In the earlier chapters different elements of physical and cultural environment, their spatial distribution and their impact on agricultural land utilization was assessed. In the chapter these relationship are further studied and analysed applying quantitative techniques like simple correlation, multiple regression and time series analysis. It would have been impossible to handle a large volume of data consisting of fifteen variables and one hundred seventy five observations without the help of Computer.

The problem of choosing the right size of sample, however, is a little more complicated. The simplest rule is that the larger the size of sample, the more likely it is to give a reliable picture of the parent population. As a further rough guide, it can be said that the size of sample should be at least 5 per cent to 15 percent of the total for satisfactory results. The decision on defining parent population and choosing the best sampling method, however, depend to a large extent on commonsense (M.Husain, 1996, pp 207).(Map - 6.1)

**Systematic Sampling**

In this method, a regular pattern of selection is made instead of choosing each individual separately. This method is also known as quasi-random. For instance, if study of crop combination is to be made in 2000 villages of an areal unit and 20 sample villages are to be selected, the villages should be given a serial order, every hundredth village of the list be chosen. The required sample villages will be reached quickly. If used sensibly, systematic sampling can often be more convenient than true random sampling and can be
equally effective. This method, though helpful in making quick and effective sampling, however, suffers from the setback of subjectivity as each village of the area does not have an equal chance of being included in the sample (M. Husain, 1996, pp 210).

Map - 6.1

In order to investigate the associations between land use types on the one hand and physico-cultural elements on the other, following fourteen variables – X1 to X6 dependent and X7 to X14 independent—were carefully selected from the set of available variables:
X1- Net sown area (NSA) (Percentage of total area)
X2- Grass (Percentage of total area)
X3- Rice (Percentage of NSA)
X4- Pulses (Percentage of NSA)
X5- Hill Millets (Percentage of NSA)
X6- Cash crops (Percentage of NSA)
X7- Irrigated area (Percentage of NSA)
X8- Accessibility
X9- Owner Cultivators (Percentage of total agricultural workers)
X10- Density of population
X11- Slope > 3° (0-50 Meters per Kilometer)
X12- Slope > 6° (50-100 Meters per Kilometer)
X13- Slope < 6° (More than 100 Meters per Kilometer)
X14- Distance from coast
X15- Distance from major stream.

Among the independent variables, distance from coast indirectly represents the variations in the slope, rainfall distribution and soil types. It is assumed that degree of slope and amount of rainfall increase as the distance from coast increases. This is backed by the fact that all the isohyets are almost parallel to the coast line (Fig.2.6). Thus, this variable in fact represents the rainfall pattern. Secondly increasing distance from coast also means change of relief from low land coastal plain to low divides and low plateaus, broad open valleys to hilly rugged areas. It, therefore, reflects the variations in climate as well as in relief. Another variable, distance from the major stream, is defined in order to bring out the variations in the land use with changes in the slope characteristics and soils across the river valleys. Two more variables of slope types represent ‘relief’ factor. The amount of slope in degrees was obtained from the available Survey of India
District planning map showing different categories of slope was prepared. This slope map was superimposed on the map showing physical regions and proportion of the area of physical region under a particular category of slope was obtained by GIS software GRAAM ++ CSRE, IIT BOMBAY. The variables irrigated area and accessibility in terms of distance from nearest town and route length per unit area, are included to estimate the relations between these two economic elements and the landuse types. Lastly the variables like population density and proportion of owner cultivators may throw light upon the impact of social factors upon land use.

**Correlation analysis**

Using the 175 x 15 data matrix ‘Pearsons product moment correlation coefficients’ were calculated. Students’t’ test was applied to determine significant ‘r’ values at 0.05 and 0.01 levels of significance. The results obtained (Table No.6.1) reveal certain significant associations between the selected variables which are summarized as follows:

**NSA**

The area under cultivation (NSA) is strongly influenced by the ‘relief’ factor. It has a positive correlation with slope > 3° (r = 0.10). It is obvious that the gently sloping lands and rolling plains would offer maximum scope for cultivation and in the hilly terrain with slopes (slope > 6°), there is very small proportion of total area available for cultivation (r = -0.10) and slopes more <6° does not appears significant. The NSA also decreases with the distance from coast (r = 0.52) as the terrain changes from low lying coastal plain to hilly rugged areas from coastal gentle slope to hilly rugged
areas steep slope. Distance from the major stream has no significant correlation with NSA indicating that NSA is independent of locations in the valleys or on the divides. The economic factors irrigation ($r = 0.10$) indicates positive correlation and accessibility ($r = -0.50$) have negative correlations with NSA meaning thereby that increase in the irrigation would offer scope for bringing more area under cultivation as expected and NSA does not influenced by accessibility. Lastly, the increase in NSA is associated with owner cultivators ($r = 0.21$) but the population density decreases with increase in NSA. This perhaps can be explained by the fact that with increase in size of holding the proportion of labour increases and relatively the proportion of owner cultivators decreases.

**Grass**

The distribution of grass is strongly affected by the nature of terrain which is indicated by a positive correlation with slope $> 3^0$ ($r = 0.34$) and a negative correlation with slope $< 6^0$ ($r = -0.04$). In the study area it is observed that the lands unsuitable for cultivation area given to grass, a fact which explains its positive correlation with slope $> 3^0$ and negative correlation with slope $< 6^0$ and also with distance from stream. Distance from coast ($r = 0.14$) influence the distribution of grass. The area under grass decreases in more accessible, and irrigated areas ($r = -0.24$ and $r = 0.02$ respectively). Population density is low in the grass concentration areas though the proportion of owner cultivators ($r = 0.13$) is observed to be higher.
Rice

The concentration of rice in the western coastal plain of the district is indicated by its association with slope > 3° (r = 0.59) and distance from coast (r = 0.41). Irrigation and accessibility both have a negative correlation with rice suggesting that due to heavy rainfall rice does not need irrigation and the accessibility in the hilly tracts is poor. Correlation of rice with density of population is weak (r = 0.06). The proportion of owner cultivators is higher in the rice growing areas indicated by positive correlation (r = 0.19). Significant negative correlations of rice with cash crops indicate that rice is not significantly grown in association with these crops.

Pulses

The area under pulses increases with the increasing distance from the coast (r = 0.30). This correlation suggests that pulses are concentrated in low moderate slope areas. Pulses are grown on the gently sloping lands below 6° of slope (r = 0.24). Irrigation and accessibility are also associated with pulses, but the proportion of owner cultivators decreases (r = -0.01) as the size of holding becomes larger away from the coast. Pulses and cash crops are positively correlated with each other while grass and rice show a negative correlation. Pulses and grass do not show any significant relation.

Hill Millets

The area under hill millets increases with the increasing distance from the coast (r=0.35), the distance from coast influences the spatial distribution of Hill Millets significantly. Hill Millets exhibits similar relationship as that of Pulses with slope elements, irrigation,
cultivators and population density. The location of Hill Millets on plateaus and hilly tracts instead of on the better land near the streams, is reflected in a positive correlation between Hill Millets and distance from stream \( (r = 0.19) \). Like in Hill Millets, pulses are associated positively with cash crops and negatively with grass and rice.

**Cash Crops**

The spatial pattern of cash crops is positively influenced by a single factor i.e. irrigation \( (r = 0.24) \) with respect to the relief factors, area under cash crops increases with increase in areas with gentle slopes below \( 3^0 \) \( (r = 0.33) \) and decreasing distance from coast \( (r = 0.28) \). It decreases in the steeply sloping hilly areas \( (r = -0.37 \text{ for slope } > 6^0) \). Improved accessibility also has some bearing on increase in the proportion of cash crops \( (r = 0.27) \). The proportion of owner cultivators is less in the areas where cash crops are important \( (r = -0.44) \) a fact which indicates that there is intensification of agriculture. The cash crops are positively related to the density of population \( (r = 0.18) \), again indicating the significance of labour inputs in intensive agriculture.

The correlation analysis provides a basic structure which can be used for identification of useful quantitative technique to be used for a more precise explanation of the spatial variations in landuse. The above analysis brings out clearly the importance of physical factors like slope and distance from coast and economic factors like irrigation and accessibility as major factors influencing the landuse patterns. The increasing proportion of cultivators in the hilly tracts with low NSA and the decreasing proportion of owner cultivators in the irrigated areas with cash crops are clearly brought out. However, the distance from major streams which differentiates
between valley locations and divides location does not show any significant relationship with the landuse variables.

**Multiple Regression**

In geographical research analyzing the degree of correspondence between different spatial patterns ‘regression model’ is a very valuable technique which helps to understand the functional relationships between variables. One variable is considered to be ‘dependent’ upon one or several other variables. Here, multiple regression model is used to obtain the degree of association between the agricultural landuse variables (X1 to X6) (dependent) and the physical and socio-economic variables (X7 to X15) (independent), which were mentioned in the correlation analysis. The multiple regression model used is:

\[ Y = a + b_1 \times X_1 + b_2 \times X_2 + b_3 \times X_3 + \ldots + b_m \times X_m + e \]

Where

- \( Y \) = dependent variable
- \( X_1 \ldots X_m \) = independent variables
- \( a \) = constant or \( Y \) intercept
- \( b_1 \ldots b_m \) = regression coefficients

In all six multiple regression equations were derived in order to estimate the influence of physio-socio-economic variables on the location of agricultural landuse in 175 sample villages of the district defined earlier. The partial correlation coefficients derived indicate the inter correlation of one independent variable with the dependent variable, with all other independent variables held constant. Thus, these coefficients indicate the relative importance of each independent variable in explaining the total
variance. The significance of the individual multiple regression coefficients was tested at 0.01 and 0.05 levels of significance. Lastly the level of ‘explained variation’ indicated by $R^2$ was calculated. The results of the analysis are summarized as follows:

1. Dependent variable X1 NSA
   Independent variables X7 to X15

   Among the variables included in the regression set distance from coast appears to be very important, followed by slope $> 3^0$ and population density. The coefficient is negative for the variable slope $> 6^0$. Slope above $< 6^0$ and distance from stream are not significant though they are included in the regression set. About seventy eight per cent of the variation is explained by the five above mentioned variables. Though the correlation analysis reveals significant relationship of NSA with all variables (except distance from stream) only five variables included in the regression set and only three were observed to be significant in explaining the occurrence of NSA. However, the economic factors having significant positive correlations with the NSA as revealed by correlation analysis do not occur in the regression set.

2. Dependent variable X2 Grass
   Independent variable X7 to X14

   The occurrence of grass is strongly influenced by distance from coast and slope $> 3^0$. Regression coefficients for both are negative. The factors distance from stream and slope $> 3^0$ are less important in the regression set. These four variables account
for about fifty three per cent of the total variation. Like NSA, grass also has significant correlation (‘r’ values) with all the remaining variables except distance from stream but only four were considered important enough to be included in the regression set. Though grass has a strong positive correlation with slope $< 6^0$, in the regression analysis the effect of slope $< 6^0$ upon grass is not that significant. The economic factors which have significant negative correlations with grass do not occur in the regression set.

3. Dependent variable X3 Rice
   Independent variables X7 to X15

   The occurrence of rice is explained by six independent variables. Of these ‘b’ coefficients for three i.e. slope $< 6^0$, distance from stream and slope $> 6^0$ are important. Regression coefficients for the coast are not significant and thus, the contribution of the variables owner cultivators, distance from coast and irrigated area to the total variation is not important. The total variation explained by six variables is about sixty per cent. The correlation analysis reveals that distance from coast has a strong negative correlation and distance from stream does not have a significant relation with rice. However, in the regression analysis distance from stream, explaining the location of rice confined to valleys appears to be more important than the distance from coast.

4. Dependent variable X4 Pulses
   Independent variables X7 to X14
Four variables in the regression set explain the occurrence of Pulses. The only variable which contributes significantly to the total variation explained is distance from coast. The regression coefficient for the remaining variable i.e. slope > $6^0$ irrigated area, and slope < $6^0$ are not significant indicating their lesser importance. About sixty five per cent of the total variation is explained by these four variables. Slope > $6^0$, which has a very strong positive correlation with Pulses does not appear that significant in this regression analysis. Another interesting relationship is between irrigation and pulses which is positive in correlation analysis but because of the combined effect of other variables it has become negative in the multiple regression analysis.

5. Dependent variable X5 Hill Millets
   Independent variables X7 to X14

The variables slope < $6^0$ distance from stream and distance from coast are more or less equally important in explaining the occurrence of Hill Millets as indicated by the respective partial correlation coefficient values. Other variables like slope > $6^0$ and population density are less important. The total variation explained is rather low at twenty six per cent. Hill Millets does not have very strong correlation with other variables as indicated in the correlation analysis, though some important relationships are singled out in the regression analysis. Hill Millets has a positive correlation with the distance from coast as revealed by correlation analysis, but the regression coefficient slopes negatively.
6. Dependent variable  X6 Cash Crops
Independent variables X7 to X14

The regression coefficient for five variables in this case is significant. Only for the variable distance from stream 'b' is not significant. The contribution of the variable irrigated area is most important in explaining the occurrence of cash crops followed by population density. Slope $< 6^0$, distance from coast and owner cultivators. The total variation explained is about sixty eight per cent. The correlation coefficient for distance from coast and accessibility are nearly equal but in the regression set accessibility has not been included. Besides, the correlation coefficient is positive for distance from coast and negative for distance from stream but the regression coefficients are negative and positive respectively.

The application of multiple regression model to explain the influence of various factors upon agricultural landuse reveals that among the set of selected independent variables, by and large, the variables related to physical environment like slope $> 6^0$, slope $< 6^0$, distance from coast and distance from major stream appear to be more important than the factors chosen to represent the socio-economic environment like irrigated area, accessibility, proportion of owner cultivators in the total agricultural workers and population density. Only in the case of cash crops the most important variable contributing to the total explained variation is irrigated area. In this particular case other variables like population density and proportion of owner cultivators are also important.

In five of the six equations, the 'b' coefficient for distance from coast is significant and the partial correlation coefficient also
indicate its importance as an explanatory variable. The variables slope > 6° and slope < 6° have significant ‘b’ coefficient in three cases each where as the distance from stream appears to be a less important explanatory variable with significant ‘b’ coefficient in only two equations. Among the socio-economic variables ‘accessibility’ was not found to be important enough to be included in the regression set at ninety five per cent level. Thus, it does not appear in any of the regression equations.
Time Series Analysis

“A time series may be defined as a collection of readings belonging to different time periods, of some economic variable or composite of variables.” (Ya-lun Chou)

Trend, by secular trend or simply trend we mean the general tendency of the data to increase or decrease during a long period of time. This is true of most of the series of business and economic statistics. An upward tendency would seen in data pertaining to population, agricultural production etc.(S.C.Gupta)

General Landuse

Trend lines for general landuse explains average situation of landuse types and future condition, trend line for forest cover decreases continuously. The area under forest has declined since 1981, and it predicts that it may gradually decline in the district. While trend line for area under non agricultural uses shows increases in the area, means over all trends towards more land brought under non agricultural uses i.e. residential, industrial etc. Trend line for barren and uncultivable land also decline means this category of land goes to other purposes i.e. non agricultural uses. Other uncultivable area does not shows significant changes. There is slightly upward moving in the net sown area. Trend line for area sown more than once shows significant growth, it is a positive sign that intensification in agriculture may increase in the next period. Gross cropped area does not show significant growth.
General Landuse Trend Lines

1. Forest (Percentage to total geographical area)
   \[ y = -0.1378x + 37.694 \]

[Graph showing the trend line for area under forest cover]

2. Area Not Available for Cultivation
   Area under Non-Agricultural Uses (Percentage to total geographical area)
   \[ y = 0.1348x + 7.3987 \]

[Graph showing the trend line for area under non-agricultural uses]
3. Area Not Available for Cultivation
Barren and uncultivable Land (Percentage to total geographical area)
y = -0.1676x + 7.0966

4. Other Uncultivated Cultivated Land
(Percentage to total geographical area)
y = -0.1206x + 12.098
5. Fallow Land (Percentage to total geographical area)
\[ y = -0.045x + 3.1029 \]

6. Net Sown area (Percentage to total geographical area)
\[ y = 0.3364x + 32.73 \]
7. Area Sown more than once (Percentage to total NSA)
   
   \[ y = 0.1601x + 0.609 \]

![Trend Line for Area Sown More than Once](image)

8. Gross Cropped Area (Percentage to total geographical)

   \[ y = 0.4963x + 32.849 \]

![Trend Line For Gross Cropped Area](image)
Agricultural landuse and Trend lines

Several crops are grown in the region, trend lines for the position of various crops in past and present help us for future prediction. There is decrease in the area under cereals. Area under pulses to net sown area has slightly increased. Area under total food grain does not shows significant growth. Trend line for cash crops continues to increase, this is a good sign. The area under fruits and vegetables may increase in near future. Trend line for the area under total food crops does not increase but there is a slight decline. Area under non food crops i.e. grass shows slight increase.

Agricultural Landuse Trend Lines
1. Rice (Percentage of Net Sown Area)
   \[ y = -0.5799x + 49.943 \]
2. Ragi (Percentage of Net Sown Area)
   \[ y = -0.1464x + 7.2587 \]

3. Vari (Percentage of Net Sown Area)
   \[ y = -0.0295x + 4.1075 \]
4. Total Cereals (Percentage of Net Sown Area)

\[ y = -0.7603x + 62.207 \]

![Trend Line for Cereals to NSA](image)

5. Total Pulses (Percentage of Net Sown Area)

\[ y = 0.0611x + 3.9635 \]

![Trend Line for Total Pulses to NSA](image)
6. Total Food grain (Percentage of Net Sown Area)
   \[ y = -0.6976x + 65.538 \]

7. Fresh fruits and Dry fruits (Percentage of Net Sown Area)
   \[ y = 0.2141x - 0.0492 \]
8. Total Vegetables (Percentage of Net Sown Area)
\[ y = 0.0349x + 0.9876 \]

9. Total Food Crops (Percentage of Net Sown Area)
\[ y = -0.4489x + 66.979 \]
10. Total Oilseeds (Percentage of Net Sown Area)
   \[ y = -0.0034x + 1.2547 \]

![Trend Line for Oilseeds to NSA](image)

11. Grass /fodder (Percentage of Net Sown Area)
   \[ y = 0.4593x + 31.025 \]

![Trend Line for Grass (fodder) to NSA](image)
12. Total Non food crops (Percentage of Net Sown Area)

\[ y = 0.4487x + 32.568 \]

![Trend Line for Non-Food Crop to NSA](image)

**Results of Quantitative Analysis**

Three different methods viz., the analysis of simple correlation, multiple regression and time series analysis were used. The analysis of simple correlation, multiple regression for finding out the correlation between characteristics of variation in the landuse and socio-economic as well as physical factors was done. Time series analysis for the temporal analysis of general and agricultural landuse in the district was also carried out. The results of these analysis indicate a strong influence of factors of physical environment on the spatial variations in agricultural landuse and time series analysis indicates the temporal changes in landuse pattern and help to predict the future condition with forecasting trends. The entire analysis for spatial data was based on the sample village observation based on the systematic sampling. And for the temporal analysis of landuse data from 1981 to 2009 was used. The results of the correlation analysis and multiple regression bringing...
out the importance of these factors of physical environment can be considered.

The time series analysis has brought out the temporal changes of general and agricultural landuse. Forecasting trend lines helps to predict the future situation of various crops and changes in landuse categories in the district. Landuse types viz. Area under forest cover tend to decline in the near future. It is shown from the trend line that land use for non-agricultural purposes increase in the future. Trend line for area sown more than once has increased since last twenty five years and it means increasing intensification of agriculture.