CHAPTER - X

IRRIGATION EFFICIENCY : A MICRO - LEVEL ANALYSIS

To testify to the authenticity of official data, micro-level field surveys have been carried out in selected ecological units of West Bengal. It has often been found that data on identical topics from various Government departments do not conform with each other as a consequence of their varied approaches and methodologies. In certain cases, inadequacy of data prevents detailed analysis. Moreover, certain important localized aspects are not incorporated in district or P.S. level analysis. Undoubtedly, in such cases, field surveys supplementing official data accords a realistic picture.

The present chapter thus purports to put forward a comprehensive analysis of irrigation with particular emphasis on its efficiency assessment based upon both generalized as well as intensive field studies of selected villages. The major criteria for the selection of villages are their ecological settings and sources of irrigation.

METHODOLOGY

As the study area is extensive, it has been found convenient to resort to random sampling, with about 10 villages representative of each of the selected physiographic units,
encompassing both irrigated and non-irrigated areas. Within these units, villages enjoying diverse irrigation types have been included for purpose of intra-unit comparative study. The impact of irrigation on net sown area, cropping intensity, cropping pattern and crop yields have been analysed. Detailed spatial models have been developed vis-a-vis to their distances from the canal nets as well as from other sources of irrigation. The amount of water utilized under diverse irrigation and physical conditions has been analysed, based upon primary information. The ultimate objective is to determine the efficiency of irrigation with reference to its cost, inputs and benefits.

PHYSICAL SETTING AND IRRIGATION TYPES

The villages surveyed belong to two types of non-irrigated to poorly irrigated tracts and two types of moderately to highly irrigated tracts, thus giving equal emphasis on the various facets of irrigated agriculture of this State. The former includes the drought prone plateau fringe zones as well as the highly humid, saline coastal zones. The latter includes the humid, Domodar-Hughli, riverine plains and the moderately humid, old alluvium regions.

Plat eau and Plateau Fringe Regions

In addition to ten villages, three more have been studied, each characterized by a miscellaneous source of irrigation. The village of Inchadih is in the hilly tract of Balarampur P. S.
(Puruliya district), an extension of the Ayodhya hills. This is a typical forested village with occurrence of localized slopes. The terrain pattern with its 'tanr' (high), 'baid' (middle) and 'bahal' (low) lands and the red, sandy loams have developed over schists. Often these rocks give rise to localized patches of white sand specially conspicuous along the 'jhors' or seasonal streams and gullies. As such this village is quite inaccessible, involving 3-4 hours journey on foot from Balarampur P. S. The setting is not congenial for irrigated agriculture. The jhors dry up during winter and summer. The dry climate, underlying hard rock with a generally hilly terrain preclude the development of adequate groundwater potential. The village possesses one or two dug wells, mainly utilized for drinking and other domestic uses. Thus, there is acute water shortage during years of deficient rainfall. Except in the immediate vicinity of the village, the entire region is forested. About 40% of the total area is under forests which constitute an important source of their livelihood.

The second cluster of villages, also located in the plateau region (Puruliya district), is confined to the immediate foothills zone of the former region. This provides a comparative study of the beneficial aspects of irrigation as influenced by the relief factor. The villages of Dumaria, Sagma, Parasya and Pawra-Pahari (Hura P.S.) are characterized by gently undulating to rolling landscape with occasional distribution of 'tors'. The soils are mostly yellow-brown loams due to greater hydration.
However 'Kankar' or stony soils are well distributed over the 'danga' or high lands, receding to depths of 2.5 cm over 'baid' lands and below 10 cm over the lowest 'Kanali' lands. 'Jhor' bundh irrigation is practised. The bundhs are located at successive levels along local slopes with one tank located above the other. At Sagma village, for example, there are two big bundhs, one in the west irrigating 11 ha and another in the south irrigating 5 ha. The level of water in the first amounts to 2m in winter and \( \frac{1}{2} \) - 1m in summer. The same for the second bundh amounts to 4m and 1.5m respectively. The villagers state that if the borders are increased by 2m they can be better used. These bundhs existed even 40 years ago but till 1987 they belonged to one family only, who used them for 'boro' cultivation. Since 1987, other villagers are being permitted to use this water. Of course, there are numerous excavated tanks as well as dug-wells. In certain cases localized cultivation or homestead gardens benefit from them. Pawra Pahari village does not get the benefit of irrigation. But an interesting fact may be noted here. The lowest or 'Kanali' lands which retain water for a longer period are at present being considered for a minor irrigation project. Such sites which usually coincide with seasonal stream courses could thus be effectively developed. In this context it may be stated that Dumaria village is located near the Hanumantha river, which is now being dammed. This village, in the near future, will benefit from this RLI scheme.
Some villages located in the plateau fringe zones, such as Mohanpur in Dubrajpur P.S., Garro and Jitusol in Jhargram P.S., Tilaiya and Andhariya in Binpur P.S. are located in undulating terrain. The soil types of the last two villages belong to yellow-brown, clayey loams whereas the others are characterized by lateritic exposures and red sandy soils. Garro and Jitusol villages have bamboo forests, which during 1971 amounted to about 40% of their total area. At present they extend over 30% of total area. Mohanpur, Garro and Jitusol are non-irrigated to poorly irrigated villages. Mohanpur enjoys tank irrigation, whereas Garro and Jitusol have 'jhor' bundh and canals respectively. However Jitusol, although located within the Kangsabati command area, is located about 1 km away from the main distributary canal. It has started receiving water since 1983 and that too intermittently. Water is brought through field channels for the cultivation of aman rice along 'danga' lands. Hence Jitusol village may aptly be stated to be poorly-irrigated. In 1971, all these villages were noted as 100% of their GIA under tank irrigation. The chief source of irrigation at Garro is the Kuaria Khal, a natural channel. This Khal was embanked by an earthen dam about 200 years ago, about 2 kms away, by the landlords. This artificial tank covers over 4 ha of land. Besides, the other villagers also embank the Khal along different reaches. Hence the villagers of Garro are deprived of water supply viz. during the critical winter and summer seasons when the water level recedes to 1 ft (.305m)
only. Hence this village may be classified as non-irrigated (Table 3i App.).

Andhariya and Tilabaid villages are officially recorded as canal irrigated, being located within the Kangsabati Command Area. However, Andhariya is characterized by the predominance of irrigation from seepage water, that has been tapped by the Karanja bundh. A little distance to the north of this village, there are several centres extending over 4-6 ha where water oozes out from underground fractures. The Karanja bundh, an earthen dam, covers 12-15 ha. It was constructed by local zamindars in 1874. Besides this, the distributary canal issuing from the Kangsabati main branch canal, flows through this village. This canal benefits the aman crop viz. during its maturing stage, when rainfall is variable. At present it accounts for only 10-15% of GIA despite its construction some 10 years ago. Tilabaid is a typical canal irrigated village. The canal is at present connected to a bundh where excess canal water is stored to be utilized during post-monsoon season. All these villages were recorded as being 100% tank irrigated in the past. The Karanja bundh also falls within this category.

Another miscellaneous source of irrigation is recorded at Mukutmanipur village, situated right behind the Kangsabati Reservoir in Khatra P.S. (Bankura district). The terrain pattern is characterized by hills of phyllite, schists and gneisses. About 90% of the soils are stony in nature. This
village receives seepage water from the reservoir. The fluctuating nature of the water level of this reservoir is a major drawback as the village is situated at a high level.

Amrai and Kandeswar villages are located in the Gondwana zone. Both are situated adjoining to Durgapur town. Tanks constitute the main source of irrigation. On an average there are 10-15 such tanks in each village, extending over 1-2 ha. Fluctuating water level is observed amounting to 2m during rains declining to only .60 m in summer. Amrai village presently utilizes sewage water through field channels for farming. This has been practised for the last 20 years or so. This water is now used mostly for rabi and boro cultivation.

Saline Coastal Region

The villages in this region are selected on the basis of their distance from the coast. The first cluster of villages occur in Sagar P.S. (24 Parganas South) in the extreme South, directly impinging upon the Bay of Bengal. Beguakhali is a typical example of a coastal village, with a distinct sand bar along its western border. The soil is of sandy loam with occasional saline crusts on the surface layer. This village is practically non-irrigated. Recently, a 'khal' or canal has been dug along one of the detached stream beds to store rain water for rabi crops. Its use is negligible. Natendrapur village is situated north-east of Beguakhali village. The soil of this village is clay loam. A characteristic feature is the
presence of a large tank (7 ha) constructed by the local landlord. Water level during rains is 3-3.5m. The tank has four longitudinal water bodies ('jheels') bordering it, from which khals convey water to the tank. There are other small tanks in this village. Narayani Abad is also tank irrigated. Mahesmari village, north of Natendrapur is located on saline, clayey soils. This village is also deprived of irrigation facilities.

The second cluster is located at Joynagar and Mathurapur within the active deltaic tract. Uttarpura Nij and Baharu villages belong to this group of non-irrigated villages characterized by moisture retentive clayey soils. Although the relief is gentle, the presence of drainage canals prevent water logging. Despite the absence of irrigation, cultivation gets the benefit of residual moisture of the soils.

The third cluster is located further north of Canning P.S. at the confluence of the silted up tidal rivers of the Bidyadhari and Matla. Khas Kumarkhalia and Taldi villages are located along the right bank of the Bidyadhari river. There is an earthen embankment constructed along this river. It is 4.5m high and 1-2m wide at the top. Due to rapid silting up, the river bed has now attained the same level as the surrounding countryside. Despite the embankment, yearly inundation occurs due to its breaching. Soils are clayey and highly saline in nature due to tidal influx. These villages are non-irrigated irrespective of the presence of tanks. A DTW exists tapping
aquifers at 140m depth, but the villagers state that the water is getting increasingly saline. At present, it has been constructed to supply drinking water. Kumarashachak and Dighirpar are example of tank irrigated villages located away from the river, hence with less saline, clayey soils. Incidentally, all these four villages are located in the vicinity of Canning.

**Old Alluvium Tract**

Both poorly irrigated and moderately high irrigated villages have been considered here. In the eastern part of Birbhum district the old alluvium occurs as detached patches, due to the superficial veneer of alluvium deposited by the Mayurakshi river system. Here conditions are better than in the Barind region of Maldah. In addition they all fall within the Command Area of the Mayurakshi River. Paruldanga, Khosh Kadampur and Donaipur villages are located within Bolpur P.S. The main source of irrigation is from tanks. At Paruldanga for instance, there are two huge tanks. The Rakta Kundabandh extends for over 60ha with water levels of 5.5m and 1.2m during rains and summer respectively. Barabandh extends well over 7 ha. These tanks were more extensive during the past but have subsequently got silted up. Although the Mayurakshi Branch Canal was cut 10 years ago, it still constitutes a minor source of irrigation, effective only during the rainy season. During winter, the water level recedes to 1.5 m and by summer the canal is practically dry exposing the gullied banks. The Tagore Society has granted
Rs. 50,000/- for purchase of pumps of 10 HP capacity each for irrigating this village. The main canal in the north irrigates 8-10 ha. At Khoshkadampur bandh irrigation predominates with 4 such bandhs irrigating 13 ha. At Donaipur, the main canal irrigates 6 ha. Since 1984, STW irrigation has been introduced but due to deep levels of groundwater which recedes to 10 m in summer, it is being discontinued. Moreover the lateritic terrain prevents economic extraction.

The second cluster of villages is situated in the typical less humid, 'barind' tract of Maldah district in Gajole P. S. They are Adina, Misipur, Pandua and Suktamahal, all characterized by undulating terrain, and tenacious, clayey loams. These villages are practically non-irrigated. Although tanks exist they dry up by summer. Moreover their water is mostly used for fish culture.

For comparative study, a third cluster of villages was selected from the moribund, riverine plains adjoining this 'barind' tract. The villages of Mubarakpur, Bidhangarh, Scindia (old Maldah P.S.) along Chunakhali River are characterized by Government operated RLI Schemes with each individual scheme commanding an area of 80 ha. In this context, it should be mentioned that this zone falls under the category of intensively RLI irrigated tracts due to the prevalence of clayey soils and extensive detached water bodies. This also facilitates exploitation of groundwater. About 75% of GIA is under
RLI and 30% under STW irrigation.

**Damodar - Hughli Riverine Plains**

This constitutes an extensively irrigated tract of the entire State, with the conjunctive use of surface and ground-water for irrigation purposes. Being mostly located within the DVC command area, canal irrigation emerges most important. As diversity is accorded mostly by soil texture and drainage features, the villages have been selected on the basis of their diverse sources of irrigation. Canal irrigated villages are represented by Sibaichandi village in (Dhaniakhali P.S.). The relief of this village is irregular consisting of a mature riverine plain. Local variations in relief are however accorded by remnants of the older flood plain surface. These form flat surfaces at a slightly higher level, about 2-3 m high. The nearest stream is the stagnant Ghia Nadi, 1 km away. The soils are yellow brown coarse loams. Located within the DVC area, the chief source of irrigation is the DVC distributary canal which traverses this village. However the availability of water throughout the year has been possible due to the presence of a large elongated pond along the Eastern Railway which passes through the village border. Canal waters are effectively stored in this pond. Tank irrigation at present accounts for 2% of total irrigated area. There are 10-12 water lifting pumps owned by affluent farmers but are hired by all. Most of them are of 3.5 HP each.
The villages of Paranpur (Balagarh P.S.), Basudevpur (Arambagh P.S.) and Barekpur (Polba P.S.) are all RLI irrigated, although under varying situations. Paranpur for instance, is located on the right levee of the Hughli river about 10 m above the river bed. Basudevpur borders the Dwarakeswar, one of the western rivers originating from the plateau region whereas Barekpur is situated along the Saraswati nadi, a typical dead river. In Paranpur, RLI pump of 14 HP capacity was installed in 1975. The water is first passed through two main pipes onto the level of the village fields and distributed through underground pipelines, below the rooting depth of crops, into spout chambers. Prior to 1975 only tank irrigation existed, as the village is at a higher elevation making it difficult to lift river water through traditional dongas. Two similar 24 HP pumps operate at Basudevpur since 1974. Initially they irrigated 40 ha. Unlike the Hughli, this river does not carry sufficient water viz. during the post-monsoon season. The prevalence of sandy loams further aggravates this problem. Hence, with the increased installation of pumps along all stretches of the river, the river bed began to dry up since 1980's. This has already led to the closure of one pump and the other is becoming ineffective. At present STWs have been introduced but they face the problem of seasonally receding water tables leading to an increase in cost of extraction by Rs. 500-600/-. River lifts also constitute an ineffective source along the dead rivers as in Barekpur. It is only during those years when Polba Canal water is permitted to enter the Saraswati Nadi that some culti-
vation can be sustained. There are 4 water pumps of 5 HP capacity each under private ownership which are rented out at Rs. 10/- per hour. One DTW, tapping aquifers at 100-120 m depth, has been installed but remains unused due to insufficient water.

Arambagh P.S. is one of the main areas of STW irrigation. The villages of Saota and Parul are characteristic examples. In Saota for example, there were about 20 STWs functioning. Due to receding water levels during summer, it was necessary to place cylinder tubewells, about 20 m below and pump out water by pipes. This problem has rendered difficult their economic exploitation. Hence during recent years some of the STWs have stopped functioning to be replaced by mini-DTW tapping deeper aquifers at 90 m and serving 10 ha. Each STW serves about 2 ha. At Parul there are about 14 STWs, 13 of them being diesel operated. There is also one DTW serving 120 ha. Tax rates of the mini DTW are less than DTW, amounting to about Rs. 100/- acre (Rs. 246/- ha) for potato and Rs. 60/- acre (Rs. 148/- ha) for wheat.

Tanrai village (Goghat P.S.) located in the Kangsabati Command Area is an interesting example of the ineffectiveness of canal irrigation. The village is set in an undulating terrain with sandy loam soil. One of the distributary canals serves this area but it is effective only during the rainy season. The villagers thus rely upon STW irrigation. At pre-
sent there are 15-20 STWs functioning at 30-40 m depth. Recently a mini-DTW has been introduced. Tanks are used to cultivate 8 ha only. Although STW irrigation accounts far about 60% of irrigated area, they are faced with the problem of fluctuating water table depth. This leads to increased lowering of the cylinder thus increasing costs.

A typical DTW irrigated village is Narayanpara village (Polba P.S.). The village is situated on a mature delta surface along a dead river, Kunti Nadi. Soils are loamy in nature. Rainfed agriculture was practised even as early as 15 years ago. The chief source of irrigation at present is a DTW introduced in 1980. The total cost of construction is Rs. 100,000 out of which Rs. 96,000 was derived from loans by the village body.

The chief problem facing the successful functioning of the DTW is current. In the beginning (1981) the DTW supplied water to 60 ha, now this has dwindled to 23 ha. The DTW is capable of operating from 10 p.m. to 6 a.m. only. Besides water cannot be adequately supplied to all the 13 chambers, chiefly the highland ones. Khanyan village is located near the tail end of the DVC canal, hence insufficient water supply has led to dependence on DTW irrigation. At Khanyan, there are 2 mini-DTWs in addition to 2 DTWs. The depth of each mini-DTW is 200' whereas the DTWs tap aquifers at 500' depth. The main DTW irrigates about 200 bighas. Bainchigram (Pandua P.S.) is another example of a DTW irrigated village, although located within the DVC Command area. Canal irrigation constitutes an
insignificant source yielding place to two DTWs. Since their introduction in 1975, STWs form another minor source. Incidentally Bainchigram is a Command Area Development Project (CADP) village hence provided with special infrastructural facilities.

IMPACT OF IRRIGATION ON LAND USE AND CROPPING PATTERN

Plateau and Plateau Fringe Tracts

About 50% of the area of the forest villages of Inchadib and Genrua are under net sown area, 20% under cultivable waste and 30% under forests. Aman rice constitutes the chief crop, occupying about 90% of the NSA, followed by aus which is cultivated along the higher 'baid' lands (10% of NSA) and inferior cereal 'Kodo' along the lowest tracts or 'gora' lands bordering the jhors. As the latter is a rabi season crop, it utilizes the residual moisture of the soil. The overall picture is one of aman monoculture with a negligible amount of double cropping. Pawra Pahari village records an almost similar situation, even though it is located in the foothills. Lack of irrigation facilities have rendered the farms of this village monocropped. No aus is cultivated here due to deficient rainfall. During years of low rainfall as in 1986, even aman cannot be cultivated successfully.

The other foothill villages of Dumaria, Sagma, Parasya etc. record 50-60% of their area under NSA, 20-40% under
cultivable waste due to prevalence of stony terrain. Increasing soil erosion tends to expose underlying lateritic horizons, thus reducing the NSA. The presence of two big bandhs in Sagma village has extended aman area over hitherto 20% jungle land and along certain highlands. Recently dependence of people on rainfall for aman cultivation has been slightly reduced. Sugar-cane although occupying 1 - 3% of NSA is occasionally grown utilizing residual soil moisture. An interesting feature is the cultivation of vegetables including potato. It is grown with bandh water. Boro rice is cultivated in localized patches with bandh irrigation. Aus rice which occupies 1% of the highland, and an early variety of aman rice cultivation are additional features.

Those villages of the plateau fringe which remain essentially unirrigated to poorly irrigated, such as Mohanpur, Garro and Jitusol, record a somewhat similar land use pattern. About 60-70% of these village area, is under net sown area with aman rice as the predominant crop. Aus rice occupies about 20% of the GCA. Boro has been introduced recently on an experimental basis along the plots directly impinging upon the Kuaria Khal. In addition maize is grown on homestead gardens. Mohanpur does not record boro cultivation.

Andhariya and Tilabaid villages, with irrigation facilities, exist as an oasis amidst the surrounding fallow lands. Both the villages record more intensive land use with over 70%
of the area under NSA. At present about 10% of the area is
cultivable waste. But prior to canal irrigation, such waste-
lands extended over a greater area. The beneficial aspect of
irrigation is well reflected in the cropping pattern. Cropping
intensity is high exceeding 150%. Aman rice amounts to 60% of
the GCA and Aus 6.3%. The share of winter and summer season
crops exceeds that of aus. In fact boro rice assumes local
importance (13% of GCA), being followed by wheat (7%) and
oilseeds (7%). Boro rice is cultivated around local tanks
which store excess canal and bundh water. Jute, potato and
other vegetables are also cultivated. The influence of the
other two miscellaneous sources of irrigation are also noted.
Both Amrai and Kandeswar village, located behind the township
of Durgapur, register intensive land use with more than 80 %
of their areas under NSA. But Amrai village records a more
diversified cropping pattern due to the presence of sewage
water. Aman and aus assume equal importance due to prevalence
of danga or highlands (33% of GCA each). Wheat, potato, onion,
mustard and pulses are also cultivated as they find a local
market. Besides wheat which occupies 11 % of the GCA, the
other crops occupy 6 % of GCA. An additional feature is the
cultivation of boro rice (6% of GCA) exclusively with sewage
water. In contrast, the relative share of all these crops
decline to 2-3% of the GCA in Kandeswar. Boro rice is not
cultivated. At Mukutmanipur village, most of the best quality
lands have been consumed by the Kangsabati reservoir. Most of
remnant stony lands are cultivated intensively (65% NSA, 10% cultivable waste). Cropping intensity is low (130%). Aus and aman again assume equal importance in the cropping pattern being followed by boro, wheat and mustard. However boro is cultivated only when reservoir seepage water is available. Prior to the construction of the dam, the villagers used to cultivate vegetables, wheat and pulses with pond water along the better quality lands. However, if seepage water is not available, it would not have been possible to extensively cultivate aman.

**Saline Coastal Zones**

Beguakhali and Maheshmari village possess more or less an identical cropping pattern. Both of them are intensively cultivated except for the sand bar which as yet remains uncultivated. The village is embanked along the edge of the sand bar which is the site for fishing. This is carried out on a co-operative basis. Absence of irrigation facilities at Beguakhali village and excessively saline clayey soil at Maheshmari prevent double cropping. About 95% of the GCA is under aman. Very recently a negligible amount of chilli and water-melons are grown here along the newly cut canal side, in the less saline sandy soils of the west. In contrast Natendrapur and Narayani Abad village, with irrigation facilities, present a better picture. In addition if there is sufficient rainfall, about 70 ha around the big tanks can be brought under rabi
vegetables, chillies and water-melons. In recent years, about 15 ha are being cultivated with boro and about \( \frac{1}{2} \) ha with sugarbeet. Cultivation of this crop has been initiated by the State Government. Hence even in this saline coastal police station, boro rice has emerged in the cropping pattern due to irrigation.

Uttarpara Nij and Baharu village located in the environment of Calcutta Metropolitan District, register a distinctive cropping pattern. About 75% of these village areas is under NSA and 10% under orchards (mango, banana etc.). Despite the absence of any significant irrigation facilities, cropping intensity amount to 184%. The presence of moisture retentive clayey soils in this highly humid tract has facilitated this, whereas the presence of a large market accessible within a few hours by rail, has provided an additional incentive. Both aman rice and a variety of vegetables assume almost equal importance. Potato and other vegetables occupy negligible area. Lady's finger is a low water-consuming crop. The residual soil moisture is used by digging up the dry top-soil to expose the moist sub-soil layers. Slight application of irrigation water meets the requirement of this crop. This vegetable is in great demand in the nearby urban markets. Fruit orchards become an additional source of income. The villages bordering the Bidyadhari river also register high degrees of net sown area (\( > 80\% \)) and are essentially aman monoculture areas. No other crops are cultivated at present. The villagers state, that about 20 years ago some amount of vegetables
were cultivated, covering about 20% NSA. But with the subsequent breaching of embankments and encroachment of saline total water and silt, increased soil salinity is being experienced. This has hindered successful cultivation of aman rice.

Dighirpar and Kumarscha-chak village register similar land use values. Due to less saline soils and presence of tanks, double cropping is gradually being pursued, cropping intensity being 115%. Although aman occupies nearly 80% of GCA, boro (5% GCA) potato (4% GCA) and water-melon (4% GCA) are also cultivated. A DTW is under construction, to tap aquifers at 600 m depth. Here it may be mentioned that as these villages are adjacent to Canning town, most villagers get part-time employment in this urban centre. Income from agriculture constitutes a secondary source, hence insufficient attention is given to it.

Old Alluvium Zone

The highland tracts are comprised of non-moisture retentive sandy/kankar soils. It prevents full-scale cultivation in the villages of Bolpur P.S. About 20-30% of the area is thus under cultivable wastelands, which if levelled and watered could be effectively brought under cultivation. Nevertheless, such lands were more extensive (40%) prior to the introduction of canal irrigation. This is reflected in the cropping pattern. Cropping intensity at present amounts to 135%, whereas previously
it was 114% only. This may chiefly be attributed to canal irrigation which is instrumental in the extension of aman lands from 80 ha to 120 ha and aus lands from only 8 ha to 27 ha along the higher tracts. Aman occupies about 74% of GCA, being followed by aus with 16% GCA. Yet due to canal irrigation about 3% of the land is now under wheat and 4% under mustard, both requiring less water. In addition, presence of big bandhs have facilitated the experimental cultivation of 'boro' rice (2% GCA) and potato (2% GCA). The presence of wet soils around bandhs favour boro cultivation.

The villages of the Barind tract of Maldah district, are deprived of any dependable source of irrigation. As a consequence the cropping intensity and cropping pattern are influenced rather than net sown area, the latter amounting to about 70%. Danga lands constitute 10-20% of the total area. Aus rice is not cultivated. In fact an early variety of aman is extensively cultivated during the early monsoon, to be followed by aman rice during the monsoon season. These two crops assume almost equal importance, both accounting for about 90% of GCA. Besides these, a negligible amount of wheat and pulse ('arhar') are also cultivated with minimum water application, as the soils remain moist immediately after the monsoons. Mention must be made of tomato cultivation which is also being practised with tank irrigation. In certain villages tomato covers as much as 20% of GCA. They fetch profitable prices in the nearby tourist centres of Panduah as well as Maldah.
In direct contrast are the villages of the adjacent moribund riverine tract with the facilities of RLI and STW irrigation. About 80% of the area is cultivated. The most characteristic feature is the absence of aman cultivation. This may be ascribed to the location of these villages along extensive low lying tracts, which are totally inundated during the monsoons thus precluding cultivation of aman rice. The moisture retentive soils, specially along the depressions, emerge as multi-cropped regions. The extensive water bodies facilitate RLI during winter whereas the presence of shallow ground water depths favour the tapping of groundwater through STWs. The overall setting is congenial for boro cultivation and this crop assumes the leading rank in the cropping pattern. In fact boro rice occupies about 50-60% of GCA, being followed by aus or jute (20-30% GCA), wheat (10-20% GCA) and negligible amount of mustard (5% GCW). In some of these villages, aus and jute cultivation are prevented due to flooding during early monsoons which incidentally occur during the maturing stage of these crops. Here boro occupies about 80% of GCA. Moreover, the floods compel the late sowing of boro rice thus extending its harvesting period. This tends to coincide with the sowing of jute/aus. Despite the favourable ecological setting, it would not have been possible to cultivate this water consuming crop extensively without existing irrigation facilities.

Damodar Hughli Riverine Plains

Generally speaking, this region is very intensively
cultivated with a negligible amount of cultivable wastelands. About 90% of the total area is under net sown area. Discrepancies are recorded only where orchards prevail. The high degree of industrialization and urbanization together with favourable ecological settings have ensured good response to easily available inputs. The impact of irrigation is thus reflected mostly on the cropping intensity and cropping pattern, the latter being dependent on the type of irrigation.

Sibaichandi is a canal irrigated village of the DVC. The CI of this village is about 210%. The predominant crops are aman and boro which occupy 75% of NSA and 36% of GCA each. Next in importance is potato covering 25% of the NSA, along the high lands where aman is not cultivated. With respect to GCA, its share is 12%, similar to gourd and vegetables which attain equal importance due to their profitable returns with least expenditure. Jute and mustard are of negligible importance. Even 10 years back, jute occupied 25% of NSA. Due to fluctuating prices it has now been replaced by gourd. Hence cropping pattern is the outcome of the variations of local relief, as well as infrastructural facilities like cold storage and adequate markets. Canal irrigation has contributed in increasing cropping intensity. The tanks by storing canal water, have further perpetuated this pattern.

The efficiency of river lift irrigation is evident along the large rivers such as the Hughli at Paranpur. Prior to RLI,
about 25% of the total area was under cultivable waste land, which has subsequently been brought under cultivation. Cropping intensity of this village has now exceeded 200%. Although aman is the leading crop (48% of GCA), boro rice also emerges important (38%). An interesting feature is the stress on vegetables viz., cabbage and cauliflowers, which occupy 10% of the GCA. Multiple cropping has thus become in vogue in this village. Jute, wheat, oilseeds and potato are of negligible importance. Prior to 1961, jute occupied 40% of NSA, being followed by potato (30% NSA). With assured irrigation water boro has gradually replaced potato in this village. Its cultivation is confined to areas lying adjacent to the river. Basudebpur village is a typical example of the failure of RLI system along small seasonal rivers. The presence of sandy soils further aggravate the problem. RLI is effective only during the aman season when sufficient water is available in the river. As a consequence aman rice occupies about 75% of GCA. Prior to 1980, when RLI was more or less effective, potato and boro were cultivated. With the gradual closure of river lifts and their replacement by STWs, potato has declined in importance. Due to high cost of irrigation in these non-moisture retentive soils, boro area has diminished from 40 ha in 1970 to about 10 ha at present. Mustard cultivation with RLI has also been replaced by STWs, as has been vegetables. Hence in this zone, the villagers prefer groundwater irrigation to RLI. The relative inefficiency of RLI along the dead and dying rivers, like the Saraswati Nadi,
is also evident at Barekpur village. This village possesses a distinctive agricultural system, namely the prevalence of banana and mango orchards which occupy considerable areas. Although net sown area is high, cropping intensity is as low as 105%. The second notable feature is negligible area under aman rice. In fact aman occupies only 10% of the NSA. Even this cannot be maintained during the years of flood. Jute occupies large areas. Some amount of oilseeds, potato and vegetables are grown during the rabi season through RLI. Overall stress is given upon bamboo and fruit orchards. In case of the latter the loamy soils are favourable. Moreover as these are deep rooted trees, they do not require much irrigation. Moreover their returns are high as these products fetch a lucrative market in the CMOA region. According to the villagers, crop returns amount to Rs. 7000/ha per annum for bamboo and Rs. 20/- bunch/year for bananas. The farmers of this village thus prefer to extend orchards along cultivable areas, rather than depend on aman rice.

The villages with STW irrigation facilities, reveal a different picture, with contrasting cropping patterns. At Saota village aman (52% of GCA) and potato (36%) are the leading crops with jute, mustard, wheat, vegetables occupying less than 5% of GCA. This may be basically attributed to the nature of the soil, which is predominantly sandy loams. Potato farming gets the benefit of both the STW and mini-DTW water, whereas other rabi crops utilize only STW water. In contrast Parul
village records aman (56% of GCA) and boro (50%) as the leading crops due to the prevalence of clayey loams. However presence of high land in the south-east encourages cultivation of aus rice occupying 6% of GCA. Besides these, mustard and potato are grown over the high land tract covering 5% and 3% of GCA each. It may be mentioned here that prior to STW irrigation facilities, these crops were of negligible importance. Moreover it has been possible to cultivate boro rice due to the DTW which provides water to nearly 70% of its area. Electricity is a critical factor as the DTW requires 400-450 volts to function whereas the STW requires about 250 volts. Tanrai village, although located within the Kangsabati Canal Command Area, is benefited more by the electricity operated STWs. The Kangsabati Distributary Canal acts as a stand-by in years of deficient rainfall, during the aman and aus season. Hence its main role is to stabilize aman area. In general this village possesses a moderately high CI (160%) with aman occupying 59% of GCA, being followed by aus (15%) potato (12%) and mustard (10%). Boro and wheat area are of minor importance. Prior to the STWs, rabi cultivation was practised only around tanks.

Narayanpara village situated along a discarded channel of the Hughli, the Kunti Nadi, enjoys the facilities of both the RLI and DTW irrigation system. There has been a steady increase in cultivated area from 72% in 1971 to nearly 90% in 1987. It may be clarified in this context, that this is inclusive of 42% under banana orchards. This implicates a similar
situation as Barekpur village, where RLI is able to meet the 
water demands of the orchards. Cultivation of field crops in 
the true sense is possible by DTW irrigation. The overall CI 
is as high as 180% with aman (56% of GCA) and jute (19% of GCA) 
as leading crops being followed by boro (13% of GCA). Potato 
extends over 10% of GCA. Other vegetables and oilseeds are of 
negligible importance. Prior to 1980 boro was not cultivated 
here due to the lack of irrigation facilities. There has been 
a decline in boro area from 47 ha in 1981 to 20 ha in 1986, 
due to erratic supply of electricity. Secondly as the major 
income is obtained from orchards, less stress is given on other 
prospective field crops. Though Khanyan village is located in 
the vicinity of the DVC distributary canal, it has to depend 
on DTW irrigation due to its location at the tail end of this 
canal net. The assured supply of DTW water permits boro culti-
vation (30% of GCA and 43% of NSA). Thus this crop ranks second 
in importance to aman (50% of GCA), followed by potato and 
mustard each occupying 10% of GCA. At Bainchigram the DVC canal 
is effective only during the aman season. Hence rabi and 
summer season cultivation have to depend on DTW irrigation 
system. About 60% of boro area is under DTW irrigation and 
only 16% under canals. Cropping intensity recorded is about 
200%, with aman accounting for 50% of the GCA, and boro 33% of 
GCA. Potato and mustard record 8% and 7% of GCA respectively. 
They are 50% DTW irrigated and 50% canal irrigated. The pre-
sence of clayey loan and infrastructural facilities, like its
location in CADP area, have played deterministic role in extending boro area in this village.

IRRIGATION EFFICIENCY WITH RESPECT TO LOCATION FROM CANAL NETS

Distribution constraints within such vast canal command areas, occasionally create disparities in the efficiency of the canal irrigation system. Specific villages have been surveyed along different reaches of the DVC canal net to highlight this situation.

**Head Reach**

Three clusters of villages have been studied along the head reach area, middle reach area and tail-end of the canal command area. Incidentally, it must be mentioned that the proposed navigation canals have been allocated as irrigation canals. The first five villages are situated in Galsi P.S. about 25 km east of the Durgapur Barrage, hence bordering the DVC Right Bank Canal. These villages are Paraj, Jharul, Pur-surah, Simnari and Manikbazar. They are located in gently sloping terrain with loam to clayey loam soils. Comparatively speaking, Manikbazar is located on high land with sandy loam soils. These villages are highly irrigated with about 70-90% of their NSA under canal irrigation. As such water is available in the main canal from the first week of July to the last week of October, at approximately the same level. This water is later supplied to the Main Distributary Branch Canal, amounting
to 3,000-4,000 cusecs, in a more or less regular manner. An interesting feature is the existence of large tanks adjoining the main canal. These effectively store excess canal waters of the rainy season for subsequent cultivation during the rabi and boro seasons, the villagers thus do not face shortage of irrigation water during the dry season. However, besides government tax rates, additional costs are incurred in lifting of water from the storage tanks through dongas and pumps.

Intensive cultivation is practised in these villages as evident from the very high share of net sown area (90%) and cropping intensity (>200%). There is a negligible amount of cultivable waste lands in these villages due to the high pressure of population as well as the assured supply of DVC waters. Mention must be made of Bardhaman town which has exerted its influence. A distinct cropping pattern is observed with boro rice assuming equal importance with aman rice, and occupying 100% of NSA. As stress is laid upon this crop, rabi crops become less significant. Wheat occupies about 10% of GCA whereas mustard, and vegetables occupy negligible areas (<5% GCA). However, during years of deficit rainfall, boro rice is not cultivated. In fact, 7-8 years before, the supply of canal water was inadequate to sustain boro rice. Hence less water demanding crops like wheat, mustard, potato, sugarcane and pulses were cultivated. Within this pattern Manikbazar records a discrepancy due to its location on slightly elevated ground and slight distance away from the canal, thus restricting
the availability of canal water. Here DVC water benefits aman rice by stabilizing its area and production. Otherwise, the villagers resort to STW irrigation for rabi and boro season cultivation. At present out of the 7 STWs, only 4 are functioning. Their average depth is 12 m but fluctuating water table is a problem. Initially, STWs were used for boro cultivation but due to its high operational cost they are used solely for less water consuming crops like wheat (5% GCA), mustard (12% GCA) and sugarcane (1% GCA). During years of sufficient rainfall about 5% of NSA is brought under boro rice, as in 1981 and 1985. Aus rice occupies 8% of GCA. Aman rice however is the predominating crop (>75% GCA). The cropping intensity of this village has been recorded as 135%.

Middle Reach

The second group of villages is located at Memari, Pandua and Mogra P.S. The villages surveyed are Nimo, Sahnui, Chaknara, Hoera and Bantika.

These villages are served by unlined Distributary Branch Canals, such as the Panagarh Navigation Canal (PNC 4) in Hoera. All these distributary canals are fed by the Right Bank main Canal. These villages are located on monotonously flat plain being formed of clayey loam and loamy soils. The distinguishing feature of this region is its dependence on ground water for supplemental irrigation water supply. These canals usually
suffer from fluctuating nature of water supply. However, this region is ideally situated for groundwater extraction due to its shallow depth and high potential. The government owned DTWs, mini DTWs and STWs thus provide additional sources of irrigation.

At Nimo village, though the distributary canal is the main source of irrigation water, 6 STWs supplement it. The STWs tap groundwater at 12m - 30m depths. The total cost of one STW amount to Rs. 10,000/- - Rs. 12,000/-. Canal Tax rates amount to Rs. 12/- per acre for aman, Rs. 96/- per acre for boro. No charges are made for potato and rabi vegetables. The latter depend on tank irrigation. Chaknara, being located along the tail-end of the canal and on a slightly higher ground, receives insufficient water. To supplement this, 8-10 STWs operated by pumps of 5 HP each have been introduced about 7 years ago. The main canal is a narrow channel. Actually it was a defunct river bed which has been converted since 1980, into a reservoir, 4-5 km long. The relative dependence on STW and canals vary with availability of canal waters. Bantika receives the facility of the Command Area Development Project (CADP) and gets the benefit of both the DVC canal and a mini-DTW. The latter taps aquifers at 60m depth. Water cannot be lifted by centrifugal pumps, instead they have to be sunk. The target of the mini DTWs is 4 ha at present. Tax rates are quite high, viz., boro Rs. 240, aman Rs. 60, potato Rs. 100, jute Rs. 60, vegetables Rs. 100 and mustard Rs. 30 per acre each. Besides
these two sources of irrigation, 6 STWs have been introduced since 1980.

Hoera village may be effectively divided into two parts, based upon the source of irrigation as well as the metalled road that passes through the village. The DVC Navigation Canal traverses through Hoera North, giving off an irrigation channel, PNC 4. When the water level in the navigation canal rises above 3m, water flows from the navigation to the irrigation channel, where the usual depth of water remains 1m high. Excess canal water is stored in 2 storage tanks and is subsequently utilized for the cultivation of rabi crops and aus rice. For boro cultivation water is lifted from the navigation canal. This is unauthorized. As Hoera is situated in the tail-end of the canal, insufficient water is received. Although there are two storage tanks along side the canal, they are partly silted up. The villagers are little benefited from the DVC canal. There is one STW of 35m depth. Hoera (South), opposite the metalled road receives DTW irrigation from 1966. This DTW taps aquifers at 200m depth. Water table is about 12m in summer and 10m during rains. The quality of ground water is somewhat inferior to canal water. The capacity of the DTW is 30,000 gallons/hour. Its normal target for irrigation is 25 ha which is extended to 40 ha during summer or drought years. The distribution system involves 10 spout chambers, each watering 1.5 ha. The village in general has a gentle relief and loamy soils. In this context, it may be mentioned that the adjacent Itachuna
village is entirely deprived of canal water. It thus resorts to STW irrigation. These villages are located in a generally well urbanized and densely populated region. As such there are negligible amount of cultivable wastelands in these villages, with about 90% under net sown area. Cropping intensity registers very high values of about 200%. Aman and boro assumes equal importance in the cropping pattern (45% of GCA). The boro cultivation in Nimo and Sahnui village are totally dependent upon availability of canal waters. At Nimo, only 10% of the boro area is cultivated by STW water. In Chaknara, however, boro rice is mostly dependent on STW water. Aus area varies with micro relief, occupying nearly 10% in Chaknara but only 2% at low-lying Nimo. Potato ranges from 4% at Nimo to 10% at Chaknara. With increased use of HYVs, potato area is registering an increase. Vegetables, pulses and mustard occupy minor areas. Jute has declined in importance in recent years. These three villages come within the perview of Intensive Area Development Programme (IADP). As such, use of HYV seeds and fertilizers in these villages are considerably high. As a consequence, yields are similar to the fertile plans of Bardhaman. A discrepancy occurs at Sahnui village which is the adopted village of the IFFCO. Thus yields are higher.

Bainchi-Dantika village records a fluctuating cropping pattern and cropping intensity, depending upon the supply of canal water. In general about 70% of GCA is under aman, 20%
under boro, 3% under mustard and 1% under potato. It is only
in years when excess water is allocated by the DVC that boro
cultivation is extended to cover 42% of GCA. Otherwise boro
utilizes STW water. The mini DTW is capable of irrigating the
minor crops as the target is 4 ha. Aus, jute and wheat are
conspicuous by their absence. Hence cropping intensity is
influenced by canal irrigation, varying from 148% to 205%.
Yield pattern remains similar.

Hoera village is an interesting example of the compara-
tive benefits of canal and DTW irrigation system. Whereas
Hoera North records CI of only 113%, Hoera South registers 174%
CI. The zone under canal irrigation is mostly monocropped with
aman (80% of GCA), Aus (8%), with potato, wheat and boro occu-
pying 4% each. In contrast, Hoera South with its more assured
DTW irrigation gives equal emphasis on aman (58%), boro (34%),
aus (19%) and a relative decline in potato, wheat and mustard
areas. Excepting boro, HYV seeds are not much in use due to
attack by pests. The productivity of aman is slightly less.
Mention must be made of the damage caused by monkeys to the
potato crops. This is one of the major reasons for the poor
coverage of this crop.

Tail Reach

The third set of villages surveyed are Brahmanpara and
Hamirgachi (Haripal P.S.), West Ramnagar and Binogram (Tarakeswar
P.S., and Hussainpur (Chanditola P.S.) in the southern part of Hughli district. Brahmanpara and Hamirgachi are located along the border of one of the Kana-Nadis or dead tributaries of the Damodar, at present forming a DVC distributary canal. Relief is gentle with loamy soil. It is only directly along the river that a high tract of land is observed. This soil has become slightly acidic in character due to persistent use of fertilizers. The DVC supplies 98% of the total irrigation water, 2% is derived from tanks. The Kapilpur lock-gate being located along Brahmanpara village, controls the incoming of water. However, water has to be pumped out of the river bed, incurring additional costs. About 95% of the families have kerosene operated pumps of 3.5 H.P. each. The people residing in the environs of the CMDA are economically well-off than those in distant rural areas. As such the people of this region can afford to purchase power pumps or hire them for irrigation. Hamirgachi village is located further down-stream of the Kana Nadi. The excavation of sand heaps here 25 years ago has resulted in the formation of extensive sand pits or 'Bali Khads' which have become the repository of excess rain water as well as canal water. In fact the canal in the true sense supplies 10% of irrigation water, whereas the sand pits supply 88%. In addition these pits accord sites for organized fishery. Prior to the inception of the DVC, RLI was practised along the Kana Nadi through the use of dongas.

Canal irrigation has been instrumental in the extension
of net sown area, which at present is as high as 90%. Before 1965, about 9% of the total village land was forest covered, which has subsequently been converted to farm land. Cropping intensity is as high as 230%. Multi-cropping is practised as reflected in the percent share of various crops to GCA, viz., aman rice (39%), boro (26%), jute (20%), potato (13%), vegetables and oilseeds (10%). The relative importance of boro thus declines in favour of jute and potato. This may virtually be ascribed to: i) inadequate supply of DVC water for boro, ii) presence of loamy soil and iii) proximity to urban areas giving incentives to potato farming. Cold storage facilities further ensure remunerative returns.

West Ramnagar and Binogram village are located on the banks of the Damodar river. An embankment has been constructed at a distance from the river levee. Beyond this, the northeastern part of W. Ramnagar village is irrigated by a DVC distributary canal which also flows through Binogram. Both these villages are formed of sandy loams, favouring potato and jute cultivation. In W. Ramnagar, about 50% of the irrigation water is from the DVC canal, 40% from the Damodar by RL system and 10% from tanks. There are 20 pumps under private ownership for lifting water. The river does not possess sufficient water throughout the year. Field observation reveals the installation of STWs along the river-bed during dry season. During floods, the river deposits fertile silt in the fields directly impinging
upon it and in front of the embankment. The relative increase of irrigation area from the DVC and a corresponding decline of RLI by 10 p.c. About 60-65 water pumps now operate under private ownership.

A distinct increase in net sown area has been achieved through the introduction of canal irrigation, from 66% in 1971 to 75% in 1986. Cropping intensity is as high as 210%, with about 54% under aman, 22% each under jute and potato and negligible area under boro, aus and wheat. The presence of sandy soils and high tract, forming favourable ecological condition, along with the economic affluence of the people have made potato cultivation more remunerative at these villages. This crop is extensively cultivated along the river which receives fertile silt. No noticeable difference in yield is noted as use of fertilizers and HYV seeds are high. The farmers state that canal irrigation has induced positive changes. Prior to this, only aman and jute were cultivated, dependent on RLI and tanks. The DVC has resulted in the introduction of the most remunerative crop viz. potato. The productivity of this crop has been simultaneously increased. The low moisture retentive sandy soil now receives irrigation water, thus improving its productivity.

Located within this tail zone, is Hussainpur village (Chanditola P.S.), a direct contrast to the other canal irrigated villages. This village is situated some distance away from
the distributary canals and as such is deprived of canal irrigation. The villagers resort to tank irrigation and traditional lifting of waters through dongas. Actually these tanks have been created during the construction of railway lines, atop embankments. Although NSA is high, cropping intensity is low (130%). Aman is the predominating crop occupying about 75% of GCA followed by jute, potato and wheat. An important aspect is the absence of any groundwater irrigation. Actually, the village is situated near the headquarter town of Singur. Hence about 70% of the villagers find more profitable jobs in the urban area.

SPATIAL PATTERN OF LAND USE IN RELATION TO SOURCE OF IRRIGATION

It is evidenced from detailed case studies of selected villages that distinctive cropping patterns evolve as a response to the types of irrigation and their respective location. Nevertheless, micro-relief differences also play deterministic roles. These features are apparent from detailed landuse studies of individual villages.

West Ramnagar village (Tarakeswar P.S.), along the banks of the Damodar, enjoys both canal and RLI irrigation. The river is situated along the western border of the village whereas the DVC Distributary Canal traverses the north-eastern corner. There is a strip of 'danga' or highland of about 75m width and at a height of 8m from the river bed, corresponding
to the river levee, directly bordering the Damodar. This portion consists of sandy loams and are inherently fertile as they are often replenished by floods. Mention must also be made of the exposed part of the river bed which is intensively cultivated during the winter and summer season. During the time of survey this appeared to be a lowlying land at the same level as the river bed, extending all along the western border of the danga land. The embankment has been constructed along the eastern border of the danga land, protecting the settlements and main village lands lying east of it. The main village road runs along the top of this embankment. It needs to be mentioned here that this is one of the most flood prone zones. The land situated east of the embankment is at a comparatively low level and is mostly comprised of loamy soils. A large pond exists along the centre of the village. The construction of the embankments created several pits that have been subsequently used to store rainwater. Such tanks were observed; at the foot of the embankment. In winter their water level amounts to less than 1 feet (0.305m) rising to 10' (3.05m) during rains.

The crop area has been influenced by relief, soil and irrigation type. For instance, jute and potato lands are mostly confined to the danga lands where the fertile sandy soils are best suited to these crops. Too much water causes rotting of the potato tubers. In contrast, no aman rice is cultivated in this zone as it thrives on reverse conditions.
Moreover stress is laid upon the other two crops which are more profitable. Hence any overlapping would curtail their normal growth period. RLI suffices to meet their requirements. Both direct pumping out of river water as well as through STWs placed along the river bed have made this possible. As the Damodar is also the recipient of DVC waters, this has confirmed the cultivation of these two crops. The aman lands are located all along the central and eastern lowlying area. With the more assured supply of DVC waters the farmers have introduced boro cultivation of about 7 ha along the plots bordering either side of the canal. The rest of the village lands cultivate wheat, mustard and other rabi vegetables around the larger tanks and along the canal area. Mention must also be made of the minor boro seedling beds along the point bars of the Damodar.

Narayanpara village (Polba P.S.) possesses DTW irrigation for the cultivation of field crops and RLI irrigation for orchards. The setting of this village is along the mature-moribund riverine tract. The decaying Kunti R. flows along the eastern and south eastern border of Narayanpara. The strip of land bordering this river as well as that to the north is danga land with loamy soils. The rest of the village, viz. along the central and western parts, constitutes a depressed tract with clayey loams. A small embankment borders the north-western corner of the village. The main road to the village parallels the river. There are two large ponds, one in the
Land Use Maps (Villagewise)

West Ramnagar

- Canal
- Embankment
- Aman
- Aman + Rabi Vegetables
- Aman + Boro + Rabi Vegetables
- Jute + Potato

Parul

- STW
- DTW
- Aman
- Aman + Boro
- Aman + Potato / Mustard

Source: Field Surveys, 1987
south and the other in the central west part. The DTW shed is launched some distance to the west of the second pond. Irrigation water from the DTW is distributed through 14 chambers, some of them opening up into the high tract of the north-west. However DTW water is also stored in the nearby pond and then pumped out onto the fields in the east.

The most distinctive feature is the presence of banana orchards which cover nearly 40% of NSA. They are mostly confined to the Kunti river side as they utilize ULI water, since this source is insufficient for crop cultivation. Most of the banana plants, in their initial stage is grown along the plots nearest the river. The main orchards are distributed along the high tracts of the north and south, as the older trees are deep rooted and are capable of sustaining themselves without much irrigation. Boro cultivation of about 20 hectares forms a conspicuous zone around the DTW and pond. However, at times water is inadequate to support this crop in the danga lands. These lands then resort to potato cultivation. DTW also supplies water to about 2 hectares of mustard crop. Jute is also cultivated along the danga lands. The plots directly surrounding the tanks cultivate some amount of rabi crops. Thus away from the DTW cropping intensity declines definitely, although the non-irrigated aman rice is cultivated all over.

Brahmanpara village (Haripal P.S.) is located within the DVC Command Area in Hughli district. One of the distributaries of the Damodar, the Kana Nadi, moves along the northern
border of this village in a west to east direction. This channel may be more precisely termed as a Distributary Canal, as at present it has been linked with the DVC canal system through the Kapilpur lockgate. The Baidyabati Tarakeswar metalled road passes through the central part of this village. The northern part of this village, bordering the Kana Nadi constitutes a high lying tract. In contrast the extreme southern part is a low lying area, liable to occasional floodings. The soils are loamy in nature with slightly higher sand content along the northern part. The distinctive aspect of irrigation, is that canal water needs to be pumped out onto the field channels. Slight variations in micro-relief has induced practise of this method, which apparently resembles a minor RLI set up.

About 75% of the NSA is under aman. The danga land forming 25% of NSA is not brought under this crop. This retains the fertility status of this soil, which is subsequently used for cultivation of potato and other vegetables. These lands also favour the cultivation of jute. Boro is cultivated mostly along the lowlying tract to the south where soils are more moisture retentive. However this is not a regular feature as this crop is cultivated only if the canal waters overflow this zone even in this lean season. If adequate water is available, boro area is extended to over 50% of NSA in the central part. Oilseeds are grown both in high as well as low lying areas as they require less water.
Parul village, (Pursurah P.S.) is an example of simultaneous benefits of STW and DTW irrigation. As such it is located along the Harinakhal, a discarded outflow channel of the Damodar. This channel lies in a N-S direction along the western border of the village. The danga land comprised of sandy loams occurs in the west lying parallel to the Harinkhola, extending into the south east. The rest of the village is comparatively lowlying with clayey loams. The 14 shallow tube wells are distributed all over the village, 6 being located in the danga tract. One of them operated by electricity. There is one DTW functioning in the central and eastern part of this village. The distribution system consists of 10 chambers and the total area irrigated amounts to 120 ha. The cropping pattern bears a distinct relationship to the two sources of irrigation. Aman is the most extensive crop covering 100% of NSA, over both danga and adjoining low lands. Aus was cultivated along these danga land about 15-20 years ago. With the introduction of STW irrigation this zone has been brought under potato and mustard. The favourable physiographic setting is an additional advantage. The areas around the DTW are of lowlying, clayey loams favouring the cultivation of boro rice. About 68% of the total boro area is irrigated by this source due to its assured water supply. About one-third of the area is under STW irrigation. The STW irrigation also benefits aman areas. The danga lands have been successfully brought under short maturing HYV aman in order to raise potato and
mustard.

Paranpur village (Balagarh P.S.), situated along the right bank of the Hughli river enjoys river lift irrigation through 14 HP pumps, set up by the Government since 1975. There is an extensive tract of danga or high land bordering the Hughli river, approximately 6m above the river bed. This merges westward into a low-lying land with fine textured soils. In general the soil is a fine textured loam. The cropping pattern has been considerably influenced by irrigation. Aman being a rain fed crop is cultivated all over this village. The 2nd important crop is boro-rice (75% NSA) which is concentrated east of the metalled road as RLI underground pipes and spout chambers do not extend beyond it. This has also been the main consideration for the cultivation of the other crops like vegetables (25% NSA), as well as negligible amount of jute, potato, and oilseeds. They are all confined to the plots nearest the river. Wheat (5% NSA) is restricted around large tanks. Hence a distinct multi-cropped zone covering over 30% NSA emerges out into a double-cropped area upto the metalled road. Beyond it occurs a monocropped zone of aman rice.

Two examples of tank irrigated villages may be cited, one situated in the western plateau tract and the other in the saline coastal zone. Parasya (Balarampur P.S.) is characterized by the presence of jhor bundh irrigation, with two tanks at successive levels. As such the village possesses
extensive 'danga' lands (50% NSA) which mostly remain fallow throughout the year due to stony terrain. This zone encircles the village along its southern and eastern parts. The rest of the land consists mostly of baid and bahal lands. Kanali or lowest lands occur along the central-west and south-east. The two jhor bundhs are adjacent to the Kanali lands in the south east. Following their alignment it may be presumed that the slope is toward the north/north east. Two other elongated tanks exist lower down. The cropping pattern is a response to both relief and irrigation. Aman extends over the baid, bahal and Kanali lands, about 80% NSA. The danga lands within the vicinity of the bundhs cultivate inferior cereals during the post monsoon season with residual moisture and bundh water. The Kanali lands bordering the bundhs sustain a negligible amount of boro. Rabi vegetables like potato, cabbages, although occupying 2-3% NSA, are nevertheless grown around the bundhs and tanks. Hence tank irrigation has been responsible for the introduction of irrigated crops, viz. boro.

A similar picture is obtained at Natendrapur (Sagar P.S.). An interesting feature is the large elevated tank about 7 ha, surrounded by four jheels or water bodies which form the source of its water supply. 'Khals' or elongated canals issuing from the tank are responsible for distributing tank water. Located in a highly humid zone with moisture retentive clayey loams, there is the absence of cultivable wastelands. Aman is cultivated all over, occupying about 90% NSA, as it is a rainfed
crop hence not affected by the salinity problem. However this village would have remained fully monocropped if not for the presence of this tank. Since 1987 a large 'khal' about 3 km long has been re-dug along one of the discarded river courses. It will be an additional source of irrigation water in the near future. At present, it has been possible to introduce boro over 13 ha, along the plots bordering the large tank during years of excess rainfall. Rabi crops like chillies and water melons are also cultivated over 27 ha of land around this tank. Along the other tanks and 'khals' about 35 ha has been brought under rabi vegetables. Hence a distinct pattern emerges with a multi-double cropped zone around the tanks merging into a mono-cropped zone.

ECONOMICS OF IRRIGATION

It would be more appropriate to make an analysis of efficiency of irrigation from the perspective of cost/benefit ratio, or in other words to calculate the economics of irrigation. In general it depends on a complicated set of factors operating in combination with one another. Irrigation efficiency is primarily determined on basis of crop yields as an increase in this factor will tend to meet the cost of irrigation and associated inputs. But crop yields depend not only HYV seeds and fertilizers, but also on the moisture-retentivity and inherent fertility status of soils as well as the socio-economic set up of the cultivators. Field methods
of measuring irrigation efficiency are varied and elaborate. Moreover they are faced with the dearth of detailed instruments. Hence it has been difficult to estimate this aspect within this time span. In fact, this forms subject matter of a separate research. In the present analysis preliminary attempt has been made to highlight certain aspects such as crop yields, use of HYV seeds and fertilizers, cost of irrigation and in certain cases an overall cost/benefit ratio as a base for further study. The survey has been based upon primary information from the villagers as official study has not yet been conducted in this respect. As such the estimates may be tentative in nature.

**Impact on Crop Yields**

The magnitude of difference in yields is not considerable when compared to that of cropping intensity and cropping pattern. In a very generalized manner it could be specified that overall yields are lowest in the hilly tract of Puruliya district, as in Inchadih, and in the villages bordering the tidal rivers as in Taldi. The yield of aman is low in localized areas as in Barekpur (1918 kg/ha) where insufficient stress is given on this crop due to prevalence of orchards yields are also low in the old alluvium zones (2466 kg/ha). Maximum yields are registered in the Damodar-Hughli riverine plains, irrespective of the source of irrigation. In case of highly irrigated boro crop, the
DTW irrigated villages register maximum values, exceeding 4933/ha. This could be due to the assured water supply which provides incentives for investment in other inputs. In the moribund plains of Maldah, RLI results in higher yields than STW for a similar reason. The yield of potato depends on soil types as well as on the quantum of fertilizer inputs as this is a soil exhausting crop. Hence 'danga' areas with sandy soils register high values (21,925 kg/ha). At Donaipur potato yields are higher with canal than tank irrigation. The IFFCO adopted village Sahnui registers maximum yields with respect to all the crops. Jute responds more to soil types; as highest values are observed along levee tracts with fertile sandy-loams. Often local practices tend to influence yields. For instance if jute is grown on potato fields with residual fertilizer content, subsequent to the cultivation of this crop, there is usually a decline in its yield. The farmers are reluctant to invest more on fertilizers in this crop as it is subject to fluctuation in prices. Yields are high in zones where jute is followed by aman only. Often use of HYV seeds lead to increased attack by pests. Hence villagers who can afford to use them prefer to use resistant local varieties. Mention must be made of the damage caused by monkeys to the potato crop in Hoera village. In addition, the size of land holding, subsidiary incomes, social structure, etc. also exert their influence on crop yields.
With respect to the use of HYV seeds it may be stated that wherever boro, wheat and potato are cultivated, 100% HYVs are used. Aman records a varying picture. Although the fertile, irrigated Damodar-Hughli riverine plains register high values, about 80% HYV, some villages digress from the general pattern. At Hoera, Paranpur and Narayanpara village, for instance, the villagers prefer local varieties due to their better resistance to diseases and pests than the HYVs. In other areas the pattern conforms to that of the officially recorded P.S. level data.

The information on consumption of fertilizers is more complicated thus preventing a generalized analysis. In certain areas absolute cost figures are stated whereas in others the amount utilized, with respect to varied types of fertilizers like Bramar (Super $N_2P_04$), Suffola, Urea, etc. are given. At times only the $N : P : K$ ratio is given. Inputs varied according to the importance of the crop and the socio-economic status of the villagers. Broadly speaking, the villages surveyed in Bardhaman and Hughli district consume the maximum amount of fertilizers due to irrigation facilities. Amongst all the crops, boro crop requires maximum fertilizer input amounting to about 220 kg/ha of Super $N_2P_04$, 290 kg/ha of mustard oil cake and 150 kg/ha of Urea. The total investment on boro thus comes to about Rs. 2670/ha; followed by potato which amounts to Rs. 2220-2960/ha. The ratio of $N : P : K$ is 26 : 26 : 26 in case of the latter.
crop. In case of aman, negligible amount of fertiliser is used if it is cultivated in the boro plots with their remnant fertilizer content. Otherwise about Rs. 1480 worth of fertilizers are applied per hectare. Similar is the case with jute and aus. Oil seeds consume low amount of fertilizers, about Rs. 650/ha. Some of the miscellaneous crops like gourd in Sibaichandi require Rs. 850 worth of fertilizers per hectare, the same for lady's finger at Uttarpara Nij being Rs. 2150/ha, watermelon and chillies amounting to Rs. 2220/ha. Fertilizer input declines in the western plateau, old alluvium and saline coastal tracts. At Inchadih village, for example only cowdung is used for aman; whereas at Dumaria and Sagma costs of fertiliser input amounts to Rs. 450/ha for aman, Rs. 1480/ha for boro, Rs. 1110/ha for potato, and Rs. 890/ha for wheat. At Dighirpar and Taldi village, the costs of fertilizer are Rs. 780/ha for aman, Rs. 1220/ha for boro and Rs. 1110/ha for potato.

Cost of Irrigation

This involves not only direct taxes imposed by Government operated major and minor irrigation schemes but also the cost of lifting water through dongas and water pumps. Moreover private owned STWs pose a different problem as they are also rented out on hourly basis. In such cases the cost of irrigation is fundamentally influenced by the terrain, climate, the distance of farms from the source of irrigation, as well as
the land holding structure. However, on the basis of primary information supplied by the farmers an account of the varied irrigation water requirement of crops has been put forward.

Direct tax rates are as follows:

<table>
<thead>
<tr>
<th>DVC at</th>
<th>Aman</th>
<th>Rabi/Boro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nimo</td>
<td>Rs. 12/acre (Rs. 30/ha)</td>
<td>Rs. 96/acre (Rs. 240/ha)</td>
</tr>
<tr>
<td>Brahmanpara</td>
<td>Rs. 55/acre (Rs. 135/ha)</td>
<td>Rs. 96/acre (Rs. 240/ha)</td>
</tr>
<tr>
<td>Hoera</td>
<td>Rs. 15/acre (Rs. 37/ha)</td>
<td>Rs. 96/acre (Rs. 240/ha)</td>
</tr>
<tr>
<td>Manikbazar</td>
<td>Rs. 15/acre (Rs. 37/ha)</td>
<td>Rs. 96/acre (Rs. 240/ha)</td>
</tr>
<tr>
<td>Mayurakshi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paruldanga</td>
<td>Aus/Aman Rs. 60/acre (Rs. 150/ha), Rabi Rs. 90/acre (Rs. 220/ha). No taxes are charged for boro as canal water is not supplied.</td>
<td></td>
</tr>
<tr>
<td>Dorsol</td>
<td>Aus/Aman Rs. 10/acre (Rs. 25/ha) Boro/Rabi Rs. 20/acre (Rs. 50/ha)</td>
<td></td>
</tr>
<tr>
<td>Kangsabati</td>
<td>Aman Rs. 15/acre (Rs. 37/ha). No taxes are charged for rabi crops.</td>
<td></td>
</tr>
<tr>
<td>DTW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hoera</td>
<td>Aman Rs. 60/acre (Rs. 150/ha) Boro Rs. 240/acre (Rs. 590/ha) Wheat Rs. 60/acre (Rs. 150/ha) Potato Rs. 100/acre (Rs. 250/ha) Mustard Rs. 30/acre (Rs. 75/ha)</td>
<td></td>
</tr>
<tr>
<td>Bainchi-mini DTW</td>
<td>Similar as Hoera, in addition jute Rs. 60/acre. (Rs. 150/ha) Potato Rs. 100/acre (Rs. 250/ha)</td>
<td></td>
</tr>
<tr>
<td>Saota</td>
<td>Wheat Rs. 60/acre (Rs. 150/ha)</td>
<td></td>
</tr>
</tbody>
</table>
Narayanpara

<table>
<thead>
<tr>
<th>Crop</th>
<th>Price/acre (Price/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aman</td>
<td>Rs.100/acre (Rs.250/ha)</td>
</tr>
<tr>
<td>Boro</td>
<td>Rs.350/acre (Rs.860/ha)</td>
</tr>
<tr>
<td>Rabi</td>
<td>Rs.75/acre (Rs.185/ha)</td>
</tr>
</tbody>
</table>

RLI

Bidhangarh Similar to Govt. DTW as in Hoera.

In case of STWs overhead costs are spread over 5-10 years. Cost of construction varies along with the depth of the STW and fluctuating water table depth. At Manikbazar the STW with a depth of 12m costs Rs. 3000. When water table drops below 7m, the machine is incapable of lifting water. At Farul village, if the first layer is within 12-18m, depth the cost of installing an electricity operated STW is Rs.12,000. Whereas if the depth is upto 30m the cost rises to Rs.15,000 to Rs.20,000. If these STWs are diesel operated the overhead costs are lower. Water is rented out at Rs. 12/hr, similar for lifting water from canals, streams and tanks by diesel operated pumps. Lifting of water by dongas is more laborious amounting to Rs. 20/day/person.

As aamn rice is mostly a rainy season crop, it generally does not require artificial irrigation. It is mostly required during the onset and withdrawal period of the monsoons or if long breaks occur during the monsoon season. The required depth of water of this crop is 2.5 cm increasing to 10 cm during October.

Boro being a totally irrigated crop best reflects the
situation. The absolute amount of water required is 49,000 lb/ha, similar to aman, in the plateau fringe zones as at Andhariya and Tilabaid village. In the zone of yellow brown, sandy loams as at Amrai, it is necessary to irrigate 3-4 days alternately in order to maintain 7.5 cm of water continuously, whereas at Mukutmanipur this frequency amounts to once every week. Here the continuous seepage from the reservoir reduces the amount. Paranpur, with its clayey loams and humid climate requires only 2.5-3 cm water and this is maintained by irrigating once a week. At Mubarakpur, along the moribund plains, irrigation is required once in 10 days each amounting to 11 hr/ha (RLI) to 30 hrs/ha (STW). At Dighirpar in the highly humid, 24 Parganas with its moisture retentive clayey soils, an initial watering of 4 hours/bigha (30 hrs/ha) sustains 7.5-10 cm of water. This is maintained thereafter by only 4-6 number of irrigations. In all cases basin irrigation is practised for boro cultivation. However, in the nursery stage level border method is in vogue. About 2.5 cm of water is needed to be maintained during seedling stage.

Potato is also an irrigated crop. Furrow irrigation is practised with longitudinal and cross graded furrows. At the initial stage of cultivation, sprinkling is required. At Brahmanpara, for instance 3 sprinklings, of 3 hours/bigha (22 hrs/ha) each, are done, 4-6 days after sowing. Then irrigation technique is by diverting water through furrows. It needs to be seen that the waterlogged front does not exceed
beyond 2/3 of the height of the ridges as potato is a perishable crop. Hence levee zones and sandy loams are preferred. At Brahmanpara, 8 times watering is required. At Paranpur, sprinkling is done twice a month and then irrigation only once in 15 days. At Amrai, irrigation is done 4 times by flushing field with water through the furrows at a gap of 15 days, each time amounting to 5 hrs/bigha at a cost of Rs.75/ha. Only 3-4 irrigations of 2 hours/bigha (15 hrs/ha) are required at Dighirpar. The optimum depth of irrigation is 30-40 mm per irrigation according to soil types. For land preparation a pre-sowing irrigation of 75 mm may be necessary. At Andhariya it was stated that 5000 lb/acre (37040 lb/ha) of water was required.

Wheat, being a rabi season crop, also requires irrigation but its water requirement is lower than the other two crops. In almost all the areas 3-5 irrigations are required, coinciding with the four physiological growth stages of the crop. Along the west 5 irrigations are necessary whereas in the cooler north 3 irrigations suffice to meet the requirement to maintain soil moisture regime at field capacity up to the effective root zone. The total consumptive use is 10,000 lb/acre (74,000 lb/ha) in Andhariya. At Manikbazar the timing for each irrigation is 4 hrs/ha (30 hrs/ha) the same at Amrai being 5-6 hrs/b (37-40 hrs/ha). At Mobarakpur the timing is slightly less for RLI = 2 hrs/bigha (15 hrs/ha) and 3 hrs/bigha (22 hrs/ha) for STW. Level border method of
irrigation is followed, where the width of each strip is 3-4m.

In case of mustard, the requirement of irrigation is less than wheat, amounting to 2-3 waterings only by level border method. Once the soil becomes wet no more irrigation water is provided after the sprouting of the seeds. Residual soil moisture is usually utilized; otherwise one or two sprinklings are resorted to. The optimum soil moisture regime is field capacity to 25% available moisture. Hence 1-2 irrigations of 75-80 mm depth is found suitable in some cases.

The mostly rainfed crops of aus and jute require about 3 irrigations each, once during sowing and twice during later stages. The soil needs to be kept at saturation point only. During rainless periods irrigation at 15 days interval is given with depth of water per irrigation being 75-80 mm.

Cost/Benefit Ratio

Direct cost/benefit ratio has been given in four villages:

Table 31

| Cost/Benefit Ratio of certain Irrigated Villages (Rs/hectare) |
|-----------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Aman | Boro | Wheat | Jute | Potato | Mustard |
| Sibaichandi | 890 | 3080 | - | 4590 | 16,130 | - |
| Narayanpara | 1480 | 1850 | 110 | +1456 | *14,815 | - |
| Brahmanpara | 244 | 995 | - | -2890 | 30,000 | 3370 |
| Bidhangarh | - | 10370 | -1333 | -680 | - | 1230 |

(Source: Field Surveys, 1987)

N.B. *If prices are low then loss of about Rs.2960/ha is incurred ** Rs.14000/ha
It is evident from Table 35 that the highly irrigated boro and potato bring in lucrative returns, specially in the moribund riverine plains of Maldah. In case of jute, a delicate situation persists with respect to fluctuating market prices. The non-profitability of wheat is creating disincentives in recent years as opposed to mustard. Rising prices have caused farmers to opt for this crop. This is a consequence of the government's recent drive to become self-sufficient in oilseeds and pulses. Some of the miscellaneous crops also bring in remunerative returns.

COMPOSITE ANALYSIS

The implications emanating from this entire analysis are varied and not definitely conclusive. This is basically because it is purely based upon the information obtained from the villagers. However, taking into cognizance all the above mentioned facts, it definitely emerges that irrigation has ushered in new dimensions in the agricultural scenario of West Bengal. This also complies with the conclusions drawn in the previous analyses on landuse, cropping pattern and crop yields based on police station level official data. It is obvious that impact has been maximum on cropping intensity and cropping pattern.

Within the highly and diversely irrigated regions a more detailed picture emerges with respect to the impact of
sources of irrigation. Besides villages located close to the branch canals, as in case of DVC area, canal irrigation is inadequate for sustaining double cropping. This has been made feasible in villages with storage tanks facilities, thus allowing excess waters of the rainy season to be stored for subsequent use. Amongst three major river valley projects, the Mayurakshi and the Kangsabati projects have not yet attained a high level of efficiency when compared to the DVC. This could be attributed to the recency of their implementation and lack of numerous, large reservoirs as in case of the DVC. Along the middle and lower reaches, supplemental groundwater irrigation is necessary, DTWs forming a more assured source. With regard to RLI, the large government operated schemes are effective. It has been observed that DTW and RLI along large rivers have been responsible for widespread boro cultivation. Favourable moisture retentive soils along lowlying tracts may well sustain this crop even with STWs. In general STW forms a costly source of irrigation for boro rice, if it is on a rental basis. Potato, a remunerative crop, is favoured along highlying tracts with sandy loam soils and as such can be grown with canal and STW irrigation as its water consumption is low. The presence of cold storages and markets provide strong incentives. Fluctuating market prices tend to obviate the role of irrigation in jute, wheat, mustard and vegetables are favoured by irrigation.

The impact of irrigation is well evident from the
individual case studies of villages. Where there are facilities of both the canal and RLI, boro is cultivated besides the canal. In case of the presence of both DTW and STW, the former forms the zone of boro cultivation whereas less water requiring crops like potato, mustard, etc. are confined to STW areas. In poorly irrigated tracts, the large 'bandhs' or tanks exist as oases in the midst of uncultivated plots. Mention must also be made of the miscellaneous sources such as sewage and seepage water which have resulted in increased cropping intensity and introduction of irrigated crops.

With respect to crop yields the influence of irrigation is not very conspicuous due to reasons already stated. Timing of irrigation as well as its cost are evident from field surveys. These are strongly dependent upon soil types, terrain and climate. In case of privately operated STWs and lifting of water from canals, etc. these factors come into play. Cost/Benefit structure depicts the positive role of irrigation, as this ratio is fairly high in case of highly irrigated crops like boro and potato.
"Forest Department Policy causing soil erosion..... Bankura, Puruliya, Birbhum, Medinipur and Bardhaman districts are most prone to soil erosion ..... The Forest Dept. afforested patches of such cleared areas with eucalyptus and Akashmoni (Acacia auriculiformis). It is found that the areas where these fast growing trees with narrow leaves are planted, land dries up fast as these plants suck underground water more quickly than deciduous trees. Thus the present policy is enhancing soil erosion and resultant water pollution".


"On an average 18 acres in Bankura and Puruliya are made barren to form one acre of fertile soil at Ghatal in Medinipur".

- THE STATESMAN, 30.4.1985

"Boro paddy in about 30,000 acres in the DVC's Command Area is shrivelling because of shortage of irrigation water. It was learnt that the water crisis was caused by an 'unilateral and wasteful' release of about 50,000 acfeet of water by the DVC".


"Fresh floods in South Bengal following the discharge of 151,000 cusecs from the DVC Barrage ...".

- THE STATESMAN, 15.9.1987

"Indiscriminate sinking of tubewells, which may have disastrous effects, is becoming apparent in parts of Nadia district. Even in Haringhata block, where more than 65% of the groundwater resources have already been utilized, shallow tubewells were installed recently .....".

- THE STATESMAN, 9.3.1989

"Illegal 'bheris' (fisheries) eating away Sundarbans land. At Haroa, Minakhan, Canning, Basanti, Gosaba ..... farmers have converted 1000's of acres of agricultural land into salt water bheris by breaching embankments..... The land will ultimately turn barren.....".

- THE STATESMAN, 21.7.1987

Part D : PROBLEMS AND PROSPECTS OF IRRIGATED AGRICULTURE