1.1 IRRIGATION & ITS IMPORTANCE:

Irrigation is defined as “Artificially supplying & systematically dividing of water for agriculture & horticulture in order to obtain higher or qualitatively better production” (After Eijkelkamp Agrisearch Equipment). Water is essential to plant growth & for millenniums. Successful farmers have used different methods to apply water to their crops. This artificial addition of water is called irrigation. Irrigation is essentially the artificial application of water to overcome deficiencies in rainfall for growing crops (Cantor, 1967). Irrigation is a basic determinant of agriculture because its inadequacies are the most powerful constraints on the increase of agricultural production. In traditional agriculture, irrigation was recognized for its protective role of insurance against the vagaries of rainfall & drought. But now, adoption of high yielding varieties, chemical fertilization & multiple cropping highly used controlled irrigation for increasing productivity.

Importance of Irrigation:

In the next 35 to 45 years world food production will need to double to meet the demands of increased population. Ninety percent of this increased food production will have to come from existing lands & seventy percent of this increased food production will have to come from irrigated land. Without irrigation farming is very limited & if the rainfall decreases to less than 30cm, agriculture becomes impossible without irrigation (King, 1953). It increases crop yield. It protects from famine. It helps to cultivate superior crops with the water supply as per need of the crops. Ultimately it helps in economic development. Irrigation water improves water conditions in the soil, increases the water content of plant fibers, dissolves nutrients & makes them available to plants. Irrigation affects temperature conditions by regulating the temperature of the surface layer of the soil & the ground layer of the air & also makes possible control of the growth & development of plants & improvement of the quality of the harvest. In fruit & berry crops that receive optimum quantities of moisture, the sugar content of the fruit increases & in oil crops the fat content in the seeds is greater. For rice & wheat) with supplementary nitrogen feeding), the protein content in the grain increases & for cotton the quality of the fiber is improved.
1.2 HISTORY OF IRRIGATION DEVELOPMENT:

Historically, civilizations have been dependent on development of irrigated agriculture to provide agrarian basis of a society & to augment the security of people (After Shirsath B. Paresh). Here history of irrigation development has been discussed.

Archaeological investigation has identified evidence of irrigation in Mesopotamia, Ancient Egypt & Ancient Persia (at present Iran) as far back as the 6th millennium BCE (Before Christ Era) (Kang, S.T-1972).

In the ‘Zana’ valley of the Andes Mountain in Peru, archaeologists found remains of three irrigation canals radiocarbon dated from the 4th millennium BCE, the 3rd Millennium BCE & the 9th century CE (Christ Era). These canals are the earliest record of irrigation in the new world (Dillehay TD, Eling HH Jr, Rossen J 2005).

The Indus valley civilization in Pakistan & North India (from 2600 BCE) also had an early canal irrigation system. Large scale agriculture was used for the purpose of irrigation. Sophisticated irrigation & storage systems were developed, including the reservoirs built at Girnar in 3000 BCE (Rodda, J.C 2004).

There is evidence of ancient Egyptian Pharaoh Amenemhet-III in the 12th dynasty (about 1800 BCE) using the natural lake of the Faiyum Oasis as a reservoir to store surpluses of water for use during the dry seasons, the lake swelled annually from flooding of the Nile (Amenemhet III. Britannica Concise).

The Qanats, developed in ancient Persia in about 800 BCE, are among the oldest known irrigation methods still in use today. The system comprises a network of vertical wells & gently sloping tunnels driven into the sides of cliffs & steep hills to tap ground water.

The irrigation works of ancient Sri Lanka, the earliest dating from about 300 BCE, in the reign of King Pandukabhaya & under conditions development for the next thousand years, were one of the most complex irrigation systems of the ancient world. In addition to underground canals, the Sinhalese were the first to build completely artificial reservoirs to store water. The system was extensively restored & further extended during the reign of King Parakrama Bahu (1153-1186 CE).
In the Szechwan region ancient China the Dujiangyan Irrigation System was built in 250 BCE to irrigate a large area & it still supplies water today (Encyclopaedia Britannica, 1994).

In fifteenth century Korea the world’s first water gauge was discovered in 1441 CE. The inventor was Jang Young-Sil, a Korean engineer of the Joseon Dynasty, under the active direction of the king, Se Jong. It was installed in irrigation tanks as part of a nationwide system to measure & collect rainfall for agricultural applications.

In the Americas, extensive irrigation systems were created by numerous groups in prehistoric times. One example is seen in the recent archaeological excavations near the Santa Cruz River in Tucson, Arizona. They have located a village site dating from 4000 years ago. The flood plain of the Santa Cruz River was extensively farmed during the early Agricultural period, circa 1200 BC to AD 150.

1.3 PRESENT STATUS OF IRRIGATION:

In the middle of 20th century, the advent of diesel & electric motors led for the first time to system that could pump groundwater out of major aquifers faster than it was recharged. This can lead to permanent loss of aquifer capacity, decreased water quality, ground subsidence & other problems. The future of food production in such areas as the North China Plain, the Punjab & the Great Plains of US is threatened. At the global scale 27,88,000 sq. km. of agricultural land was equipped with irrigation at present, which was 19,31,000 sq. km. in 1980. About 70% of the area equipped for irrigation is located in Asia which was 68% in 1980. 9% of the area equipped for irrigation in Europe, which was 7% in 1980. In Africa it was 5% both in 2003 & 1980. In America the area equipped for irrigation was 15% in 2003 & 18% in 1980. In Oceania it was 1% in 2003 & 0.9% in 1980. The largest contiguous areas of high irrigation density are found in North India & Pakistan along the rivers Ganges & Indus, in the Hai He, Huang He & Yangtze basins in China, along the Nile River in Egypt & Sudan, in the Mississippi-Missouri river basin & in parts of California.

1.4 DEVELOPMENTAL ASPECTS OF IRRIGATION:

Irrigation is practiced to maintain the different developmental parameters. Those are:

- To make up for the soil moisture deficit.
- To ensure a proper & sustained growth of crops.
- To make harvest safe.
- To colonize the cultivable wasteland for horizontal expansion of cultivation.
- To shift from seasonal cultivation.
- To promote more intensive cultivation by multiple cropping.
- To improve the level of agricultural productivity by acting as an agent for adoption of modern technology.
- To lessen the regional & size-class inequalities in agricultural productivity that will reduce in turn socio-economic imbalances.

1.5 DIFFERENT TYPES OF IRRIGATION SYSTEM:

Irrigation systems are often designed to maximize efficiencies & minimize labour & capital requirements. There are three broad classes of irrigation system:

1. **Pressurized distribution.**

2. **Gravity flow distribution.**

3. **Drainage flow distribution.**

1. **Pressurized distribution**: The pressurized systems include sprinkler, trickle, in which water is conveyed to & distributed over the fields through pressurized pipe networks.

2. **Gravity flow distribution**: This system conveys & distributes water at the field level by a free surface, overland flow regime.

3. **Drainage flow distribution**: Irrigation by control of the drainage system sub irrigation is not so common but is interesting. Relatively large volumes of applied irrigation water percolate through the root zone & become a drainage or ground water flow. By controlling the flow at critical points, it is possible to raise the level of the ground water to within reach of the crop roots.

To supply water the entire field uniformly so that each plant would get sufficient amount of water, there are various types of irrigation techniques that differ in how the water obtained from the source is distributed within the field. These are:

1. **Surface Irrigation**: In this irrigation system water moves over & across the land by simple gravity flow in order to wet it & to infiltrate into the soil. Surface
irrigation can be subdivided into furrow, border strip or basin irrigation. It is often called flood irrigation when the irrigation results in flooding or near flooding of the cultivated land.

2. **Ditch Irrigation:** This is the simplest & oldest irrigation system & it is still common in many parts of the world. The only technology essential is the manpower or machines to dig ditches or furrows between the rows of plants. Water is added to the ditches by means of gravity flow, pumps & siphons.

3. **Localized Irrigation:** It is a system where water is distributed under low pressure through a piped network, in a pre-determined pattern, & applied as a small discharge.

4. **Drip Irrigation:** This is also known as trickle irrigation. Water is delivered at or near the root zone of plants; drop by drop. This method can be the most water efficient method of irrigation.

5. **Overhead Irrigation:** This is the artificial application of water to crops from above. Central pivot systems, which are in wide use in areas of flat terrain, have sprinklers spaced along very long aluminum or steel pipes that extend in two directions from a central supply point. Sprinkler systems are another very common overhead irrigation system. In these systems, water is piped to a point within the area to be irrigated.

6. **Sub-Irrigation:** This is also called as seepage irrigation used for many years in the fields where water table is high. This method artificially raises the water table by allowing the soil to be moistened from below the plants’ root zone.

7. **Manual Irrigation:** This system has low requirements for infrastructure & technical equipment but needs high labour inputs by using buckets or watering cans.

According to the different sources of irrigation there are two major divisions found. These are:

1. **Flow Irrigation:** The water of a reservoir or tank usually remains at a higher level & when a channel is connected to it, water automatically flows down the channel.
which fulfills the purpose of a canal for irrigation. In this case water level remains higher than the fields. Such irrigation is known as the flow irrigation.

2. Lift Irrigation: Where the fields lie at a higher level & the canals or tanks lie at a lower level, it becomes essential to lift the water by pump etc. to irrigate land. Water is lifted from tanks, wells & tube wells by pumps for irrigation through channels. This method of irrigation is known as the lift irrigation.

1.6 CANAL IRRIGATION IN THE WORLD CONTEXT:

Canals are manmade channels of water. There are two types of canals:

- Water ways: These are navigable transportation canals used for carrying ships of goods & conveying people. These may be connected to existing rivers or oceans such as Suez Canal & connected in a city network such as Canal Grande.

- Aqueducts: These are water supply canals used for the conveyance & delivery of portable water for human consumption & agricultural irrigation.

The oldest known canals were irrigation canals built in Mesopotamia circa (modern day Iraq & Syria) 4000 BC. The Indus Valley Civilization, Ancient India (Circa 2600 BC) had sophisticated irrigation & storage systems developed, including the reservoirs built at Girnar in 3000 BC.

In ancient China, large canals for river transport were established as far back as the Warring States (481-221 BC), the longest one of that period being the Hong Gou, which connected the old states of Song, Zhang, Chen Cai, Cao (Needham 1971). By far the longest canal was the Grand Canal of China, still the longest canal in the world today & the oldest extent one. It is 1794 km long.

In the middle Ages, the first artificial canal in Christian Europe was the Fossa Carolina built at the end of the 8th century. The first summit level canals were developed with the Grand Canal of China in 581-617 AD whilst in Europe the first, also using single locks, was the Stecknitz Canal in Germany in 1398.

In the early modern age, the first to use pound locks was the Briare Canal connecting Loire & Seine (1642), followed by the more ambitious Canal du Midi (1683) connecting the Atlantic to the Mediterranean. In post Roman Britain, the first canal
built appears to have been the Exefer Canal, opened in 1563. In Russia, the Volga-Baltic Water ways was opened in 1718.

In the period of Industrial Revolution, the opening of Sankey Canal in 1757, followed by the Bridgewater Canal in 1761, halved the price of coal in Liverpool & Manchester respectively. By 1825, the Erie Canal, in 1829, the Welland Canal, in 1832, the Rideau Canal were opened.

Canals have found another use in the 21st century as easements for the installation of fibre optic telecommunication network cabling. Canals are still used to provide water for agriculture.

1.7 CANAL IRRIGATION IN INDIA:

Rain water is considered as one of the most ideal sources of irrigation if in case it is timely & adequately received. But rainfall in India varies in different regions. It is uncertain, uneven & prominently seasonal. Notwithstanding that long dry period in India also badly affects the agriculture. Irrigation in India, carried are on in three different ways according to their sources such as; by canals, by wells or tube wells, & by tanks. Out of the total area under irrigation 40 percent are irrigated by canals, 40 percent by wells or tube wells & 12 percent by tanks. The rest 8 percent of land are irrigated by other methods.

1.7.1 History of Canal Irrigation Development in India:

Vedas & ancient Indian scriptures made references to wells, canals, tanks & dams. There is evidence of practice of irrigation since the establishment of settled agriculture during the Indus Valley Civilization (2500 BC). In the south, perennial irrigation may have begun with construction of the Grand Anicut by the Cholas as early as second century to provide irrigation from the Convery River (Ministry of Water Resources).

1.7.2 Canal Irrigation during Medieval India:

In the medieval India, rapid advances took place in the construction of inundation canals. Water was blocked by constructing bunds across streams. This raised the water level & canals were constructed to take water to the fields. Ghiyasuddin
Tughluq (1220-1250) is credited to be the first ruler who encouraged digging canals. Fruz Tughluq (1351-1386) is considered to be the greatest canal builder.

1.7.3 Canal Irrigation Development under British Rule:

Close to nineteenth century according to sources of irrigation; canals irrigated 40 percent, wells 35 percent, tanks 15 percent & other sources 5 percent. Upper Ganga Canal, Upper Bari Doab Canal, Krishna & Godavari Delta System were completed during 1836 to 1866. In 1867, the Government adopted the practice of taking up works for the construction of major canal works like, Sirhind, the Lower Ganga, the Agra & the Mutha canals. The Lower Swat, the Lower Sohag, Lower Chenab & the Sidhnai canals under Indus system were also come up. To cope up with the situation of famine during 1897-98 & 1899-1900, it was necessitated to appoint first Irrigation Commission in 1901. Significant protective works constructed during this period were the Betwa Canal, the Gokak canal, the Khaswad Tank & the Rushikulya Canal.

1.7.4 Canal Irrigation Development at the Time of Independence:

The net irrigated area in the Indian Sub Continent, comprising the British Provinces & Princely States, at the time of Independence was about 28.2 Million Hectare. The partition of the country brought about drastic changes in irrigated area between India & Pakistan; net irrigated area in India & Pakistan being 19.4 Million Hectare & 8.8 Million Hectare respectively. Major canal system including the Sutlej & Indus system fell to Pakistan share.

1.7.5 Canal Irrigation Development after Independence:

In the initial phase of water resources development during the plan period after Independence, rapid harnessing of water resources was the prime objective. Accordingly, the State Governments were encouraged to expeditiously formulate & develop water resources projects for irrigation, flood control, hydropower generation, drinking & industrial water supply. As result a large number of projects comprising dams, barrages, hydropower structures, canal network etc. have come up all over the country in successive Five Year Plans.
1.7.6 Irrigation Development during Plan Periods:

The irrigation potential through major, medium, & minor irrigation projects has increased from 22.6 Million Hectares in 1951, to about 102.77 Million Hectare at the end of 2006-07 (Ministry of Information & Broadcasting Govt. of India 2008).

The following table shows the plan wise irrigated area under different sources:

Table: 1.1 IRRIGATED AREA UNDER DIFFERENT SOURCES DURING PLAN PERIOD

<table>
<thead>
<tr>
<th>Year</th>
<th>Canals</th>
<th></th>
<th>Ground Water</th>
<th>Other</th>
<th>Net Irrigated Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Govt.</td>
<td>Private</td>
<td>Tanks</td>
<td>Tube wells</td>
<td>Other Wells</td>
</tr>
<tr>
<td></td>
<td>7.2</td>
<td>1.1</td>
<td>3.6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>1955-56</td>
<td>8</td>
<td>1.4</td>
<td>4.4</td>
<td>0</td>
<td>6.8</td>
</tr>
<tr>
<td>1960-61</td>
<td>9.2</td>
<td>1.2</td>
<td>4.6</td>
<td>0.2</td>
<td>7.2</td>
</tr>
<tr>
<td>1965-66</td>
<td>9.8</td>
<td>1.1</td>
<td>4.4</td>
<td>0</td>
<td>8.6</td>
</tr>
<tr>
<td>1970-71</td>
<td>12</td>
<td>0.9</td>
<td>6.1</td>
<td>4.5</td>
<td>7.4</td>
</tr>
<tr>
<td>1975-76</td>
<td>12.9</td>
<td>0.9</td>
<td>4</td>
<td>6.8</td>
<td>7.6</td>
</tr>
<tr>
<td>1980-81</td>
<td>14.5</td>
<td>0.8</td>
<td>3.2</td>
<td>9.5</td>
<td>8.2</td>
</tr>
<tr>
<td>1990-91</td>
<td>16.1</td>
<td>0.3</td>
<td>3.3</td>
<td>14.2</td>
<td>9.9</td>
</tr>
<tr>
<td>1995-96</td>
<td>17.6</td>
<td>0.5</td>
<td>3.2</td>
<td>15</td>
<td>11.7</td>
</tr>
<tr>
<td>2000-01</td>
<td>15.99</td>
<td>0.3</td>
<td>3.5</td>
<td>20.3</td>
<td>14.3</td>
</tr>
</tbody>
</table>


1.7.7 Present Status of Canal Irrigation Development in India:

India’s irrigation development in 20th century has seen large number of large storage based systems, all by the Government effort & investment. It has seen more than 60 percent of irrigation budgets going for major & medium projects (Projects which have a Cultivable Command Area (CCA) of more than 10,000 hectares are termed as major projects, those which have CCA less than 10,000 hectares but more than 2000 hectares are termed as medium projects & those which have CCA of 2000 hectares or less are known as minor projects). India’s ultimate irrigation potential was estimated of 139.9 Million Hectare, comprising of 58.46 Million Hectare through major, & medium irrigation projects & 81.43 Million Hectare from minor irrigation schemes (Directorate of Economics & Statistics, Ministry of Agriculture 2002-03). The following table shows irrigation potential & utilization up to 2002-03 in Million Hectare (Mha.):
Table: 1.2 IRRIGATION POTENTIAL & UTILIZATION UP TO 2002-03 (MHA)

<table>
<thead>
<tr>
<th>Source</th>
<th>Ultimate Irrigation Potential</th>
<th>Potential Created</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMI</td>
<td>58.47</td>
<td>37.05</td>
</tr>
<tr>
<td>MI-Surface</td>
<td>17.37</td>
<td>13.66</td>
</tr>
<tr>
<td>MI-Ground Water</td>
<td>64.17</td>
<td>54.61</td>
</tr>
<tr>
<td>MI-Total</td>
<td>81.54</td>
<td>68.27</td>
</tr>
<tr>
<td>Total</td>
<td>140</td>
<td>105.32</td>
</tr>
</tbody>
</table>

Source: Narayanamoorthy, A. Trends in Irrigated Area in India: 1950-51 to 2002-03.

Where,

MMI- Major & Medium Irrigation & MI- Minor Irrigation.

With the creation of irrigation potential of 89.56 Million Hectare by 1996-97, India has the largest irrigated area among all the countries in the world. The major increase has been made in potential due to ground water irrigation development & also due to minor surface potential (Govt. of India 1997:477).

1.8 CANAL IRRIGATION IN WEST BENGAL:

In Bengal, the first major irrigation scheme was undertaken during execution of Eden Canal System in 1981 in the district of Burdwan. The Midnapore Canal System came later in 1989 in the district of Midnapore. Both these canal systems were constructed to utilize the flood water for irrigation purpose during flood period only. In 1935, a project consisting of a weir & under sluices named as Anderson Weir was taken for construction & completed in 1939. In 1901, the Indian Irrigation Commission was set up & recommended in 1903, a definite line of policy regarding the selection, financing & maintenance of productive irrigation works. Apart from these, liquidating or remunerative works, the Commission also examined the desirability of extension of irrigation as a means of production against famine in areas of insecure & precarious cultivation. Such irrigation based on expensive storage works might not be directly remunerative to the Government but the Commission recommended that the net financial burden which such schemes would impose on the state would not be too
high a price to pay for the protection against famine which they would afford, so a foundation for the storage reservoir project has been established in India in 1903 & schemes were taken up for productive measures in Bengal as well as elsewhere in India. The total irrigated area prior to Independence with the Eden Canal system, Midnapore Canal System & Damodar Canal System resulted benefit for 149 thousand hectares. After Independence the following projects have been started in West Bengal to meet various demand i.e. irrigation water supply, hydropower generation, fishery, tourism etc.

The projects are:

1. Midnapore Canal System.
2. Barrage & Irrigation System of D.V.C.
3. Mayurakshi Reservoir Project.
4. Kangsabati Reservoir Project.
5. Teesta Barrage Project.
6. Subarnarekha Barrage Project

West Bengal Water Resources: The state is endowed with 7.5 percent of the water resource of the country & that is becoming increasingly scarce with the uncontrolled growth of population, expansion of irrigation network & developmental needs. The spatial & temporal variability of rain within the state causes the twin menaces of flood & drought. The Irrigation & waterways Department (1987) of Government of West Bengal made an assessment of the available water resources within the state in 1987. The Expert Committee explored in detail on the 26th river basins of West Bengal & stated that though the surface water in West Bengal is estimated to be 13.29 Mham. (Million Hectare Meter), only about 40 percent of it is useable, while the available groundwater though being 1.46 Million Hactare Metre only is totally useable (Rudra, K. 2009).
The availability of water resource within this state is spatially & temporally uneven. The one dimensional supply side management of water involving an almost deep faith on large dams & long distance supply of water proved futile due to evaporation & seepage losses. About 63 percent of the water resource of the entire state is carried by eight river basin of North Bengal while the Rarh & Eastern Plains are endowed each with 22 percent & 15 percent of water respectively. Regular flood in the river basins of North Bengal, loss of storage capacity of the reservoirs across the rivers of South Bengal highly reduced the water supply in the agricultural sector of West Bengal.

The futility of water supply from the river basins leads over exploitation of the ground water often beyond the naturally replenishable limit. This was directly related to the introduction of high yielding but water intensive seeds that replaced the traditional ones. Now more than 0.60 million of shallow & more than 5000 deep tube wells are operating in the agricultural fields of the state.

1.9 SELECTION OF THE STUDY AREA:

In the present study, Mayurakshi Reservoir Project has been chosen. The project comprises the Birbhum district excluding entire Rajnagar & Khoyrasole blocks, western part of Dubrajpur block. It includes the blocks of Murshidabad district, west of River Bhagirathi & Ketugram-I & II blocks of Burdwan district. The entire area under the canal command of Mayurakshi Reservoir Project includes Dwarka, Brahmani, Bakreswar & Kopai rivers along with Mayurakshi. Barrages & weirs have been constructed across the river to store rain water so that this water may be supplied in the dry winter.

Socio-economically this is one of the most backward & neglected region. Disadvantaged rural scheduled caste, scheduled tribe & Muslim population dominate this region. Industrial development is also limited here due to paucity of resources & less governmental infrastructure. This leads to impoverishment & unemployment among the people.

This region is entirely dependent on agricultural activity which is directly controlled by the nature of rainfall which is highly erratic & uneven in this region. Uneven &
irregular nature of rainfall highly hampered the agricultural production by reducing the storage capacity of the reservoirs. Moreover, heavy downpours in the upper catchment of the rain fed rivers of this region causes flood in frequent years. This flood also affects the whole agricultural sectors as well as creates disastrous effect to the human life. The maximum portion of the canal command area is characterized with hard crystalline rock structure & infertile laterite soil which is not highly suitable for agriculture & needs more irrigation for crop production. That’s why canal irrigation water is needed. In 1951, just after Independence the project got started & completed with its all phase in the year of 1985, by the Bengal Government, with the financial assistance of Canada Government. That’s why Massanjore Dam is named as also Canara or Kanara Dam, so as to give gratitude to Canada Government.

The objective of this project was to supply water for Rabi crops as well as Kharif crops for transplantation. Enhancement of crop production & crop yield also was its one of the main principles, so as to achieve optimum irrigation efficiencies. According to the Bengal Irrigation Department & Mayurakshi Project Division, this will benefit the farmers immensely & will put an impact on their socio-economic condition.

This rain fed river irrigation system now only carries water in the heavy rainy season but in the dry winter all the canals remain dry & do not help the irrigation systems. The canal command area is characterized with numerous large & small tanks which used to use for irrigation. But more faith & dependency on canals, all the tanks have lost their importance in irrigation. So they are now beyond of regular maintenance being unexcavated since last 20 to 25 years & do not support the irrigation system in the dry season. All the farmers now entirely depend on the ground water for irrigation in the dry months. Excessive lifting of ground water now highly depletes the ground water level. Under these circumstances the present study examines the sustainability of this project & how far this project is truly making an impact on the socio-economic condition of the people there.
Introduction
SATELLITE IMAGERY OF MAYURAKSHI IRRIGATION CANAL COMMAND AREA

Source: Sensor: Landsat TM  Imagery No. 1
Date of capturing: 15th December 2010
Type of Image: True colour composit

1.10 LOCATION OF THE STUDY AREA:

Geographically the Mayurakshi Canal Command Area lies within 23°32' North to 24°31'20" North latitudes & 87°26'40" East to 88°7'30" East longitude comprising the parts of Birbhum, Murshidabad & Burdwan districts of West Bengal (vide fig. no.1.1). Physiographically, the canal command area is lying within a number of river basins, such as, Mayurakshi, Dwarka, Brahmani, Bakreswar & Sal or Kopai. Among
these river basins Mayurakshi is the main which covers maximum portion of the command area. Dwarka & Brahmani river basins occupy the Northern portion of the command area whereas, Bakreswar & Kopai cover the entire Southern portion of this canal command area. The researcher has selected Mayurakshi Irrigation project under which Massanjore Dam, Tilpara Barrage across the main river Mayurakshi; Brahmani & Kopai barrage across Brahmani & Kopai river respectively; Dwarka & Bakreswar weir across Dwarka & Bakreswar river respectively have been considered as these are controlling construction of this major canal irrigation system.

The Mayurakshi Canal Irrigation Command Area comprises maximum areas at Birbhum district including entire Muraroi-II, Nalhati-II, Rampurhat-II, Mayureshwar-I&II, Suri-II, Sainthia, Labpur, Bolpur, Nanoor & partly Muraroi-I, Rampurhat-I, Nalhati-I, Md.Bazar, Suri-I, Dubrajpur, Illambazar blocks; western blocks of Murshidabad district i.e. entire Burwan, Khargram, Bharatpur-I&II & partly Kandi, Sagardighi, Nabagram, Raghunathganj-I & Suti-I; and only Ketugram- I&II blocks of Burdwan district. All the canals of this Irrigation System are spread over these blocks, so these have taken under the consideration of analysis. The Canal Command Area includes 2209.27sq.km. of Birbhum district; 805.49 sq.km. of Murshidabad district & 196.84 sq.km. of Burdwan district.

1.11 SCOPE OF THE STUDY:

After the Independence during plan periods, number of multipurpose river valley projects have been constructed, big dams & reservoirs have been built for agro-economic growth & national prosperity, through irrigation management, hydropower generation, flood control, soil conservation, water supply etc. the main objective of this type of river project is to supply irrigation water to the fields where there was none or little before. With the supply of irrigation water to the fields throughout the year, agriculture is practiced all over the year. Number of crops is grown.

Mayurakshi Reservoir Project & its Canal Irrigation System has been started in the year of 1954. Since a long year of irrigation practice, this Irrigation System how has brought the changes in the physical landscape as well as in socio-cultural profile, is to determine. How this Irrigation System damaged the hydrological structure, is to find out. How this Multi Purpose River Project has altered the socio-economic characteristics of the people, which is to be judged. The author believes that this type
of research will encourage further intensive research on this type of Multipurpose River Project & its actual benefits.

1.12 LITERATURE REVIEW:

The main motto of the literature review is to get an idea, different observations & findings of other scholar’s work that will be necessary in substantiating the agreement put forward in the present study. It also helps to realize the magnitude of the problems related.

The studies have been grouped into number of following types:

a) Studies emphasizing the need of multipurpose river project, especially rain fed surface water based projects.

b) Studies on impact of rain fed canal irrigation projects in respects of agriculture in India.

c) Studies on impacts of rain fed canal irrigation projects in respects of socio economic aspects in India.

d) Studies on impacts of tank & tube well irrigation in respects of agricultural development.

e) Literature related to impacts of canal irrigation in Mayurakshi Canal Irrigation Command Area comprising Birbhum, Murshidabad & Burdwan district.

The present works have raised a number of important issues like whether multipurpose river valley projects may serve multipurpose or not, are they co-friendly to environment, to economic development, is there any need to rejuvenate ancient water harvesting structures i.e. tank, ponds, why tube well irrigation are considering main source of irrigation?

In this section the discussion has been initiated about the advantages & disadvantages of canal irrigation surface water based projects & dams, barrages.

The following discussions will depict the above mentioned issues.

Willcocks, W. (1930) explained the ancient irrigation system in Bengal. He mentioned the practice of overflow irrigation of the Ganges & Damodar deltas which
Bhattachariya, K. (1954) explicated the drainage characteristics of Bengal, their changes in courses. He analyzed the effect of these changes on the human life & environment. He mainly stressed on the river systems of Gangetic delta, highlighting the matured & active deltaic part & its rivers. He also explained the river characteristics of Rarh region, with the special emphasis on river projects. He also justified the duty of water in various agricultural methods. He tried to explain the change of river depth during flood & its magnitude.

Singh, J. & Dhillon, S.S. (1984) signified the impact of various factors on agro-economic development & socio-economic betterment of the ruralites. They tried to analyse the factors that determine agricultural patterns & the location of agricultural activities. In this regard, they gave importance on man's agricultural enterprises. For example, they have chosen Punjab-Haryana region & put various statistical techniques for analyzing the impact of various factors that determine the agro-economic growth. They also discussed on the differentiation of agro-economic growth in different states of India due to different physical & cultural variations. They vividly mentioned the impact of canal irrigation system on the agro-economic as well as socio-economic conditions of the people with the reference of Punjab Haryana plain. The authors clearly discarded the long term practice of canal irrigation, Green revolution technology & stated how these put adverse effect on the agricultural status of a region.

Goldsmith, E. & Hildyard, N. (1984) stated the failure of Dams of Multipurpose River Project by quoting the collapse of Teton dam in December 1976 that caused the death of 14 people along with a billion dollars worth of damage & the collapse of Johnstown Dam in Pennsylvania the led to the death of over 2000 people. They mentioned the incidence of flood that overtops the dam & causes death of the people.
For example, they remarked on Machau II Dam in India 1979 that caused the death of 1500 people downstream.

Chambers, Robert. (1989) discussed the mismanagement of canal irrigation projects. He talked about the investment of many billion dollars in canal irrigation which have had disappointing results. He also expressed how much investment had been done through the Third World on programmes for rehabilitation, canal lining, on farm development, & farmers organization. He showed that much of the canal irrigation policies & practices are based on misleading research & misdiagnosis. He also suggested that before starting canal irrigation system there should be maintained a strong co-ordination between civil & agricultural engineers, economists & local farmers. He also stressed on the supply of canal water at night to resist evaporation. According to him, canal irrigation system should be managed jointly by farmers & officials.

Barrow, J. Christopher (1999) described runoff agriculture which is a form of agricultural irrigation. He mentioned how the use of surface & sub surface water often overlooked wasted that enables both small farmers & commercial agriculturists to improve yields & the security of harvest, even in harsh & remote environments. He introduced number of techniques & strategies, as well as the challenges & the potential of the crucial approach, so much to reduce land degradation & improve conservation & sustainability.

Nagchoudhury, S. (2000) blamed dams for Bengal flood than rains. He stated that excessive & unregulated releases from dams cause floods. For instance, he referred Farakka Barrage & Dams in Massanjore and Hinglow, those have been wrecking havoc year after year.

Vidal, A. (2000) emphasized on the satellite remote sensing & Geographic Information Systems (GIS) for the successful irrigation system management. He proved that with the help of remote sensing satellite, the rock characters, ground water storage can easily be traced out. This attempt will highly help the irrigation system & control seepage losses.

The World Commission of Dams (WCD) Report on November 2000 yet stated the contribution of dams to human development. The report also mentioned the benefits
of dams are that dams support 30 - 40 percent of the entire irrigated area of the world; around 12 percent of all dams supply water for drinking & sanitation but discarded the long term benefits of dams. This report proved that dams generate temporal employment during construction but create permanent displacement of the local people from their homes & traditional livelihood, which leads to impoverishment among the migrant. The report established that the forcibly displaced people are inadequately compensated, so their poverty is increased. Besides, the uncontrolled & unscheduled releases of water from dams & barrages threaten the lives of people living near the banks. In this regard, the report dealt with number of dams & barrages in worldwide mainly India & Pakistan. With the dealing of number of studies on different dams, reservoirs & barrages the report established that the dams provide number of adverse effects on environment disturbing rivers hydrology & ecosystem.

Fahlbusch, H. & Schultz, B. (2004) discussed historical picture of Indus Valley Civilization, its irrigation techniques & agricultural practices. They explained the canal irrigation system in the basin during British rule. They emphasized on the large infrastructure development in the basin comprising dams, barrages, canals which has helped in transformation of the basin as a bread basket for India & Pakistan. They highlighted the canal irrigation development of the Indus Valley region & expressed how irrigation system now has become world’s largest integrated & physically contiguous system.

Sne, M. (2006) emphasized on micro irrigation as a system which has matured into reliable water & fertigation management system for crop production. Micro irrigation is in arid & semi arid regions as an effective water conservation & demand management measure to cope up with the increasing scarcity of water in agriculture.

Ghinassi, G. (2008) talked about the improvement of on farm irrigation efficiency that is important according to him not only to enhance the overall irrigation efficiency of the irrigation schemes but also to boost the crop water productivity. He proved that the use of sprinkler & micro irrigation methods have been steadily increasing worldwide, in order to cope with declining water withdrawals to irrigation. He also suggested that these methods of irrigation should be operated & maintained properly for having expected benefits. In this regard he felt the need of periodic irrigation of the crops.
Vaidyanathan, (2008) described the water resource management in India after Independence & a major shift towards integrated water shed development in rain fed areas reducing waste & over exploitation of water & more efficient use of irrigation water. For example, he selected Chennai city as a case study to deal the urban water scene, its systematic use & management.

Ramachandran, V. (2010) highlighted the benefits of irrigation to agriculture. According to him, without agriculture, man cannot live & without irrigation man cannot have agriculture. He realized, the food is essential for human beings as well as for animals for their sustenance. Before irrigation, man satisfied his hunger by eating fruits from the forest & drinking water from natural streams. Slowly man’s demands grew & men felt the need of different types of food. So cultivation & growing crops has been started. To produce crops regularly by resisting drought he suggested the application of different irrigation methods.

1.13 HYPOTHESES:

The entire research & experiment are revolved around the following research hypothesis, created by the present researcher based on the outcome of research & experiment. Those are:

- Canal irrigation facilities are not distributed uniformly within command area.
- Canal irrigation support during off season is not available as expected.
- Farmers’ interests are gradually shifting towards tube well irrigation instead of canal irrigation.
- Target achievement of canal irrigation is fulfilled for decades only from its inception.

1.14 RESEARCH QUESTIONS:

Before the experimental study & analysis on the impact of Mayurakshi Canal Irrigation Project some research questions have been formulated. Those are:

- Whether the Mayurakshi Canal Irrigation System met its own target?
• Whether the dam & barrages fulfilled the demand of water throughout the canal command area?

• Whether the dam & barrages may control flood?

• Whether there is any improvement in socio-economic conditions in post barrage periods?

• What are the perceptions of local people about this irrigation project?

1.15 OBJECTIVES:

The present research work stresses upon the Mayurakshi Irrigation Canal System & the impact on the socio-economic life of the people of its command area. The vastness of its command area, its droughty climatic characteristics give us an idea of the magnitude of the problem.

The major objectives of the present work are as follows:

➢ To examine present condition of the Mayurakshi Irrigation Canal System.

➢ To measure the water management throughout the canal command.

➢ To explore the effect of Mayurakshi Irrigation Canal system on the land use pattern of its command area.

➢ To examine the socio-economic settings of the command area.

➢ To measure the irrigation potential & optimum land use of each land parcel through the use of canal water.

➢ To find the nature of development of irrigation system on agricultural scenario.

➢ To find out the changes in land use & socio-economic aspects of this area over the decades 1981-2001.

➢ To analyze the nature of change in socio-economic conditions of the inhabitants of the command area during present period in comparison with the period before full phased starting the project.
To measure the extent & nature of relationship between land use & irrigation system.

1.16 METHODOLOGY:
To give the answers of the research questions & to find out the impact of Mayurakshi Canal Irrigation Project, the following methods have been adopted. The process has been divided into three phases. They are pre field, field, & post field period.

Pre field:

In pre field phase number of data, information, regional & topographical maps from different sources were collected at the time of initiation of the study. The study is time framed into three periods. One before the full phase completion of the irrigation system, second just after the completion of the total irrigation system & last the present. Because the irrigation project got started & the full phase completion of the project was in the year of 1985 hence the condition before the completion, during the completion & after the full phase completion of the project are to consider for discussion, to analyze the past & present situation of the canal system & its impact.

Spatially the command area has been divided into two areas i.e. South Bank canal command area, North Bank canal command area & these two are also divided into three sectors according to their position along the canals i.e. Head Reach canal, Middle of the canal & Tail end of the canal. Villages have been selected by the thorough observation on their location & availability of canal water for the comparative study of the different socio-economic parameters for the villages. The researcher also followed the tributary & distributary canals along with the main canals.

Village Monpur at the Head Reach, village Dhalla at the Middle, Jaulia at the Tail End from the South Bank canal, village Krishnagar at the Head Reach, Kaluha at the middle, Muhammadnagar at the tail end, of the North Bank canal have been selected by the present researcher to measure the variation in socio-economic impact. Akalipur from the middle of the North main canal, Bandhnabagram from the middle of the South main canal have been picked up to analyze the impact of the distributary canals.
The researcher was interested to assess whether these canals have brought any change in socio-economic life & living standard of the people or not. The researcher also tried to find out through this phase whether this multipurpose river project is actually multipurpose or not; how far it is friendly to the environment & agriculture & its reality to present situation.

The following sources are consulted for data, information, and map collection.

Sources of data:

West Bengal Irrigation Department of Bolpur Division provided the followings:

- Report of Mayurakshi Reservoir Project.
- Catchment & Command Area specification.
- Dam & Barrages under this project & their set up, length.
- Characteristics of the Dam, Barrages (whether it is earthen, rock built or weir type).
- Number & names of benefitted villages under the Mayurakshi Irrigation Canal Command Area.
- Characteristics of main, tributaries & distributaries canal network.

West Bengal Irrigation Department Head Office at Kolkata provided the Official Record of the Project & number of published documents regarding the Project to assess the Government declared irrigated area & targeted area for irrigation. West Bengal District Gazetteers of Birbhum, Murshidabad & Burdwan districts have been consulted to have comprehensive knowledge on physical & cultural landscape of the command area.

Birbhum, Murshidabad & Burdwan District Village Census Directory 1971, 1981, 1991, and 2001 have been consulted for demographic data information, land use & basic amenities for all of the villages under the canal command. The researcher collected the Meteorological data from the District Meteorological Office.
Agricultural variation in production of crops & cropped area was collected from the District Agricultural Office, to assess the impact of canal system on agricultural production of crops. The researcher followed the Toposheets from NATMO, as the blocks of Murshidabad districts are under the areas of restricted zone. For geological information Geological Survey of India was under the consultation by the researcher.

Annual Report of Ministry of Water Resources, Govt. of India also has been consulted to find out the present status of surface & ground water potential of the canal command area & their utilization.

Primary data were collected through household survey of the villages with the help of questionnaire. Mouza land use data for each plot have been collected from village Panchayat Revenue Office.

Sources of Maps:

1. Consulted Toposheets of the Study Area:
   - Massanjore Dam Area: 72 P/3, 72 P/7, 72 P/8,
   - Birbhum District under the Irrigation canal Command Area: 72P/12, 72P/14, 72P/15, 72P/16, 73M/5, 73M/6, 73M/7, 73M/9, 73M/13.
   - Murshidabad District under the Command Area: 78D/2, 78D/3, 78D/4, 79A/1, 79A/2.
   - Burdwan District under the Canal Command Area: 73M/10, 73M/11, 73M/14, 73M/15.

2. Command Area Map has been collected from Irrigation Department, Government of West Bengal, Bolpur Division.

3. Command Area Satellite Imagery from Landsat Imagery.

4. District Soil & Geological Maps were collected from the Geological Survey of India.
5. Mouza Maps were collected from Village Panchayat Revenue Office of concerning Mouzas & Land & Land Reform Office, Government of West Bengal.

❖ Field:

To find out the nature & extent of social & economic impact the following methodology has been adopted. Those are:

i. A number of villages have been selected from the canal command area to conduct the impact study.

ii. The command area has been divided into two divisions based on the position of the canals. They are North Main & South Main Canal Command Area. These two Main Canal Command Areas are again named differently according to the availability of water from which river it is received.

iii. Surveyed Villages are:

   Monpur, at the Head Reach of Mayurakshi Bakreswar Main Canal Command Area. Krishnagar, at the Head Reach of Mayurakshi Dwarka Branch Canal. Dhalla, at the Middle reach of Kopai South Main Canal. Kaluha, at the Middle reach of Dwarka Brahmani Main Canal. Bandhnabagram, under Bakreswar Kopai Branch Canal. Akalipur, under Dwarka Brahmani Branch Canal. Jaulia, at the Tail End of Kopai South Main Canal & Mohammadpur, at the Tail End of Brahmani North Main Canal.

iv. From each village 35 – 40 households have been surveyed with the help of questionnaire.

v. The questionnaire was discussed thoroughly with the villagers of the surveyed households to collect the information of their socio-economic life & get realize the impact of canal on their life at present.

❖ Post Field (Data Analysis):

From the primary & secondary data collected respectively from the village survey & different Government sector, number of variables is outlined to analyze the data for

The Social Variables are: Population Density, Physiographic Density, Man Cropland Ratio, Shifting of Main Labour Force, Literacy Rate, Women Participation in Agriculture, and Centrality Index for Various Service Centres, etc.

The Economic Variables are: Irrigated Area to Total Command Area, Unirrigated Area, Culturable Waste Land, Gross Cropped Area, Forest Area, Net Cropped Area, Production of Crops, Yield of Crops, Occupational Structure, Etc.

Different conventional statistical techniques have been used to find out the characteristics of the variables, to explore the significance of the variables, to explicate the nature of inter relationship among the variables & to measure the scientific impact assessment of the canals throughout the canal command area. These techniques are: Description of Data, Relationship by Bivariate Analysis, Correlation Matrix etc.