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Impact of Agricultural Mechanization on Production and Income Generation in Afghanistan
Case Study of Herat Province

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Keywords

Agricultural Mechanization, Production, Productivity, Income Generation

Abstract

Agricultural mechanization is the utilization of different power sources and advanced farm tools and equipment to decrease the drudgery of farmers and replace the use of draught animals. It helps increase income, cropping intensity, production and efficiency, causing to the benefits different crop inputs and decreasing the losses at different stages of crop production. The purpose of farm mechanization is to increase overall production and income generation and to lower costs. Agriculture is critical for Afghanistan’s food security and is a key driver of economic growth. Most Afghan families live in rural areas and rely on agriculture and farming for their livelihoods and to feed their families. Agriculture also creates employment and investment opportunities for people living in urban areas.

This study found that agricultural mechanization has helped to increase the overall income and production of farms in five districts of Herat Province. By applying the Cobb-Douglas production function, we found that in our first model, which looks at crop production, farm size, quantity of seed, quantity of fertilizer, irrigated area and quantity of agrochemicals all have a positive effect on production: an increase or decrease in any of these inputs will increase or decrease production respectively. In our second model, which looks at income, we found that price and production are closely related to income. However, the other variables, including labor, education and experience, are not associated with income at the farm level in the study area.
Description of Data

Both primary and secondary data were collected for this research. Primary data were gathered through a standardized questionnaire survey. The sample was 400 farmers from five districts (Injil, Guzara, Ghoryan, Pashtun Zarghun and Zinda Jan) of Herat Province. The questionnaire was divided into three sections. The first section collected information on the demographic characteristics of the farmers. This data was obtained to establish the structure of the farming population in terms of their age, gender, household members, household size, and the educational experience and other qualifications of the heads of households. The second section was the largest. It collected data on the quantity of product, farm size, quantity of seed, quantity of fertilizer, labor input, quantity of agrochemicals, farm assets, access to tractors, irrigated area and price of product. Problems faced by the farmers were also included in this section. The last part of the questionnaire asked about the farmers’ sources of income and expenditure. Before the individual interview, the farmers had an interactive session where the questionnaire was explained to them.

The handwritten data recorded on the questionnaire sheets were checked for recording and transfer errors, missing values, and outliers before being entered into a personal computer for analysis. Secondary data were collected from the Ministry of Agriculture, Irrigation and Livestock of Afghanistan. After the investigation, the data related to Herat was selected and used. The main programs used for data analysis were the econometrics package Eviews 9, SPSS and Stata. Microsoft Excel was used for some parts of the data analysis.

Research Question/Theoretical Contextualization

Afghanistan’s economy is dependent on the agricultural sector, which makes significant contributions to food security, economic growth, poverty alleviation, employment enhancement, and the fiscal health of the nation. For example, agriculture plays a significant role in the livelihoods of the more than 80 percent of the country’s population and almost 90 percent of the deprived who live in rural areas (World Bank, 2014). Therefore, agriculture is the most significant economic activity and livelihood component in Afghanistan (NRVA, 2007).

Agriculture is also important for the growth and development of Afghanistan. This sector provides employment for more than fifty percent of the population and contributes one quarter of gross domestic product (GDP) (MAIL, 2017). Moreover, the existence of links between agriculture and other sectors is vital for the growth and development of the country. For example, agriculture provides raw materials and labor supply for industry, while the agricultural sector uses products
from the industrial sector, like machinery. Therefore, the lack of an effective agriculture sector can affect both sectorial growth and the growth of the country.

Robert C. Hsu (1979) investigated the problems, policies and prospects of agricultural mechanization in China. He found that as mechanization proceeds, the income inequality between rural and urban areas decreases, while interactions between the two areas increase. He also added that agricultural mechanization is accelerated by the technical skills of peasants and increases in the supply of fertilizer and petroleum.

Verma (2008), in research on the “Impact of Agricultural Mechanization on Production, Productivity, Cropping Intensity, Income Generation and Employment of Labour” in India, found that mechanization leads to the development of new jobs such as managerial and supervisory jobs, driving jobs, service jobs, and jobs in the maintenance and repair of machines. He also mentions that farm mechanization has considerably assisted farmers, giving them overall economic improvements.

Musa et. al (2012) used the investigative research approach to examine the effect of mechanization on farm practices in north central Nigeria. They found that modern technology in agriculture has strong potential for increasing farm productivity.

According to Ruttan & Hayami (1971) and Ruttan & Binswanger (1978), the rate and pattern of mechanization is deeply influenced by the relative scarcities of capital and labor, and other macroeconomic variables. The responsiveness of invention and innovation to economy-wide factors has become recognized as induced.

Hans Binswanger (1986) clarified that mechanization is the main facilitator of the trend towards bigger farms. Large farms adopt new forms of machinery considerably faster than small farms.

Muhammad Qasim (2012) applied the Cobb-Douglas production function and found that irrigated areas, off-farm income, the number of livestock, hired labor and tractor ownership were positively correlated with farm income.

Singh (2015) found that physical and institutional infrastructure, along with laws, regulations and business-friendly policies, are the key factors in the success of agricultural mechanization in India. Mankaran Dhiman and Jaskaran Dhiman (2015) believe that the mechanization of farm operations has greatly assisted in reducing the labor requirements, drudgery and costs of cultivation, and helps save farmers from vagaries of the weather. To make farmers globally competitive and prevent the
harm of natural resources, a major shift towards farm mechanization is required to realize the goal of eco-friendly, sustainable agriculture with a low cost of production and high-quality produce.

Zaijion Yuan (2011) published a paper on agricultural input-output in northern China. He analyzed agricultural input and output in the last ten years by applying the Cobb-Douglas production function. He found that agricultural output, effective irrigation area, rural electricity consumption, use of agricultural machinery and chemical fertilizer usage in Hebei Province are increasing, while cultivated land area and rural manpower are decreasing. In this research we will also use the Cobb-Douglas production function because of its many advantages, which are explained below.

The Cobb-Douglas production function (CDPF) is among the best production functions used in applied production analysis (Enaami, et al., 2011). The Cobb-Douglas production function is widely used in economic analysis to show the relationship of output to input (Qasim, 2012, p. 29). The procedure was first suggested by Knut Wicksell (1851-1926). The formula was then tested again by Charles Cobb and Paul Douglas in 1928. They investigated a simple way in which production output is determined by the amount of labor and capital. It is one of the most important methods used in many sectors, such as agriculture, education and health. This form of production function has several advantages. For example, it is widely applied in economic and econometric analysis and is flexible in the number of input variables used. Furthermore, economies of scale can be computed as limited input coefficients that sum to one or without this limitation. In addition, this method of production is easy to estimate and interpret. Using the CDPF unconstrained increases its potential to handle different scales of production. Different econometrics estimation problems, such as serial correlation, heteroscedasticity and multi-collinearity, can be handled adequately and easily using this method. The only criticism of the model is lack of parsimony and flexibility. This can be solved by making some assumptions in the model. The problem of simultaneity can be accounted for by the use of a stochastic approach to the CDPF (Bhamnumurthy, 2002, p. 75). The main characteristic of the CDPF is that the elasticity of substitution is unified. The original form of the Cobb-Douglas production function is:

\[ P = F(A K^\alpha L^\beta) \]  

where

- \( P \) = total production output (the monetary value of all goods produced)
- \( K \) = capital input (the monetary worth of all equipment, buildings, machinery, etc.)
- \( L \) = labor input (the total number of hours worked by people)
A = total factor productivity

α and β are the output elasticities of capital and labor respectively, and are constants between 0 and 1 (0 < α < 1).

Ordinary Least Squares (OLS) is a practical method of analyzing linear relationships in a linear regression model. But it is pointless when a non-linear relationship between an independent variable and a dependent variable can be converted into a linear relationship by changing the model into a logarithmical one (D'Ambra & Sarnacchiaro, 2010). The Cobb-Douglas production function has exponential relationships, which are quite often observed in theories of economics and can be converted into a linear relationship by taking the logarithm of the separate variables (Pennings, et al., 2006, p. 324). In applying this method, most economics researchers start by estimating the CDPF using OLS and hoping to get estimates of the labor and capital output elasticities that look probable and interpretable from a theoretical point of view (Armagan & Ozden, 2007).

The stochastic form of the Cobb-Douglas production function is:

\[ Y_i = \beta_0 X_{1i}^{\beta_1} X_{2i}^{\beta_2} e^{ui} \]  \hspace{1cm} (2)

where

\( Y_i \) = total output

\( X_{1i} \) = labor input

\( X_{2i} \) = capital input

\( u \) = stochastic disturbance term

\( e \) = base of natural logarithm

\( \beta_1 and \beta_2 \) = output elasticities of labor and capital respectively.

The model above shows a non-linear relationship between output and inputs. The model can be converted into a logarithmic function or transferred to a log model as follows:

\[ \log Y_i = \beta_0 + \beta_1 \log X_{1i} + \beta_2 \log X_{2i} + u_i \]  \hspace{1cm} (3)

The model is linear in parameters \( \beta_0, \beta_1 \) and \( \beta_2 \) and it is therefore a linear regression model. The equation is a log-log model. Some attributes of the Cobb-Douglas production function will be explained in more detail in the following paragraphs.
\( \beta_1 \) is the partial elasticity of the output with respect to labor input. This represents the percentage change in output for a one percent change in labor input when capital input is constant.

\( \beta_2 \) is the partial elasticity of the output with respect to capital input. This represents the percentage change in output for a one percent change in capital input when labor input is constant.

The aggregate of parameters \( \beta_1 \) and \( \beta_2 \) shows the returns to scale. It represents the output level for the proportionate change in inputs. If the sum is equal to one, it shows constant returns to scale. If the sum is lower than one, it shows decreasing returns to scale and if the sum is bigger than one, it represents increasing returns to scale.

In a log-linear regression model with any number of variables, the coefficient of each of the X variables measures the elasticity of the dependent variable Y with respect to that X variable. Therefore, if we have K number of variables, the log-linear model will be of the following form:

\[
\log Y_i = \beta_0 + \beta_1 \log X_{1i} + \beta_2 \log X_{2i} + \cdots + \beta_k \log X_{ki} + u_i \quad (4)
\]

where the regression coefficients \( \beta_2 \) through to \( \beta_k \) are the elasticities of Y with respect to the variables \( X_1 \) through to \( X_k \) (Gujarati, 2003).

This research uses the log-linear form of the Cobb-Douglas production function to investigate the impact of agricultural mechanization on production and income generation in Afghanistan, especially in Herat Province. We estimate the value of the coefficients that represent the effect of mechanization on the output elasticities of each variable in the model. The details of the functional form of the Cobb-Douglas production function are given in the Methodology section of this article.

The production function used in this research (a double-log production function) determined the effect of mechanization on production and income generation. If the regression coefficients of quantity of product, farm size, quantity of seed, quantity of fertilizer, labor input, quantity of agrochemicals, access to tractors, irrigated area and price of product take positive values, this means that an increase in each of these variables would lead to an increase in the effect of mechanization on production. The second equation showed the effect of mechanization on income generation. All costs were deducted from the revenue of the farm and then the data was analyzed to find the effect of mechanization on production and income generation at the farm level.

Moreover, further analysis compared the output of farms that use tractors with the output of farms that do not use tractor.
Research Objectives:

1- To analyze the impact of agricultural mechanization on production and income generation in Afghanistan.
2- To identify the factors that drive the adoption of mechanization in Afghanistan.
3- To assess the current level of mechanization in the selected research areas.
4- To provide policy recommendations to the relevant government ministries and international donors.
5- To compare the level of mechanization in five districts.

Research Questions:

1- Does agricultural mechanization affect production and income generation at the farm level in Herat?
2- Does the effect of mechanization on output differ at the farm level?
3- What are the factors that drive the adoption of mechanization in Herat?
4- Does the level of mechanization differ in different parts of the research area?

Field Research Design/ Methods of Gathering Data

The main purpose of this study was to determine the impact of agricultural mechanization on production and income generation in Afghanistan. In order to achieve this objective, primary data were collected from five districts of Herat province. These five districts were selected for two reasons:

1) They are the most populated districts, and thousands of families living in these districts work in the agricultural sector.

2) These districts are more accessible for the field research compared to other areas of the province and have better security than the other districts. Additionally, it was possible to obtain assistance in making contact with farmers and attracting support for the field research process from the department of agriculture. Primary data collection involved a sample survey, which was conducted in the study locations during the period March - June 2019. The survey involved interviewing 400 farmers in the study locations (Injil, Guzara, Ghoryan, Pashtun Zarghun and Zinda Jan). Secondary data sources, including reports, were used by the researcher. Sample farmers were selected using the stratified random sampling method.
Table 1: Distribution of sample size in the selected districts

<table>
<thead>
<tr>
<th>District</th>
<th>Population</th>
<th>Percentage</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injil</td>
<td>233,900</td>
<td>38</td>
<td>152</td>
</tr>
<tr>
<td>Guzara</td>
<td>140,300</td>
<td>23</td>
<td>92</td>
</tr>
<tr>
<td>Ghoryan</td>
<td>84,300</td>
<td>14</td>
<td>56</td>
</tr>
<tr>
<td>Zinda Jan</td>
<td>54,600</td>
<td>9</td>
<td>36</td>
</tr>
<tr>
<td>Pashtun Zarghun</td>
<td>95,900</td>
<td>16</td>
<td>64</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>609,000</strong></td>
<td><strong>100</strong></td>
<td><strong>400</strong></td>
</tr>
</tbody>
</table>

Source: CSO (2011-2012)

Two models, both in the form of the Cobb-Douglas production function, were used to analyze the data. The first model investigated the level of production and the second model investigated the effect of mechanization on income generation at the farm level. The Cobb-Douglas production function was used because it has many advantages and is used by many researchers in different fields, especially in applied economics and econometrics. Furthermore, it is a very flexible function and allows the researcher to use several input variables to investigate the effect of each variable on the production process. The most important property of the function is its elasticity of substitution (Mohammad Abdallah Khreisat 2011 p. 36).

In this research, econometrics instrumentations were used to establish the effect of mechanization on production and income generation in Herat Province. A log function model of the Cobb-Douglas production function was used with the Ordinary Least Squares (OLS) method to verify the relationship between input and output (independent variable and dependent variable) (Muhammad Qasim 2012 p. 99).

We used the Cobb-Douglas production function to investigate the level of production:

\[ Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, U_i) \]  (5)

where

\( Y \) is the quantity of crop produced (kg)

\( X_1 \) is the farm size (hectares)

\( X_2 \) is the quantity of seed (kg)
$X_3$ is the quantity of fertilizer (kg)

$X_4$ is the labor input (man-days)

$X_5$ is the quantity of agrochemicals (liters)

$X_6$ is the access to tractors

$X_7$ is the irrigated area (hectares)

$X_8$ is the farmers’ education (years)

$U_i$ are the error terms.

This function takes the following form:

$$
\log Y = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + \beta_6 \log X_6 + \beta_7 \log X_7 \\
+ \beta_8 \log X_8 + U_i (\text{doublelog}) \quad (6)
$$

In the second model we investigated the effect of mechanization on income generation at the farm level:

$$
Y = f(X_1, X_2, X_3, X_4, X_5, U_i) \quad (7)
$$

where

$Y$ is the amount of income (US$)

$X_1$ is the price of product (US$)

$X_2$ is the quantity of crop produced (kg)

$X_3$ is the farmers’ education (years)

$X_4$ is the labor input (man-days)

$X_5$ is the farmers’ experience (years)

$U_i$ are the error terms.

This function takes the following form:

$$
\log Y = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 \\
+ U_i (\text{doublelog}) \quad (8)
$$
Results

As mentioned in the field research design section of this article, the primary data was collected from five districts in Herat Province (Injil, Guzara, Ghoryan, Pashtun Zarghun and Zinda Jan) through a standard questionnaire that contained 25 questions in three sections. The data were analyzed with the following two models.

Empirical Analysis:

The following equations were used to determine the effects of mechanization on production and income generation in the research area.

\[ \log Y = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + \beta_6 \log X_6 + \beta_7 \log X_7 + \beta_8 \log X_8 + U_i \] (9)

\[ \log Y = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + U_i \] (10)

The above equations explain the relationship between all the independent variables and the dependent variable. In the first equation, the data on the effect of mechanization on production were analyzed with all control variables. In the second equation, the control variables, including price of product, level of production, farmers’ education, labor input and farmers’ experience were analyzed. The descriptive statistics were also analyzed and are depicted in Table 2.

Table 2: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm size</td>
<td>400</td>
<td>1.00</td>
<td>10.00</td>
<td>2.6275</td>
<td>1.00312</td>
<td>1.006</td>
</tr>
<tr>
<td>Labor</td>
<td>400</td>
<td>1.00</td>
<td>35.00</td>
<td>3.6050</td>
<td>2.88788</td>
<td>8.340</td>
</tr>
<tr>
<td>Tractors</td>
<td>400</td>
<td>0.00</td>
<td>8.00</td>
<td>4.1025</td>
<td>1.71883</td>
<td>2.954</td>
</tr>
<tr>
<td>Education</td>
<td>400</td>
<td>0.00</td>
<td>8.00</td>
<td>2.2050</td>
<td>1.13631</td>
<td>1.291</td>
</tr>
<tr>
<td>Experience</td>
<td>400</td>
<td>1.00</td>
<td>6.00</td>
<td>2.9775</td>
<td>1.16421</td>
<td>1.355</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>400</td>
<td>1.00</td>
<td>10.00</td>
<td>2.6275</td>
<td>1.00312</td>
<td>1.006</td>
</tr>
</tbody>
</table>

Table 2 shows the descriptive statistics for the study area. The average farm size was 2.6 hectares, the average amount of labor working on the land was 3.6 persons per hectare, the average number of tractors each farmer had access to was 4.1, the education of farmers in the study area was on average 2.2 years and the average experience of farmers in all districts was 2.9 years.
Table 3: Effects of Mechanization on Production and Income Generation

<table>
<thead>
<tr>
<th>District</th>
<th>Production with Mechanization</th>
<th>Production without Mechanization</th>
<th>Difference</th>
<th>Income with Mechanization</th>
<th>Income without Mechanization</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injil</td>
<td>27,647,275 (41.11)</td>
<td>12,278,470 (39.60)</td>
<td>15,368,805 (125)</td>
<td>25,221,320 (37.58)</td>
<td>11,733,143 (35.74)</td>
<td>13,488,177 (115)</td>
</tr>
<tr>
<td>Guzara</td>
<td>14,508,312 (21.57)</td>
<td>7,426,015 (23.95)</td>
<td>7,082,297 (95)</td>
<td>12,916,250 (19.24)</td>
<td>6,352,770 (19.35)</td>
<td>6,563,480 (103)</td>
</tr>
<tr>
<td>Ghoryan</td>
<td>11,121,751 (16.54)</td>
<td>4,099,600 (13.22)</td>
<td>7,022,151 (171)</td>
<td>11,487,991 (17.12)</td>
<td>7,012,700 (21.36)</td>
<td>4,475,291 (64)</td>
</tr>
<tr>
<td>Zinda Jan</td>
<td>3,932,130 (5.84)</td>
<td>2,230,370 (7.19)</td>
<td>1,701,760 (76)</td>
<td>3,657,674 (5.54)</td>
<td>2,300,160 (6.80)</td>
<td>1,357,514 (59.01)</td>
</tr>
<tr>
<td>Pashtun Zarghun</td>
<td>10,031,898 (14.92)</td>
<td>4,964,970 (16.01)</td>
<td>5,066,928 (102)</td>
<td>12,821,645 (19.10)</td>
<td>6,392,400 (19.47)</td>
<td>6,429,245 (101)</td>
</tr>
<tr>
<td>Average Changes in Income &amp; Production</td>
<td></td>
<td></td>
<td><strong>113.8</strong></td>
<td></td>
<td></td>
<td><strong>93.8</strong></td>
</tr>
</tbody>
</table>

Note: values in parentheses are percentages

Table 3 highlights that agricultural production is significantly higher with than without mechanization. It shows that production has increased by 113.8 percent or 36,241,941 kg overall, and income has increased by 93.8 percent (34,283,707 AFA, equivalent to 42,329 US$).

Comparing the districts, we found that agricultural mechanization has made a substantial contribution to increasing agricultural production. Injil district has benefited the most from mechanization. In this district, production increased by 125 percent and income by 115 percent. Zinda Jan district benefited from mechanization less than the other districts in the study area. Here production increased 76 percent while income increased 59 percent.

**Results of the First Model**

The first model investigates the effect of mechanization on production at the farm level. This model shows that farm size, seed, fertilizer, irrigation and agrochemicals are highly significant and have a positive impact on production. It indicates that a one percent increase in each of the variables will cause an increase of more than one percent in the total production at the farm level. The labor variable is also significant but has a minus sign. The results are illustrated in Table 4.
Table 4: Effect of Mechanization on Production

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>t</td>
</tr>
<tr>
<td>(Constant)</td>
<td>3.749</td>
<td>0.113</td>
<td>33.189</td>
</tr>
<tr>
<td>Log farm size</td>
<td>0.401</td>
<td>0.084</td>
<td>4.788</td>
</tr>
<tr>
<td>Log seed</td>
<td>0.179</td>
<td>0.017</td>
<td>10.666</td>
</tr>
<tr>
<td>Log fertilizer</td>
<td>0.053</td>
<td>0.010</td>
<td>5.365</td>
</tr>
<tr>
<td>Log labor</td>
<td>-0.127</td>
<td>0.047</td>
<td>-2.666</td>
</tr>
<tr>
<td>Log irrigation</td>
<td>0.024</td>
<td>0.011</td>
<td>2.127</td>
</tr>
<tr>
<td>Log agrochemicals</td>
<td>0.058</td>
<td>0.011</td>
<td>5.275</td>
</tr>
<tr>
<td>Log tractors</td>
<td>0.037</td>
<td>0.074</td>
<td>0.505</td>
</tr>
<tr>
<td>Education</td>
<td>0.011</td>
<td>0.012</td>
<td>0.916</td>
</tr>
<tr>
<td>Experience</td>
<td>0.004</td>
<td>0.013</td>
<td>0.338</td>
</tr>
</tbody>
</table>

Dependent variable: log production

Farm size, seed, fertilizer, irrigation and agrochemicals all have a positive effect on production. An increase or decrease in these inputs will increase or decrease the production at the farm level respectively because the signs of these variables’ coefficients are positive. However, labor has a negative relationship with production, which means an increase in labor may directly decrease production at the farm level.

Table 5: Analysis of Variance (ANOVA)

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>15.629</td>
<td>9</td>
<td>1.737</td>
<td>23.495</td>
<td>0.000b</td>
</tr>
<tr>
<td>Residual</td>
<td>28.825</td>
<td>390</td>
<td>0.074</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>44.453</td>
<td>399</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent variable: log production
b. Predictors: (constant), experience, log agrochemicals, log fertilizer, log seed, log labor, log irrigation, log farm size, education, log tractors

Table 5 shows that the regression model predicts the dependent variable (quantity of crop produced) significantly well. The F value is 23.49 and the P-Value is 0.000, indicating that overall the regression model is statistically significant and shows a good fit for the data set.
Table 6: Model Summary

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.593a</td>
<td>0.352</td>
<td>0.337</td>
<td>0.27186</td>
</tr>
</tbody>
</table>

a. Predictors: (constant), experience, log agrochemicals, log fertilizer, log seed, log labor, log irrigation, log farm size, education, log tractors

Table 6 shows how much changes in the quantity of crop produced are explained by changes in farm size, seed, fertilizer, irrigation, agrochemicals, labor, education and experience. The value of R square shows that almost 35.2 percent of the variance or changes in the quantity of crop produced are influenced by all the independent variables that are already used in the forecasting of the model. However, 64.8 percent of the changes in production are caused by other factors that are not directly connected with the quantity of crop produced.

Results of the Second Model

The second model investigates the effect of mechanization on income generation in the study area. The model examines the impact of changes in price, production, labor, farmers’ education and farmers’ experience on income generation at the farm level. After running the regression on the data set, the following results were obtained.

Table 7: Effect of Mechanization on Income Generation

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>t</td>
</tr>
<tr>
<td>(Constant)</td>
<td>0.895</td>
<td>0.097</td>
<td>9.230</td>
</tr>
<tr>
<td>Log price</td>
<td>0.121</td>
<td>0.007</td>
<td>17.215</td>
</tr>
<tr>
<td>Log production</td>
<td>0.765</td>
<td>0.020</td>
<td>38.206</td>
</tr>
<tr>
<td>Log labor</td>
<td>-0.017</td>
<td>0.033</td>
<td>-0.513</td>
</tr>
<tr>
<td>Experience</td>
<td>0.003</td>
<td>0.008</td>
<td>0.325</td>
</tr>
<tr>
<td>Education</td>
<td>0.003</td>
<td>0.009</td>
<td>0.367</td>
</tr>
</tbody>
</table>

a. Dependent variable: log income

Table 7 provides some information regarding the changes in income that would occur due to changes in each of the independent variables in the model. The results of the model show that price and production are highly related to income because the coefficient of these variables is highly significant. The other variables, including labor, education and experience, are not related to income at the farm level in the study area.
Table 8: Analysis of Variance (ANOVA)

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>87.749</td>
<td>5</td>
<td>17.550</td>
<td>480.014</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>14.405</td>
<td>394</td>
<td>0.037</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>102.154</td>
<td>399</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent variable: log income  
b. Predictors: (constant), education, log production, log labor, experience, log price

Table 8 shows that the regression model predicts the dependent variable (income) significantly well. The F value is 480.01 and the P-Value is 0.000, indicating that overall the regression model is statistically significant and shows a good fit for the data set.

Table 9: Model Summary

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.927a</td>
<td>0.859</td>
<td>0.857</td>
<td>0.19121</td>
</tr>
</tbody>
</table>

a. Predictors: (constant), education, log production, log labor, experience, log price  
b. Dependent variable: log income

Table 9 shows how much changes in income are explained by changes in price, production, labor, education and experience. The value of R square shows that almost 85.9 percent of the variance or changes in income are influenced by all the independent variables that are already used in the forecasting of the model. However, 14.1 percent of the changes in income are caused by other factors that are not directly connected with income.

**Discussion & Conclusion**

After analyzing the impact of agricultural mechanization on production and income generation in Herat Province, we found that income was higher on mechanized farms than non-mechanized farms. Moreover, the findings of this research show that mechanization has substantially contributed to enhancing the level of agricultural production. However, mechanization had a negative relationship with labor, because in the areas where agricultural technology was used, the local laborers were no longer needed and could not find any other employment opportunities. Analysis of the data showed that mechanization has doubled the income of those farmers who used...
tractors and other farm technology compared to those who did not. Comparing the different districts in the study area, Zinda Jan district benefited the least from agricultural mechanization, while Injil District benefited the most. The findings of the first model in this study, which analyzed production, show that farm size, seed, fertilizer, irrigation and agrochemicals all have a positive relationship with production, which means that an increase or decrease of these inputs will cause an increase or decrease respectively in production. In the second model, which analyzed income, it was found that price and production are highly related to income. However, the other variables, including labor, education and experience, are not associated with income at the farm level in the study area.
References


