CHAPTER - 1

INTRODUCTION

1.1 Introduction

Irrigation is an art of supplying water to the fields for rising crops in areas where the rainfall is either limited or not properly distributed throughout the crops season. (Chandrasekhara, 1965). It is a method in which a controlled amount of water is supplied to plants at regular intervals for agriculture. It is also used to assist in the growing of agricultural crops, maintenance of landscapes and re-vegetation in dry areas during the periods of inadequate rainfall. Water is indispensable to agricultural production. In areas where rainfall is sufficient and well distributed throughout the year, there is no problem in agricultural production. In tropical monsoon climatic region, nearly 80% of rain falls during three to four months of a year and the remaining period is almost devoid of rainfall. Therefore, irrigation plays a significant role towards successful crop cultivation. There is always a need for irrigation to sustain agricultural production throughout the year. Moreover, after Green Revolution in India cultivation of HYV seeds plays a significant role in crops production and the success of HYV seeds is directly dependent on the availability of irrigation water. Formerly the farmers used several type of methods i.e. Shallow Tube Well (STW), Deep Tube Well (DTW), Dug Well, Tube Well, Jhora Canal, Dun system, Ponds etc. for irrigation purpose. Since 1996-1997 considerable importance has been attached to the provision of Teesta canal. The construction of different sub canals, minor canals and micro canals under the Teesta canal irrigation was completed in 1996, and the constructed canals are operational since then. This has helped in the increase of irrigated area in Rajganj and Jalpaiguri Sadar block. In 1997-98 the area under canal irrigation was 18145 hectares, which has increased to 46415 hectares only in Rajganj block. At present times, the strategy for increasing agricultural production is the increasing reliance on irrigation. For intensive agriculture in the study area, the HYV seeds have been introduced only those areas which have assured rainfall and irrigation facilities. As the scope for extending the cropped area is limited, greater reliance has to be placed on irrigation, so as to have double or multiple cropping. The basic objective is not only to have higher yield per hectare of crops, but also to produce a much higher yield per hectare, which is possible with proper means of irrigation. This is done by promoting the sowing of two or more

crops on irrigated land supported by the facilities which is necessary for the optimum use of irrigation, land leveling, land shaping, land consolidation, efficient canal system, etc. at present faulty irrigation practices and absence of proper and adequate drainage facilities have been responsible for wastage of water. Education in water management and provision of drainage facilities will help to remove this problem.

Irrigation is needed for making the soil suitable for ploughing so the fields can be prepared for agriculture where sufficient moisture (soil) for germination of seeds can be provided which will ensure healthy growth of crop. Many farmers of this district get irrigation facility and they easily cultivate the land. Increase in productivity after irrigation in this area changes the production of crops like paddy, various vegetables etc. on the other hand, harmful effect of excessive irrigation is also a matter of concern. The changing pattern of agricultural land use in Jalpaiguri district is experiencing numerous good effects as well as facing some adverse effects especially in respect to introduction of HYV seeds which requires special attention in terms of clearance of weeds on time, judicial use of chemical fertilizer, pesticides, etc. Simultaneously, financial problems and lack of education of the farmers particularly in respect to mechanized farming is also responsible for low yield. Excessive irrigation causes various harmful effects on standing crops. Crops roots don not grow properly in standing water except the local varieties of wet paddy. Excessive use of irrigation water in the field increases the amount of salt on the surface soil due to evaporation. For boosting agricultural output in any scheme the use of chemical fertilizers has an important role. The soil as found in the study area has deficiency of nitrogen and phosphorus, which together with organic manure influence crop return. However, as population tends to grow at a very faster rate, the usage of chemical fertilizers is the only way to solve the problem. However, due to continuous use of chemical fertilizers in the same plot of land is responsible for decreasing the fertility of land. The researcher has selected the area which comprise of Rajganj, Jalpaiguri, Mynaguri, Dhupguri, Mal, Matiali and Nagrakata CD blocks. In irrigated areas, crops like Boro and Amon (rice), tea plantation, wheat, potato, tomato, cabbage, brinjal and many other vegetables are cultivated. But crops were not cultivated in those areas during non-monsoonal season before the introduction of canal irrigation. This is due to supply of ground and surface water, production has gradually increased. According to the Statistical Report of the Department of Agriculture, Jalpaiguri (1997), the production was less before introduction of canal irrigation.

For example, earlier the production of Boro rice was 1200 kg per hectare, but after the introducing canal irrigation it became 1800 kg per hectare. Similarly, the production of potato also increased in the same time period. On the basis of distribution of land, Agriculture Census of India classified the farmers as marginal (below 1.0 hectare of land), small (1.0 to 2.0 hectares of land), semi-medium (2.0 to 4.0 hectares of land), medium (4.0 to 10.0 hectares of land), and large farmer (10.0 or above hectares of land). Most of the farmers of the study area are marginal farmers, followed by small, semi medium and medium farmer.

Gross cropped area of the district was 239021hectares (2014) in which 72129 hectare area was under irrigation in 2014 (CWC, Dept. of Water resources in district & status report). Total length of Karotwa-Talma canal is 55.874 km, Teesta-Jaldhaka canal is 33.881 km and Teesta-Mahananda link canal 144.096 km in 2016 (CWC, CGWB, District Irrigation and Agriculture Office, Jalpaiguri). The farmers have gained the impact of irrigation. It is noticed that there are mainly two types of crops cultivated here, i. Local variety, and ii. HYV Seeds. They mainly used the chemical fertilizers, insecticides and pesticides, like Urea, DAP, Théoden, etc., and also use the HYV seeds to get high productivity of crops. But on the other hand, those who do not get irrigation facilities or any help of water supply, cannot cultivated the HYV seeds. They are still using local variety of seeds and following the traditional method of ploughing. Their cultivation is in very poor condition and continuously demanding for irrigation facilities from Government and local authorities.

1.2 The Study Area

The study area (Jalpaiguri District) is bounded by Bhutan and Darjeeling District in the north, Alipurduar District in the East, Bangladesh and Coochbehar District in the south and Darjeeling District in the West. The district shares two international boundaries. The Latitudinal and Longitudinal Extent of the study area are 26˚15´47″N to 26˚59´34″N and 88˚23´02″E to 89˚07´30″E, administratively it comprises with Seven CD Blocks, these are – Jalpaiguri Sadar, Rajganj, Mal, Matiali, Nagrakata, Dhupguri and Mynaguri. Its geographical area is 3386.18sq km, which occupies 80 Gram Panchayats with 1177 Gram Samsads. Geologically the area is important because of coal; dolomite and enormous deposits of construction materials e.g. gravel sand, brick earth etc. The district is entirely underlain by alluvium except its northern border where

hard rocks are exposed (Pawde, et al, 1982).Inhabitants of the district according to 2011census are 2381596 persons of which 51.12% is male and 48.88% female.

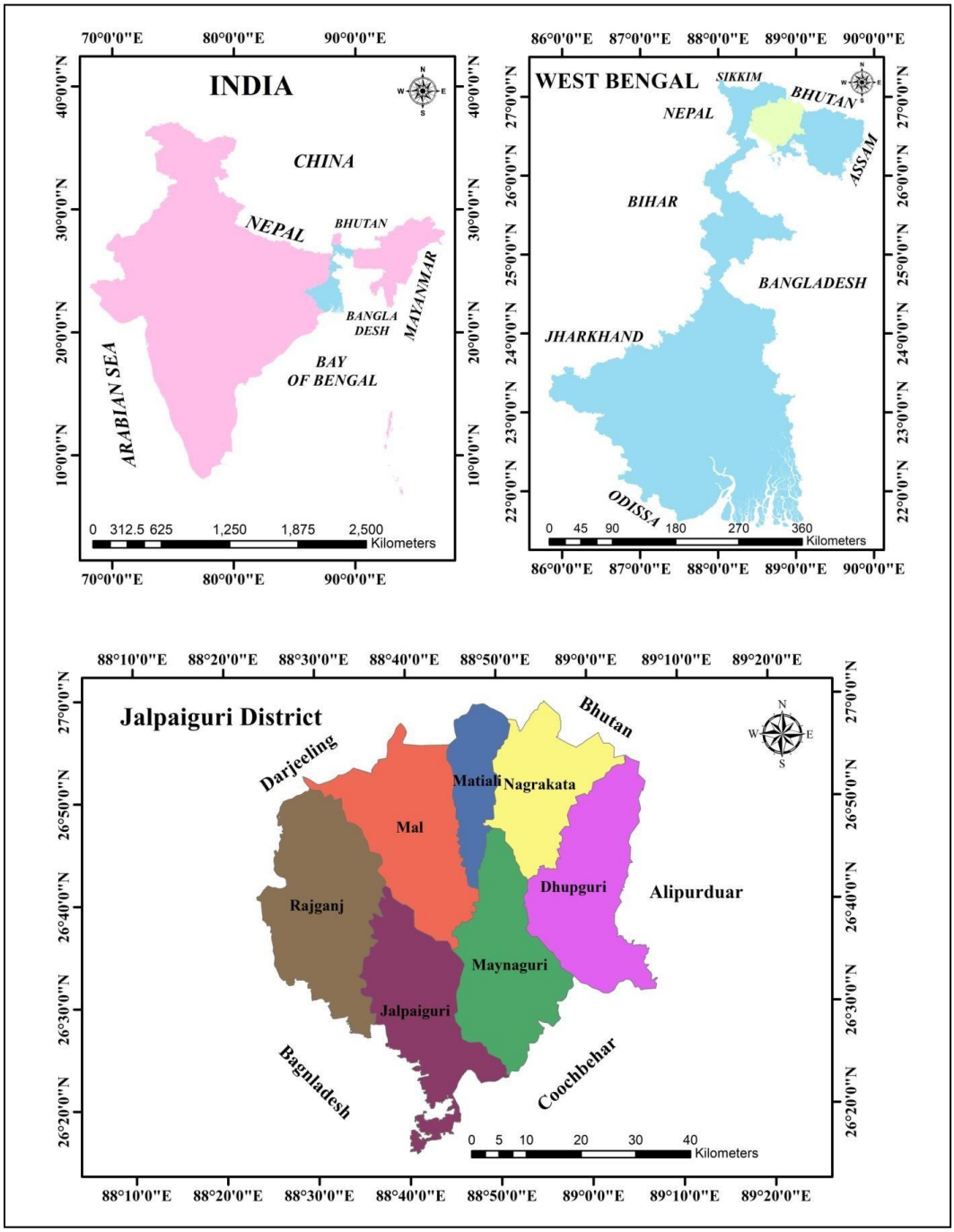

Figure 1.1 Location Map.

Source: Survey of India, 2017

Prepared by the Researcher.

1.3 Previous Works

Irrigation is the most important ingredient for modern agricultural development. After independence it slowly increases, but in different Five Year Plan it has developed only in some states of India like Punjab, Uttar Pradesh, Haryana, etc. The Researcher has selected the study area Jalpaiguri District Particularly in relation to Teesta Barrage Project irrigation facility and Ground Water condition in Jalpaiguri District and its effects on agricultural production.

The literature on historical development of origin of the irrigation wells, ground water, dam, DTW, STW, DW, and RLI etc. is available in many famous treaties, written by famous workers like Bhalla and Singh (2009), Prabakaran and Sivapragasam (2013) etc. They have studied the difference in the rate of growth of rice yield in India and stated that the difference in yield was primarily due to difference in factors like infrastructure development as a whole and lack of proper irrigation facilities in particular.

Alexander, K.C. (1982) in his article "Agricultural Development and Social Transformation" attempted to prepare a comparative framework for both the irrigated and non-irrigated area of the Ganga Nagar District, Rajasthan State. He observed that irrigation facilitated intensification of agricultural activity through the large use of labour, fertilizer, insecticides and other inputs enable the farmers to use modern tools and machines which ensure the increase in the amount of per acre production & productivity and gross income. He also noticed that there are significant differences in sickness and health care behavior among the two places i.e. command area and controlled area. He interviewed 900 persons of which 600 from the irrigated area (Ganganagar and Padampur tehsils of Kanpur) and 300 respondents from the non-irrigated area (Nauhar and Bhadra Tehsils).

In the article "Assessment of ground water potential in Jalpaiguri District of West Bengal", Unda, Mal and Chowdhury (2009) discussed about the various scope for utilizing the groundwater in different irrigation project. In the paper "Optimal design planning for minor irrigation structures in Jalpaiguri District of West Bengal in India", Singh & Mal (2007) Discussed about the utilization of water resource in seven administrative blocks of Jalpaiguri District by allocating the land water effectively. Barrow, J. Christopher (1999) in his article "The

promise of Runoff Agriculture" expressed runoff agriculture which is a form of agricultural irrigation. He stated how the use of surface & subsurface water often overlooked wasted that enables both small farmers & commercial agriculturists to improve yields & the security of harvest, even in harsh & remote environments. He expressed a number of techniques & strategies, as well as the challenges & the potential of the crucial approach, so much to reduce land degradation & improve conservation & sustainability of irrigation in this region.

Chowdhury (1971) in his book "Economics of tube well Irrigation in West Bengal", studied the economics of tube well irrigation in Nadia District of West Bengal. The study was carried out in the irrigated area during Rabi crops in whole Nadia district except Krishnanagar-I. High cost involved in the installation of deep tube wells and excessive fragmentation of land compelled the medium and large farmers to turn towards shallow tube wells which can irrigate nearly 10 acres of land.

In the article "Soil Health and Water quality issues for sustainable agricultural production in the eastern region of India", Kundu, Singh and Mahapatra (2013) have described the vital points like water resource, soil resource and ground water resource etc.as the controlling factors related to irrigation status. In the article "Irrigation System and Pattern of Crop Combination, Concentration and Diversification Barddhaman District, West Bengal" Chakraborty and Mistri (2017) investigate the cropping pattern of Bardhaman District. They also emphasized on the irrigation facilities and health of the soil as the key components for the choice of crop combination in the region.

Chatterjee (1995) in her book "Irrigated Agriculture; A case study of West Bengal" have discussed the entire scenario of irrigation in West Bengal. She also recounts physical, social, Climatological as well as historical aspect of the development of irrigation in West Bengal. She also mentioned different types of irrigation like overflow irrigation, zamindary bank irrigation, canal irrigation, tank irrigation; poor irrigation, river lift irrigation and tube well irrigation which are prevail in the region. An assessment of underground as well surface water has been done by the author. Lastly, she highlighted various constraints for the development of irrigation.

Dr. Shyamal Kr. Sarkar (2015) has written an article on "Teesta's Turn Next" in The Statesman where, he highlighted that storage of water for irrigation in Jalpaiguri District mainly

requires in between the month of November to April. He also described the significance of the project in the eastern region of India, involving irrigation potential of 9.22 lakh hectares of land.

In the article "Surface water potential of Jalpaiguri District", Sunanda Das (2012) briefly discussed about the potentiality and importance of surface water in irrigation purpose and also ground water recharge in Jalpaiguri District. She also highlighted that Sustainable agriculture is one of the greatest challenge for modern time.

Dhawan (1988) in his book "Irrigation in India's Agricultural Development, Productivity, Stability, and Equity" highlighted the national level impact of irrigation on agricultural productivity. He observed that land productivity on irrigated lands was average 22 quintals crop per hectares in 1983-84 which was 9 quintals more than the un-irrigated lands. Also, the study indicated that productivity differential 5 years later was estimated 13.3 quintals during 1983-84. This was because of a firm upward character in the overall irrigated yield during the 14-year period from 1970-71 to 1983-84. This indicated that the production and productivity in agriculture had increased in nature.

Ghosh (2012) in his research work "Impact of Mayurakshi irrigation canal system on the socio-economic aspects of its command area" explored that the Mayurakshi canal irrigation system determines the socio-economic aspect of the command area. The head area of the canal gains more water than the lower end area of the canal which adversely affect the production of crops and the economy. Sometimes the higher discharge of water, failure of the embankment, water logging behind the canal embankment badly affect the production of crops and crop failure due to water borne diseases in the crops. He suggested that scientific and systematically application of geological knowledge, proper training of the farmers and proper management of cropping pattern help to develop the agriculture as well as the economy of the farmers.

Gogoi, (1993) in his book chapter "Irrigation and Agricultural Development in Assam" has described the impact of irrigation on agricultural development in Kamrup district of Assam. In her study, Gogoi made an attempt to compare between the farmers who are benefitted from irrigation and those who did not deprive of the irrigation facilities. The author did not find any change of cropping pattern in the irrigated area but HYV has been introduced in the irrigated

area**.** As a result of increased crop intensity and the introduction of HYV rice cultivation in the irrigated areas, the overall production of agricultural crops has been in increased.

Kallur (1988) in his book "Irrigation and Economic Development" has highlight the impacts of irrigation on different categories of farmers in terms of crop rotation, cropping pattern, cropping intensity, input uses, production and productivity in the study area of left bank canal of Tungabhadra project in Karnataka. He discussed the cropping intensity between command area and controlled area. He also mentioned that the modern mechanical inputs were more in command area than the controlled area. In the article "Contamination of shallow aquifers by arsenic in upper reaches of Teesta River at Siliguri-Jalpaiguri area of West Bengal, India" Deb Kr. Bhattacharya and Pradip Kr. Mukherjee (2009) have written about the contamination of shallow aquifers by arsenic in the upper reaches of Teesta River in Jalpaiguri District and its impact on agriculture.

Pal (1985) in his article "Contribution of Irrigation to Agricultural Production and Productivity" evaluates the contributions of irrigation to agricultural production and productivity. According to the study he mentioned that different types of irrigation help agricultural productions in three ways, first, it raises yield per unit area by inducing the use of other complementary yield raising inputs namely, high yielding varieties of seeds, fertilizers and patricides secondary it leads to a development in the gross cropped area by making double and multiple cropping possible. Thirdly, for a given amount of output and input prices irrigation may raise the production by introducing farmers to allocate their lands to high yielding and high valued crops.

Gireeshayya Udagatti (2005) stated an Economic Analysis of Farming Systems in Tank Commands of Northern Karnataka. The study was based on Jala Samvardhana Yojana Sangha of northern Karnataka which includes three districts. The study carried out with the main objective of identifying and analyzing the cost and returns of major farming systems and impact of on farm demonstrations on socio – economic conditions of farmers.

Suresh E. (2010) described an Economic Analysis of Cropping Systems under Tank Irrigation in Northern Karnataka. The study has been conducted in two districts of northern Karnataka. The

main objective of the study is to analyze the economics of cropping pattern under tank irrigation system with cost and returns of crops.

Van den Berg J (2013) studied on Socio-Economic factors affecting adoption of improved agricultural practices small scale farmers in Sothern Africa. The main objective of the study has to collect information on socio-economic aspects of farming community in the study area.

Abraham Gebrehiwot Yihdego (2015) studied the "Impact of Small Scale Irrigation on income of rural farm households: Evidence from Ahferom, Woreda in Tigray- Ethiopia". The objective of the study has been to examine the impact of small scale irrigation on income rural farm households.

Dereje Mengistite, et al, (2016) described the assessment of the impact of small scale irrigation on household livelihood improvement at Gubalafto district North Wollo, Ethiopia". The study conducted with the main objective to addition the productivity and diversifies livelihood scenarios in small scale irrigation.

Krishna Reddy (2012) described the Public Expenditure on Irrigation and its Impact on Agriculture production, evidence from an Indian State. The study has been carried at Andhra Pradesh of India. The main objective of the Study has been to analyze the public expenditure on irrigation and its impact on agriculture production. Thakur et.al (2000) assessed the impact of irrigation on production and economic level of farmers. Study is conducted in command area flow irrigation scheme of Hurla in Kullu district of Himachal Pradesh.

1.4 The Scope of the Study

Agricultural Geography is one of the most highly developed branches of Geography in the 20th Century. A few decades ago it was almost at the primitive stage of its development. In recent years it has made considerable progress towards maturity as Agricultural Geography has begun to treat data concept and interpretation quantitatively. It is related to the changing economic, social and political phenomena which have resulted from progress in Science and Technology. In India the growing population demands higher quantities of food grains for its consumption. But food grain deficiency in India has forced to import from outside. To cut short imports self-sufficient in food grains is very necessary. This can be achieved through increasing irrigation

facilities. In fact, among the measures that may be adopted for increasing area under cultivation and the yield of crops, the first place must be given to the works for the supply and conservation of water.

1.5 Hypothesis

Following are the hypothesis considered for the present study:

1. Topography has a direct influence on the present irrigation practices.
2. Expansion of irrigation has enhanced the cropping intensity.
3. Irrigation has enhanced the yield rate of crops per hectare.
4. Irrigation of HYV seeds in Jalpaiguri district has enhanced irrigation practice.
5. Modern techniques of irrigation are practiced by educated farmers.

1.6 Objectives

To carry out the present research work, the following objectives are taken into consideration:

1. To analyze the status of irrigation since 1996 in Jalpaiguri District.
2. To analyze the factors controlling irrigation practice in Jalpaiguri District.
3. To assess the economic impact of irrigation.
4. To assess the social impact of irrigation.

1.7 Database and Methodology

In order to bring a reasonable outcome of the attempted research work with keeping in view certain parameter and circumstances, the following methodology has been followed:

i. In order to analyze the past and present status of irrigation in Jalpaiguri district both primary and secondary data have been used by the researcher. To analyze the present scenario of irrigation status, extensive field survey, discussion with the local people and various government authorities etc. have been done. The secondary data and information related to the status of irrigation have been collected from different Government offices like Irrigation and Waterways Department, Agricultural Development, Offices of different CD Blocks of Jalpaiguri District, Census report, District Gazetteer, Old Records etc. Identification of dug well, deep tube well, open well, shallow tube well, river lift irrigation, etc. have been done

through field observation by using the GPS and also from various published and unpublished maps, diagrams, etc. and mapping of these aspects have been done through proper cartographic techniques in GIS platform.

ii. In order to analyzed the factors controlling the irrigation of the proposed area, its geology, geomorphology, climatic condition, soil condition, surface water potential, land use and land cover, various government policies etc. have been studied by consulting already published documents, maps, diagrams and other sources. Data on ground water analysis have been collected from the Central Ground Water Board, Eastern Zone Office, Kolkata and Jalpaiguri. Necessary data and information regarding properties of soil and water have been taken from Regional Chemical and Hydrological Laboratory, Jalpaiguri. Data on rainfall, temperature, relative humidity etc. have been collected from the Indian Meteorological Department of Jalpaiguri town and several cartographic techniques have been adopted to analyze the climatic condition of the study area and its relationship with the status of irrigation.

iii. To assess the impact of irrigation on economy, various data, reports, questionnaire related to agricultural production and irrigation would be incorporated. Questionnaire survey has been conducted among farmers to know how irrigation changes the pattern of agricultural land use in recent times. Data on the changes in cropping pattern, transformation of agricultural land into tea gardens, conversion of Rabi crop land into Boro paddy cultivation, etc. have been collected from the Agricultural Development Office of different Blocks of Jalpaiguri District. Maps have been prepared to show the location and other details of beneficial and non-beneficial areas as well as to show the relationship between irrigation and economic development of the study area through GIS tools. Finally, the cost-benefit ratio has been calculated based on collected data.

iv. In order to analyze the social impact of irrigation, extensive field survey has been carried out. For the collection of primary data, a random sampling without replacement have been made by the researcher by taking 28 villages (4 villages each from 7 CD blocks) from the study area. To carry out the field observation, particular and relevant questionnaire have been used. To collect primary data, direct field observation has been done through questionnaires and interviews of 28sample village of seven blocks. To study the social impact of irrigation in the

study area 560 (20 households from each village) household survey have been done through random sampling method.

Some of the statistical methods have been used to represent data scientifically. These are following:

1.7.1 Karl Pearson's Product Moment Correlation Coefficient

The word 'Correlation' is used to denote the degree of association between variables. Correlation coefficient is one kind of bivariate analysis where it can be showed that changes in magnitude of one variable are so associated with the changes in magnitude of other variables. For the analysis of correlation between the various sources of irrigation and net sown area, the researcher has used Karl Pearson's Product Moment Correlation Coefficient. Pearson (1920) systematized the analysis of correlation of coefficient and established a theory of correlation. It is a unit free measure of relationship between two variables and takes value in -1, +1. When the calculated correlation coefficient value close to +1 or -1, there is strong positive or negative relationship established between the variables.

$$r = \frac{\frac{\sum xy}{N} - \bar{x}.\bar{y}}{\sigma x.\sigma y}$$

Where,

r = Product-moment correlation coefficient
N = Number of data pair
$\bar{x}$ = Mean of x
$\bar{y}$ = Mean of y
$\sum xy$ = Sum of the products of x and y
σx = Standard Deviation of x
σy = Standard Deviation of y

1.7.2 Yang's 'Crop Yield Index' method Crop productivity (1965)

Yang's 'Crop Yield Index' method Crop productivity variations were computed by applying 'Crop Yield Index' method devised by W.Y. Yang (1965). This method considers the yield of all crops on a farm compared with the average of crop yield of region. Before calculating the crop yield index, the average yield of each of the crops grown in the region were determined. Then by dividing the yield per hectare of the crop on the particular farm by the average yield of the crop in the region, a percentage was obtained which when multiplied by 100, gives the index number.

By using the area devoted to each crop as a weight to multiply this percentage index, the products obtained were added the products thus the obtained were divided by the sum of the products by the total crop hectares of the farm and (using the crop area as the weight) the resultant average index is the desired index for the particular farm (Rehman, 2003).

The procedure for calculating the crop yield index is explained in table 1.1 below:

Table 1.1 Method to Calculate Crop Yield Index by Yang.

Name of Crops	Yield (kg/ha)		Area (ha) of crop in District	Crop Yield in block as % of District	Percentage Multiplied by area in ha
	Avg. Yield in Blocks	Yield in District			
Aus	3515	3405.57	10082	103.21	1040596.14
Amon	3415	3631.29	107456	94.04	10105561.38
Boro	3372	4274.00	17954	78.90	1416492.47
Wheat	2250	2097.57	9363	107.27	1004340.74
Maize	1472	1471.86	1172	100.01	117211.15
Jute	15.47	13.86	26310	111.62	2936621.21
Mashkalai	755	478.00	352	157.95	55598.33
Mustard	526	631.57	3403	83.28	283417.20
Till	664	661.29	1109	100.41	111354.47
Potato	32853	28923.57	24975	113.59	2836799.45
Total			**2,02,176**		**1,99,07,992.54**

Computation of Crop Yield Index for the block of –

$$\mathbf{C\,Y\,Index} = \frac{\sum \mathbf{P} * \mathbf{A}}{\sum \mathbf{A}}$$

Where,

P = Crop Yield in block as % of District

A = Area (ha) of crop in District

1.7.3 Agricultural Efficiency by S.S. Bhatia

To measure the agricultural efficiency, methods proposed by S.S. Bhatia (1967) have been introduced. There are two advantages which are apparent by using this method. This is as follows:

$$lyn = (y1 / y) \times 100$$

Where,

lyn = percentage yield of crop n

y1 = yield of individual crop in an aerial unit

y = yield of individual crop in the total area

$$Ei = (ly1c1 + ly2c2 + ly3c3 + \ldots\ldots + lyncn) / (c1 + c2 + c3 + \ldots + cn)$$

Where,

Ei = Agricultural Efficiency Index (AEI) y1, ly2, ly3……. lyn = the indices of different crops c1, c2, c3……..cn = Percentages of crop area to total

1.7.4 Cost Benefit Analysis of Major Crops (for irrigation)

Cost–benefit analysis (CBA), sometimes called benefit costs analysis (BCA), is a systematic approach to estimating the strengths and weaknesses of alternatives used to determine options which provide the best approach to achieving benefits while preserving savings (David. et. al. 2013). In case of agriculture the cost benefit analysis refers to the total estimated input and the output benefits from the agricultural production.

$$NR = AI - CP$$

Where,

NR= Net returns per hectare

AI= Annual income per hectare CP=

Cost of production per hectare.

1.7.5 The χ^2 Square Test

The χ^2 square test (pronounced as chi-square test) is one of the simplest and most widely used non-parametric tests in statistical work. The χ^2 test was first used by Karl Pearson in the year 1900. The quantity χ^2 describes the magnitude of the discrepancy between theory and observation. It is defined as:

$$X^2 = \frac{(O - E)^2}{E}$$

Where,

O refers to the observed frequencies and **E** refers to the expected frequencies.

1.7.6 Dimension Index

$$\textbf{Dimension Index} = \frac{Observed\ Value - Minimum\ Value}{Maximum\ Value - Minimum\ Value}$$

1.7.7 Composite Index after Iyengar & Sudarshan's Method: In 1982 Iyengar & Sudarshan put forwarded this method following modified dimension index. They used dimension index for making data standardized in this compositing approach. Using dimension index they transformed original data into a new form of data set. Divided dataset summed up region/block/district wise and after that ranked on that data set by descending order. This value range from 0 to 1, greater the value of compositing indicate higher development. The following formula have been used -

Composite Index =

$$\frac{X1 + X2 + X3 \ldots \ldots n}{No.of\ Variables}$$

Table 1.2 Parameters for calculating Economic Condition of the farmers.

X1	House types
X2	Vehicles availability
X3	Communication facilities
X4	Annual income
X5	Annual expenditure
X6	Mechanical instrument
X7	Livestock profile

1.8 Conclusion

This chapter tends to highlights literature review, introductory discussion, the Scope of the study, location of the study area, hypothesis, objectives, database and methodology, Choice and Selection of Sample Size and Sample Design for the research thesis, and also a brief selected review of literatures directly or indirectly related with the social and economic impact of irrigation on the study area has been outlined.

References

Alexander, K.C., 1982: Agricultural Development and Social Transformation. *Journal of Rural Development*, Hyderabad, vol.1, issue 1, pp. 1-71.

Barrow, J. C., 1999: *Alternative Irrigation: The promise of Runoff Agriculture*. Earths can from Routledge, New York, ISBN 978-1-85383-496-7, pp. 34-52.

Bhalla, G.S., and Singh, Gurmail, 2009: Economic Liberalization and Indian agriculture: A state wise analysis. *Economic and Political Weekly*, New Delhi, vol. xliv, issue 52, pp. 34-44.

Bhatia, S.S.,1967: Spatial Variations Changes and Trends in Agricultural Efficiency in Uttar Pradesh, 1953-63.*Indian Journal of Agricultural Economics*, Bombay, Vol. XXII, No. 1,ISSN 0019-5014, pp. 66-80.

Bhattacharya, D.K., and Mukherjee, P.K., 2009: Contamination of shallow aquifers by arsenic in upper reaches of Teesta River at Siliguri-Jalpaiguri area of West Bengal, India. *Environmental Geology*, vol.57, issue 7, pp. 1687-1692.DOI 10.1007/s00254008-1450-6.

Chakraborty, K. and Mistri, B., 2017: Irrigation System and Pattern of Crop Combination, Concentration and Diversification in Barddhaman District, West Bengal. *The NEHU Journal*, vol. XV, no. 2, ISSN 0972-8406, pp. 45-65.

Chandrasekhara V. S., 1965: A Text Book of Irrigation, Rakamari Book House, Calcutta, pp. 1

Chatterjee, N., 1995: *Irrigated agriculture: a case study of West Bengal.* Rawat Publications, Jaipur, India, ISBN: 8170332834, pp.1-324.

Chowdhury, B.K., 1972: Economics of tube well Irrigation in West Bengal, *Agro-Economic Research Centre*, Visva Bharati, West Bengal, pp. 38.

Dhawan, B.D., 1988: Studies in Economic Development and Planning, Institute of Economic Growth, Sage Publications (Pvt.) Ltd., New Delhi, pp. 1-205, ISBN: 8170360811

Yihdego, A.G., Gebru, A.A. and Gelaye, M.T., 2015: The impact of small-scale irrigation on income of rural farm households: Evidence from Ahferom Woreda in Tigray, Ethiopia. *International Journal of Business and Economics Research*, vol. 4, no. 4, pp. 217-228.

Ghosh, A., 2012: *Impact of Mayurakshi irrigation canal system on the socio-economic aspects of its command area* (Doctoral Thesis Department of Geography Visva-Bharati Santiniketan, West Bengal, India). pp. 167-249. Retrieved from – http://hdl.handle.net/10603/29282.

Gireeshayya, Udagatti, 2005: An Economic Analysis of Farming Systems in Tank Commands of Northern Karnataka. *The University of Agriculture Sciences*, Dharwad, pp. 113136.

Gogoi, K., 1989: *Irrigation in Assam in P.C Goswami (Ed, 1989) Agriculture in Assam.* Assam Institute of Development Studies, Guwahati, Assam, pp. 78-91.

Iyengar, N. S. & Sudarshan, P., 1982: A method of classifying regions from multivariate data. *Economic and political weekly*, 2047-2052.

Kallur, M.S. 1988: *Irrigation and Economic Development*. Chugh Publications, Allahabad, India, pp. 1-296.

Kothari. C.R., Garg, G., 1985: *Research Methodology- Methods and Techniques.* New Age International (P) Ltd., Kolkata, pp. 139-140 and 235-260, ISBN 10 9386649225

Kundu, D.K., Singh, Ravendra and Mahapatra, B.S., 2013: Soil Health and water quality issues for sustainable agricultural production in the eastern region of India. *Journal of Agricultural Physics*, New Delhi, vol. 13, no. 1, pp. 1-12, ISSN: 0973-032X.

Mengistie, D., & Kidane, D., 2016: Assessment of the impact of small-scale irrigation on household livelihood improvement at Gubalafto District, North Wollo, Ethiopia. *Agriculture*, vol. 6, no. 3, pp. 27.

Pal, S.P., 1985: *Contribution of Irrigation to Agricultural Production and Productivity*. National Council of Applied Economic Research, New Delhi, pp. 67-88.

Pawde M.R. and Saha, S.S., 1982: *Geology of the Darjeeling Himalayan*. Geology Seminar 1976. Section 1 B. Geological Survey of India, Misc. Publications, pp. 50-54.

Prabakaran, K., and Sivapragasam, C., 2013: Analysis of growth rates of rice and sorghum in Andhra Pradesh, *International Journal of Farm Sciences*, vol. 3, no. 1, pp. 1-9.

Rehman, H., 2003: Spatial Distribution of Agricultural Productivity and its Correlates in North Bihar Plain, *The Geographer*, Vol. 50, No. 1, Jan., pp. 73-84.

Sarkar, S.K., 2015: "Teesta's Turn Next", The Statesman, 6th June, Kolkata, pp. 6.

Singh, R.K. and Mal, B., 2007: Optional Design Planning for minor irrigation structures in Jalpaiguri District of West Bengal. *Journal of Agricultural Engineering*, vol. 44, no. 4, pp. 43-47.

Suresh, E., 2010: Economic Analysis of Cropping Systems under Tank Irrigation in Northern Karnataka. *The University of Agriculture Sciences*, Dharwad, pp. 109-120.

Unda, A.P., Mal, B.C., and Chowdhury, V.M., 2009: Assessment of groundwater potential in Jalpaiguri District of West Bengal. *Journal of Indian Water Resources Society*, Ghaziabad, India, vol. 29, no. 3, pp. 34-39, ISSN 0970-6984

Van den Berg, J., 2013: Socio-economic factors affecting adoption of improved agricultural practices by small scale farmers in South Africa. *African Journal of Agricultural Research*, *8*(35), 4490-4500, ISSN 1991-637X

Yang, W.Y., 1965: Methods of Farm Management Investigations for Improving Farm Productivity. *FAO, Agricultural Development Paper No. 80*, Rome, pp. 258.

.