decisions on the use of input are taken on the basis of short-term planning horizon while the adoption of new technology represents a shift in a farmer's production strategy which analogous to investment decision (Caswell, 2001). Hence, the question may be asked: what are the driving factors of farmers nonadopting certain technologies which may be rational decisions whereby the farmer is either unwilling or unable for a set of reasons. Such reason may be related to the expected outcome of technologies, the cost of adoption, lack of information, complexity, and investment horizon and it is reasonable to assume that the reason of farmer's non-adoption of new technology is more related to system failure than farmer failure (Nowak, 1992) and farmers tendency to be risk aversion especially when enough information is not available (Thuo et.al, 2014).

Nonadopters may view the technology as not profitable or perceive the adoption as more profitable but there are barriers to adopt the technology and hence policies should be designed to reduces the barriers for both types. Pioneer research on technology adoption indicated that profitability and relative advantage[2] are strong determinants for adoption (Gribiche 1957; Rogers, 2003). Although return on the adoption of new technology may seem conceptually apparent, there are difficulties to acquire the required data, particularly in agriculture where family labor is dominant in many countries, however, net gain is a major determinant for technology adoption and thus profit maximizing and technology profitability is a key measure for adoption (Foster and Rosenzweig, 2010). These findings differ from "contagion theory" of adoption and Trade's "imitation theory" which associate the probability of adoption with early neighboring adopters, however when technology first becomes available uncertainty is high and over time farmers gain experience through learning, extension, and demonstration, and hence uncertainty and adoption cost fall (Caswell et.al, 2001). Further, capital, in form of accumulated saving or access to market capital, contribute to the differential rate of adoption (Feder, Just and Zilberman, 1985).

While adoption of new technologies or inventions, generally, is subject attentional, retention, production and motivational processes (Straub, 2009), the adoption of new technologies in farming would likely to be influenced by motivational and production processes. Both processes are associated with the learning process and economic drivers in terms of the cost and profitability of adoption. Rogers (2003) conceptualize he decision to adopt based on five processes represented by knowledge, persuasion, decision, implementation and confirmation and individuals seeks information throughout the stages in order to reduce the uncertainty associated with adoption decision.
Research has attempted to explain the empirical findings of S-shaped pattern of aggregate diffusion over time and stressed the rule of communication and can be

[2] "Relative advantage" is a ratio of the expected benefits and the costs of adoption of an innovation. Subdimensions of relative advantage include economic profitability, low initial cost (Rogers, 2003)

described compact mathematical formulas such as sigmoid function (Feder, Just and Zilberman , 1985). Rogers (1957) constructed sigmoid to estimate the aggregate awareness function and Griliches (1957) estimated the fraction of land utilized by hybrid corn varieties with respect to profitability using logit model.

The commonly used qualitative response models are linear probability model, logit model and probit model, which correspond to distribution functions which specify the relation between the probability of adoption and the explanatory variables. Linear probability model (LPM) follows normal distribution while probability of the outcome of 0 or 1 follows Bernoulli distribution and as the sample size increases the statistical theory shows that OLS tends to be normally distribution and the variance of the disturbance terms is heteroscedastic and the estimation of LPM using OLS method is used to find out whether the estimated outcome lies between 0 and 1 (Gujarati, 2003).

The logit model identifies the key variables affecting the decision outcome in relation to dichotomous outcome depending on several farm and farmer's attributes including institutional attributes. The decision of adoption which represented by 1 "adopt" and 0 "do not adopt" reflects the underlying assumption such a decision maximizes the decision-maker utility i.e. maximizing profit (Sheikh et al. 2000).

The analysis reported in this paper attempts to identify the core factor which drive the farmers to adopt wheat technology packages introduced by Iraq ministry of agriculture using logistic regression which include continouis and discrete prdictors and estimate the marginal effect of the predictors. Logit function differs from LPM in that it is not contrained by normaility or equal variance assumption for residuals and garantees that the probability logical range between 0 and 1. Logistic regression is used to describe the relationship between vector of prdictors or expalnatory variables and farmer decision to adopt wheat improvement technology. The outocme of the decsion is described by the probability of event (adoption of technology) which is simplified by "success or 1" or the nonadoption whch is simplified by "failure or 0" . The typical regression model is simplified by :

$$E(Y_i)= \pi_i = \alpha+b_1x_1+b_2x_2 \ldots + b_kx_k \qquad (1)$$

Equation 1 can be represented by vector notation $\pi_i=X'_i\beta$, where X is the vector of predictors and β the vector of coefficient which can be estimated by the linear probability model. Model 1 is linear probability model LPM which can be estimated by ordinary least square OLS. As mentioned above, the estimation of the probability should be restricted to be between zero and one, but under OLS it is not possible to guarantee the predicted value of the righthand side to be in the range of zero and one.

The logistic regression is based on the logistic function $f(z)$ which describes the mathematical form of the model and is represented by the following equation:

$$f(z) = \frac{1}{1+e^{-z}} \qquad (2)$$

the value of the logistic function varies from $-\infty \ to \ +\infty$ when z is $-\infty$ the f(z) equal 0 and when z is $+\infty$ f(z) equals 1 which can be derived from the following equations:

$$f(-\infty) = \frac{1}{1+e^{-(-\infty)}} = \frac{1}{1+e^{\infty}} = 0 \qquad (3)$$

Similarly for $f(+\infty) = \frac{1}{1+e^{-(+\infty)}} = \frac{1}{1+e^{-\infty}} = 1 \qquad (4)$

Hence the range of the function $0 \leq f(z) \leq 1$ regardless of the value of z and thus designed to describe the probability which is expected to be between 0 and 1 and the shape of the function S-shaped as function value moves from $-\infty$ to $+\infty$.

The logistic model is based on the logistic function and to obtain the logistic model form the logistic function we construct z as the linear sum of right hand-side of equation 1:

$$z = \alpha + b_1 x_1 + b_2 x_2 \ldots + b_k x_k \qquad (5)$$

from equation 2 we show that:

$$f(z) = \frac{1}{1+e^{-(a+\sum biXi)}} \qquad (6)$$

the α and b_i are unknown parameters to be estimated. In the context of the farmer's decision to adopt wheat technology improvement, the probability can be modeled as conditional probability such that:

$$P(\pi=1|x_1, x_2, \ldots x_k) = \frac{1}{1+e^{-(a+\sum biXi)}} \qquad (7)$$

π is the expectation binary response of interest equal to 1 whereby the farmer decided to adopt the wheat improvement technology based on given observed predictors. One of the features of logistic curve is that it allows to directly estimate the odds ratio (OR) because the model describes the probability of the decision to adopt wheat improvement technology as a function of set of explanatory variables. The concept of OR is a measure of association which is a ratio of two odds and the odds (or the likelihood) in turn is a ratio of number of events to number of nonevents (Morgan, 1988) which is described by the following ration:

$$odds\ (adopt) = \frac{\pi}{1-\pi} \qquad (8)$$

To present the logit form of the logistic model we adopt logit transformation which can be denoted by the following relation:

$$\log\left(\frac{\pi}{1-\pi}\right) = \alpha + X\beta + \varepsilon \qquad (9)$$

the coefficient estimates β_i is represented as log-odds and the exponential of the ith estimate is the odds ratio (Finger and Elbenni,, 2013) :

$$\exp(\beta_i) = \frac{\pi(X1, \ldots Xi+1, \ldots Xp)}{1-\pi(X1, \ldots Xi+1, \ldots Xp)} \qquad (10)$$

which reflects the multiplicative change in the odds with respect to the variable increase by 1 unit where other variable are hold constant. sAnd odds ratio greater than 1 indicates an increasing the likelihood of an event occurring while the odds ratio less than

1 indicates a decreasing likelihood and adds equal to 1 indicates no association. The likelihood function formula describes the joint probability of technology adoption and nonadaptation:

$$L=\prod_{l=1}^{ml} p(y_{l\,)} \prod_{l=m+1}^{n}[(1-p(y_l)] \qquad (11)$$

Where y denotes the probability of farmer decision to adopt wheat improvement technology. Maximum likelihood function L is generally used to estimate the parameters of logistic model which can be alternatively stated by $L(\boldsymbol{\Theta})$, where $\boldsymbol{\Theta}$ denotes the vector of unknown parameters being estimated by the model and individual parameter is denoted by Θ.

Since the probability of adoption is described by equation 7, which can be restated as the following:

$$P(\pi=1|x_{1,}\ x_2,\ldots x_k) = \frac{1}{1+e^{-(a+\sum biXi)}} = \frac{e^{(a+\sum biXi)}}{1+e^{(a+\sum biXi)}} \qquad (12)$$

The loglikelihood function them can be represented:

$$L = \frac{\prod_{l=1}^{n} e^{(\sum biXi)}}{\prod_{l=1}^{n}[1+e^{(\sum biXi)}]} \qquad (13)$$

To maximize the likelihood function, we take the derivative with respect to each individual parameter in the model and since maximizing the likelihood is equivalent to maximizing the $L(\Theta)$ is equivalent to $\ln(L(\Theta))$ then the first partial derivate can be stated in log form and set to 0:

$$\frac{\partial ln(L(\boldsymbol{\Theta})}{\partial(L(\Theta\mathrm{i})} = 0,\ for\ i = 1,2 \ldots q \qquad (14)$$

The partial derivatives can be solved numerically using statistical programs like Stata. The slope coefficient of the variables in the logit model indicates the unit change in the log odds associated with unit change in the variable assuming all other variables constant, while the rate of change in the probability is estimated by $B_j p(1-p_i)$

We have used cost-benefit analysis methodology to evaluate government wheat improvement program, The concept of cost-benefit analysis is generally adopted as economic analysis approach and decision-making methodology for evaluating investment projects or technologies used in a specific production project and which aims to achieve the highest return for the producer and for the national economy in general (Potter, 2017). The use of the cost-benefit analysis to evaluate the economic feasibility of the implementation of new technologies and assess their economic feasibility. It is also used to evaluate options between two alternatives based on their economic priorities. CBA is an important for the evaluation of policies, including agricultural policies to be selected based on their economic and social acceptability.

There is a difference between the Pareto criterion and the method benefit cost analysis, which can be determined by two points, which are first / that the Pareto criterion concern the redistribution of resources in a fair manner among the members of society, but the benefit cost analysis of is concerned with the optimal distribution of resources and achieving the largest possible benefit, and justice in the distribution of resources is not of great importance in its calculations. It is an analytical tool designed to develop comparison among options by identifying their cost and returns (Blum et. al, 1980)

The procedure of benefit cost analysis is based on identification of the project or projects under study, determining all the positive and non-positive effects, whether present or future, where the positive effects are calculated as revenues and the non-positive effects as costs, converting costs in intangible returns into monetary values, calculation of net returns total returns minus total costs and determine the best option according to the available criteria.

3. Study area and data

The study was conducted in Babylon region which is one of the important cereal crop farming in Iraq due to the availability of irrigation water. The region is highly representative of cereals farming in Iraq south and middle region of Iraq whereby there are small an middle size landownership which is widely prevailing in Iraq. The social and economic stricture is similar to that of other regions in Iraq. Wheat agronomic practices in Babylon is also similar to that practiced in the middle and southern of Iraq.

To examine the extent of the adoption of the government wheat improvement prgramme by the famers and to determine the possibility of the wider diffusion of the technology package on the country level and to be adopted by famers on the country level, the study has identified that the famers who have adopted the technology in the study population as those farmers took the risk and the uncertainty to adopt the technology package.

The sampling covered 16 administrative districts which constituted the entire region. The sample size was 45 famers and the survey was conducted to include the household attributes, farm attribute and policy attributes. Table 1. Depicts the farmer attributes of the sample which indicates ages of the farmers, farming experience, number of the members of the household, the number of household working in farming, size of land ownership, the number of women working in agriculture, the number of years enrollment in the program and the size of land allocated to the wheat improvement program.

Table 1. Descriptive statistics for farmers Socioeconomic characteristics

Variable	Mean	Minimum	Maximum	Standard deviation
Farmers age	55	28	80	13
Experience in Agriculture	25	7	50	11
Household members	10	4	35	5.6
Household member work in farming	4	1	15	3.2
Number of women work in farming	3	1	7	1.6
Total landownership size (donum)	279	5	6337	996

Wheat crop area	186	5	4000	610
Program allocated area	11	3	25	6
Program enrollment years	4	1	10	2

Data source: Research survey sample data.

The survey covered the education level of the sampled farmers to examine the relationship between education and wheat productivity. Table 2 lists the farmers education.

Table 2. Farmers education level and average wheat productivity

Education level	%	Productivity Kg/donum (.25 ha)
Illiterate	4	1350
Read and write	12	1242
Primary school	28	1185
High school	48	1273
Graduate	8	1125

Land ownership is a key variable for the farmer's decision to adopt wheat improvement program including land improvement investment in owned land which normally raises its market prices compared to farmer with lease basis. Table 3 shows the distribution of type of the land ownership in the study sample.

Table 3. Land tenure characteristics

Land ownership type	Percentage of the total
Freehold	50
Lease	30
Lease and freehold	12
Rent and freehold	4

To examine the determinant of the adoption of wheat improvement technology package, the study sample included early adopters and late adopters within last two years are considered non-adopters. Three types of variables to represent adoption are considered: household related variables and farm attributes and policy variables such as input subsides including, fertilizers, subsidized seed purchase, fuel subsidy offered by the program to adopter. The late adopter constitutes 39% (Table 4) of the sample size we considered those late adopters who have enrollment for one or two years as non-adopters in order to estimate influence of the factors determining adoption. For non-adopters, we considered their pre-enrollment wheat per unit wheat productivity while for other adopter post adoption productivity is used.

Table 4. Farmers' enrollment number of years in the program

Years of enrollment	Number of farmers	Percent	Cumulative enrollment
1	12	27	27
2	5	11	39
3	5	11	50
4	7	16	66
5	6	14	80
6	2	5	84
7	3	7	91
8	3	7	98
10	1	2	100

4. Program technology package

Wheat improvement technology package constitutes of modern agronomic practices and extension services with clear objective to raise farm level wheat productivity. The program began in 2011 which covered several governorates. Extension activities constituted a major service of the technology improvement package including extension demonstrations, seminars, field visits, farmers field schools, poste, and electronic media communication. The technology package is described in table 3.

Table 5. Wheat improvement technology package components.

Technology item	Percentage of farmers using the technology
Lazer level technique	15
Crop rotation	10
Seeder and fertilizer machine	10
Micronutrients	24
N Fertilizer partitioning	12
Integrated pest and disease management	21
K fertilizer	8

Data source: Study survey data.

One of the objectives of the program is to improve the performance of wheat varieties through seed cleansing and production of highly performing varieties and breading heat and salinity tolerant varieties. The program also aims at improving land productivity of wheat by adopting best agronomic practices such as efficient irrigation methods, optimal application of fertilizers, weed and disease control and management as well improving post harvesting services.

5. Analysis and discussion

5.1 Cost benefit analysis

The general information of the sample as described in table 1 shows that the average age of the famers ranges from 28 to 80 year with standard deviation of 13 years which reflects the fact that the ownership of land is registered under the older age but the management is conducted by either their sons or the farmers who rent the land. The average years of experience was 25 with a maximum of 50 years which is sufficient for the famers to conduct acceptable level of agronomic activities required to improve wheat production and adopt wheat improvement program. The average number of household members was 10 and the number of members who work in agriculture ranges from 1 to 7 members which may reduce the demand of labor in agriculture and induce the household members to seek for jobs in other sectors which may diversify the household income sources. On the aggregate level, labor surplus may lead to rural migration or induce post-harvest opportunities.

The survey shows that 67% of the land was allocated to wheat farming and only 6% was allocated for the improvement program. The data shows that small holders allocated high percentage of their cultivated land to the improvement program compared to the farmers with large land holdings as depicted in figure 1. Figure 1 shows that farmers with small holding allocated high percentages of their total cultivated land compared to those with large holdings who allocated lower percentage of their cultivated land to the program. The reasons for such relationship is that farmers with large landholding may more risk averse than small landholding owners. Specific human capital represented by farmers years of experience and education may negatively correlated with adoption because farmers with long experience may developed a solution to maintain high productivity and farmers with higher education may have additional source of revenue and therefore less likely to adopt the new technology.

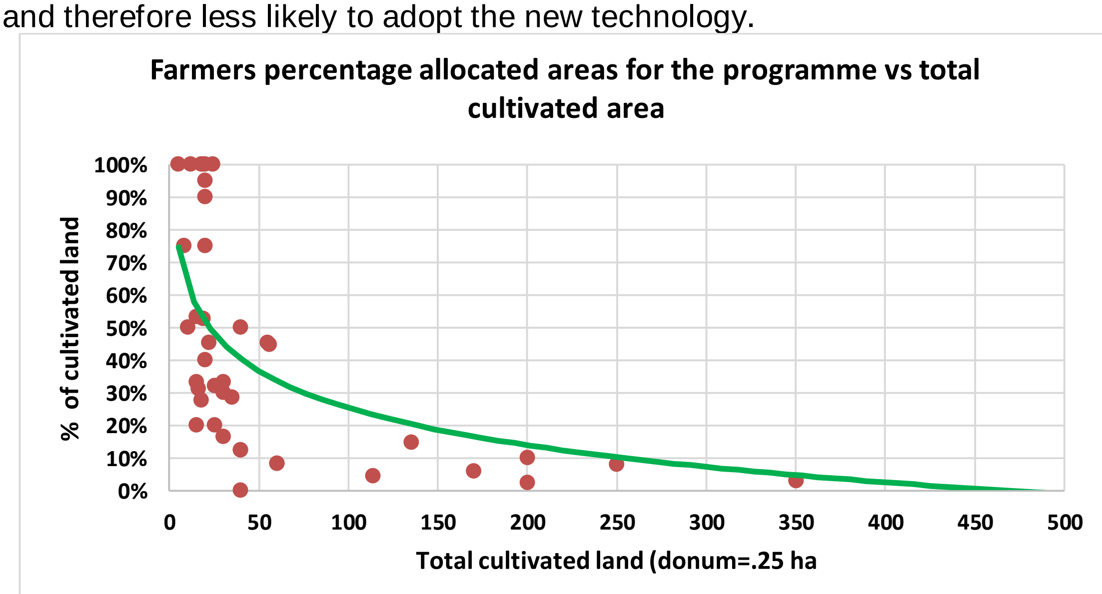

Figure 1.Relationship between land allocated to the technology program and farmer total cultivated area.

Further, farmer with lower education level (illiterate) performed higher productivity which was estimated at (1350 kg/donum) although this category constituted small percentage of the total sample as shown in table 2 . High productivity can be attributed to the fact that this category has long farming experience and the contribution of the wheat technology program through the assistance of the program experts. The second level of productivity was associated with farmers with high school education, it is expected that this category is more receptive to the technology adoption compared with the higher education level which performed lower productivity as shown in table 2. Farmers with higher education category performed lower productivity and can be interpreted that famer in this category have other sources of income while illiterate rely on farm income as mentioned above.

To evaluate the technical and field benefit of wheat improvement program, cost-benefit analysis has been used to estimate the financial costs of the inputs and the present value of the returns, the cost benefit ratio and the estimation of the internal rate of returns which is simply the discount rate at which the net present value would be equal to the costs under technology adoption situation.

The results in table 5 indicates that the net returns for the adopter was 393,932 IQD/donum which was 64% higher than the net returns achieved by non-adopter which was estimated at 239,760 IQD/donum. Further, the estimated IRR for adopters (16%), calculated by dividing the changes of net returns on the change of total cost, is greater than bank interest rate on capital borrowing which is 8% and thus the adoption of wheat improvement program provide higher return in investment than the interest rate on capital invested in banks. The returns-cost ratio in the case of adoption generates higher returns estimated at 2.25 IQD which is higher that in case of non-adoption which is only 1.7 for traditional farming. Comparing net return increase estimated at 64% for adopters compared with total cost changes for adopters which is as low as 4% increase which is translated in high increase in returns and marginal increase in costs.

Table 6. Cost benefit analysis for technology adoption and non-adoption

Non adopters				**Adopters**						
Cost (IQD/donum)	Revenue (IQD/donum)	Net Returns (IQD/donum)	Benefit cost ratio	Cost (IQD/donum)	Revenue (IQD/donum)	Net Return (IQD/donum)	Changes in Net returns %	Changes in total costs %	IRR (%)	Benefit cost ratio
303,740	543,500	239,760	1.7	315,536	709,468	393,932	64	0.039	16	2.25

5.2 Logistic regression analysis of farmer's adoption of wheat improvement programs.

To examine the factors affected the adoption of the wheat technology packages, we selected main variables as determining factors for adoption including farm type that is whether the farm is luminous or traditional farm, seed or grain producer, human capital using experience and education as proxy, total cultivated area, income source, total area and productivity. Using the basic specification model Eq. 4, the logit regression equation to estimates adoption model is

$$\ln(P_i/(1-P_i) = B_0 + B_1FT + B_2PT + B_3FA + B_4EL + B_5CA + B_6IS + B_7PORD + B_8TA$$

Where

FARM TYPE (FT) Farm type traditional or luminous
FARM TYPE (PT) Seed production or grain production
FARM AGE (FA) Farmer age
EDUCATION LEVEL (EL) Education level (Illiterate, read and write, primary school, high school and graduate)
CULTIVATED AREA (CA) Total cultivated area.
INCOME SOURCE (IS) Income source (agriculture, non-agriculture, gov. employment)
PRODUCTIVITY (PROD) Wheat production per unit of land (kg/donum donum=.25 ha).
TOTAL AREA (TA) Total land ownership

The result from the logit model is summarized in table 7.

Table 7. Logit regression estimates of coefficients associated with predictors determining adoption of wheat improvement technology package.

Adoption	Coef. (*B*)	S.E	Z (Wald)	Sign.	Exp(B)
FARM TYPE (FT)	9.409262	3.769431	2.5	0.013	12200.86
PRODUCTION TYPE (PT)	-2.161622	2.231418	-0.97	0.333	0.115138
FARMER AGE (FA)	-0.0141797	0.04815	-0.29	0.768	0.98592
EDUCATION LEVEL (EL)	-0.1840873	0.783302	-0.24	0.814	0.831863
CULTIVATED AREA (CA)	-0.0020849	0.002543	-0.82	0.412	0.997917
INCOME SOURCE (IS)	-1.254802	0.965761	-1.3	0.194	0.285132
PRODUCTIVITY (PROD)	0.0175055	0.006324	2.77	0.006	1.01766
TOTAL AREA (TA)	0.0159461	0.011267	1.42	0.157	1.016074
Constant	-26.16159	11.57904	-2.26	0.024	

N	44
Loglikelihood Ratio LR chi-square(8)	42.17
Prob. > X^2	0.0000
Log likelihood	-8.2692354
Pseudo R^2	0.7183

Table 7 depicts the output of the logistic regression analysis using Stata software. We included main attribute which should influence farmer adoption decision. The table lists several parameters including the predictors coefficients, the standard error of the *B* coefficients, the Z which is by estimated by dividing B_i/S.E, significance level of probability and the Odds Ratio which is represented by Exp(B_i).

The result of the logit regression indicates that for farm type (FT) coefficient (B_1) indicates that the luminous farmers by far are more receptive to adopt modern technology which is represented by the direction of the effect of on the probability of adoption P(Y=1) for FT. Luminous farmers may more risk takers and well informed about the benefit than others about the technology.

The magnitude is determined by $\sum(B_i X_i)$ hence the effect is not constant (Sheikh et al., 2003). The column Exp(B) in table 7 represents the exponential of the logistic regression coefficient that indicates the odds of farmers will adopt wheat technology package with respect to an increase in one unit a given explanatory variable. The converse would apply for negative coefficients. The loglikelihood ratio was 42.17 which is significant at 0.00001 level and provides a measure indicates that at least one of the coefficients is not equal to 0. LR Chi-square is calculated using the iteration begins with constant only model through the final iteration to calculate the likelihood ratio with inclusion of the independent variable (-2 *LL0 (loglikelihood 0 (constant model only) – LLF (loglikelihood with independent variables iteration final iteration).

The productivity variable (PROD) coefficient is positive and statistically significant ($P<0.05$) and positively influences the probability of farmers' adoption of the technology package. One unit increase in productivity increases adoption by 1.01-folds holding all other variable constant thus farmer with higher per unit of land productivity are more likely to adopt new technology (Dinar and Yarn, 1990). The results also revealed that years of farming experience and age did not have a significant effect on the decision of the farmers to adopt the technology. This implies that farmers who have long experience is not inclined to adopt the technology and may consider their experience could substitute the productivity benefits that could be attained by adopting the technology (Dinar and Yarn, 1990; Sheikh et.al, 2002). Other studies suggested that experience has a positive relationship with adoption (Legesse (1992), Kidane (2001) and Melaku (2005).

For education as human capital variable the analysis shows that education is not statistically significant with a negative coefficient, similar research has also indicated similar outcome (Sheikh et.al, 2002). The study sample indicates that farmers with higher education have less interest in adopting the technology as farming is secondary source of revenue.

Model results also indicate that farm total area and cultivated area did not have a significant influence on the farmers' adoption of wheat improvement package. However, small holding farmers allocated high percentage foe the program compared than farmer with large hold as indicated in the cost-benefit discussion. It is hypnotized that the more off the farm activities, the more likely are farmers to adopt time-saving technologies and the less likely are they to adopt time-intensive technologies (Caswell et. Al, 2001), however the analysis shows that income sources has no effect on the odds of adoption.

Other variables including number of house members, number of household work in farming, number of women working in farming, cooperative membership are excluded from the model as they have no influence on adoption.

6. Conclusion

Wheat is strategic crop as it is connected to the country food security policy which aims to meet the basic food supply fast growing population. The government policy allocates considerable resources in terms of procurement price support and input subsidy in order to increase production and stabilize rural-urban migration.

The government has adopted as set of wheat improvement technology package for adoption and diffusion. The results of the cost-benefit analysis (CBA) shows that the net returns in the case of adoption of technology package amounted to (393,932) dinars/ dunum, is higher than the net returns for non-adoption of the technology package, amounted to (2397,60) Dinar / dunum, by (64%), which indicates a net benefit for the adopters. The internal rate of return (IRR) estimated at (16.55%) and indicates that the investment in adopting the program's technology package has achieved higher returns for farmers than in the case of investing the capital in banks. Further the cost benefit ratio (CBR) of 2.25%, indicates that one dinar invested in the technology package m returns (2.25) dinars.

The logistic regression analysis was applied to evaluate the determinant factors which influence the decisions of early and late adopter of the government technology package. We considered the late adopter for the one and two years as late adopters' group and the rest early adopters. The analysis of the logistic regression shows that type of farmers one of the strong determinants of the technology adoption and positively influence odds for adoption. The analysis also indicates that the wheat productivity as explanatory variable was significant, and it could be interpreted that framer with high productivity may tend to adopt the technology. Other predictors such as farmer age, farmer experience were not statistically significant and may be interpreted that farmer with high experience are slow in adopting the technology as they perceive that the new technology may not add additional benefits. Wheat farms are managed by younger generation, but they are owned by old famers and hence the data may not represent the actual situation and hence the age variable has no influence on adoption.

Education, contradictory to the expectation, is not statistically significant and the analysis shows a negative coefficient. However, farmers with higher education have lower tendency to adopt new technology as they have alternative source of income. The sample survey shows that illiterate famers perform better productivity compared with graduate farmers.

Future research is required to expand the sample size of adopters and non-adopters and include other governorates. The sample data may include policy variables including, famer characteristics, water resource variables and subsidies.

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