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An Econometric Study On Wheat Production in Bhaktapur District, Nepal

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A. Introduction

In recent years the importance of quantifying economic phenomena is being increasingly recognised and "has been readily adopted into the main stream of economics in the form of econometrics."[1]

The application of formal production function concepts in agricultural research is a relatively recent development. The area of analysis was initiated by W. J. Spillman and other pioneer economists and physical scientists in agriculture.[2] One reason for estimating agricultural production function is to provided basic scientific knowledge.

In the past, a few research projects were carried with the aid of production functions. As early as 1958 agricultural economists began to investigate the economic benefits of scientific research in agriculture. But very few studies have been done in this field in Nepal.

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1 Rao, Potburi M. and Miller, Rager L. "Applied Econometries"

2 Heady, Earl. O. and Dillon John "Agricultural Production Functions."

The production function seems to have been first used in Nepal only in the 60s. on the date obtained for the period 1965/66, a study was carried out by the joint collaboration of the Ministry of Economic Planning and the Departments of Economic and Commerce, T. U. to understand the input output coefficients for some cereal crops in five different areas of Nepal.3 They made a study to see the characteristics of physical input–output relationship of cereal grain production for the year 1965/66. The data were cross sectional and the sample size was 1,000 households selected randomly from 50 different districts of Nepal. A Cobb-Douglas production function was fitted to the data for the analysis. The results thus obtained were unacceptable because all the input coefficients were insignificant and unrealistic.

Nepal Rastra Bank also made a micro–level study in this field.4 It tried to analyse the responses of credit facilities and borrowing made by households. It was an extensive study covering 3,195 sample households collected from 22 different districts of Nepal. Data were cross- sectional for the period 1969/70. The main objective of this study was to analyse the demand and supply side of credit and the effect of borrowing activity of farmers' incomes. Cobb–Douglas production function was fitted for all major crops and for the farming, business as a whole and for large, medium and small farms in each of the 22 districts.

The marginal physical productivities were calculated with respect to fertilizers, seeds, manure, pesticides, human labour, bullock labour and irrigation. Data were stratified by district, farm size and crop's variety and the production function were also estimated accordingly. The analysis showed different characteristics of response of inputs for each stratum, regression coefficients were significant and the coefficient of multiple correlation for each crop were indicating strong relationship between input and output.

In another study, Mr. Jagadish Chandra Gautam5 made an attempt to test the hypothesis that there are comparatively few significant inefficiencies in the allocation of resource. Cross–sectional data for the year 1963/69 and sample size 120 households from five village

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3 Ministry of Economic Planning and Department of Economics and Commerce, T. U. Nepal "Physical Input-output Characteristics of cereal grain production for selected agricultural areas in Nepal: crop year 1965/66

4 Nepal Rastra Bank "Agricultural Credit Survey Nepal" Vol 1-iv

5 Gautam, Jagadish Chandra, "Allocative Efficiency of Nepalese Farms: A case study of Rupandehi District".

Panchayats of Rupandehi district were taken and Cobb–Douglas production function with four independent variables viz. land, human labur, bullock labour and capital was fitted. The analysis was made cropwise (wheat and paddy) and also with farm size stratum. In case of wheat, land variable was seen significant and others were insignificant whereas in case of paddy all the coefficients except for capital were found significantly different from zero at the 10 percent level of significance or less. Coefficient of multiple correlation and adjusted coefficient of determination for both crops were quite high to show the strong relationship between the independent variables and dependent variables.

His study tended to support the hypothesis that there are significant inefficiencies in the allocation of resources in traditional agriculture. The overall regression for wheat shows diminishing returns to scale whereas in the case of paddy is shows constant returns to scale.

Mr. Som Prasad Pudasaini[6] made another study in this field. Here he has done a comparative study of traditional and mechanized farming with respect to resource prouductivities, income and employment in Bara District of Nepal. It is also a micro level study. Data were cross for the year 1975 with sample size 102. Eight variables were taken for analysis and Cobb–Douglas production function was fitted to see the characteristics of resources of various inputs concerned.

Coefficients of multiple correlation for both traditional and mechanized farming were high to show the close relationship between inputs and output. The conclusion drawn from the study was that on research activity, both the traditional and mechanized farmers, income could be raised through the increased use of land, human labour, cash expenses on chemical fertilizers and pesticides.

Besides, there are some degree thesis in Economics (submitted to the Department of Economics, T. U. Nepal), which deal on Econometrics. They have analysed and fitted the production functions of maize, wheat, paddy etc. All have used Cobb–Douglas production functions and all the coefficients of multiple correlation are quite high to show the strong relationship between the inputs and output.

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6 Pudasaini, Som Prasad "Resource Productivity Income and Employment in Traditional and mechanized farming: An Empirical Evidence from Bara District, Nepal-1975" Agricultural Development Bank, Nepal.

B. Theoretical Framework:

Production function

Production is a technical process whereby inputs are transferred into output. In other words, production is the result of cooperative effort on the part of various factors of production. Production function is a technical relationship between the quantities of various factors of production or inputs and quantities of output. It describes the maximum output that can be obtained, with an existing state of technbogical knowledge, from given quantities of inputs.[7] A pordtiction function is a schedule (or table, or mathematical equation) showing the maximum amount of output that can be procuced from any specified set of inputs, given the existing technology or state of the art. In short the production function is a catalogue of output possibilites[8].

The production function may be shown as a table or, alternatively, as a mathematical equation. Mathematically it can be expessed as

$$Yt = f\,(Xit,\ X^2t \quad \ldots \ldots \ldots \quad Xnt)$$

Where yt= output, Xit are inputs (i=1,2,......, n) all at time t; and f denotes the functional relationship.

Though production is purely a technical relationship between inputs and output, its study is of great importance in economics. Economics is actually concerned with the most efficient way of using the scarce resources. We are concerned with marginal productivities of various factors of production, marginal rate of substitution, returns to scale, isoguants etc. for the optimum use of inputs. Production function estimation allwos the derivation of these quantities. According to micro economic theory, inputs will be optimally used if the ratio of their marginal productivities is equal to their price. ratio. or

$$fx_1 / fx_2 = Px_1 / Px_2$$

where $fix = \delta y / \delta xi$

Pxi = Price of Xi

$$\text{Then } Fxi / fx_2 = \delta x / \delta x_1 .\ \delta x_2 / \delta y = \delta x_2 / \delta x_1 = Px_1 / Px_2$$

7 Walters, A. A. "Production and cost functions.: An Econometric survey", Econometrica, 1963,

8 Ferguson, C. E. "Microeconomic Theory"

Production function study is of great importance to compare the productivities of resources under various types of technology.

Types of Production Function.

Numerous algebraic equation forms can be used in deriving productions. The best algebraic form should be selected which can explain the actual production process. An infinite number of functional forms are possible in productivity study but those considered in following sections either (a) have logical implication which cause them to "stand out" from the others or (b) have been widely used in production function studies.

Some production functions are examined here,

(i) CES production function : This function was developed by K. J. Arrow, H. B. Chenery, B. S. Minhas, and R.M. Solow. So it is also known as SMAC production function. This function is characterized by a constant elasticity of substitution (CES) with a (constant) value other than 1.

The equation of this function is

$$Y=A\left[\delta x_1^{-P}+(1-\delta)x_2^{-P}\right]^{-\frac{1}{e}}$$

$$(A7O;O<\delta<1;P7-1)$$

This function is linearly homogeneous. X_1 and X_2 are two factors of production. A is the efficiency parameter, δ is the distribution parameter, e is the substitution parameter. It cannot be estimated in linear form.

(ii) **Cobb-Douglas production function** : One specific production function widely used in economic analysis is the Cobb–Douglas production function. This function was formulated by Cobb and Douglas in 1928. They formulated this production function in which sum of the elasticites is equal to one. But the sum of the elasticities equal to one was vehemently criticized by Durand, the restrian that the sum of the elasticities should equal to one has been dropped, and new function which is also known as 'power function' came into existence. The generalised version of this function is

$$Y=Ax_1^{\alpha}x_2^{\beta} \qquad (A>O;\ \alpha,\beta,\geqslant O)$$

A is positive constant, α and β are exponents of the factors of production X_1 and X_2 denoting the respective elasticities. If $x_1 = O$ (or $X_2 = O$), $Y = O$. α and β are assumed to be constant over the production surface. Some of the major features of this function are:

(a) It is homogeneous of degree ($\alpha + \beta$)

(b) In the special case of $\alpha + \beta = 1$, it is linearly homogeneous.

(c) Its isoquants are negatively sloped throughout and strictly convex for positive values of X_1 and X_2.

This production function is linear in logarithmic form. This (linearly homogeneous) CES function. This function has got great merit in that is comprises non linearities of the production process on the one hand and yet benefits from simplifications of calculations from linear relationships by transforming to logs.[9]

(iii) **Quadratic form:**

$$Y = a + b_1X_1 + b_2X_2 - b_3X_1^2 - b_4X_2^2 + b_5X_1X_2$$

It is non–linear and a large number of parameters are to be estimated.

(iv) **Square root form:**

$$Y = a - b_1X_1 - b_2X_2 + b_3X_1^{\cdot 5} + b_4X_2^{\cdot 5} + b_5X_1^{\cdot 5}X^{\cdot 5}$$

(v) $$Y = b_1X_1 + b_2X_2 - b_3X_1^{1.5} - b_4X_2^{1\cdot 5} + b_5X_1X_2$$

(vi) **Transcendental function:**

$$Y = aX_1^{b_1}e^{c_1X_1}X_2^{b_2}e^{c_2X_2}$$

But all these functions are difficult to estimate and comprise smaller degrees of freedom.

9 Klein, L. R. "A text book of Econometrics", New Delhi, 1975

Purpose of present study:

Agriculture plays a significant role in the Nepalese economy. More than 65% of total GDP is produced in agricultural sector and 94.4% of working population is engaged in this sector.[10]

Wheat is the main crop cultivated in the world in both area and quantity. Paddy is the major crop of the east whereas wheat is the major crop of the west.

Wheat is the major winter cereal crop spread widely in the Hills and Terai regions of Nepal and is grown during the months between November and March. The importance of growing winter crops especially wheat was little realized in the past. About two decades back, numbers of farmers in wheat farming has increased considerably during the winter.[11]

In Nepal the total production of wheat and the wheat growing area has been increasing. In particular, Bhaktapur is the major supplier of wheat in Kathmandu valley.

Annual wheat acreage, praduction, productivity in Bhaktapur district and Nepal have been presented in the tables given below.

Table-I

Wheat acreage, production and productivity in Bhaktapur district.[12]

Year	Acreage	Production	Productivity (Mt/Ha)
1967/68	4,200	5,880	1.40
1968/69	4,200	6,510	1.55
1969/70	5,500	8,250	1.50
1970/71	5,800	5.800	1.00
1971/72	6,233	8,477	1.36
1972/73	5,500	9,810	1.78
1973/74	5,500	7,480	1.36
1974/75	5,500	7,480	1.36
1975/76	6,299	7,410	1.24
1976/77	6,461	10,676	1.65

10 Minisry of food, Agriculture and Irrigation, D. F. A.M. S. 1977 "Agricultural Statistics of Nepal"

11 Ministry of food and Agriculture, HMG "Farm Management study in the selected regions of Nepal" 1971.

12 Op. cit. 10

The case of this district is similar to the aggregate national wheat production. The following table shows the annual acreage, production and productivity of wheat production in Nepal.

Table-II

Wheat acreage, production and productivity in Nepal.[13]

(Production : 000Mt)
(Area : 000Hect.)

Year	Acreage	Production	Productivity (MT/Hcet)
1967/68	192	205	1.07
1968/69	208	233	1.12
1969/70	226	265	1.17
1970/71	228	193	0.85
1971/72	239	223	0.93
1972/73	259	312	1.20
1973/74	274	308	1.12
1974/75	291	340	1.17
1975/76	329	387	1.18
1976/77	348	362	1.04
1977/78	360	401	1.11

From the above presented tables, it is obvious that the highest productivity of wheat in national level as well productivity of Bhaktapur districtis is always higher than the national level.

The basic objective of this study was to examine the characteristics of the response of diffe rent inputs: Farmyard manure, Nitrogen nutrient and labour in wheat production. Though the agricultural system of Nepal is a very traditional one; slower change can be observed in the

13 "Ministry of Food, Agriculture and Irrigation, 1978 "Some Agricultural Data of Nepal."

agricultural techniques. Farmers are using wore chemical fertilizers. The use of chemical fertilizers has increasing year by year. Here I have tried to find whether the used doses of chemical fertilizer (nitrogen) are efficient doses or not.

The next input which has been used as fertilizer is farmyard manure (FYM). It is made of the refuse from stables and barnyard together with the dung of their livestocks. So, most of the farmers use it in their farms. Here it has been attempted to see the response of FYM in wheat production whether it has positive effect or not.

The last input is labour. In hilly regions labour is more intensively used. In the context of increasing pressure of population on land, an effort has been made here to see the response of labour in wheat production.

The other inputs are phosphorus, potash, improved seeds, etc. Since the available data on them are only a few and if we include all of them in our production function, the calculation would be more difficult, computation would be more complicated and sophisticated since the computing instrument is not available, I have avoided them all.

The main purposes of this study are

(i) To estimate wheat production function in relation to there inputs FYM, nitrogen and labour in the noted area of Bhaktapur district.

(ii) To examine the response of the inputs to the output of wheat on soil type, land size, land with irrigation facility and doses of nitrogen.

(iii) To test the significance of the effect of the different inputs on output.

However, the concluding analysis of this study may not be generalized in the context of national aggregate level due to two important limitations.

Firstly, the sample used here was taken from a single village Panchayat the Bageshwory Village Panchayat of Bhaktapur district which cannot be said as a representative of the country. The pattern of soil, technique of farming, socio-economic conditions and the modern know- how of wheat farming differ from region to region.

Secondly, the variables used in the present study are few in numbers. To estimate a realistic production function, all the relevant inputs should be included. Here, some inputs are excluded due to several reasons, mainly due to unavailability of data and problem of computation. Affer all it can be said that the conclusions drawn from the analysis of the present study can be helpful in policy suggestions and recommendations for the area which has been covered by this study.

Methodology

This present study is based upon cross-sectional data for the year 1976. The data used here were obtained from ADC (Agricultural Development Council) for Nepal. The data were collected by interviews performing primary field survey by using a random sampling technique.

Bhaktapur, which is one of the three centers in the Kathmandu valley, is situated at a distance of approximately 16 kilometers east of the main capital city. This study was undertaken in one of the 21 village Panchayats which fall under the district boundary of Bhaktapur.

Since the topography of Bhaktapur district can be divided mainly into two regions– hilly region and valley region, Bageshwory village Panchayat was selected for this study mainly for the reason that – it is similar to other Panchayats in the district with respect to soil, productivity, climate, and other socio-economic factors. Moreover it also represents Bhaktapur district in the topographic feature. The sample that has been used here represents the wheat g rowers of Bageshwory Panchayat of Bhaktapur district. 48 farms were taken as sample.

As discussed earlier, the two most popular forms of production function ever to appear in economic literature are the Cobb–Douglas function and the CES function. Since the CES function cannot be estimated in linear form and is difficult to estimate; and the Cobb–Douglas function has got great merit in that it comprises non–linearities of the production process on the one hand and yet benefits from simplifications of calculations from linear relationships by transforming to logs. I have used this production function. It is also convenient to interpret elasticities of production, marginal productivities, returns to scale from this function.

Since only three inputs were considered in the study, the research hypothesis here is **that there is significant statistical relationship between the output of wheat and the selected inputs : famyard manure, chemical fertilizer (nitrogen) and labour.**

Multiple regression on analysis has been applied to explain the relationship between the dependent and independent variables.The correlation between the observed values of Y and the corresponding Y values is shown by the coefficient of multiple correlation, R_2. The coefficient of multiple determination, R^2 indicates the percentage of the variation in the 'n' observed Y values that is explained by the fitted regression equation. Thus it is a measure of the goodness of fit of the estimated regression equation. It is calculated by

$$R^2 = \frac{\text{Regression sums of squares}}{\text{Total sums of squares}}$$

A high R^2 may imply the appropriateness of a regression equation for explaining the movements of a dependent variable, but a low R^2 does not necessarily imply that the regression equation is inappropriate.

When the number of parameters to be estimated is large or, as often happens in production function estimation, the sample size is small, the above calculations tend to overestimate R^2.To take account of this, the adjusted coefficient of multiple determination is calculated by using the following formula :

$$\bar{R}^2 = 1 - (1 - R^2)\frac{n-1}{n-k-1}$$

Where n is the sample size and k is the number of independent variables.

The Cobb-Douglas production function is

$$Q = bo\ FYM^{b1}\ N^{b2}\ L^{b3}\ 10^{k4}$$

Taking Logs, we have

$$\text{Log } Q = \text{Log } bo + b1 \log FYM + b2 \log N + b3 \log L + u$$
$$\text{or } Y = bo^{*} + b_1X_1 + b_2X_2 + b_3X_3 + u$$

we have E (u)=o.

Specifically, the statistical hypotheses are

Null	Alternate
$b_0^{*}=0$	$b_0^{*}>0$
$b_1=0$	$b_1\neq0$
$b_2=0$	$b_2\neq0$
$b_3=0$	$b_3\neq0$

My hypotheses are the alternate hypotheses and these hypotheses are tested by using t-ratios at 0.05 level of significance (otherwise mentioned) which means that hypotheses are tested at 5 percent chance of error.

Analysis of data.

All the variables are measured in physical units; output (Q) in kilograms per hectare, farmyard manure (FYM) in Dokos per hectare, nitrogen (N) in kilograms per hectare and Labour (L) in man days per hectare.

Six different types of models considered were : Model (a) : In this model, data for all observations were used. Then the estimated production function in linear form is

$$\text{Log } Q = 2.157 + 0.090 \text{ Log FYM} = 0.282 \text{ Log N} + 0.133 \text{ Log}^{14}$$

$$\begin{array}{cccc} (\cdot 284) & (\cdot 023) & (\cdot 062) & (\cdot 121) \\ t=7.60^{*} & 3.91^{*} & 4.55^{*} & 1.10^{*} \end{array}$$

Production function in nonlinear form is N=48

$$Q = 143.55 \text{ FYM}^{\cdot 090} \quad N^{\cdot 282} \quad L^{\cdot 133}$$

$R^2 = .58$

$\bar{R}^2 = .55$

Model (b): Here the third independent variable labour has been dropped because it is seen in significant in model.

(a). The estimated production function in linear form is

$$\text{Log } Q = 2.451 + 0.085 \quad \text{Log FYM} + 0.300 \text{ Log N}$$

$$\begin{array}{ccc} (.100) & (.023) & (.060) \\ t=24.51^{*} & 3.70^{*} & 5.00^{*} \end{array}$$

Production function in non-linear from is N=48

$$Q = 282.49 \text{ FYM}^{\cdot 085} \quad N^{\cdot 300}$$

$R^{2*} = \cdot 57$

$\bar{R}^2 = .55$

14 Values given in the parentheses are standard errors of coefficients.

* indicates significant at 0.05.

Model (c): In this model soil type A and B have been considered. Out of 48 observations only 7 had soil type A or B. The production function in linear from is

$$\text{Log } Q = 2.183 + 0.025 \text{ Log FYM} + 0.490 \text{ Log N}$$

	(.228)	(.045)	(.145)
t=	9.57*	0.56*	3.38*

Production function in non-linear form is

$$Q = 152.41 \text{ FYM}^{.025} N^{\cdot 490} \qquad N=7$$

$$R^2 = .87$$

$$\bar{R}^2 = .81$$

Model (d): In this model, the observations relating to the irrigated farms have been taken. There were 28 irrigated farms out of 48.

The estimated production function is

$$\text{Log } Q = 2.353 + 0.103 \text{ Log FYM} + 0.354 \text{ Log N}$$

	(.143)	(.029)	(.084)
t=	16.45*	3.55*	4.19*

The production function in non-linear form is

$$Q = 225.42 \text{ FYM}^{.103} N^{.354} \qquad N=28$$

$$R^2 = .66$$

$$\bar{R}^2 = .63$$

Model (e): In this model, the production function was fitted to the data on farm size greater than or equal to 0.051 hectare. There were 41 such observations out of 48. The production function in linear form is

$$\text{Log } Q = 2.471 + 0.077 \text{ Log FYM} + 0.287 \text{ Log N}$$

	(.096)	(.024)	(.057)
t=	25.75*	3.21*	5.04*

Production function in non–linear form is

$$Q=295.80\ FYM^{.077}\quad N^{.287}$$

N=41

R^2 =59

$\bar{R}^2$ =56

Model (f): In this model production function was fitted to the data on the doses of nitrogen used greater than ore equal to 100 kgs per hectare. There were 10 such observations out of 48. The estimated production function in linear form is

$$\text{Log } Q=2.076+0.120\ \text{Log FYM}+0.447\ \text{Log } N$$

(.622)	(.044)	(.298)
t=3.34*	2.73*	1.50*

N=10

R^2 =.63

$\bar{R}^2$ =.52

Major Empirical Findings

From the analysis of data, t-ratios for the regression constants "bo*s" were found significant which indicates that output is positively effected by inputs. So I accept the alternate hypothesis that bo > O

Model (a) : Here, two inputs FYM and nitrogen are significant at .05 level. But the third input labour is insigificant output of wheat.

So for b_1 and b_2 I accept the alternative hypothesis that b_1 #O, b_2 #O; for b_3 I accept the null hypothesis b_3 =O

In this model all the three inputs FYM, nitrogen and labour have positive coefficients indicating lesser use of these inputs that what is required. FYM and nitrogen inputs are positively significant at .05 level but the third input labour is not significant even at .20 level. This may have happened due to :

(i) Land is fixed, but the population is increasing. There is no diversification of labour from agriculture to other jobs. So the increased population also is engaged in agriculture. Hence the amount of labour needed is already maximized.

(ii) Wheat generally does not need much of labour as in maize or paddy. It is the winter crop, so we should not serve it more. The extra labour also might have been unnecessarily used in wheat farming is found to be insignificant.

The average output and inputs per hectare and MPP of inputs are found as

$\bar{Q}$=1855.45 Kgs/hectare

$\overline{FYM}^{*}$=76.96 Dokos/hectare

$\bar{N}$ =54.04 Kgs/hectare

$\bar{L}$ = 230.63 mandays/hectare

MPP_{FYM} = 1.59 Kgs
MPP_{N} = 7.08 Kgs
MPP_{L} = 0.78 Kgs

The actual dose of nitrogen used is too low. The recommended doses of nitrogen for wheat is 100 kgs to 150 kgs per heactare depending upon soil type and seeds. But the average dose of nitrogen applied here is only 54.04 kgs per hectare.

Model (b) : Since labour is seen insignificant in model (a), in this model attempts are made to study the response of only two inputs FYM and nitrogen. The results are almost same as drawn in the first model. Hence the conclusions drawn in the first model represent the second model also. The average output and inputs per heactare are also same as in model (a) only marginal productivities are different.

MPP_{FYM}=1.49 kgs
MPP_{N} = 7.58 kgs

Model (c) : This model tried to study the response of FYM and nitrogen to output in the first two types of lands namely A and B. There are four different types of land classified roughly according to the fertility and irrigation facilities. they are 'Abbal', 'Doyam', 'Sim', and 'Chahar'. They are generally written as A, B, C and D respectively. There were only 7 observations out of 48 having A or B type of land.

In this model t-value for the FYM coefficient is positive but insignificant, and its elasticity is also less than in model (b). The main reason behind this is that since the land types are generally classified according to the soil fertility, A and B types land contain more of the natural nutrient, humus and organic matter required for the crops. From FYM also we get the same nutrients. What we get from FYM is already present there in such types of land. If we apply more than necessary, then it will have no significant effect upon output. Coefficient of nitrogen is positive and significant. Elasticity of nitrogen is greater than in model (b) showing that nitrogen is more needed in such types of land.

Average and marginal productivities found in this model are :

$\overline{Q}$ =1538.66 Kgs/hect

$\overline{FYM}$ =151.36 Dokos/hect

$\overline{N}$ = 86.81 Kgs/hect

MPP_{FYM}=0.26 Kgs

MPP_{N}=8.68 Kgs

Here all the averages are higher than in model (b). It is observed that the MPP of nitrogen is higher but that of FYM is lower. This decrcase in MPP of FYM may be due to excess use of it as explained above.

Model (d) : This model is restricted to the study of responses of FYM and nitirogen to the wheat production in the irrigated farms only. Out of the total sample size 48, there were only 28 samples having irrigation facilities. In this model the coefficients of FYM and nitrogen are positive and significant. The elasticities of both of them are also greater than in the second model. The average and marginal productivities were found as

$\overline{Q}$=1518.55 Kgs/hect

$\overline{FYM}$=82.22 Dokos/hect

$\overline{N}$=60.60 Kgs/hect

MPP_{FYM} =1.91 Kgs

MPP_N =8.87 Kgs

All the averages and marginal productivities are greater than in the second model. Irrigated farms give higher productivities.

Model (e): In this model, studies are made only in such land whose size is greater than or equal to 0.051 hectare. Coefficients of FYM and nitrogen are both positive and significant. The elasticities of FYM and nitrogen are less than in model (b). This may be due to that though we increase FYM and nitrogen, there may be labour defficiency in large farms in proportion to other inputs. In Nepal, we see that land is concentrated among size groups with insufficient supply of family labour, and labour among groups where the compliment land input is insufficient. Since most of the hill farmers depend upon family labour, therefore inadequacy of labour is frequently felt with the large size of holdings. Hence, the average production will also decline as farm size increases. From the analysis, we get

$\overline{Q}$ =1276.01 Kgs/hect

$\overline{FYM}$ =75.86 Dokos/hect

$\overline{N}$ =50.91 Kgs/hect

MPP_{FYM} =1.30 Kgs

MPP_N =7.20 Kgs

All the averages and MPPs are lower than in the second model where all sizes of farms are taken together. So, the average and marginal productivities will be higher in farm sizes less than .051 hectare.

Model (f): This model is depicted to the study of the responses of FYM and nitrogen to the output of wheat in the farms where nitrogen was used equal to or greater than 100 Kgs per hectare. Thare were 10 such observations out of 48. The coefficients of FYM and nitrogen are positive to show the positive relationship with output. The coefficient of FYM is found to be significant, but that of nitrogen is insignificant. The main cause behind this is that since the recommended doses of nitrogen for wheat production is 100 Kgs to 150 Kgs per hectare, the increment in nitrogen (when its dose is 100 Kgs per hectare) though increases output, but not significantly. The excess use of an input than necessary does not increase the output significantly. From the analysis, we get:

$\bar{Q}$ =2065.38 Kgs/hect

$\overline{FYM}$=269.15 Dokos /hect

$\bar{N}$ =131.52 Kgs/hect

MPP_{FYM}=0.92 Kgs

MPP_N=7.02 Kgs

The sum of the elasticities (exponents) of the particular production function give us the idea about returns to scale to that function. Since the sums of the elasticities in all models range from .36 to .57 and they are always less than 1, there is decreasing returns to scale operating in wheat production. Each of the elasticities is less than 1 in every model, it shows diminishing marginal productivitity of each and every input.

Recommendations:

The conclusions drawn from the analysis will be helpful in policy suggestions in particular for the area covered by the present study. Some rec mmendations can be made as follows:
(a) The mechanization of Nepalese agriculture is growing. The use of chemical fertilizers is also increasing but at a slower rate. Since the elasticity of nitrogen input is positive, quantity of nitrogen used is smaller than what is required technologically. Hence, the farmers should be asked to use greater amount of chemical fertiilzers and its use should be directed towards such fertilizers which contain more nitrogen nutrient. The concerning departments and agencies should facilitate the farmers to get required amount of chemical fertilizers in appropriate time.

The labour is seen insignificant. This might be due to excess supply of labour in wheat production. So labour should be diversified from wheat production to other crops and other jobs.

(b) The effect of FYM is also found significant. It is because FYM has a long-term effect upon the soil, it has been used from the very beginning. From it we get natural nutrient, humus and organic matter required for the crop, so it is effective. But the method of making FYM is yet traditional. The appropriate recommendation in this regard is that scientific methods of compost making should be tought to the the farmers by the Department of Agriculture through J. T. and J. T. As. It can have more effect upon output.

(c) In A and B type land, elasticity of nitrogen is greater than in the general model. It means such type of lands need more nitrogen. So larger doses of chemical fertilizer (here nitrogen) should be applied in such lands.

(d) Since the average productivity in irrigated farms is higher than the general model, so the farms should be irrigated. Also, since the elasticities and marginal productivities of FYM and nitrogen should be increased in irrigated farms, their dose is not in sufficient amount. Increase in their dose in irrigated land in particular could raise productivity.

(e) In large sized farms, average output and inputs used are seen less than in model (b) where all types of farms have been taken. So, the average output will be higher in small sized farms. In this aspect, two lines of thinking can be raised for the recommendation :

(i) Either more even distribution of land ownership should be brought about, and/ or

(ii) Farming should be mechanized by using tractors. For the first recommendation, proper evaluation of present land reform programme should be made which is a time consuming research. Therefore, for immediate purposes, the mechanization of farms appears to be a sound recommendation. Farmers should be initiated towards the use of two-wheeled tractors, since four wheeled tractors use is not feasible in hilly region. For this, farmers should be financially helped.

(f) When using more nitrogen, one should be careful about applying it more when its dose has already reached 100 Kgs per hectare.

Appendix

Table I

Regression constants and coefficients.

	b_0	b_1	b_2	b_3
Model (a)	143.55 (.284)	.090 (.023)	.282 (.062)	.133 (.121)
Model (b)	282.49 (.100)	.085 (.023)	.300 (.060)	
Model (c)	152.41 (.228)	.025 (.045)	.490 (.141)	
Model (d)	225.42 (.143)	.103 (.029)	.354 (.084)	
Model (e)	295.80 (.096)	.077 (.024)	.287 (.057)	
Model (f)	119.12 (.622)	.077 (.044)	.287 (.298)	

Table-II

Coefficients of correlation and determiniation

	R^2	R	$\bar{R}^2$
Model (a)	.58	.76	.55
Model (b)	.57	.76	.55
Model (c)	.87	.93	.81
Model (d)	.66	.81	.63
Model (e)	.59	.77	.56
Model (f)	.63	.79	.52

1 Figures in the parantheses indicate errors of the parameters.

Teble III

Marginal physical products (Kgs)

	FYM	N	L
Model (a)	1.59	7.08	0.78
Model (b)	1.49	7.58	7.58
Model (c)	0.26	8.68	
Model (d)	1.91	8.87	
Model (e)	1.30	7.20	
Model (f)	0.92	7.02	

Teble IV

Average production and inputs

(physical units per hectare)

	$\overline{Q}$	$\overline{FYM}$	$\overline{N}$	L
Model (a)	1355.45	76.96	54.04	230.63
Model (b)	1355.45	76.96	54.04	
Model (c)	1538.66	151.36	86 81	
Model (d)	1518.55	82.22	60.60	
Model (e)	1276.01	75.86	50.91	
Model (f)	2065.38	269.15	131.52	

Table V

Production functions

Model (a)	$Q=413.55\ FYM^{.090}$	$N^{.282}$	L^{133}	n=48
Model (b)	$Q=282.49\ FYM^{.085}$	$N^{.300}$		n=48
Model (c)	$Q=152.41FYM^{.025}$	$N^{.490}$		n=7
Model (d)	$Q=225.42\ FYN^{.103}$	$N^{.354}$		n=28
Model (e)	$Q=295.80\ FYM^{.077}$	$N^{.287}$		n=41
Model (f)	$Q=119{\cdot}12\ FYM^{.120}$	$N^{.447}$		n=10