Chapter III

Water Resources
3.1 Introduction:

Water resources, as a basic determinant of high agricultural growth and productivity, immensely influence the economic development of a region. In areas having meagre, concentrated and highly fluctuating rainfall, the establishment of prosperous farming begins with the utilization of water resources—both surface and subsurface. So is the Kangsabati basin, primarily an agricultural region, where rainfall is scanty and a good monsoon still the only key to a good harvest.

The upper part of the Kangsabati basin suffers from severe scarcity of water all the year round. The middle part shares the similar problem. Scarcity of water is also acute in some areas of the lower part. Thus, drought being a common phenomenon badly affects the agricultural development in the basin area.

Depth of ground water table is also high during summer in the upper part of the basin. Due to geological condition, it is not possible to tap ground water resources in every part of the basin and it is uneconomic as well. Again, in the lower part of the basin, the problem is different. As the ground water is salty in this part, it is harmful for most plants and thus, irrigation from ground water sources is not possible here.

Owing to meagre rainfall, most of the streams, viz., Kangsabati and its tributaries are non-perennial in most parts. During the dry season, most of the river beds remain dry. So, irrigation from these rivers is not possible without construction of storage ‘bandha’. To solve this problem, a number of barrages have been constructed on the river Kangsabati and its tributaries. But most of these projects are not working properly and scarcity of water still remains a chronic problem (Plate: 11 & 12).
Agriculture is the main means of livelihood of people in this part. Among different factors affecting agriculture, irrigation is the most important one. But the percentage of irrigated area to gross cropped area shows that a very little land is under irrigation. As a result, production and yield rate is also low in this area and it remains economically backward.

So, for the total economic development of this area, it is necessary to study the existing water resources in detail and to suggest the future areas for water resource development and also to solve the problem of irrigation in some parts.

3.2 Methodology:

Firstly, the existing water resources of the basin, both surface and subsurface have been studied in detail in terms of average rainfall, drainage density and depth of ground water table in summer and in the rains. Secondly, irrigation potential of different parts of the basin has been studied during different seasons. Thirdly, the Kangsabati project and its contribution in terms of water resources and lastly, a number of irrigation schemes, particularly small ones, and their contribution are also taken into consideration.

(i) Isopleth maps have been drawn to show the average rainfall in different parts of the basin.
(ii) Drainage density has been calculated for each 5'x 5' quadrat of topographical sheets covering the basin area. The formula is,

\[ Dd = \frac{\text{length of drainage lines in each quadrat}}{\text{area of each quadrat}} \]

Then, an isopleth map has been prepared with those values.

(iii) Two isopleth maps have been prepared to show the depth of ground water table during the summer and the rains.

(iv) Three isopleth maps showing percentage of irrigated area to net sown area, percentage of kharif irrigated area to net sown area and percentage of rabi irrigated area to net sown area have been drawn.
Two graphs are drawn – one to show the inflow-outflow in hectare metre in the Kangsabati reservoir from 1970 to 1986, and the other to show the amount of irrigation – actual and computed from the Kangsabati reservoir from 1969 to 1987.

3.3 Analysis:

3.3.1 Average Rainfall:

Average annual rainfall considered for the period from 1901 to 1950 in the Kangsabati basin varies from 1089 mm to 1737 mm (Fig. 3.1). Rainfall is very scanty in the blocks of Bankura and its variation is also high. It ranges from 1089 mm to 1355 mm within a short distance. Minimum rainfall of 1089 mm is recorded in Manbazar block of Puruliya district. In general, rainfall increases from northwest to southeast of the basin. In most parts of Puruliya and Bankura, it is less than 1400 mm. Rainfall is comparatively higher in the Jhalda block of Puruliya. Rainfall increases from the western part of Medinipur up to 1646 mm in the central part after which it decreases. It again increases in the extreme southeastern part up to 1737 mm in the Sutahata-II block. Nowhere in the district of Medinipur rainfall is below 1400 mm. The coefficient of variation of rainfall mainly in the upper part of the basin ranges from a minimum of 34.02 per cent in July to a maximum of 243.67 per cent in December. From the Ombrothermic diagrams (shown in the second chapter) it appears that the dry period extends from November to May. As the brief spell of rainy season is followed by long dry season, the soil moisture is rapidly depleted by high evaporation. Above all, the rainfall is highly unreliable owing to the erratic nature of the monsoons.

The heavy rainfall over the Gangetic West Bengal which leads to flood condition in the lower part of the basin is generally associated with the passage of storms or depressions from the Bay of Bengal into the interior of the country during monsoon and post-monsoon months. The depressions which form in the head of the Bay of Bengal crosses Orissa and West Bengal coasts and move west-north-west wards. The areas on both sides of the depression track receive precipitation with comparatively heavier rainfall occurring in the southwest sector of the depression. The storms or depressions tend to weaken after they cross the
coast and move inland. The coastal district of Medinipur which lie fairly close to storm tracks is liable to receive more rainfall than the interior districts. Occasionally, depressions also develop over the Gangetic West Bengal. The depressions remain stationary or move across the Kangsabati and adjacent basins (Appendix: 3.1).

Analysis of rainfall during a few major storms followed by floods show that rainfall exceeding 1" a day, generally occurs on three or four consecutive days and only in a few cases on five days. Of these storm periods, more concentrated rainfall generally occurs in the second day of the period. In the lower catchment, total storm rainfall may be of the order of 7" or 8" in three day storms and 9" to 10" in a four day storm with extreme maximum of 15". In the Puruliya district, the total storm rainfall is about 4" for three day storm and 6" for four day storm with extreme maximum of 7" except in 1978.

3.3.2 Drainage Density:

Drainage density varies between less than .5 km per km² and more than 2.5 km per km² within the Kangsabati basin area (Fig. 3.2). Generally, it decreases from the northwest to the southeast of the basin. Highest drainage density coincides with the two hilly tracts of Baghmundi and Banduan blocks of Puruliya district and the Patamdah block of Bihar. From this western side, drainage density decreases towards east and south. In most parts of Puruliya, it varies between .5 km to 1.5 km per km². It is less than .5 km per km² in Hura, Puncha and Manbazar-II. Drainage density is high in these hilly tracts as numerous streams originate from them. But, in the eastern side the main stream Kangsabati is flowing. So, drainage length is less in this part causing low drainage density. Up to the western part of Medinipur, one or two tributaries join the river Kangsabati. But, in the south central part only the main river flows. Near Itamogra again, the Kaliaghai river joins the river Kangsabati and as a result, drainage density is slightly higher, i.e., .5 km to 1.5 km per km² in that part.
Thus, studying the two surface water sources, it is observed that though average rainfall is less than in the upper part of the basin, drainage density is very high. But this does not imply that surface water condition is good in the area. Though there are a number of drainage lines, most of them are non-perennial due to uncertain and insufficient rainfall. On the contrary, in the lower part of the basin, fewer perennial drainage channels supply more water.

3.3.3 Depth of Ground Water (Summer):

Depth of ground water table varies in the summer and the rains. During summer, it varies between less than 3 metres to more than 21 metres in depth (Fig. 3.3). This suggests a great variation in ground water condition within the basin. In most parts of the basin, the depth is between 9 metres and 15 metres. Maximum depth is observed in the Jhargram block and also in Kharagpur-I block of Medinipur district. Minimum depth of 3 metres and less is found in the extreme southeast in Tamluk-I, Sutahata-II and Bhagwanpur-I blocks of Medinipur East district. The depth of ground water table in the upper part of Puruliya, in most parts of Bankura and in Medinipur East is between 3 metres and 9 metres.

3.3.4 Depth of Ground Water (Rains):

Depth of ground water table during the rains vary from less than 2 metres to more than 6 metres (Fig. 3.4). In most parts of Bankura and Medinipur, the depth is less than 2 metres. It is at or near the surface in the blocks of Medinipur East. More than 6 metres depth is observed in Puncha and Manbazar-II blocks of Puruliya and Jhargram block of Medinipur. In most parts of Puruliya, it is between 2 metres and 4 metres (Appendix: 3.1).

Thus, from the study of two maps showing the depth of ground water table, it appears that the depth is high in most parts of Puruliya and in the Jhargram block of Medinipur West. This
implies that scarcity of water is acute in those areas as availability of surface water is also negligible. Construction of tube wells is uneconomic in the area as depth of ground water table is high. In the lower part, on the other hand, deep and shallow tube wells are the major sources of irrigation which can tap the underground water easily.

Recently, the district of Medinipur is facing a severe crisis of ground water. In Medinipur West, ground water is gradually being depleted and as a consequence, depth of water table is increasing. In most blocks of Medinipur West, ground water table is between 9.14 metres and 12.19 metres. Centrifugal shallow pump cannot lift water which is below 0.71 metres. For this reason, 80 per cent pumps in Medinipur East are not functioning.

From the satellite photograph of Medinipur West district, taken by Indian Space Research Organisation (ISRO), it is observed that hard laterite zone covers almost 50 per cent area of the district, which indicates that there is no chance of getting underground water. In other blocks, depth of ground water table is increasing. The main reason behind this is the unscientific operation of a large number of shallow tube wells in the district. The affected blocks are Binpur-I, Binpur-II, Jamboni, Jhargram, Salbani, Medinipur, Kharagpur-I, Kharagpur-II, Keshiary and Keshpur where the first level of ground water has almost been depleted.

The eastern blocks of Medinipur East are facing another crucial problem regarding the availability of ground water. It may be ascribed to the rise in the water table which has created such hazards as salinity and waterlogging. The ground water in this part is becoming saline mainly in the blocks of Tamluk-I, Mahisadal-I, Mahisadal-II, Nandigram-I, Nandigram-II, Nandigram-III and Sutahata-II. Besides this, a number of tube wells in the block of Tamluk-I are not functioning as the depth of ground water table is increasing and it is below 13.11 metres at some places. So, this part is plagued with scarcity of water.
3.4 Influence and Importance of Kangsabati and Other Small-scale projects on Water Resources:

Studying the surface and subsurface water resource conditions, it is observed that they are completely dependent on monsoon rainfall and very little water is available for irrigation. Before 1956, there were also no such schemes which could supply sufficient water to the decadent lands in the western part of West Bengal. An ancient scheme, i.e., the Midnapore High Level Canal, near Medinipur town about 102 km downstream from Ambikanagar was functioning on the river Kangsabati from 1884 providing satisfactory irrigation to an area of 36,500 hectares on its right bank in the alluvial plains of eastern Medinipur. The scheme is still functioning satisfactorily although it is very old.

This western part of West Bengal is a rugged terrain full of gullies, hillocks and small ravines. The denuding effect of nature through the ages has removed the top soil in varying degrees, thus diminishing the fertility of the soil. The unfavourable distribution of rainfall during cropping season and infertile nature of eroded soil had so long made agriculture an uncertain occupation entirely dependent on vagaries of the monsoons. On the other hand, the lower valley of the basin used to be very frequently flooded by the river Kangsabati breaching the flooded embankment below Midnapore town which resulted in great devastations of land and property. A study of drought, famine and flood was made from 1866 to 1944 in Bankura and 1966 to 1951 in Medinipur district. It was observed that out of 79 years in Bankura district, the occurrence of drought and famine and scarcity of water was 21 years whereas that of flood was in six years. Similarly, in Medinipur district, the occurrence of drought and famine was five whereas that of flood was 18 years in a span of 86 years.

Therefore, to relieve people from chronic threats of famine and scarcity, to save people from the ravages of flood and to give protection to the decadent land, it was decided to harness the river Kangsabati and its tributary Kumari and its other tributaries flowing through the region by building a storage reservoir on the river Kangsabati and Kumari just above their confluence in Bankura district.
Plate- 13

View of the Kumari irrigation project near the village Darbaria, P.S.-Balarampur.
The primary objective of reservoir operation is to achieve maximum benefit from the storage capacity created without harmful effect to the interests that co-exist in the river basin. The Kangsabati reservoir has been created mainly for irrigation purposes. There is, however, some storage space kept in the reservoir for flood absorption.

The project would help in reclaiming 20,243 hectares of waste land by turning the same into profitable paddy lands. Spirable canal water can be stored in tanks for drinking water. Eisciculture in the Kangsabati reservoir and also ponding of canals, tanks etc. in the command area was another aim of the project. This will also help in the regeneration of denuded forest cover by minimising soil erosion. The project will also provide recreational facilities. All these were the primary aims and objectives of the Kangsabati project.

3.4.1 Geology of the Dam Site:

Kangsabati Dam: Along the proposed alignment rocks are exposed in the abutment hillocks on either side of the river Kangsabati at higher elevation away from the river banks. The intervening area is covered by soil. No exposure of rock is found in the river bed save some decomposed rock at left edge of the river to which side the main water channel is confined. The rest of the river is dry and covered with sand. However, about 314.40 metres downstream of the tentative axis the left bank exposes some rocks which project into the river for some distance.

Kumari Dam: The principal country rock consists of quartz and sericite schists. The foliation strike is almost east to west with steep dips towards south. Dark weathered ferruginous, brecciated quartzitic rocks and quartzites are exposed in the hillocks into which the left abutment will be keyed. There are also exposures of vein quartz which is intrusive into the country rocks. Similar ferruginous quartzitic rocks are found in the higher land, where the right abutment has been keyed (Plate:13).
3.4.2 Salient Features of Kangsabati Reservoir Project:

The river Kangsabati and the river Kumari fall within "Ganga" basin and Haldi sub-basin in the State of West Bengal. The catchment area up to the dam site is 3,626 km². The reservoir has been created over the river Kangsabati and its main tributary, the river Kumari, with a hillock in between the two dams. The dams are located in the district of Bankura within the State of West Bengal. The dam is situated at Mukutmanipur, Bankura district, on the river Kangsabati and the river Kumari about 3 km upstream of their confluence (Appendix).

It is mainly an irrigation project with some provision of flood control. Gross command area is 6,17,408.9 hectares. Culturable command area is 3,96,050 hectares and irrigable command area is 3,40,750 hectares. Of these irrigable command areas, 3,40,746 hectares are irrigated during kharif season and 60,703 hectares during rabi season. About 1,587.20 km² area and 96,000 people are protected from floods. Although there is no provision for water supply, villages near the reservoir use the reservoir water for drinking purpose and domestic use. There is ample scope for fish culture in the reservoir.

About 58,681.5 hectares of kharif land were used to be irrigated in the pre-project stage, including 50,587.5 hectares under the Midnapore Canal System. The proposed utilisation at this project is 3,40,757.4 hectares during kharif season and 58,681.5 hectares during rabi season.

Maximum water level is 135.640 metres, full reservoir level is 134.112 metres and dead storage level is 120.396 metres. The capacity at maximum water level is 1235.1019 million cubic metres, at full reservoir level is 1053.5353 million cubic metres and at dead storage level is 136.9676 million cubic metres. Flood absorption capacity is 246.658 million cubic metres.
Plate- 14
The Kangsabati canal with forest-clad low residual hills in the rear.

Plate- 15
Dry bed of the river Kangsabati on the opposite side of the reservoir in Mukutmanipur, P.S.- Ranibandh, Bankura.
Length of the Kangsabati dam at the top is 4 km and it is 5.2 km, including dyke. Length of the Kumari dam is 2.4 km and it is 4.8 km, including dyke. There are altogether three dykes.

Maximum discharge capacity of the spillway is 6369.49 cubic metre per second (cumec) as per design. But, actual discharge capacity is 5685.83 cumec.

There are two head regulators, one on each bank for irrigation. Discharging capacity at full reservoir level by the left bank head regulator is 192.5 cumec and by the right bank head regulator is 70.75 cumec.

There are three pick up barrages in this project, viz., Silabati, Bhairab banki and Tarafeni which are situated at Kadamdeuli, Indpur police station; at Jatadumur, post office Dudhiya and at Vaisnabpur, post office Chotosuklyora, of Bankura district respectively.

Canal system is there mainly for irrigation purpose. Both lined and unlined canals are at present existing. Canals are used mainly for flow irrigation, but cultivators also use the canal water by lift to high lands above full supplying level (F.S.L.). There are two main canals, one is left bank flow canal (L.B.F.C.) and the other is right bank main canal (R.B.M.C.) (Plate: 14 & 15).

Benefitted police stations in different districts from the project are - Onda, Kotalpur, Khatra, Raipur, Indpur, Bankura, Bishnupur, Jaypur, Simlapal, Taldangra and Ranibandh in Bankura district; Binpur, Gorbeta, Salbani, Medinipur, Jhargram, Sankrail, Kharagpur, Narayangarh and Jamboni in Medinipur district and Goghat in Hooghly district.

3.4.3 Water Utilisation System:

Within the command area of the Kangsabati project, the following irrigation facilities existed in the pre-project stage:

(a) Irrigation schemes executed by the Irrigation and Waterways
Department, West Bengal Government.

(b) Irrigation schemes of the Agriculture Department, West Bengal Government.

(c) Irrigation schemes by the Department of West Bengal Government under the Tank Improvement Act.

(d) Private irrigation arrangement from tanks and wells.

The total irrigable area served by the Irrigation and Waterways Department schemes was 58,880 hectares, including 50,586 hectares under the Midnapore canal system. In the absence of storage, it was not possible to supply water to crops during critical period of kharif season when generally there is a shortfall of rains and thus, the existing irrigation arrangements were not adequate.

The Kangsabati project is designed to create an irrigation potential of 3,40,746 hectares of kharif and 60,703 hectares of rabi. It is proposed that during critical period irrigation water will be supplied by this project and keeping in with the proposal a reservoir has been constructed with conservation storage capacity of 78,696.024 hectare metre at reservoir level (R.L.) 131.68 metre.

There is some impact of the project on pre-project schemes. The irrigation system under Medinipur High Level Canal which has got a riparian right so far as utilisation of the Kangsabati water is concerned, would suffer if all the water in the upper reaches are diverted to the Kangsabati project area. The Enquiry Committee, set up by the West Bengal Government to enquire into the shortfall in irrigation from Medinipur High Level Canal has, in its report of June, 1976, recommended that the Kangsabati Reservoir Project should assume supply of 6,291 hectare metre of water to Medinipur High Level Canal as contemplated in the project during kharif season.

There is also some irrigation problem on development of full command. If the monsoon storage level is kept at R.L. 131.68 metre as contemplated in the project, irrigation interests suffer. There is negligible rainfall in October in most of the years and withdrawal from the reservoir to support kharif irrigation would amount to
INFLOW-OUTFLOW CURVE IRRIGATION FROM THE KANGSABATI RESERVOIR
1969-87

(a)

(b)

INFLOW-OUTFLOW CURVE OF THE KANGSABATI RESERVOIR
1970-86

Fig. 3.5
37,004.4 hectare metre in October itself. Requirement for rabi irrigation to support 60,703.00 hectares would be 27,753.3 hectare metre. Evaporation loss after considering 'inflow' in the dry season would amount to 6,167.4 hectare metre. Total utilisation storage that should be available in the reservoir on October 1 should, therefore, be 70,925.56 hectare metre. This corresponds to a reservoir level of R.L. 132.28 metre which means an encroachment of 0.609 metre in the flood absorption space contemplated in the project. Thus, it is found that operation criteria for fulfilment of irrigation function and flood moderation function are conflicting. For flood moderation, all available reservoir space should be kept empty whereas for irrigation, all available reservoir space should be filled up. Therefore, reservoir operation should be carefully planned.

Now, the inflow and outflow in the Kangsabati reservoir in different years have been studied with the help of two curves (Fig. 3.5a). This will help to know the storage condition of the reservoir. The data has been taken from 1970 to 1986 (Appendix 3.2). Several peaks are observed in the inflow curve in the years 1971, 1973, 1975, 1977, 1980-'81 and 1984. These are probably due to heavy rainfall. The outflow curve also corresponds with the inflow curve in almost every year. Inflow varies from 37,004 hectare metre to 3,20,705 hectare metre whereas outflow varies from 37,004 hectare metre to 2,46,696 hectare metre. From the year 1970-'72, outflow was meagre compared to the inflow indicating an increase in the storage. Inflow is slightly higher than the outflow in almost every year except 1975 and 1984. In those years, there was scarcity of water in the reservoir. In 1979, inflow in the reservoir was comparatively higher, i.e., of 86,344 hectare metre. This implies that there was acute scarcity in the reservoir in 1979.

Data for the actual amount of irrigation from the Kangsabati project from 1968-'69 to 1986-'87 has been obtained (Appendix 3.2). With that data a graph which shows the actual amount of irrigation and a regression line have been drawn (Fig. 3.5b). It is observed that there are many fluctuations in the graph. The amount of
irrigation from the project up to 1973 was very little, i.e., up to 47,163.01 hectare metre. Irrigation has increased from 1974 and reaches a peak of more than 1,28,000 hectare metre between 1974 and 1975. Then, again it decreases. Another peak, slightly higher than the first one is observed between 1981 and 1982 after which it decreases up to 49,000 hectare metre. A peak of 1,15,000 hectare metre is observed between 1985 and 1986. The regression line shows a steady increase from 53,000 hectare metre to 1,10,000 hectare metre.

3.4.4 Flood and Flood Control System in the Kangsabati Basin:

The floods in the Kangsabati basin are flushy in nature and generally last for a short duration. Frequency analysis shows that a flood of 7,600 cumecs (flood volume 7,70,925 hectare metre) has a returned period of 100 years while a flood of 6,787.55 cumecs (flood volume 48,106.00 hectare metre) has a returned period of 50 years. The design flood for the Kangsabati dam which is 10619.00 cumecs has a higher return period and has not exceeded even in 1978 during which peak discharge was 9911.00 cumecs, the highest on record.

The contribution from the uncontrolled catchment below the dam may be very high when there is heavy rainfall in Bankura and Medinipur district.

There is no flood problem in the upper valley up to Mukutmonipur Dam. In the reach between the dam and the Medinipur anicut, local inundation takes place along two banks in certain reaches for a short duration and normally crop damages does not occur except that sand deposition takes place during very high floods. The lower valley below Medinipur anicut, part of which is within the tidal zone is low lying and is subject to inundation by upland flood as well as by tide in certain areas. The low tracts in this reach are the Mohankhali area, the Durbachati area, the Panskura-Kolaghat area, the Mayna-Sabong area etc.

Before the Kangsabati Reservoir Project came into operation, flood protection measures in the lower valley considered only of protective embankments about 434.51 km in length. Majority of
the embankments, specially private embankments belonging to Zamindars, were not maintained properly and breaches were frequent during high floods. There were heavy damages to crops and sometimes extensive loss of property during high flood years.

Because of ineffectiveness of embankments in combating high flood, it was proposed to provide flood absorption space in the Kangsabati reservoir. As complete absorption of the maximum probable flood will require an excessively high reservoir (the cost of which will not be commensurate with the benefit to be derived), it was proposed to down the peak flood within comparatively harmless limits. In the reservoir as contemplated a flood absorption space of 24,669.9 hectare metre has been provided above R.L. 131.68 metre to moderate design peak flood of 10,619 cumecs to 6,371.28 cumecs.

Flood control procedure envisaged in the project is as follows: From June 1 to August 31 when probability of high floods is more than in the later part of monsoon, a flood storage space of 24,669.60 hectare metre is kept. Between September 1 and September 10, the flood storage is reduced to 12,334.80 hectare metre. Thereafter no flood storage space is provided. Subsequently, the flood Advisory Committee, West Bengal Government, advised that provision of 24,669.60 hectare metre should remain inviolate up to October 15.

Flood control measures adopted so far have not been as effective as these were expected to be. This is mainly due to insufficient flood reserve in the Kangsabati reservoir, huge runoff from uncontrolled catchment below dam, inadequate channel capacity in the reach below Medinipur anicut and restriction in spill area due to construction of embankments.

Total runoff at dam site is 104,846.00 hectare metre from 1978 storm and 172,687.2 hectare metre from design storm 1898, whereas flood storage space provided in the reservoir is only 24,669.8 hectare metre. It has also been observed that contribution from the uncontrolled catchment below the dam may be very high, and during 1978 flood, even if entire runoff from catchment above the dam site had been absorbed in the reservoir, it would not have been possible to mitigate the damages in the lower reaches.
Combined capacity of old and new Kangsabati along with branch channels is 2,831.68 cumecs to 3398.00 cumecs. Contribution from uncontrolled catchment itself may exceed this. In 1978, the peak contribution from uncontrolled catchment was about 4,955.44 cumecs.

Breaching of embankments during high floods is, therefore, frequent resulting in widespread submersion. The submersion becomes prolonged and cause great damages when outfall rivers Rupnarayan and Haldi rule high, due to heavy runoff from adjacent basins and also due to tidal effect.

The problem of sedimentation in the reservoir which is reducing the storage space of the reservoir is increasing day by day. During 1978, annual sediment load was 3.717 hectare metre per km$^2$ in place of 3.296 hectare metre per km$^2$ as adopted in the design.

From a brief report of sedimentation survey of 1982-'83 of the Kumari reservoir, it is observed that first filling of the Kumari reservoir was done in 1976. The cumulative capacity as obtained from 1982-'83 at full reservoir level (FRL) is 53,674.85 hectare metre which is less by 768.80 hectare metre relative to the pre-dam capacity which was 54,443.65 hectare metre thereby causing a total loss of storage by silting within seven years by 1.41 per cent. The corresponding loss in live storage region is 1.04 per cent and that in dead storage is 3.58 per cent. From this the sedimentation index has been calculated,

\[
\text{Sedimentation Index} = \frac{\text{Loss during 7 years}}{\text{Effective catchment area}} \times \frac{100}{7}
\]

\[
\frac{6235}{7} = \frac{100}{7} = 121.5 \text{ acre feet per year per 100 square miles} = 38.80 \text{ hectare metre per year/100 km}^2
\]

There are a number of small irrigation schemes in the district of Puruliya, viz., Saharjore, Buridumur, Kansai, Tara, Fuljore, Bandhu, Kumari, Patleli, extension of Bandhu, Hanumata, Barabhum and Totko, to supply irrigation water to drought-affected blocks of Puruliya and to solve the problem of water scarcity to certain extent.
(Table 3.1). But during the dry season due to scarcity of water in these reservoirs, the supply is far below the target.

Of all these projects, Saharjore is the largest one with highest potential for irrigation. The potentials for irrigation and actual area irrigated in different seasons of different projects are given below.

Table: 3.1

<table>
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<th>Name of the project</th>
<th>Potential in hectares</th>
<th>Actual area irrigated</th>
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<td>Kharif</td>
<td>Rabi</td>
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<td>Kumari</td>
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<td>Rupai</td>
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<td>Patlo (continuing)</td>
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From the table it appears that excepting Kumari and Rupai, irrigation from all other projects are far below the target. During field survey, it was observed that despite of installation of a number of projects, the blocks of Puruliya are facing the same crisis of water as the supply is far below the requirement. This problem can be solved to a certain extent if the targets of these projects are achieved.

3.4.5 Irrigation:

After studying all the sources of surface as well as subsurface water, condition of irrigation in different seasons has been studied in detail. From the isopleth map showing the percentage of irrigated area to net sown area (NSA), it appears that in general it increases from northwest to southeast of the basin (Fig.3.6). In most blocks of Puruliya, it is between 20 per cent and 40 per cent. In the blocks of Bankura, this percentage is as high as 100 per cent. In western blocks of Medinipur again, this percentage decreases and in some blocks, say, Jhargram, Sankrail, Dantan-I and Narayangargh, it is below 20 per cent. This value again increases towards southeast
and is very low, i.e., below 20 per cent. The percentage of gross irrigated area to gross cropped area is very low in most parts of the basin which shows that a large part of the total cropped area is unirrigated and there is need for further extension of irrigation.

The map of percentage of kharif irrigated area to net sown area shows that maximum kharif irrigation is in the blocks of Bankura and also in some blocks of Puruliya (Fig. 3.7). But, in most parts of Puruliya, it is less than 20 per cent. The percentage is comparatively high in a few blocks of Medinipur West, but in most parts, it is between 10 per cent and 30 per cent. In the extreme southeastern part, kharif irrigation is negligible and somewhere it is totally absent. It implies that kharif crops need no irrigation water in the lower part of the basin, whereas in the dry and rugged upper part of the basin irrigation is also necessary during kharif season.

Just the opposite picture is observed in the map of percentage of rabi irrigated area to net sown area (Fig. 3.8). In general, it increases from northwest to southeast of the basin. The percentage is very low, i.e., below 10 per cent in most part of Puruliya district. In the blocks of Bankura, the percentage is somewhat higher and varies between 30 per cent and 50 per cent mostly. In the western blocks of Medinipur, it varies between 20 per cent and 30 per cent, but around Panskura, Tamluk and other southeastern blocks irrigated area increases up to 70 per cent and more. As rabi crops are cultivated mostly in this part, it needs higher irrigation than the upper part where rabi crops are grown to a limited extent.

3.5 Conclusion:

Certain points of importance emerge from the study of water resources of the Kangsabati basin. Firstly, the intensity of irrigation varies with available water, both surface and underground over the basin. Secondly, in the driest part of Puruliya district, nothing has so far been achieved in supplying water despite development of a number of small-scale irrigation projects. Thirdly, the middle part of the basin has a favourable water resource condition compared to other parts. Lastly, due to
excessive irrigation, the low lying areas have been subjected to irrigation hazards.

So, studying the existing water resource condition, it can be said that improvement of the system is necessary. In the upper part of the basin, construction of tube well is difficult owing to rugged terrain. Availability of ground water is also insufficient for tube well irrigation. Zore bandhs and other bandhs can solve the problem to certain extent. The irrigation projects, if operated at their full capacity, can also solve the problem to certain extent. Canal irrigation is important in the middle part of the basin. But, an interesting feature is observed during field study. It was observed that though the immediate surroundings of the Kangsabati project are included in the irrigated zone, they are not getting water from the project. The lower part of the basin is facing another crucial problem of increasing depth of ground water table. In the extreme southeastern part, the underground water is completely saline.

To solve the problem of increasing depth of ground water table, it is necessary to prohibit the unscientific use of a number of shallow and also deep tube wells which are now operating in the district of Medinipur. In many places as the water level of 6.4 metres to 6.71 metres has completely depleted, people used to dig soil up to 6.71 metres and set pumps at that very level which involves a great risk. The situation is worst in some places under the Jhargram police station where a good number of small industrial units are using the first level of ground water at 6.71 metres ignoring repeated cautions against it. As the problem grows day in day out, immediate measures should be taken to stop unscientific methods of using ground water. The measures follow:

(a) Micro level research is necessary to find out the underground water table.

(b) It is necessary to store the surface water for irrigation.

(c) Farmers should also co-operate with the Government in using ground water scientifically.

(d) If possible, the time of cultivation should also be changed.
On the other hand, the eastern part of Medinipur is facing another serious problem of salinisation of ground water. The use of ground water for irrigation poses a special problem as the water contains salts especially in this part where ground water is not refreshed so frequently as in humid climates. Each irrigation brings a certain amount of salt into the root zone. As the water evaporates the salt is left behind in the root zone. Evaporation of ground water from the soil is another common cause of soil salinisation.

So, in this part where risks of salinisation are high, irrigation method and cultivation techniques must be carefully selected. This is especially important as irrigation water itself is saline. If the risks of salinisation are high and water for irrigation is scarce during the growing season, or where salts continue to rise, it may be necessary to pre-irrigate to wash salts out of the ground water as salt levels in the soil are lowest after irrigation and highest just before the next application. In this eastern part, which is a seasonal rainfall region, salts in the soil are highest at the end of the dry season.

It may be possible to adopt a planting pattern which takes advantage of points of relatively low salinity, for example, at the side of wide ridges. Cereals, notably rye, barley, wheat and forage crops with improved salt tolerance capacity can be cultivated.

Although the Kangsabati project has solved the problem of surface irrigation and flood control to a certain extent, it has also created a number of problems. For flood moderation, all available reservoir space should be kept empty whereas for irrigation, all available reservoir space should be filled up. To cope with this problem, the following procedures have been adopted in evolving regulation plan of the Kangsabati reservoir.

(1) Monsoon storage level has been fixed at reservoir level (R.L.) 132.28 metres from the consideration that the live storage available at this level should be adequate to cater for kharif irrigation during October.

(2) With the starting water level as determined above, the major floods have been routed. The criteria adopted in the trial routing
are as follows:
(a) Reservoir level should not exceed maximum water level (M.W.L.), i.e., 135.64 metres after absorption of flood volume.
(b) Flood peak should be moderated to the maximum extent possible.
(c) Synchronisation of routed peak discharge with the peak discharge from uncontrolled catchment should be avoided in the reach below Medinipur anicut as far as practicable.
(d) During low flood stage, outflow from the reservoir should be made equal to inflow so as to provide flushing dope to the river channel in the lower reach.

With the passage of time, as more and more information will be available, the reservoir operation should be reviewed and modified to suit the objective of regulation to the best possible extent. In particular, the following points should be kept in view:
(a) Discharge capacity of the spillway should be reviewed on the basis of hydraulic characteristic.
(b) Guide curve for inflow into the reservoir and outflow from it should be developed on the basis of actual reservoir operation data.
(c) A technique of forecasting inflow hydrograph at dam site should be developed as early as possible.
(d) Impact of upper Kangsabati reservoir should be taken into consideration when it comes into operation.

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