CHAPTER: 1
INTRODUCTION
INTRODUCTION

1.1 Statement of problem:

Water management is the activity of planning, developing, distributing and managing the optimum use of water resources. In an ideal world, water management planning has regard to all the competing demands for water and seeks to allocate water on an equitable basis to satisfy all uses and demand. This is really possible in practice.

Water is one of the most important inputs essential for the production of crops. Plants need it continuously during their life and in huge quantities. It profoundly influences photosynthesis, respiration, absorption, translocation and utilization of mineral nutrients and cell division besides some other processes. Both its shortage and excess affect the growth and development of a plant directly and consequently, its yields and quality. Rainfall is the cheapest source of natural water supply for crop plants. In India, however, rainfall is notoriously capricious, causing floods and droughts alternately. Its frequency distribution and amount are not in accordance with the needs of the crops. Artificial water supply through irrigation on one occasion and the removal of excess water through drainage on another occasion, therefore become imperative, if the crops are to be raised successfully. Water management in India, thus comprises irrigation or drainage or both, depending considerably on the environmental conditions, soil, crops and climate. It is a situation oriented entity.

Water affects the performance of crops not only directly but also indirectly by influencing the availability of other nutrients, the thing of cultural operations, etc. Water and other production inputs interact with one another. In proper combinations, the crop yields can be boosted manifold under irrigated agriculture.

Water is a costly input when canals supply it. The construction of dams and reservoirs, the conveying of water from storage points to the fields, the operating and the maintaining of canal systems involve huge expense. The misuse of water leads to the problems of water logging, salt imbalance, etc. thus rendering agricultural land unproductive. Hence a proper appreciation of the relationship among soils, crop, climate and water is essential for an efficient and economic utilization of water resources for maximum crop production.

Taking the total geographical area of the country at about 328 million hectares and the average annual rainfall at about 112 cm, the total annual precipitation in the country is
estimated at about 3,700,000 million cubic meters. The south westerly monsoon contributes over 80% of the total precipitation in the country. The central water and power commission, New Delhi, has estimated that of the total annual precipitation amounting to about 800,000 million cubic meters seeps into the ground, about 1,700,000 million cubic meters flows into the rivers and the remaining amount of about 1,200,000 million cubic meters evaporates back into the atmosphere.

The water, flowing on the surface and that seeping into the ground, thus forms the two major sources of water for irrigating crops –

(a) Surface water resources and

(b) Ground water resources.

(a) **Surface water resources** – A large number of rivers of various potentials and discharges are spread all over the country. The rivers in the north, which originate from the Himalaya are snow fed and, thus, have less seasonal fluctuation in their flow than the rivers in other parts of the country. The flow in the rivers of the central and southern parts of the country depends entirely upon the monsoon. The rivers flow to the full during the rainy season (July to September) and their flow dwindles with the approach of summer.

The surface flowing water needs to be trapped flowing in ponds, tanks, lakes or artificial reservoirs when it is available in abundance so that it can be fruitfully used for irrigation during the rainless period to meet the water needs of crops. Of the annual surface flow of 1,700,000 million cubic meters, only about 666,000 million cubic meters can be utilized for the purpose of irrigation owing to the physiographical limitations.

(b) **Ground water sources** – Substantial supplies are also available from ground water resources. Of the 800,000 million cubic meter of rain water that seeps into the ground annually, about 430,000 million cubic meters of it is absorbed by the surface layers of the earth’s crust and, thus, can be utilized directly by the vegetation in the process of evapotranspiration and growth. The remaining 370,000 million cubic meters of rain water percolates deep into the porous strata of the earth’s crust, representing the gross annual enrichment of the underground water. This ground water is tapped by digging or drilling shallow or deep wells and is lifted by using mechanical devices for irrigating the crops.

The scientific utilization of water resources for crop production involves the consideration of the suitability of land and water for irrigation and then the planning of crops and water management practices commensurate with them. Water management practices include irrigation and drainage. Irrigation comprises three fundamentals, viz. When to
irrigate, how much to irrigate and how best to irrigate. Likewise drainage comprises there fundamentals: how much to drain, how best to drain and how rapidly to drain under a given situation of soil, water and crops.

1.2 Objectives of the study:

The study possesses following objectives:

I. To find out the socio-economic characteristics of farms and farmers of the sample villages.

II. To study the spatial pattern of irrigated area

III. To observe the landform condition of the area helping in water management

IV. To elaborate the soil water system and suitability of soil for irrigation

V. To examine the role of climate in water management practice

VI. To observe the quality of irrigation water

VII. To find out how the planning performances are performed for water management

VIII. To uncover the problems and to suggest the policy measures for the practice of water management

1.3 Data Base:

The data base has been collected from two sources, (a) primary and (b) secondary.

The term primary data refers to the statistical materials where the investigation originates for the purpose of the enquiry in hand. As for example if the researcher desires to conduct an enquiry into different aspects of water management and if the facts pertaining to this enquiry are collected by the investigator from the agricultural fields by interviewing the farmers and other related personals then such data would be termed as primary data.

The term secondary data on the other hand refers to those statistical materials which are not originated by the investigator herself. But which she obtains from someone else’s records. Thus if instead of obtaining the data from the farmers and relevant authorities the researcher gets them from the records of the Government and other offices. These data will be called secondary data.

The difference between the primary and secondary sources of data is largely one of degree. Data which are primary in the hands of the researchers may be secondary in the hands of another. Thus the data collected for agricultural practices are primary to the annual reports
of the principal agricultural office, but to a person who makes use of these data for further research they will be termed secondary.

The researcher collected primary sources of data which are basic for the study. She collected data regarding caste background, educational status of the farmers, sex wise family members and amount of ownership holding of individual farmers, then she collected data regarding land utilization of individual farmers. The technological factors which are used by them are also derived from the farmers like the net irrigated area, source wise irrigated area etc. Side by side of it the quantity used and costs involvement of different technological factors are also taken care of. The data regarding cropping pattern and production, productivity of different crops are also collected from individual farms. Labour is an important factor for the cultivation of crops because the cost of cultivation largely depends on labour factor, that is why the researcher considered the man days and cost of labour for both family and hired labour. Although two basic component of water management are irrigation and drainage, however the marketing and consumption factors of agricultural and consumption factors of agricultural crops deserved worth mentioned which may indicate the amount of profit and the consumption character of agricultural operations. All this items are collected of individual forms from different farmers. These are the data collected from individual farmers.

The secondary sources of data have been collected from different books, booklets, pamphlets, research papers, annual reports, census hand book, district gazetteer and alike aspects. These are collected from different Government offices related to the water management. As for example, Block, Sub-Division and Principal agricultural office, canal and minor irrigation office etc. From these sources different data related to environmental, technological, institutional, infrastructural and socio economic characteristics of farms and the farmers are obtained.

1.4 Methodology

The total work has been done in three steps:

(i) Pre field work
(ii) Field work
(iii) Post field work

In the pre field work the researcher studied different aspects of water management from different books and reports as it is provided in the literature survey. Then from these studies she formulated questionnaires.
The procedure of field methodology involves three steps (a) field reconnaissance (b) framing and testing the trial questionnaire and (c) final questionnaire.

(a) Field reconnaissance
At first the researcher visited a large number of mouzas/villages of the study area. She has observed the nature of physical configuration, changes of soil types, nature of drainage condition and other physical aspects of the study area. She had initiated several group discussions about different problems of water management with the farmers, belonging to different socio economic classes of the villages. She also discussed the problems with the field staff of canal irrigation, operators of dip tube well, assistant and executive engineer (irrigation) and with other relevant technical personal. She had further discussions about the above mentioned problems with the block development officers, sub-divisional officers, district magistrate and other relevant administrators of Birbhum district.

(b) Framing and testing trial questionnaire
The researcher, after consulting her supervisor prepared the trial questionnaire. This questionnaire contains the questions regarding irrigation, drainage and other aspects of water management of the region. The questions were set on the nature of water management for agricultural development.

The researcher faced some problems while administering these questionnaires. Some questions were so straight forward that the respondents hesitated to answer them. Sometimes the answers were either false or only partially correct. Some of the questions were not properly framed, so both the researcher and respondent were puzzled by them.

(c) Final questionnaire.
On the basis of the first responses of the villagers the trial questionnaires have been suitability altered. The questions are made easy to understand. In this way, the trial questionnaires have been made.

The final questionnaire consists of two sets of questions. The first set includes the questions on the name and different socio economic background of the head of the farms. Then questions on land use irrigation and its beneficial and harmful effects on drainage, flood, soil erosions etc. questions are formulated. Then the questions regarding crop wise area, production cost of technological and labour factors, marketing of crop are framed.
The second set includes the questions regarding planning of water management. As for example the length, depth of inlet and outlet of water channels, the nature and configuration of farm lands, different implements for draining out surplus water, irrigation quantity, number of times duration and depth are taken. The questions on rotation of irrigation, water quality, soil texture infiltration capacity are formulated. Then the questions are on root system, life span of crop, need and availability of irrigation, critical period with respect to moisture, market value of crops.

Then questions regarding width and height of bunding, nature of irrigation and drainage channels, land drainage, spacing of irrigation and drainage channel, tolerance of different crops, availability of dew, depth of irrigation water, gap of days for irrigation etc. are framed. This questionnaire has been tested in the field and accordingly the nature of questions was modified in order to obtain perfect and correct information from the field. Before doing field work the researcher had identified five sampled villages for her investigation. After considering the irrigation and drainage practices in the study area. In this context she considered five villages from the study area by means of purposive samples. Because the purpose is to organize water management practices by means of best way or irrigation and drainage. From each village 50 farmers have been interviewed. These farmers have different sizes of land ownership which can be found out from the following table:

Table 1: Nature of land ownership according to size classes of landholdings

<table>
<thead>
<tr>
<th>Nature of land (Ownership)</th>
<th>Size of land (amount in area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big farmer</td>
<td>more than 10 acres</td>
</tr>
<tr>
<td>Medium farmer</td>
<td>7.5-10 acres</td>
</tr>
<tr>
<td>Low medium farmer</td>
<td>5-7.5 acres</td>
</tr>
<tr>
<td>Small farmer</td>
<td>2.5-5 acres</td>
</tr>
<tr>
<td>Marginal farmer</td>
<td>less than 2.5 acres</td>
</tr>
</tbody>
</table>

Source: Report of the Planning Commission, 1951

The number of farmers chosen for interviewing in each category after considering their numerical strength. In this way the sample villages and small farms are selected.

After preparing the final questionnaire the researcher visited the villages one by one and in each village she interviewed 50 farmers of different categories of land holding one by one.

In post field work a master table has been prepared with all the questions of the questionnaire in the column and name of the farmers in the rows. Therefore the entire master
table of a village will indicate different agricultural characteristics of farmers and farms individually. The master table is then processed statistically because the figures in this master table are size and scale biased which are not suitable for the research analysis. Therefore, by means of using appropriate statistical techniques these biased data were transformed into size and scale free data. Therefore, the data have been transformed into indicators. These indicators are further processed by means of computer analysis to get several results. Then appropriate maps, charts, diagrams etc. have been drawn and ultimately bi-variate two ways contingency tables and simple frequency tables have been constructed. Besides these the computer results have also been shown in tabular forms. All these tables and cartograms are analysed by the researcher herself which is her original contribution. The field work has been done in two steps. (a) Perception studies i.e. Qualitative data and (b) collection of data i.e. quantitative data. In the perception study the researcher had thorough discussions about different aspects of water management practices in the study area and observed how the farmers consider and perceive the concept of water management in quantitative forms. However, in qualitative data they have expressed their ideas by means of some numerical observations.

The analytical procedure considers different techniques which are identified below.

(a) Statistical methodology
(i) Mean, standard deviation, co-efficient of variation
(ii) Co-relation matrix with bi-variate co-efficient co-relation
(iii) Bi-variate regression analysis.
(iv) chi-square test
(v) analysis of variance

(i) Mean, standard deviation and co-efficient of variation
Mean is computed to find out the average with the help of following formula

\[ \bar{X} = \frac{\sum x}{n} \]

Where,

\( \bar{X} \) = Arithmetic mean
\( n \) = Total number of observation
Standard deviation is the positive square root of the averages of squares of deviation about means and is given by

$$s.d. (\delta) = \sqrt{\frac{\sum x^2}{n} - \left(\frac{\sum x}{n}\right)^2}$$

Where,

\(\bar{x}\) = Arithmetic mean

n = Total number of observation

\(\delta\) = Standard Deviation

**Co-efficient of variation**

Co-efficient of variation indicates relative desperation. The units of measurement of variability are the same as the units or measurement of the original data. Thus the variability of the variables are measured in different unites and can not be compared. Secondly, variability becomes more meaningful if given in relation to the means of the research. Thus, there is a need to measure the dispersion in a distribution in relation to its central value for expressing the consistency in the data. The most commonly used measure of such relative variability in the co-efficient of variation. The formula is

$$\left(\frac{\text{standard deviation}}{\text{mean}}\right) \times 100$$

As the standard deviation and mean have the same dimension, co-efficient of variation is a dimensionless quantity and show the different values of co-efficient of variation is comparable. A higher value of co-efficient of variation shows higher inconsistency of data where a lower value shows lower consistency. The higher consistency in data give rise to better analysis mean standard deviation and co-efficient of variation are computed in case of following variables.

**(ii) Co-relation matrix**

Indication of the inter relationship among the different characteristics of the study is the essential concern of a scientific investigation. An inter relationship between the two characteristics exists only when one of them may logically considered as the causes of the other. In the present study one dependent variable may be explained in terms of the variations
in the independent variables. In case of inter relationships both the values of independent and dependent variables will vary together. This property of co-variance is also known as correlation. In the co-relation matrix the logically settled variables are attempted to find out inter relationship among themselves and with the dependent variables. Therefore, measurement of the degree and direction of co-relation help particularly in explaining the variations in the various spatial phenomena. To represent the co-relation between two variables the researcher considered the values of the independent variables and the x day y co-ordinates of a two dimensional space, each part of observations can then be plotted on the graph paper according to X and Y co-ordinates. This is the scatter diagram which is shown in different parts of the thesis.

The degree of relationship linear or non linear between any two variables on the closeness of the cluster of points to the straight line or to any curve. If the values of X and Y vary such that each points fall exactly on a straight line or curve the relationship is said to be perfectly linear or non linear. The higher the deviation to these points from the straight line or curve the weaker will be the co-relation. Methods of studying only the linear co-relation is discussed in the study because of two factors namely
(i) The majority of variables are generally co-related in linear fashion.
(ii)Many of the non-linear co-relation becomes linear after the two variables are properly transformed.

\[
\begin{align*}
    r &= \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{\left(\frac{n}{n^2} - \frac{\sum x^2}{n}\right)\left(\frac{n}{n^2} - \frac{\sum y^2}{n}\right)}} \\
    t &= r \sqrt{\frac{n-2}{1-r^2}}
\end{align*}
\]

Where,
- \(y\) = dependent variable
- \(x\) = independent variable
- \(t\) = test of significance
- \(r\) = correlation coefficient
- \(n\) = total number of observation

The co-efficient of co-relation based on smaller number of observation is generally considered as the sample co-relations. Using the test of significance of \(r\) it is possible to infer whether the co-relation co-efficient of the bi-variate normal population, (the co-relation
between the same variables is based on a fairly large number of observation) will be zero or not. Under the null hypothesis that the population co-relation is $o$, the expression is followed by the student $t$ test with n-2 degree of freedom. It is evident from the text that, the significance of the co-relation co-efficient is directly proportional to not only $r$ but also to $(n-2)$. In some cases, because of a large value of $n$ a smaller co-relation co-efficient may become significant where as in some other cases a larger co-relation co-efficient may become insignificant because of the smaller value of $n$. The correlation matrix of different parameters of climate are made.

(iii) **Regressions analysis:**

The study of casual relationship between a dependent variable at one or more independent variables becomes more useful when the relationship is defined in terms of a mathematical form. The mathematical form of the relationship is used in making prediction and also helps us in assessing the relative influences of each of the independent variables on the dependent variables. From regression analysis statistical infrarancas can be derived. As the relationship in social sciences are not very exact, some amount of errors are to be tolerated which approximating them into any exact form of relationship. The simplest form in which the relationship between a dependent variable and an independent variable can be approximated is that of a straight line. The linear forms of relationships are important because many non-linear forms of relationship also become linear after some kinds of transformations (Croxtonte, Cowden D.J. and Cleins applied general statistics – Primitc Hall India, 1975, pp 431-440)

In social sciences any dependent variable is rarely explained by only one independent variable, the bi-variate model has limited scope. Thus, in order to have a better explanation of any dependent phenomena it is necessary to explain it by all of possible explanatory variables.

(iv) **Chi square**

The chi square test is use with the help of two way cross classified contingency tables. If the attributes are cross classified into a contingency table, a value of chi square can be computed under the assumption of the independence of the two attributes. If the row and column attributes are independent, the expected frequency of the self in the $i^{th}$ row and the $j^{th}$ column in a contingency table is equal to
\[ \frac{R_i \times C_j}{N} \]

Where,

\( R_i \) and \( C_j \) are the tables of the \( i^{th} \) row and \( j^{th} \) column and \( N \) is the total number of frequencies.

The degree of freedom in case of a contingency table of \( r \) rows and \( c \) columns is \((r-1)(c-1)\). The formula of chi square test is as follows

\[ x^2 = \sum_{i=1}^{n} \left[ \frac{(Q_i - E_i)^2}{E_i} \right] \]

Chi square tests are attempted with help of different variables.

(v) **Analysis of variance**

Analysis of variance is the standard parametric test of difference between three or more samples. Like other parametric tests, however, it is often used in situations where the rather rigid assumption of such tests can not be justified. Analysis of variance can only be applied to data measured on an interval scale.

The null hypothesis of analysis of variance is that the samples are taken from a common, normally distributed population or from identical population. The alternative hypothesis is that the samples come from populations with different distribution.

The rational of analysis of variance is to find out whether there is more variation between the samples than within them. If the samples are taken at random from a common population, it is reasonable to expect the variation within the samples to be about the same as the variation between the samples, since both the reflections of the overall variation in the population. Any difference in these two measures of variation is namely due to change in sampling process. If the samples are taken from different population, this is not a reasonable expectation, since the variation within each sample is a reflection of a variation within the particular population from which it has come. Variation between samples in this case is a reflection of the difference between the population.

(b) **Cartographic Methodology**

The descriptive analytical any synthesized diagrams have been prepared to interpret different aspects of water management of the study area. The descriptive mapping include the contour
map, slope map, drainage map etc. the analytical map shows the proportion of irrigated area, proportion of net sown area, production and productivity of crops. Several pie diagram, square diagram, bar diagram, scatter diagram will be drawn to analyse the aspects of water management.

The synthesized diagrams have been drawn after superimposing some of the variables related to water management. These synthesized diagrams are known as schematic diagram which indicates path analysis. This diagram indicates the causes and effects of water management in the study area.

**Application of Remote sensing and GIS**

a) With the help of satellite imagery it is easily possible to identify surface water. The sources of surface water may be tank, lake, reservoir, rivulet, alluvial cannal.

b) By using the Remote sensing technique it is easy to monitor the fluctuation of surface water body.

c) Rill erosion, gully erosion, vertical seepage can be identified using the satellite; porosity, permeability can also be assumed by using remote sensing technique. If the area has any fracture, joint etc. that can also be identified by interpreting the satellite imagery. Above all the terrain condition can be assumed by using the satellite imagery.

d) The researcher can use global positioning system (GPS) to identify the co-ordinate of any point. By means of this process latitude, longitude as well as height can also be identified. That means micro level contouring gradient of the area can be assumed by the system.

**1.5 Location and salient features of the study area:**

Sriniketan Santiniketan Development Authority has the responsibility to develop surrounding rural areas of Bolpur town. For that purpose a distinet area has been identified which possesses the name“Sriniketan Santinketan planning Area” (SSPA).It includes the Bolpur urban area and 44 villages around the town. It is located in the central part of Bolpur Block. At southern part of Birbhum District in between latitude 23°37’ N to 23°43’ N and longitude 87°37’E to 87°47’E.This planning area is located at Rarh natural region. It possesses 108.08 sq.km and population of core area of SSPA is 85 thousand (census, 2001) which includes 10 villages; other 34 villages have total population 59 thousand. Bolpur Municipality area has total population of 1Lakh 10 thousand. So the total population of SSPA is 2 Lakh 54
This planning area is surrounded on the north by Nanoor, on the south by Ajoy river and on the west by Illambazar block. The Kopai river marks the northern boundary and the Ajoy river indicating the southern boundary of this region. The entire region has come close to the base level of erosion. Agriculture and its allied activities are the primary occupations which are practiced in this region. Some industrial establishment are also located there, that engage large number of workers of the region. This tract has potential of development and is enriched with plenty of diversified natural resources.
Sriniketan Santiniketan Planning Area (SSPA) has multiple urban and rural local bodies within it. Sriniketan Santiniketan Planning Area as notified under provisions of West Bengal
town and country planning and development act 1979, vide gazet notification no. 4069-
Tanal CP/IS-25/87 dated 27th December 1997 is estimated to be about 108.08 sq. Km. Compromising 44 mouzas under Bolpur Police station, Birbhum district West Bengal.

Out of 44 mouzas 40 fall under Sian Muluk, Raipur-Supur, Ruppur and Kankalitala gram panchayet.

Sriniketan Santiniketan Development Authority (SSPA) was formed on December 14, 1989.

Its aim was to undertake planned Development of rural and urban areas under the Sriniketan Santiniketan Planning Area (SSPA) without interfering with the administration of local self Govt. SSPA regulated land uses in order to prevent unplanned and haphazard growth of the region.

### 1.6 Aims and objectives

(i) Documentation of information regarding present land use including maps of the area.

(ii) Documentation and execution of development plans for the region.

(iii) Regulation of land use in the region.

(iv) Undertake various development related work.

(v) Co-operate with other administrative bodies and sections. Regulate and reclaim land for development purposes.

(vi) Procure land for development work through purchase or leasing.

The Bolpur municipality is under the jurisdiction of SSPA. The authority has taken up various development works in its planning area. Bolpur bi pass road project has been taken up to solve the problem of traffic congestion, and important satellite township i.e. Prantik has been developed together with a commercial complex. SSDA has also taken up a joint venture housing project with Peerless Housing Company.
Table: 2  Administrative jurisdiction of local bodies within SSPA

<table>
<thead>
<tr>
<th>Administrative Jurisdiction</th>
<th>Area in sq km</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visva-Bharati</td>
<td>4.45</td>
<td>4.12</td>
</tr>
<tr>
<td>Bolpur Municipality</td>
<td>13.13</td>
<td>12.14</td>
</tr>
<tr>
<td>Rural area under 40 gram Panchyet</td>
<td>88.70</td>
<td>82.08</td>
</tr>
<tr>
<td>Land directly under SSPA</td>
<td>1.80</td>
<td>1.66</td>
</tr>
<tr>
<td>Total area under SSPA</td>
<td>108.08</td>
<td>100</td>
</tr>
</tbody>
</table>


1.7 Chapter scheme:
The thesis has been constructed by dividing it into the following chapters:

Chapter I: Introduction:
In this chapter the researcher introduces the readers about the topic. Here discussion is made firstly about the statement of problem. Next the researcher discussed the objectives of the study, followed by the data base where the type, sources and necessity of different types of data are given. The next part is allotted to make discussion about the analytical procedure, location of the study area and justification of selection of the study area. Lastly the chapter scheme has been given which deals with the sequential arrangement of different chapters of the thesis.

Chapter II: Literature Survey:
This chapter deals with the literature regarding historical background of water resource management in the study area, spatial distribution of water resources, the problems which prevail in water resource management in the study area have been studied from different books, journals, websites and newspapers.

Chapter III: Historical perspective of water resource management in the Study Area:
In this chapter an attempt has been made to discuss about the past situation of water resources in the study area and availability of infrastructure in the study area. This chapter reflects the changing patterns of water resources and problems related to management of water resources from earlier days to recent time.
Chapter IV: Regional Structure of the Study Area:
This chapter throws light on the physical set up of the study area like relief, soil, slope, drainage, its climatic situation, vegetation. From the relief and slope it is evident that the general slope of the area is from west to east and all the rivers flow in this direction. The eastern most part is a low lying area and during the rainy season water logging is common phenomenon.

Chapter V: Socio-economic characteristics of farms and farmers of the sample villages:
This chapter deals with the social and economic status of the sample households of the selected villages as well as the sample households of the Sriniketan-Santiniketan Planning Area (SSPA). The purpose of this chapter is to describe the socio-economic characteristics of the farms and farmers of the five sample villages. The socio-economic character includes: distribution of land ownership pattern, distribution of castes, distribution of educational status of the heads of the households and distribution of family members. The spatial, distribution of net irrigated area is an important parameter for the measurement of water resources because by this technological factor agricultural development may be achieved.

Chapter VI: Spatial pattern of irrigated area
In this chapter an attempt has been made to discuss about the direct and indirect benefits of irrigation on the primary, secondary and tertiary sectors of economy. In Sriniketan–Santiniketan Planning Area there are altogether 42 villages. Out of which there are some, villages where 96.45% of the total cultivated areas are irrigated area. However, it is surprising to know that there are as low as 1.96% of the net sown area which is irrigated. Therefore, this chapter discusses about the extreme two ends within where all the villages have their percentages of net irrigated area. The spatial pattern of net irrigated area indicates that larger proportion of net irrigated area to net sown area. These villages are spread on the northern, north-western, western, south-eastern and southern parts of the Sriniketan-Santiniketan Planning Area, making a semi-circle on the western part. However this chapter also discusses about the moderately irrigated areas as well as the dry areas where no irrigation facility is available.
Chapter VII: Landform and water management
Here landform and configuration of terrain have explained with the help of average contour map, absolute relief, average slope, etc. conditions of the region. The researcher has discussed about the high ranges of absolute relief that is situated in the entire northern, north-western and western part as a semi-circle. Its value decreases towards the southern part of the area.

Chapter VIII: Soil water system and suitability of soil for irrigation
This chapter is concerned with the soil water system and suitability of soil for irrigation, types of soil, water-holding capacity of different soil types, groundwater resource, depth of water table and their use for irrigational purposes.

Chapter IX: Role of Climate in Water Management Practice
In this chapter the purpose is to identify the role of climate in water management practices. In the present study the climate of Sriniketan-Santiniketan Planning Area has been observed by means of (a) temperature, (b) rainfall, (c) rainy days, (d) humidity, (e) wind speed. With this kind of data several studies have been made in respect of average monthly rainfall, deviational diagrams of annual rainfall, rainfall dispersion diagram, co-efficient of availability of annual rainfall, average moisture between patterns. Water management indicates the demand and supply of water resources in the soil for crop growth. It considers two components: irrigation during the time of need, drainage out of surplus water.

In the field of irrigation the most important three questions to be answered i.e. when to irrigate, how much to irrigate and how to irrigate.

Likewise drainage comprises three fundamental questions to be answered, how much to drain, how best to be drained and how rapidly to drain under a given situation of soil, water and crops. Therefore, these fundamental questions to be answered through different components of climatic factors, as for example when to irrigate, question to be answered that during the time of sowing season larger amount of soil moisture is required, whether adequate amount of rainfall takes place or not during the time of land preparation and sowing time. During the time of land preparation alternative sunshine, cloudiness and rainfall are required. It should be observed whether the sunshine, cloudiness and rainy days are adequately available during the time of land preparation and sowing. In this way in different
phases of agricultural operation the demand for soil moisture should be compared with the availability of soil moisture through rainfall, humidity, rainy days and temperature condition, wind speed is also plays significant role along with temperature which helps to continue evapotranspiration from this region. Therefore, the role of climatic factors to determine water management practices is an important aspect which the researcher has discussed in this chapter.

Chapter X: Quality of irrigation water:
In this chapter the researcher has thrown light on the matters like soil quality, pH value of soil, classification of soil pH ranges, quality of irrigation water, characteristics to determine water quality, pH value of irrigation water, distribution of net irrigated area and soil pH of the study villages, distribution of net irrigated area and pH of the tanks of the villages, distribution of net irrigated area and shallow tube well water pH of the villages. The researcher has surveyed minutely to show how these factors affect irrigation of the area and thus water management.

Chapter XI: Planning water management:
The water management system on a farm includes farm inlet and outlet of irrigation and drainage ditches, the erecting of water control, structures such as water gates, diversion borders and drop structures and the grading or levelling of the land. It may also include the construction of storage tank, the installation of pumps, etc.

After a proper assessment of these factors and topographic survey, a farm is divided into a convenient number blocks and plots. Each block should have an independent irrigation and drainage channel and an approach road. There should be the minimum wastage of land under field bunds and channels. However, distribution of irrigation engineering structures, distribution of inlet length, width, depth, distribution of outlets, distribution of inlets, distribution of level, gentle slopping and terrace land, etc are also discussed by the researcher in this chapter.

Chapter XII: Statistical analysis in respect of irrigation
In this chapter different types of primary and secondary data have been analysed statistically to find out the correlationship and cause and effect relation between the variables. Statistical techniques like correlation coefficient, regression, analysis of variance have been applied and interpreted.
Chapter XIII: Problems and policy measures of water management
This chapter deals with the problems regarding irrigational facilities and water management. The researcher has thrown light on the problems which prevail in the study area and also put forward a perception study on the problems which the individual households belonging to different socio-economic groups and their landholdings. After noting down the crucial problems, policy measures have been suggested which may reduce and minimise those problems regarding irrigational facilities, water management and will be fruitful for agricultural activities.

Chapter XIV: Major Findings and Conclusion
The last chapter summarizes the entire work on availability of irrigational facilities both at meso and micro levels and how the distribution of structures may be helpful for irrigation and controlling the flood and thus will be beneficial to agriculture. This provides the main theme of the study. Major findings and facts have been noted down and conclusion of the study has been drawn.

References
Bibliography
Appendix