CHAPTER - III

MATERIALS AND METHODS

This chapter deals with the methodology adopted for achieving the objectives of the present study. It provides an insight to source of data collection, statistical analysis and the statistical tools employed. The methodology section for the study entitled "Groundnut Production Dynamics during Pre and Post-Liberalization Eras: A case of Gujarat" is discussed under the following heads.

3.1 Source of data and reference period

3.2 Period of study

3.3 Statistical Analysis

3.1 Source of data and reference period

Since groundnut crop is one of the major crops of Gujarat state as well as a whole, it has become necessary to capture the trends underlying the components of groundnut crop production. Accordingly, time series analysis, has been utilized to determine the underlying patterns in data collected over time. It is used to detect patterns of change in statistical information over regular intervals of time to arrive at an estimate for future period (Harvey, 1981). The parameters of area, production, productivity, cost of cultivation, FHP, MSP, profitability and income measures parameters have been subjected for time series analysis. The necessary data were collected from 1980-81 to 2015-16 and trend equations were fitted to examine the pattern of growth dimensions. First of all, percentage analysis was carried out to study the performance of the growth dimensions. Subsequently the components of trend factor, cyclical factor, seasonal factor and irregular variation were attempted.

Various crop production techniques introduced under the umbrella of Green Revolution in the mid-1960s made a major impact on raising the aggregate crop output in India. It is beyond confirmation that the agricultural sector has performed impressively in terms of increasing productivity and intensity of cultivation since Green Revolution (Jose, 2008). Post Green Revolution, irrigation availability has doubled and cropping intensity has increased significantly across the country. This

may be due to the decision of the government to accord high priorities to agriculture by making large investments in irrigation projects, agricultural research and extension (Bhalla, 2009).

The data were collected from various reports of the Cost of Cultivation of Principal Crops (CCPC) project of the Department of Agricultural Economics, Junagadh Agricultural University, Junagadh and from the various reports and publications of the Commission for Agricultural Costs and Prices (CACP), Ministry of Agriculture and Farmers' Welfare (MoAFW), Government of India.

3.2 Period of study

Considering the availability of data for area, production, productivity, cost of cultivation, FHP and MSP of Groundnut crop from 1980-81 to 2015-16 from various sources, the entire study period was categorized into three different sub-periods as follows.

1. Pre-Liberalization Period (1980-81 to 1991-92)

2. Post-Liberalization Period was split into two sub-periods and are as follows

a. Post-Liberalization Period - I (1992-93 to 2003-04)

b. Post-Liberalization Period - II (2004-05 to 2015-16)

3. Overall Period (1980-81 to 2015-16)

3.3 Statistical analysis

The statistical analysis was carried out for showing the trends in area, production, productivity, FHP, MSP, profitability, cost of cultivation and income measures. The percentage analysis of growth dimensions of groundnut crop, descriptive statistics and trends in growth dimensions of groundnut crop in Gujarat state for the study period were carried out. In addition, the components of trend factor and cyclical factor was analysed by using Growth rate and Fourier methods, respectively.

Resource use efficiency was also carried out using Cobb-Douglas production function. The best model for estimating MVP was identified using stepwise backward elimination method. The results were presented in the stepwise regression and

backward elimination and the contribution of regressors towards change in returns per unit area.

3.3.1 Growth rates

Growth rate can be defined as the rate of change per unit time (Mohan and Sunny, 1993). It is used to measure the past performance of the economic variables in question and describe the trends in those variables over time. The normal statistical procedure to obtain a measure of growth dynamics of crops over a period is to postulate a hypothetical function which would adequately describe the series of economic variables over time and estimate their parameters. Growth rate is generally expressed in two forms, *viz.*, linear and compound. The linear form is obtained by fitting a straight line to the yearly data and estimating the parameters. The compound growth rate is obtained by fitting a straight line to the logarithms of the data and estimating the slope of the line (Acharya *et al.,* 2012).

The growth dynamics of groundnut crop in the present study has been estimated by using both linear and compound growth rates.

3.3.2 Linear growth rate

The linear growth rate is estimated using the following form,

$$Y = a + b_t + u \tag{1}$$

Where,

Y = dependent variable (Area/ Production/ Productivity/ FHP);

t = time variable in years, 1, 2, 3 . . . n;

a = intercept;

b = regression coefficient;

u = random error term.

The parameters of '*a*' and '*b*' were determined through least squares method. Generally, trend is a quantitative description of the central tendency of past values. It is a smooth, regular, long-term movement of the data showing the tendency to increase or decrease over a long period. For the analysis of secular trend linear growth

equation will be utilized in the study. Thereby, the linear growth rate analysis fulfilled the purpose of analyzing both growth rate and secular trend.

At the same time, the slope of a linear trend is a fixed value per unit time period. But over long span of time this is an inadequate description. A time series increasing by a constant percentage has the growth properties of compound growth rate. Thereby a compound growth rate function of the following form was also fitted in the present study to analyze the growth dimension under question.

3.3.3 Compound growth rate

The compound growth rate was estimated as follows,

$$Y_t = Y_0 (1+r)^T e^u \tag{2}$$

Where,

Y_t = dependent variable (Area/ Production/ Productivity/ FHP);

Y_o = initial value;

T = time variable in years, 1, 2, 3 . . . n;

u = random error term.

For the purpose of estimation, the equation was expressed in logarithmic form,

$$\ln Y_t = \ln Y_0 + T \ln (1+r) + u \tag{3}$$

Which can be further expressed as,

$$Y_t = a + bT + u \tag{4}$$

Where,

Y_t = $\ln Y_t$

a = $\ln Y_0$

b = $\ln (1+r)$

It could be observed that the semi log function is linear in parameters. The compound growth rate (r) in percentage is then computed using the relationship,

r = [(Anti ln of ln b)-1] X 100　　　　　　　　　　　　　　　　　**(5)**

3.3.4 Cyclical variations

Apart from secular trend, which is determined using linear growth rate, it is also possible for a trend to have seasonal, irregular and cyclical components. Among which, seasonal variation can be defined as respective and predictable movement around the trend line in one year or less. In order to detect seasonal variation, time intervals must be measured in small units, such as days, weeks, months or quarters (Pangayarselvi *et al.,* 2015). But since, yearly data is used in the present study, it is impossible to estimate seasonal variations. Coming to irregular variations, they are accidental in nature (like floods, fires, earthquakes, revolutions, epidemics, strikes and many other natural and man-made calamities) which may cause changes in growth dimensions and are unlikely to be repeated. Thereby, it is also not in the purview of the study to measure such irregular variations in context of growth dimensions. The only possible thing left to estimate is cyclical variation and it is measured using Fourier analysis.

Cyclical variation is one of the components of a time series data that tends to oscillate above and below the secular trend line for periods longer than one year. In this study, Fourier analysis is used to capture this cyclical factor (Fox, 1958) by using Harmonic model.

The Harmonic model is applied to the actual data in order to detect the presence of any long term cycles (Fox, 1958). In order to test the length of the cycle, Fourier coefficients need to be computed. Given a time series $X_1, X_2, X_3, ... X_n$ with a period of length T, the deviations of the actual value from the trend value is represented as,

$$Y_t = 1/2\,A_0 + \sum_{j=1}^{n}\left(A_j\,Cos\,\frac{360j}{T} + B_j\,Sin\,\frac{360j}{T}\right)$$

(6)

Where,

Y_t　　=　dependent variable (Area/ Production/ Productivity/ FHP);

t　　=　time variable in years, 1, 2, 3 . . . n;

A_0, A_j and B_j are constants and are given by,

$$A_0 = \sum_{t=1}^{n} \frac{X_t}{N} \tag{7}$$

$$A_j = \frac{2\left[\sum_{t=1}^{n} X_t \, Cos\left(\frac{360j}{T}\right)\right]}{N} \tag{8}$$

$$B_j = \frac{2\left[\sum_{t=1}^{n} X_t \, Sin\left(\frac{360j}{T}\right)\right]}{N} \tag{9}$$

It is more convenient to group the data as shown below for investigating a given period P, where mP was equal to N or the nearest integer below N.

X_1	X_2	...	X_P
X_{p+1}	X_{p+2}	...	X_{2P}
$X_{(m-1)(p+1)}$	$X_{(m-1)(p+2)}$	...	X_{mP}
Sums $\quad U_1$	U_2	...	U_P

$$\tag{10}$$

If a term of period 'P' is present in the series, the column total ($U_{j, j=1,2,..p}$) indicate the periodic effects, but if the remaining element is random, the effect of summing 'm' rows reduce the relative contribution of that element to the column totals. Similarly, if there are other elements with different periods, they are out of phase in successive rows and tend to cancel out in the totals. Hence, if there are enough rows, the total (U_j) reveals the periodic effects and reduces marking effects, if any, resulting from random components or oscillatory components of different periods, which prevent discernment of the periodic effect in the primary series. The Fourier coefficients A_P and B_P are computed with the following formulae,

$$A_P = \frac{2\left[\sum_{j=1}^{P} U_j \, Cos\left(\frac{360j}{P}\right)\right]}{mP} \tag{11}$$

$$B_P = \frac{2\left[\sum_{j=1}^{P}\left(U_j \, Sin\left(\frac{360j}{P}\right)\right)\right]}{mP}$$

(12)

The squares of the amplitude R_P^2 are obtained by adding Fourier coefficients A_P^2 and B_P^2. Hidden periodicities are found out by periodogram analysis. The procedure for testing the periodogram involves in computing the square of this amplitude (R_P^2). If no periodic fluctuations are observed, then mean square amplitude for a random series without periodic fluctuations is arrived at by,

$$R_m^{\;2} = \frac{4\sigma^2}{N}$$

(13)

Where,

$$\sigma^2 \quad = \quad \text{variance of the series } X_t$$

Then the indicator of the cycle, K will be calculated as follows,

$$K = \frac{R_P^2}{R_m^{\;2}}$$

(14)

3.3.5 Instability in production

In order to examine the sources of instability, the area and yield data for groundnut crop are detrended (Hazell, 1982) using linear equation of the following form:

$$\mathbf{Z_t = a + b_t + u_t} \tag{15}$$

Where,

$\quad Z_t \quad = \quad$ dependent variable (Area/ Productivity);
$\quad a \quad = \quad$ intercept;
$\quad b \quad = \quad$ parameter to be estimated;
$\quad t \quad = \quad$ time variable (in years);
$\quad u_t \quad = \quad$ error term with usual assumptions.

After detrending, the residuals are centered on the mean area or yield for each period z, resulting in detrended time series data of the form:

$$\mathbf{Z = u_t + \bar{z}} \tag{16}$$

Time series data on detrended production for groundnut crop are then calculated as the product of the detrended areas and yields.

Further, variance of production is decomposed into its constituent sources *viz.* area variance, yield variance, area-yield co-variance and higher order interaction area and yield to examine the source of instability.

Let Q denote production, A the area sown and Y, yield. Then for groundnut crop

$$V(Q) = \bar{A}^2 \, V(Y) + \bar{Y}^2 \, V(A) + 2 \, \bar{A}\bar{Y} \, \text{Cov}(A, Y) - \text{Cov}(A,Y)^2 + R \qquad \textbf{(17)}$$

Where,

$$
\begin{aligned}
V(Q) &= \text{production variance;} \\
\bar{A} &= \text{mean area;} \\
\bar{Y} &= \text{mean yield;} \\
V(Y) &= \text{yield variance;} \\
V(A) &= \text{area variance;} \\
\text{Cov}(A,Y) &= \text{Area – yield co–variance;} \\
\text{Cov}(A, Y)^2 &= \text{Higher order co-variance between area and yield;} \\
R &= \text{Residual.}
\end{aligned}
$$

The above equation is not only a function of variances of yields and areas sown, but also the mean area and yield of co-variance between areas and yields. Clearly, a change in any one of these components would lead to a change in V (ʋ) between two periods of time.

The change in variance of production $\Delta V(Q)$ can be decomposed as given in the following equations 18 to 22.

Methods of decomposition of the changes in variance of production is carried out by constructing a method to partition the changes in variance of production (V(Q)) between the first and the second periods into its constituent parts.

As shown in Eq. (17), the variance of production, V(Q) can be expressed as,

$$V(AY) = \bar{A}^2 \, V(Y) + \bar{Y}^2 V(A) + 2 \, \bar{A}\bar{Y} \, \text{cov}(A, Y) - \text{cov}(A, Y)^2 + R$$

Using Eq. (17), variance of production in the first period is

$$V(P_1) = \bar{A}_1^{\,2} \, V(Y_1) + \bar{Y}_1^{\,2} \, V(A_1) + 2 \, \bar{A}_1\bar{Y}_1 \, \text{cov}(A_1,Y_1) - \text{cov}(A_1, Y_1)^2 + R_1 \qquad \textbf{(18)}$$

and in the second period is

$$V(P_2) = \bar{A}_2^{\,2} \, V(Y_2) + \bar{Y}_2^{\,2} \, V(A_2) + 2 \, \bar{A}_2\bar{Y}_2 \, \text{cov}(A_2, Y_2) - \text{cov}(A_2, Y_2)^2 + R_2 \qquad \textbf{(19)}$$

Each variable in the second period can be expressed as its counterpart in the first period plus the change in the variable between the two periods, *i.e.*,

$\bar{A}_2 = \bar{A}_1 + \Delta\bar{A}$

$\bar{Y}_2 = \bar{Y}_1 + \Delta\bar{Y}$

$V(A_2) = V(A_1) + \Delta V(A)$

$V(Y_2) = V(Y_1) + \Delta V(Y)$

$\text{Cov}(A_2, Y_2) = \text{Cov}(A_1, Y_1) + \Delta \text{Cov}(A_1, Y_1)$

Eq. (19) can, therefore, be rewritten as

$V(P_2) = \{\bar{A}_1 + \Delta\bar{A}\}^2 \{V(Y_1) + \Delta V(Y)\} + \{\bar{Y}_1 + \Delta\bar{Y}^2\}\{V(A_1) + \Delta V(A)\} + 2\{\bar{A}_1 + \Delta\bar{A}\}\{\bar{Y}_1 + \Delta\bar{Y}\}\{\text{cov}(A_1, Y_1) + \Delta\text{cov}(A, Y)\} - \{\text{cov}(A_1, Y_1) + \Delta\text{cov}(A, Y)\}^2 + \{R_1 + \Delta R\}$ **(20)**

Which can be expressed as

$V(P_2) = \bar{A}_1^2 V(Y_1) + \Delta\bar{A}^2 V(Y_1) + 2\bar{A}_1\Delta\bar{A} V(Y_1) + \bar{A}_1^2\Delta V(Y) + \Delta\bar{A}^2\Delta(Y)$

$\quad + 2\bar{A}_1\Delta\bar{A}\Delta V(Y) + \bar{Y}_1^2 V(A_1) + \Delta\bar{Y}^2 V(A_1) + 2\bar{Y}_1\Delta\bar{Y} V(A_1) + \bar{Y}_1^2\Delta V(A)$

$\quad + \Delta\bar{Y}^2\Delta V(A) + 2\bar{Y}_1\Delta\bar{Y}\Delta V(A) + 2\bar{A}_1\bar{Y}_1 \text{cov}(A_1, Y_1)$

$\quad + 2\bar{A}_1\Delta\bar{Y}\text{cov}(A_1, Y_1) + 2\bar{Y}_1\Delta\bar{A}\text{cov}(A_1, Y_1) + 2\Delta\bar{A}\Delta\bar{Y}\text{cov}(A_1, Y_1)$

$\quad + 2\bar{A}_1\bar{Y}_1\Delta\text{cov}(A, Y) + 2\bar{A}_1\Delta\bar{Y}\Delta\text{cov}(A, Y) + 2\bar{Y}_1\Delta\bar{A}\Delta\text{cov}(A, Y)$

$\quad + 2\Delta\bar{A}\Delta\bar{Y}\Delta\text{cov}(A, Y) - \{\text{cov}(A_1, Y_1)\}^2 - \{\Delta\text{cov}(A, Y)\}^2$

$\quad - 2\text{cov}(A_1, Y_1)\Delta\text{cov}(A, Y) + R_1 + \Delta R$ **(21)**

The change in variance of production, $\Delta V(P)$ is then obtained by subtracting Eq. (18) from Eq. (21). Thus,

$\Delta V(P) = V(P_2) - V(P_1) + \Delta\bar{A}^2 V(Y_1)$

$\quad + \bar{A}^2 V(Y_1) + 2\bar{A}_1\Delta\bar{A} V(Y_1) + \bar{A}_1^2\Delta V(Y) + \bar{A}^2\Delta V(Y)$

$\quad + 2\bar{A}_1\Delta\bar{A}\Delta V(Y) + \bar{Y}^2\Delta V(A_1) + 2\bar{Y}_1\Delta\bar{Y} V(A_1) + \bar{Y}_1^2\Delta V(A)$

$\quad + \bar{Y}^2\Delta V(A) + 2\bar{Y}_1\Delta\bar{Y} V(A) + 2\bar{A}_1\Delta\bar{Y}\text{cov}(A_1, Y_1)$

$\quad + 2\bar{Y}_1\Delta\bar{A}\text{cov}(A_1, Y_1) + 2\Delta\bar{A}\Delta\bar{Y}\text{cov}(A_1, Y_1) + 2\bar{A}_1\bar{Y}_1\Delta\text{cov}(A, Y)$

$$+ 2\overline{A}_1\Delta\overline{Y}\Delta \text{ cov } (A,Y) + 2 \overline{Y}_1\Delta\overline{A} \Delta\text{cov } (A,Y)$$

$$+ 2 \Delta\overline{A} \Delta\overline{Y}\Delta\text{cov } (A,Y) - \{\Delta \text{ cov } (A,Y)\}^2$$

$$- 2 \text{ cov } (A_1, Y_1) \Delta \text{ cov } (A,Y) + \Delta R \tag{22}$$

Similarly, the decomposition of the change in variance into ten components can also be given in the form of the following table 3.1.

Table 3.1 Components of Change in the Variance of Production

Change in mean yield	$\Delta\overline{Y}$	$2 \overline{A}_1 \Delta\overline{Y}\text{cov } (A_1,Y_1) + \{ 2\overline{Y}_1 \Delta\overline{Y} \Delta (\Delta\overline{Y})^2 \}$ $V (A_1)$
Change in mean area	$\Delta\overline{A}$	$2\overline{Y}_1 \Delta\overline{A}\text{cov } (A_1,Y_1) + \{2 \overline{A}_1 \Delta\overline{A} \Delta (\Delta\overline{A})^2 \}$ $V (Y_1)$
Change in yield variance	$\Delta V (Y)$	$\overline{A}_1^2 \Delta V (Y)$
Change in area variance	$\Delta V (A)$	$\overline{Y}_1^2 \Delta V (A)$
Interaction between changes in mean yield and mean area	$\Delta\overline{A} \Delta\overline{Y}$	$2 \Delta\overline{A} \Delta\overline{Y}\text{cov } (A_1,Y_1)$
Change in area–yield covariance	$\Delta \text{ cov } (AY)$	$\{2 \overline{A}_1 \overline{Y}_1 - 2 \text{ cov } (A_1,Y_1)\} \Delta \text{ cov } (A,Y) \Delta \{ \Delta \text{cov } (A,Y)\}^2$
Interaction between changes in mean area and yield variance	$\Delta\overline{A} \Delta V (Y)$	$\{2 \overline{A}_1 \Delta\overline{A} \Delta (\Delta\overline{A})^2 \} \Delta V (Y)$
Interaction between changes in yields and area variance	$\Delta\overline{Y} \Delta V (A)$	$\{2 \overline{Y}_1 \Delta\overline{Y} \Delta (\Delta\overline{Y})^2 \} \Delta V (A)$
Interaction between changes in mean area and yield and changes in area–yield covariance	$\Delta\overline{A} \Delta\overline{Y}$ $\Delta \text{ cov } (A)$	$(2 \overline{A}_1 \Delta\overline{Y} \Delta 2 \overline{Y}_1 \Delta\overline{A} \Delta 2 \Delta\overline{A} \Delta\overline{Y}) \Delta \text{ cov } (A,Y)$
Change in residual	ΔR	$\Delta V (AY) - \text{Sum of the other components}$

3.3.6 Cost of Cultivation

The data pertaining to the cost of cultivation of groundnut crop are those which are generally adopted in the farm management studies. The various cost concepts (Kuthe, 2012) being used by agricultural economists while analysing the data are as follows,

(a) Cost A includes,

1. Value of hired human labour;

2. Value of hired and owned bullock labour;

3. Value of hired and owned machine labour;

4. Value of seed (both farm seed and purchased);

5. Value of manures (owned and purchased);

6. Cost of fertilizers;

7. Plant protection charges (insecticide/pesticide);

8. Irrigation charges;

9. Land revenue;

10. Interest on working capital;

11. Miscellaneous expenses;

12. Depreciation.

Generally, family labour is charged at the rate of hired labour charges prevailing in the region. Owned bullock labour is taken on the basis of hire rate prevailing in the village.

(b) Cost B = Cost A + interest on value of fixed capital (excluding land) + rental value of owned land

(c) Cost C_1 = Cost B + imputed value of family labour.

(d) Cost C_2 = Cost C_1 + 10 per cent of cost C_1 as managerial charges.

3.3.7 Profitability analysis

The study used the cost of cultivation data during 1980-81 to 2015-16 and worked out profitability analysis of groundnut crop. The CACP uses different cost concepts for estimating costs and returns. In the present study, the cost C_2 is considered for computing profitability. The cost C_2 in CACP data covers all the variables and fixed costs. To see how the costs and returns have changed in real terms, costs are deflated by the Consumer Price Index for Agricultural Labourers (CPIAL) with 1986-87 as base year (Narayanamoorthy, 2013). The profitability is computed as the gross value of output (VOP) minus cost C_2 and in the form of income measures, such as:

(i) Profitability = VOP - Cost C$_2$ (23)

(ii) The income measures:

1. Farm business income = Gross return - Cost A_1

2. Owned farm business income = Gross return - Cost A_2

3. Family labour income = Gross return - Cost B

4. Net income = Gross return - Cost C_2

5. Intensive income=Net income + Rental value of owned land+ Interest of fixed capital

6. Farm investment income = Farm business income - Imputed value of family labour.

3.3.8 Resource use efficiency

Resource use efficiency refers to how efficiently the resources are utilized in production of groundnut. The resource use efficiency was worked out in the following steps

1. The data was made to stationary

2. Analysis was carried out

3. Stepwise regression and backward elimination.

Cobb-Douglas production function was used to estimate the effects of various inputs in the production of groundnut in consultation with the previous studies. Data pertaining to the entire study period (i.e. 1980-81 to 2015-16) concerning all the variables of CACP data which are likely to have an impact on groundnut production

was taken in the analysis. All the variables were expressed in monetary terms. To determine the contribution of the technical factors in the production process, the following model specification was applied:

$$Y = a\, X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} X_6^{b_6} X_7^{b_7} X_8^{b_8} X_9^{b_9} e^u \tag{24}$$

Where,

Y	=	gross returns from production (Rs./ha)
X_1	=	family labour cost (Rs./ha);
X_2	=	hired human labour cost (Rs./ha);
X_3	=	bullock labour (Rs./ha);
X_4	=	seed cost (Rs./ha);
X_5	=	chemical fertilizer cost (Rs./ha);
X_6	=	manures cost (Rs./ha);
X_7	=	insecticides / pesticides cost (Rs./ha);
X_8	=	irrigation cost (Rs./ha);
X_9	=	other cost (Rs./ha);
b_1 to b_9	=	parameters to be estimated;
U	=	error term.

For the purpose of estimation, the equation was transformed in the logarithmic form,

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + U \tag{25}$$

However, the production model specification as given in equation 25 will be of use only when the equation is stationary.

In the absence of stationarity, the estimated relationship may be spurious without any significant meaning. The relationship is also expected to hold good when the model specification is found stationary at the same level of differencing. All the components of the model specification were first checked for stationarity by using Augmented Dicky-Fuller (ADF) unit-root test. The test was applied after running the regression of the following form:

$$Y_t = \alpha_0 + \delta\, Y_{t-1} + \alpha_I \sum \Delta Y_{t-i} + \varepsilon_t \tag{26}$$

Where,

Y_t = Price of a commodity in a given market at time 't';

$\Delta Y_{t-i} = Y_{t-1} - Y_{t-2}$;

ε_t= Pure white noise error-term.

Y_t refers to the gross returns from groundnut production as well as all the technical factors involved in groundnut production which were all expressed in Rs./ha.

Specification of Variables

Dependent variable

The gross returns from groundnut production obtained in rupees per hectare was taken as dependent variable.

Independent Variables

Family Labour Cost (X_1)

Family labour are employed to perform farm operations and it has been duly represented in CACP data. That is why, in this model family labour cost was included as one of the contributing variables X_1.

Hired Human Labour Cost (X_2)

This input was expressed in terms of man days of eight hours each. It includes the cost of all hired human labour utilized for performing crop production activities right from preparation of land to threshing.

Bullock Labour Cost (X_3)

Bullock labour used for different farm operations has been considered as a separate variable and its cost has been measured in Rs./ha. A pair day refers to eight hours of work by one pair of bullocks and the cost incurred for bullock labour is referred to as bullock labour cost.

Seed Cost (X_4)

The cost incurred in buying the seeds of groundnut from the market it has been measured in Rs./ha.

Chemical Fertilizers Cost (X_5)

The cost incurred in the purchase of chemical fertilizers for effective growth of groundnut crop has also been expressed in Rs./ha.

Manure Cost (X_6)

Manure has been considered as a separate explanatory variable. This variable is measured in physical units and expressed in Rs./ha. This variable is measured in cartloads and one cartload refers to the quantity of manure in one bullock cart.

Plant protection Cost (X_7)

This input has been expressed in Rs./ha. It included cost of all plant protection chemicals that were used from sowing to before harvesting operations.

Irrigation Cost (X_8)

This includes the cost of irrigation that is used for application in the field to the groundnut crop.

Other Cost (X_9)

This variable cost included all the managerial costs incurred in cultivation of groundnut crop.

The best model was identified using stepwise regression and backward elimination method. Using backward elimination method the least contributing variable was removed and again a Cobb-Douglas production function was fitted. In this way, the adjusted R^2 could be improved to a higher value. This procedure was repeated and ultimately, the best model for prediction was identified based on maximum value of adjusted R^2.

Calculation of Returns to scale

Returns to scale indicates what would happen to output if all inputs were increased simultaneously. The sum of b_i is then used as an indicator of return to scale. The constant, increasing and decreasing return to scale occur when the sum of coefficients equal to 1, > 1 and < 1value, respectively (Mushunje and Belete, 2001). The 't' test for return to scale was computed by the following formula.

$$T = (\sum b_i - 1) / \text{Std. Error of } \sum b_i \qquad \qquad \textbf{(27)}$$

Where,

$\sum b_i$ = Sum of elasticities

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Calculation of resource use efficiency

To accomplish the objective of profit maximization for efficient allocation of resources, one should use more of the variable resource so long as the value of the added production is greater than the cost of the added amount of the resource used in producing it. The standard way to examine such efficiency is to compare marginal value product (MVPs) with marginal factor costs (MFCS) of each variable input. Resource use efficiency of an input is calculated using the basic economic formula;

MVP/MFC=1 **(28)**

The resource is considered to be efficiently used as well as profit will be maximized when the ratio of MVP to factor MFC approaches one, if in other words MVP and MFC for each input are equal. If the ratio is greater than 1, the resource is underutilized and the gross return could be increased by using more of the resource and if it is less than 1, the resource is overutilized and the excess use of resource should be decreased to minimize the loss (Taru, 2008).

Decision rule

If r = 1, resource is efficiently utilized;

r> 1, resource is underutilized;

r< 1, resource is overutilized.

When marginal physical product is measured in monetary term then it is called Marginal Value Product (MVP). But in this model, MVP is estimated in terms of an additional BDT invested on individual inputs. According to Dhawan and Bansal (1977), the useful estimate of MVP is obtained by taking the geometric mean of the resources (x_i) as well as the gross return. MVP is calculated by multiplying the coefficient of a given resource with the ratio of the geometric mean (GM) of gross return to the GM of the given resource. Thus,

$\text{MVP}(x_i) = b_i \cdot (Y / X_i)$ **(29)**

Where,

b_i = Regression co-efficient;

Y = Mean value (GM) of gross return in BDT;

Xi = Mean value (GM) of different resources in BDT

i = (1, 2, 3…………..n)

GM = Geometric mean

The equation can also be written as;

dY/dXi = bi. (Y / Xi)   **(30)**

Where,

dY/dXi = slope of the production function = Marginal Value Product (MVP).

Since, all the inputs and outputs were expressed in monetary terms, the acquisition cost of the inputs was taken as one BDT. The criteria used here to assess the resource allocation efficiency are to test the MVPs against MFC (Heady and Dhillon, 1988).

The efficient production was represented by an index value of 1.0, while lower values indicate a greater degree of inefficiency. The ratio based on the estimated regression coefficients were used to estimate the relative efficiency of resource use (r)

r =MVP/MFC   **(31)**