CHAPTER VI

IRRIGATION TYPES

It is imperative that the choice of any specific irrigation type should give due consideration to the physical environment, so as to make its implementation technically and economically viable. It transpires from this fact, that the diverse irrigation types of West Bengal are a direct response to her varied terrain, soils and climate. In the temporal perspective, as modern technologies evolve and traditional farming systems undergo changes, irrigation types also experience transformations.

In this context, one should state, that the term "irrigation type" has no precise definition. Its implication varies with the nature of water resources of the regions. Broadly speaking, there are two parameters for identifying irrigation types:

1) Source of Irrigation Water: In a region like West Bengal, with its prolific surface and groundwater resources, emphasis is usually given on the source of irrigation. Surface water is utilized either by direct river lift irrigation or from reservoirs through canal irrigation. Another source of irrigation is direct rain water and run-off through tanks. Groundwater exploitation is carried on by shallow tubewells, tapping
Pl 33. Canal water is stored in tanks for future use in the dry season, Galsi PS

Pl 34. The DVC Distributary Canal at its lower reach, Dhanakhal PS, Hugli Dist
an upper aquifer or two and by deep tubewells extracting water from deeper aquifers. Dugwells, leading to direct tapping of the water table, are not much in vogue in West Bengal.

ii) Techniques of Water Application: This criterion is used where the sources of water are less abundant and water budgeting is essential for maximum utilization of available resources. In West Bengal, although at present the first criterion is used to identify irrigation types, both indigenous and modern methods of water application are practised. Traditional methods involve lifting of water from water bodies by canoe shaped wooden devises locally termed as 'donga'. Use of power pumps, either diesel or electricity operated, seems to be the present trend.

With increased demand of irrigation water and evolution of modern techniques, the need for environmental protection through the rational use of water resources seems imperative. Stress should now be laid upon the hitherto neglected second parameter, that is, development of more economic methods of water extraction and application. To provide a comprehensive picture, the analysis of irrigation types of West Bengal should involve three aspects, namely, sources of irrigation, methods of water application to fields and lastly the methods of water distribution to the farm lands. In fact, these are interlinked processes, upon which depend the efficiency of the irrigation system of the region.
HISTORICAL PERSPECTIVE

In West Bengal, essentially a humid riverine tract, utilization of her water resources for agriculture has formed an integral part of her agriculture since ancient times. Hence an insight into the characteristics of her ancient irrigation systems, some of which exist even at present, is essential.

Overflow Irrigation System

This system of overflow irrigation was evolved by the rulers of ancient Bengal some 3000 years ago, and it could be classified as a major, scientific irrigation system best suited to the conditions of this region. It consisted of a series of excavated canals issuing from the major rivers, chiefly the Damodar. These canals were long and continuous, fairly parallel and at right distance from each other for the purpose of irrigation. They were initially broad and shallow carrying the crest waters of the river floods, hence rich in fine silt. Irrigation was performed by a series of cuts in the banks of the canals, which were closed with the cessation of the seasonal floods. They were thus operated during the rainy season. All these canals were originally dug straight, but due to the friability of the soil they assumed winding courses later on. Whereas ordinary irrigation canals carry nothing but river water, 'overflow canals' functioned differently. The irrigation of the country was done principally through basin irrigation by embanking the fields. These
canals carried excess river water at their heads but at their tail ends they practically contained only rain water.

The overflow canals also served other scientific purposes. Once the engineers made the breaches, the water was handed over to the local boards. The latter were expected to see that the water reached every field. The properly controlled muddy flood waters replenished soil fertility after the main 'aman' rice was cultivated. Sometimes the residual moisture was utilized for the cultivation of winter crops. It also prevented the spread of malaria by the yearly flushing out of stagnant waters. Another interesting fact was that it restricted the growth of the dangerous 'Kaus' grass which usually destroyed soil fertility. The area irrigated was extensive amounting to 2,835,000 ha. By 1815 these canals had decayed due to the neglect of the landlords and the British who were then basically traders with no positive interest in this direction.

Zamindary Bank Irrigation

This developed around the 19th century. Maximum negligence of private canals occurred in Central Bengal, faced with the Mahratta-Afghan wars. In the West, as along the Damodar, the decay of these canals caused water levels to rise within these rivers and cause floods. The Damodar banks then assumed a fresh importance. These were termed 'zamindary' banks and were surreptitiously cut by the Zamindars (landlords) and
Pl 35. Kangsabati Distributary Canal its lower reach, Goghat PS, Hugli Dist

Pl 36. Irrigation canal being channelised through tunnels to overcome physical barriers, Medinipur Dist
tenants to irrigate their lands. The Government failed to know about this and recorded such breaches as the consequences of uncontrolled floods.

**Public Canals**

With such deteriorating conditions the Government constructed as a relief measure the Jamalpur Regulator in 1875, Eden Canal in 1881 and Medinipur Canal later on. The Jamalpur Regulator opened into the two dead-dying rivers, the Kana Damodar and the Kana Nadi, by a canal with a bed width of 4.5 m and depth of 1 m. The height of the bed prevented it from taking low water. The Eden Canal fed the decaying Kana rivers with a sluice which opened onto the rice fields and certain others with little water courses 2.4 m wide and 1 m deep. Both these canals were capable of irrigating only 4050 ha. Along the Kasai river in Medinipur district, damming of the river provided irrigation for about 4000 ha. Dams were usually constructed across the Silai by the zamindars and it was estimated that about 6075 ha were irrigated in Ghatal area alone (Hunter, 1876). In Hugli district such unscrupulous damming led to defective drainage. The water, however, was extensively used for irrigating valuable crops like indigo, mulberry, sugarcane, cotton and jute, all cash crops.

The Eden Canal was constructed originally for the purpose of flushing adjacent river beds and to provide drinking waters in the neighbouring areas. Subsequently it came to be
used for irrigating 10,000 ha of land. The construction of Anderson Weir and Damodar Canal in 1926-33 was designed to supply more water to the Eden Canal and to irrigate an additional 64,400 ha of land, but this scheme did not succeed (Banerji, 1972).

Mention must also be made of the canal network termed 'Subhankar Danra' executed during the 1st half of the 18th century in the northern part of Sonamukhi (Bankura district) to counteract the natural susceptibility of the area to droughts. The system consisted of several main branch channels, fed by the monsoon, which irrigated about 20,700 ha (O' Malley, 1908). At one stage a revenue of Rs. 12,000 was derived from the area irrigated by it (Banerji, 1968). To-day these have become obsolete.

**Tank Irrigation**

This was the most prevalent indigenous method of irrigation all over Bengal, and exist even to-day. The extensive 'bandh' irrigation of Bankura district is a striking example. These bandhs (tanks) were constructed by the local rulers. These storage pools were set up at levels higher than the surrounding fields and were created by throwing embankments across local drainage channels and slopes. In certain areas they created large artificial lakes such as the Jamuna and Krishna bandhs of Bishnupur P.S. (Bankura district). The stored rainwater and run-off was also used for domestic con-
This was thus a most effective system of water storage in the drought prone areas.

**Ponri Irrigation**

This was an indigenous method of irrigation in the northern hills and foothills. The slope of the land and the numerous small streams favoured its development. Lands to the north as along the Mechi, Baiasan and Mahanand rivers, where it is generally easy to dam up the streams and water channels, benefited most. Water from these sources was conveyed to the fields, sometimes situated at long distances (6-8 km), through irrigation channels called 'ponris' or 'pauris' and lifted through 'dongas' or bamboo baskets (O'Malley, 1907).

**GENERAL CONDITIONS**

A changing scenario with regard to the sources of irrigation is observed throughout the decades (Table 10). During the 1950s the primary source of irrigation was private canals (33.56% of GIA) and tanks (32.31%), the former predominating in the eastern riverine plains and the latter in the western plateau sections and the old alluvium tracts as in Maldah, Bardhaman and Koch Bihar districts record exceptions. In case of Bardhaman 49.73% GIA was under Government canals due to the inception of the DVC and in Koch Bihar 62.26% GIA was under dugwells.

By the 1960s, private canals (27.45%) had yielded place
### Table 10
Sourcewise Irrigation of West Bengal

<table>
<thead>
<tr>
<th>Source</th>
<th>1975</th>
<th>1985</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Govt.</td>
<td>Private</td>
</tr>
<tr>
<td>Puruliya</td>
<td>4.020</td>
<td>1.76</td>
</tr>
<tr>
<td>Bankura</td>
<td>30.73</td>
<td>11.04</td>
</tr>
<tr>
<td>Birbhum</td>
<td>61.76</td>
<td>3.65</td>
</tr>
<tr>
<td>Bardhaman</td>
<td>48.73</td>
<td>12.26</td>
</tr>
<tr>
<td>Medinipur</td>
<td>9.29</td>
<td>46.00</td>
</tr>
<tr>
<td>Haorah</td>
<td>62.76</td>
<td>5.63</td>
</tr>
<tr>
<td>24 Parganas</td>
<td>48.95</td>
<td>10.17</td>
</tr>
<tr>
<td>Hugli</td>
<td>50.97</td>
<td>16.65</td>
</tr>
<tr>
<td>Nadia</td>
<td>35.25</td>
<td>2.46</td>
</tr>
<tr>
<td>Murshidabad</td>
<td>43.60</td>
<td>11.12</td>
</tr>
<tr>
<td>Nadia</td>
<td>35.25</td>
<td>2.46</td>
</tr>
<tr>
<td>W. Dinajpur</td>
<td>41.90</td>
<td>10.01</td>
</tr>
<tr>
<td>K. Bihar</td>
<td>48.95</td>
<td>10.17</td>
</tr>
<tr>
<td>Jalpaiguri</td>
<td>14.00</td>
<td>81.53</td>
</tr>
<tr>
<td>Darjiling</td>
<td>6.22</td>
<td>10.05</td>
</tr>
</tbody>
</table>
to government canals (33.79%) due to the implementation of the DVC and Mayurakshi Projects. Tanks came third in order of importance (24.28%). Groundwater irrigation (0.13%) was negligible. In fact, miscellaneous irrigation (13.35%) was more important. Along the eastern districts tanks and private canals vied with each other.

The 1970s still reveal this changing trend, with Government canals (42.27%) gradually replacing private canals (22.21%) and tanks (20.32%). This occurred due to the full fledged operation of the river valley project in the western districts. Dugwells and miscellaneous sources still retain their importance in Koch Bihar and Darjiling districts.

During 1980s another significant fact emerged. Hitherto groundwater exploitation was negligible, but the current decades is characterized by increasing use of this more assured source of irrigation necessary for the implementation of the New Agricultural Strategy. Although Government canals continue to retain their leading position (35.54%), shallow tube-wells rank second (24.19%) being followed by irrigation from miscellaneous sources (15.66%). Deep tube-wells are also introduced. The districts of Murshidabad, Nadia, Naidah, W. Dinajpur and Hughli, that is the Bhagirathi Hughli tract emerges as the chief user of groundwater. Thus at present both surface and groundwater are being stressed upon simultaneously.
CANAL IRRIGATION

Canal irrigation constitutes the major source of irrigation in West Bengal, accounting for 35.54% of gross irrigated area at present. As such, two major types of canals are recognized in West Bengal, based upon the governing authority, namely private and public canals.

Private canals... To-day, these canals are either totally discarded or have become obsolete. This is evident from the following fact. Whereas in 1955 the total area irrigated by these canals was 361,058 ha (74%) and those of public canals only 127,778 ha (26%), the private canals irrigated only 133,893 ha (35%) while public canals served 254,016 ha (65%) of land in 1967-68. Hence, a total reversal may be recorded in the trend. Most of these private canals were confined to Jalpaiguri, Medinipur, Hugli, Bankura and Bardhaman. The western districts are located in the transition zone i.e. in between the plateau fringe and the plains, forming cushions for excess drainage, during the rainy season. They were essentially used for distributing silt laden flood water to the field for 'aman' rice cultivation. To-day their usage is no longer confined to irrigation and associated flood cushioning but for domestic uses. The dire consequence has been their decadent state.

Public canals emerged significantly only after independence, forming integral parts of the three major river valley
projects namely the DVC, Mayurakshi and Kangsabati projects (Ch. IV). These being under government control, hence easier maintenance and operation together with their extensive command areas, are not only beneficial but also considerably economical for the beneficiaries. This has been the principal reason behind the decay of private canals, since the latter involved higher overhead costs, less command area and non-assured water supply, resulting in unremunerative returns.

**Alignments of Public Canal System**

Public canals are extensive systems involving the following alignments: (a) **Main Canals** are directly linked with the headworks and are essentially contour canals. They are not directly used for irrigation purposes, (b) **Branch Canals** originate from the former and are ridge canals, cutting across contours and built along artificial embankments. They too, do not directly irrigate land, (c) **Distributary Canals** are small canals taking off from the branch canals and are the main source of irrigation water to field channels, (d) **Water courses or field channels** directly irrigate the fields and are constructed and maintained by the farmers, whereas the other three are under government supervision (Lai & Ahuja, 1979, Priyani, 1982). Besides, the main canals and to some extent the branch canals, the rest are unlined. Another fact is their non-perennial nature.
Spatial Distribution

The spatial pattern of canal distribution as well as the areas irrigated from them (1985) reveals their concentration in the western districts, that is, in the command areas of the three major river valley projects (Fig. 27). Of the districts, Birbhum and Bardhaman emerge as the most intensely canal irrigated areas as 69% and 56% of their gross irrigated areas (GIA) are canal irrigated, followed by Huglii (43%) and Medinipur West (34%). The chief reasons for this concentration are:

1) **High monsoon discharges** of the rivers in the plateau section which can be effectively harnessed by reservoirs at their headwater reaches, facilitated by the presence of impervious hard rock and hilly terrain,

2) The prevalence of more or less **straight, wide reaches** of the major rivers e.g. the Damodar with uniform width traversing undulating to plain country forming ideal settings for diversion works at the head reaches of the main canals, as well as in the canals themselves,

3) The underlying **laterites and bedrock** do not facilitate tapping of groundwater through tubewells, hence canal irrigation is the next best alternative,

4) **Meagre discharges** during winter and summer incapacitate river lift irrigation,

5) Prevalence of **already cultivated and populated areas** as in Huglii and Bardhaman districts, within canal command areas, ensure remunerative returns.

Within this generalized pattern, spatial variations
exist in compatibility with differences in micro-relief, soil type, distance from headworks and prevalence of other irrigation types. In the DVC command area, for instance, highly irrigated canal areas (greater than 60% GIA) occur along the upper reaches as in Gaisi and Bardhaman P.S. (Bardhaman district), Sonamukhi P.S. (Bankura district) as well as Dhania-Khalî, Haripal and Jangipur P.S. (Hugli district). They are all devoid of lateritic terrain and gently sloping in nature. Within the Kangsabati project area this zone extends along the lower reaches Joypur and Kotulpur P.S. (Bankura district) Kharagpur and Kespur P.S. (Medinipur district) due to the occurrence of hilly to highly undulating stony terrain in the upper reaches. Such highly canal irrigated areas also exist along the lower reaches in the Mayurakshi project area, due to similar reasons. Medium values (40-60%) surround the above zone. Low to very low values (20-40% less than 20%) are observed along the rocky upper reaches of the canals within the Kangsabati and Mayurakshi project areas, areas with excessively sandy soils around Durgapur P.S. (Bardhaman district), as well as in eastern Bardhaman and most parts of eastern Hugli where groundwater irrigation is conjunctively used with canal waters. Moreover, groundwater potential is low in the western parts.

The pattern of 1971 as computed from village level data of 1971 census, reflects a different picture. The areas within DVC and Mayurakshi project areas were more intensively
canal irrigated. In fact, canal irrigated areas exceeded 90% of the net irrigated area (NIA) in eastern Bardhaman and Hughli districts. The plausible reason is lack of significant groundwater exploitation at that time. However, the Kangsabati project being a more recently implemented one, the regions within its command area are yet to be irrigated comprehensively by canals. Such abnormally high values may be attributed to their being related to net sown area.

**Water Application System**

The pattern of water allocation occurs at three principal levels - i) at the higher level with the allocation of the available water in the reservoir to the canal i.e. year to year rotation, ii) at the intermediate level with rotation among different seasons, iii) at the farm level with rotation among the farmers (Palonisami, 1984). An interesting fact to be considered is the application of water to the fields in West Bengal. Although, canal irrigation, is essentially gravity flow irrigation, this does not apply to the whole State. The gently undulating tracts of the west facilitate gravity flow but in the eastern parts (viz. eastern parts of Bardhaman and Hughli district), the moribund tracts with micro-relief variations are not conducive to direct diversion of canal water to the field. Hence, in certain areas, water has to lifted by ‘dongas’ or water pumps, thus incorporating lifting costs in addition to taxes levied by the government.
The amount and interval of water application is dependent upon the crops involved along with terrain and soils. It is here that 'duty' and 'delta' factors emerge significant. 'Duty' or area irrigated by an average discharge of 1 cumec for the specified crop period, actually expresses the relation between the area of crop to be irrigated and quantity of water required. 'Delta' implies the depth of water required per ha for the full growth of the plant (Lal and Ahuja, 1979). A prior knowledge of these is important for designing an efficient canal system.

It has been estimated that, in general, in West Bengal 6.25 cm is counted on during the crop season; with a total depth of 100 cm inclusive of rain. For Kharif crop 25-40 ha/cusec and rabi crop 50-145 ha/cusec is required. Duty for individual crops amounts 35 ha/cusec for apanic, 55 ha for aus, 50 ha for boro, 70 ha for potato, 145 ha for tobacco, signifying the greater water requirements of the summer and 'rabi' (winter) crops. This fact is supported by agro-climatic studies. Supplementary irrigation is required for 'amann cultivation. For a crop period of 150 days about 50 cm is required in West Bengal (Ghose, 1972).

Actual duty varies from place to place and from year to year, dependent upon a number of factors. In the DVC area, for example a total requirement of 100 cm has been agreed upon. Delta at canal head on an average, has been estimated
to be 35 cm. Actual take-off into the Damodar canal system is however, much higher. This high take-off is explained due to the anxiety on the part of the farmers to withdraw the maximum quantity of water (Report of Advisory Committee DVC, 1958).

In the Mayurakshi area, duty of canal water in the Kharif season is assumed to be 35 ha/cusec and for rabi season 80 ha/cusec. Optimum requirement of irrigation water in the field during Kharif season is 25-30 cm and about 15 cm during rabi season. In the Kangsabati area estimated duty is 100 cm (inclusive of rainfall) for the Kharif season, water allocation is based upon these estimates.

Canal irrigation involves cheap tax rates as the basic motive is to benefit the cultivators. Of the three projects, the Mayurakshi and Kangsabati projects have not yet fully implemented any definite tax. In the DVC command area tax rates amount to Rs. 237/ha for 'boro' and 'aus' rice as well as the other winter season crops like potato and mustard. 'Aman' rice tax rate is considerably lower, about Rs. 135/ha.

**Characteristic Features**

Canal irrigation with its greater command area, and being under the maintenance of the Government definitely forms a cheaper source of irrigation. Yet the full potential of such irrigation facility has not been fully utilized. This may be attributed to the following:

1) Canal water in West Bengal is susceptible to the vagaries
of the monsoon rain, due to fluctuations in reservoir level, ii) lack of cooperation between Government and farmers in the functioning of distributary canals and water courses, iii) percolation and silting up of canals as they are unlined and gullying along their banks, iv) excessive water discharges at distributary ends than can be absorbed by field channels during monsoons, creating water logging, v) impact of microrelief on canal construction. Villages at the tail-end of canals receive insufficient water. Further if one village is situated on slightly higher level than the adjacent canal irrigated one, it may not receive the same facility. This has been observed during field studies.

RIVER LIFT IRRIGATION

In West Bengal, river lift irrigation (RLI), constitutes a medium/minor irrigation scheme, accounting for 7.21% GIA (Fig. 28). Prior to independence, this type of irrigation was not in vogue, since the rivers which carry sufficient water during winter and summer seasons, are essentially large with steep banks. This did not render the lifting of water by 'dongas' to be technically feasible. The subsequent introduction of pumpsets has brought this type of irrigation into perspective.

Spatial Distribution

Broadly speaking, RLI is a characteristic feature of the north-central and eastern districts. Of all of them,
Naldah emerges as the leading district with 27.31% GIA under RLI, being followed successively by W. Dinajpur (20.13%), Murshidabad (10.31%), Nadia (9.20%) and Hugli (8.45%). This pattern ascertains its concentration in the moribund riverine tracts of the north.

Detailed spatial variations are also observed. Very high river lift irrigated areas (greater than 30% of GIA), occur along the moribund regions of Naldah and W. Dinajpur districts, including the 'barind' tracts east of the Mahananda river as well as the 'tal' and 'diara' lands west of this river.

This can be attributed to the following. In the 'tal' and 'diara' lands, there is the presence of a maze of dead to decaying channels as well as marshy pockets, oxbow lakes etc. characterized by micro-relief variations. These form effective sites for tapping run-off as there is no predominant slope. This situation is further favoured by the presence of fine textured soils. Moreover, moderate rainfall does not create high groundwater potential. Hence the only alternative is RLI, facilitated by the low banks of the rivers. Another possible reason for this concentration could be the implementation of the Farakka Barrage Project. This has resulted in the flooding of the upstream areas and to some extent raised the water level of the channels.

In contrast, the old alluvium blocks lie above the present flood plain. The underlying laterite along with meagre
Pl 37. Mechanism of river lift irrigation along the Hughli river, Balagarh PS

Pl 38. Minor mechanism of RLI from the Damodar river at Pursurah PS, Hughli Dist
rainfall prevents the development of high groundwater potential. Moreover, groundwater table occurs at medium depths. These do not form congenial settings for groundwater extraction. The intervening river valleys accord settings for HLI. This accounts for such high values in old Maldah P.S. (34.73%) and Habibpur P.S. (40.65%) of Maldah district as well as Kumarganj P.S. (40.72%) and Gangarampur P.S. (42.14%) of W. Dinajpur district.

Minor areas exist in Balagarh P.S. of Hugli district, along the levee of the Hugli R., Khanakul P.S. (Hugli district) a low lying tract and those parts of western Bardhaman (Faridpur and Kanksa P.S.) which do not receive the facility of canal irrigation.

Highly irrigated tracts (20-30% of GIA) surround the former regions. Moderately irrigated tracts (10-20% of GIA) are confined mostly to Murshidabad and Nadia districts, some parts of Bardhaman (Purbasthali and Kalna P.S.) Hugli, (Arambagh & Pursuah P.S.) and parts of Haorah district. All these form parts of humid, mature-moribund deltaic plains with deep, meandering channels. But these are also regions of high groundwater potential hence groundwater exploitation is predominant. Moreover the river banks are quite high as in western part of Murshidabad district for HLI to be economically viable.

Poorly irrigated tracts (less than 10% of GIA) are concentrated along the western districts which are canal or tank
PI 39. RLI along the Chunakhali river, Maldah Dist

PI 40. River water being pumped into pipes that open into field channels
irrigated. The meagre rainfall, with low post-monsoon discharges along with the coarse textured soils do not favour BLI.

The *past pattern (1971)* depicts a basically similar pattern. However BLI was not as extensive as at present. It can be assumed that improved technology in water lifting has been the chief incentive.

**Water Application**

Since BLI is to a large extent determined by the size and nature of rivers, no definite command area is allocated. The potential is determined by the above factor as well as the energy of the pumps involved. Field surveys reveal a varied picture. In Gopalpur village along Hugli R. (Balagarh P.S., Hugli district) one 20 HP pump, electrically operated has been installed discharging 162,000 litres/hour. At Bidhangarh mouza (old Maldah P.S., Maldah district) along Chunakhali R., a 25 HP diesel-operated pump discharges 225,000 litres/hour. Such large pumps are usually under BLI schemes of the State Government mostly along rivers with considerable water level. Privately owned pumps are also used as at Barekpur village (Hugli district) along the dead Saraswati nadi, where a 5 HP diesel-operated pump is used for irrigating the bordering banana orchards. The large BLI schemes with greater command areas, besides serving 'amam' rice also allow 'rabi' and 'boro' cultivation, in accordance with their command area limits. Usually, 80 ha/annum is
served by a 25 HP pumps. One pump may serve two or more villages. In contrast, one village may come under the command area of two or more different RLI schemes, thus covering its entire NSA.

Water distribution system to fields involves an elaborate set up. The most common distribution is through underground pipelines with overhead spouts or chambers as at Gopalpur. However, at Bidhangarh, water is lifted from a depth of 5-10 m in the main river through two pipes, which subsequently discharge water into large field channels. Such differences do have an impact upon the cost of construction since the former incurs expenditure of Rs. 300,000 while the latter Rs. 200,000. However, tax rates remain similar, reflecting the government's basic motive to increase yield rather than to ensure returns such as aman Rs. 237/ha, aus Rs. 245/ha, jute Rs. 148/ha, wheat Rs. 148/ha, mustard Rs. 75/ha and boro Rs. 593/ha. As in canal irrigation, such taxes are usually not paid.

Characteristic Features

River lift irrigation, operating on a smaller scale, that is, with a command area of about 80 ha, can be better moulded according to the demand of the villagers, and can be implemented irrespective of terrain. But it is subjected to a number of disadvantages:

1) In the absence of any storage, river waters are more responsive to monsoonal fluctuations hence less available during
PI 41. River water being pumped into open chambers through underground pipes, Old Maldah PS

PI 42. River water being pumped into closed chambers through underground pipes, Balagarh PS
critical 'rabi' and 'boro' seasons. For HLI to be effective, water level has to be at least 3-4 m. Hence it is best suited to the larger rivers, ii) **Excessive withdrawal** along silting up rivers is harmful, iii) **Tax rates** are high, iv) For villages like Gopalpur (Hughli) **shortfall in electricity** adversely affects cultivation specially if it occurs during 'boro' cultivation, a crop with high water requirement, and v) In case of diesel operated HLI as at Mubarakpur (Maldah), **diesel shortage** creates crisis. In fact during such a period, although government allocated certain amount of diesel for the villagers, it never reached them.

SHALLOW TUBEWELL IRRIGATION

Shallow tubewell irrigation (STW) accounts for 24.19% of GIA in West Bengal. Prior to 1970, STW irrigation was relatively insignificant in this State. The New Agricultural Strategy (1966) has helped in considerable spurt of this type. Since increased stress is laid on intensive agriculture through the consorted use of HYV seeds and fertilizers, this necessitated a more assured water supply than provided by surface water.

**Spatial Distribution**

The distribution of shallow tubewells is a function of several geo-economic variables namely groundwater depth, thickness of aquifers, groundwater potential, terrain and soils which consequently influence extraction costs.
The spatial pattern for 1985 depicts the large scale development of STW irrigation in the eastern districts characterized by unconsolidated, thick and extensive alluvial deposits of the Bhagirathi-Hughli river system (Fig. 29).

The leading district is 24 Parganas (68.84%), being followed by Nadia (66.35% of GIA), Maldah (45.69%), Murshidabad (42.78%), W. Dinajpur (34.50%) and Hughli (20.67%).

Very highly STW irrigated tracts (greater than 50% of GIA) occur at Nadia, south-eastern part of Murshidabad, parts of Medinipur East, and north-western part of Maldah and north-central part of W. Dinajpur district. Excluding the last three districts, thick, extensive aquifers at relatively shallow depths with high discharges of 3,182-3,636 l/min at 4-6 m drawdown render STW irrigation technically and economically feasible. Detached zones occur along the marshy 'daira' lands of Maldah and W. Dinajpur, where water tables alongside streams are comparatively shallow than in the 'barind' tracts. Such zones also occur along Pingla, Pataspur, Dantan P.S. (Medinipur E) where not only thick alluvial deposits occur but which are away from the coast, hence not influenced by saline water intrusions.

Highly irrigated areas (30-50% of GIA) tend to concentrate around the previous zones as in western Murshidabad, eastern Bardhaman, Hughli and parts of central Medinipur districts. Although conditions in Hughli district are conducive
Pl 43. Shallow tubewells being used to lift river water along the Damodar river, Pursurah PS

Pl 44. Diesel operated STLJ, typical irrigation devices in the eastern plains
to the economic exploitation of groundwater by STW's, it does not fall under the first category due to the prevalence of cheaper canal irrigation from the DVC. In western Murshidabad the high river cliffs and meagre post monsoonal discharges preclude ELI. In addition they lie along the tail end of the Mayurakshi canals. Thus STW irrigation is favoured preferably alongside the Mor, Dwarka and other rivers, where groundwater lies at a shallow depth.

**Moderately Irrigated Areas (10-30% of GLA)** tend to encompass the former zones, extending into eastern part of Bardhaman district in Purbasthali, Ketugram, Kalna P.S. Moribund conditions with dense network of water bodies, favour STW irrigation as the terrain does not favour canal construction.

**Poor Irrigated Areas** (less than 10% of GLA) are confined to the dry western tracts as well as the saline, southern coastal tracts. In Jalpaiguri and Koch Bihar district, the coarse soils lead to large scale fluctuations of groundwater, thereby creating problems in the setting up and maintenance of STW's.

The past pattern (1971) (Fig.29) depicts a slightly different picture. The regions west of Mahananda i.e. the 'diara' and 'tal' lands emerge as the more important STW irrigated areas, most probably due to the unimportance of ELI, at that time, when 'dongas' were used. Excepting this, the pattern remains essentially similar. However, STW irrigation
was practised in a dispersed manner and its use was less intensive with most areas registering less than 10% of GLA.

**Water Application System**

The water application system of STW is less elaborate, with water being directly pumped into field channels. However, this type of irrigation incorporates lifting costs of either diesel or electricity operated pumps, depending upon the availability of the former facility. It was observed that villages located close to large urban centres used electricity. At Parul mouza of Ilughli district, such STW's are launched in separate sheds. However, diesel operated STWs are more in use and as such the pumps are removed to safety daily. The STWs are also termed private tubewells since they are essentially owned by individual farmers. Hence no taxation system is involved. But the owner usually rents out water at a rate of Rs. 10-12/hr. The average overhead cost of the installation of one STW range from Rs. 10,000-15,000. Additional costs are incurred for lifting water, more so if diesel is used. The STW irrigation benefits mostly 'aman' and 'rabi' or winter crops, the latter with moderate water requirements. In case of aman, rainfall variability is compensated for by this groundwater source. The command areas of STW's cannot be precisely delineated since it depends on the depth of pipe, its diameter etc. Moreover, renting out water causes complications in such estimations.
Pl 45. Electricity operated STU launched in sheds in the urbanised Hugli Dist

Pl 46. Lowering of STU devices during fall in groundwater level in summer, Goghat PS, Hugli Dist
Characteristic Features.

Undoubtedly, STW irrigation is a more assured source of irrigation as groundwater is not as responsive to rainfall fluctuations as surface water. In addition being privately owned, timely and adequate supply of water for irrigation is ensured, without transmission losses or excess supply. Nevertheless, the following demerits are observed: i) Seasonal fluctuations of groundwater depth do occur along sandy soils and in the plateau fringe tracts. In such cases extra costs are incurred in lengthening the tubewell pipe and in lowering the STW as in case of Tanrai village (Hughli district), ii) Erratic supply of electricity is another problem, iii) Crops with high consumptive use like 'boro' are not favoured, specially if STW water is on a rented basis, iv) In excessively sandy soils as in the bhabar tract the problem of choking arises, and v) In case of red soils STWs get silted up due to walling of iron oxides.

DEEP TUBEWELL IRRIGATION

Deep tubewell irrigation, involving more complicated technology and greater overhead costs, is a recent introduction, progressing at a slow pace. Nevertheless, at present it accounts for 4.90% of GIA. It is less susceptible to water table fluctuations than STWs as it taps deeper, permanent aquifers.

Spatial Distribution

According to an Enquiry Committee set up by the Govt.
of West Bengal, the best area for deep tubewell irrigation is
the Ganga-Damodar basin where aquifer materials down to depths
of 200 m are capable of yielding 80,000 litres/hour. The
spatial pattern (1985) also supports this fact (Fig. 30).

Very high irrigated areas (greater than 30% GIA under
DTW irrigation) are confined mostly in Khanakul, Pursuah,
Arambagh, Tarakeswar P.S. and parts of Balagarh, Polba-Dadpur,
Chanditala, Mogra P.S. of Hugli district.

High irrigated tracts (20-30% GIA) occur along western
part of Hugli district, S. En part of Murshidabad dist.
(Jalangi, Raninagar & Domkal P.S.) and central Maldah dist.
(Ratua & English Bazar P.S.). Western part of Hugli dt. is
characterized by very high groundwater potential exceeding
150 mcm, thick alluvial fill of about 33.4 m and moderately
extensive aquifers. The chief reason for DTW irrigation is
the absence of canal irrigation, deeper groundwater table
with high fluctuations less favourable for STW irrigation
despite the high potential of the latter. In eastern Hugli
and parts of Nadia, thickness of aquifers range from 100-160 m;
with discharges of 3,113 lit/m at 3-4.5 m depths, favouring
DTW irrigation. Similar factors have influenced the pattern
in south-eastern Murshidabad dist. Moreover, another factor
is their location along major rivers e.g. Hugli river in
Hugli and Nadia districts, Padma and Mahananda rivers in
Maldah district.
Moderate irrigated areas (10-20%) surround the former zones with extensions in eastern low-lying tracts of Bardhaman and parts of Medinipur East and 24 Parganas district. Poorly irrigated tracts (less than 10%) occur in most parts of the north Jalpaiguri, Koch Bihar, the dry western tracts with low groundwater potential and saline coastal tracts where fresh water aquifers occur at depths exceeding 190 m.

The depth of DTW's vary from 53 m in Murshidabad, 108-129 m in Nadia to well below 314 m in 24 Parganas (S) due to increasing salinity of upper aquifers further south. Variations do occur within one district also due to differences in soil and relief.

The pattern of 1971 depicts a slightly different picture from the present, viz., maximum concentrations in Nadia and eastern Murshidabad district where values exceed 70% of NIA under DTW irrigation. Hughli district emerges as an insignificant area, along with the western tracts. The excessively high values could be attributed to their relation to NIA rather than GIA, in these multi-cropped districts.

Water Application System

Deep tube-well irrigation is more costly and complicated than STW irrigation system. Not only water is to be lifted from deeper more permanent aquifers by electricity operated pumps but it also involves an expensive water conveyance system through spout chambers as in HLI. Deep tubewells are
Pl 47. A typical view of Deep Tubewell set-up in Hugli Dist

Pl 48. Jhor Bundh irrigation at different levels in Puruliya Dist
thus direct government schemes. In certain cases co-operative bodies may accept loans from the State Government for installing DTW, as in Narayanpara village, Polba P.S. (Hughli dist.). The total cost incurred was Rs. 190,000. High costs necessitate imposition of considerable taxes such as mustard Rs. 75/ha, aman Rs. 148/ha, boro Rs. 593/ha, wheat Rs. 148/ha, potato Rs. 40/ha.

Characteristic Features

This is the most assured source of irrigation as it taps deeper and more permanent aquifers. In fact this may be the only answer to the saline coastal tracts. Moreover, even crops consuming more water may be benefited by this source. The following disadvantages are noted: i) This is a costly source of irrigation, ii) Since electricity plays a vital role, current shortage has serious repercussions as at Narayanpara (Hughli district) where, due to this, a decrease in 'boro' rice area has occurred between 1981 to 1986, amounting to 20 ha, and iii) Regular maintenance of the elaborate DTW set-up is required.

MINOR AND MISCELLANEOUS SOURCES OF IRRIGATION

This includes such minor sources as dugwells, tanks, boro-bundhas and other minor irrigation schemes as well as certain indigenous sources characteristic only of certain local areas. In this analysis dugwells, tanks and minor irrigation schemes have been dealt with together, as the data
base did not deal with them separately for most of the districts.

**Tank Irrigation**

A close perusal of the past agrarian set-up of the State, reveals that this is the most widely practised method of irrigation since pre-independence days. This method was useful in the past when population density was low and intensive agriculture was not a necessity. But to-day its importance has declined considerably. Tank irrigation is more characteristic of the western plateau tracts as in Puruliya and Bankura. Here the tanks possessed distinctive characteristics of their own. Wherever the terrain offered any perceptible slope, crescent shaped tanks with earthen embankments on the downslope sides, were constructed at different levels to harness surface run-off, along with rainwater as observed in Sagma village (Puruliya Dist.). This was termed 'bundh' irrigation. Another variety of this type was 'jhor bundh' irrigation, which is characterized by earthen dams constructed across small seasonal streams ('jhors') along different reaches. In times of scarcity, the waters of the upper reservoirs are first utilized. Through gravity flow channels, water is distributed to irrigate fields. In some cases trees are planted along such reservoirs to prevent soil erosion as well as to reduce evaporation.

Along the relatively flat terrain, rectangular tanks or circular ponds with raised banks prevail. During pre-
Pl 49. Tank irrigation in Barind Tract

Pl 50. Traditional tank used in irrigation and domestic use
independence days, canals were drawn from nearby streams to tap their flood waters in these reservoirs. Such type of tanks are more common in the eastern districts (Murshidabad, Nadia, etc.) and southern districts (24 Parganas North) where they form the only effective method of tapping fresh rainwater at present due to saline surface and groundwaters. But they also exist along the undulating tracts of the west. In the moribund to mature deltalic terrain of 24 Parganas South, elongated tanks or 'khals' are also observed as in Natendrapur village (Sagar P.S.). These are redug, discarded channels. It should be stated that such 'khals' are often dealt under 'canals' in official records due to their elongated nature. But as they are not connected to river systems, and store only rainwater, they should be precisely termed 'tanks'.

For irrigation, mechanical devices are often used for lifting water from tanks. The traditional apparatus or 'dongas' are mostly used. This usually involves family labour and in certain cases hired labour engaged at rates of 8,10/hr. With the introduction of power operated pumps, using diesel, dongas have been replaced in certain cases. Tank irrigation is usually practised on a localized scale to irrigate adjacent plots for cultivation of less water demanding crops. For most parts, in the highly irrigated districts, tanks are used for domestic purposes.

The main constraint of tank irrigation is inadequate water supply during winter and summer seasons. Secondly, with
the passage of time they are subjected to silting up. Renova-
tion of such tanks is an expensive process compared to its returns.

**Dugwell Irrigation**

Dugwell irrigation through tapping of the water table, constitutes an almost negligible source of irrigation in West Bengal. However it emerges significant mostly in the 'bhabar' tract of the north - a relatively, poor irrigated tract - where coarse pebbly soils prevent tank irrigation. Dug-wells are common along the western plateau tract of the west as in Puruliya district. Generally speaking, dug-wells are a source of irrigation to homestead vegetable gardens as in Sagma village (Puruliya district) and along adjacent plots if situated amidst fields. They are ineffective sources of irrigation almost drying up during the winter and summer in the west due to evaporation and in the north due to receding water tables along the coarse soils.

**Spatial Distribution of Minor Irrigation Types**

Taking all the minor sources into consideration, i.e. tanks, dug-wells etc. the most obvious fact that emerges is their concentration in three separate zones. The first lies in the dry, western plateau tracts viz. Puruliya. Here the absence of any major rivers precludes RLI. These tracts lie either above or in the upper reaches of the canal irrigated areas. Hence they do not receive any benefit. Groundwater
depths and potential being low do not favour STW or DTW irrigation. This accounts for 60.66% GIA of Puruliya being under tank and dug-well irrigation. The second tract lies in the north as in Jalpaiguri and Koch Bihar where dug-well irrigation assumes predominance. In W. Dinajpur minor sources of irrigation account for 42.44% of GIA. The third zone occurs along the saline coastal tracts of Medinipur E (44.84% GIA), 24 Parganas S (5.4% GIA and inclusive of 'khals') and Haorah district (79.77% of GIA) where rain water is the only source of fresh water.

Miscellaneous Sources

i) Underground Seepage Water: Such sites usually occur along the plateau and plateau fringe tracts where underground water seeps out from underlying fracture zones as in Andhariya village (Medinipur West). They are termed 'auto-flows' and form extensive seepage sites. At Andhariya for instance, the water is impounded by an earthen dam and used to irrigate 22 villages creating an oasis amidst dry, uncultivated terrain. Although seepage water does form a perennial source as its origin is from deep extensive fracture zones such sites are few. 'Artesian' conditions mostly occur along the upper reaches of the Kasai and Haldi rivers.

ii) Reservoir Seepage Water: This is best exemplified at Mukutmanipur village (Khatra P.S., Bankura dist.). This village, situated behind the Mukutmanipur reservoir along the Kangsabati River, receives seepage water from the reservoir.
enabling it to practise double cropping although located in a
dry, undulating terrain. However, fluctuations of reservoir
water impose problems. As this village is located at a sligh­
tly high level seepage water enters whilst the reservoir water
level is at 132 m. But if this falls below 125 m, no seepage
water enters the village.

iii) Sewage water: This source is receiving increasing empha­
sis in resource conservation policies pertaining to urban
fringe areas. One such area, namely, Amrai village, situated
just behind the Durgapur township, utilizes sewage water for
'boro' cultivation, in an otherwise mono-cropped area. The
villages along the borders of east Calcutta is practising
double cropping with such sewage water. Water quality is the
only criterion to be reckoned with.

The planned utilisation of such miscellaneous sources
may lead to, if not extensive, localized benefits of hitherto
monocropped villages.

FIELD METHODS OF IRRIGATION

Irrigation efficiency, to some extent, is dependent
upon the distribution of water at the field levels. In case
of crops with high consumptive use such as the transplanted
'aman' and 'boro' rice, basin irrigation is practised. The
fields are bounded by levees and irrigation is done by flood­
ing such basins. This method is highly beneficial for 'aman'
rice as it requires continuous shallow submergence during
certain stages. **Level border method** of irrigation is practised for irrigating the pre-monsoon "aus" rice to retain maximum water. The plots are properly levelled and the land is divided into longitudinal strips 2–4 m wide depending on size of the streams by putting temporary levees. Irrigation is done strip by strip, the levees checking the lateral spread of water. This method of irrigation is also characteristic of wheat and mustard cultivation as it ensures maximum use of water without undue wastage for less water demanding crops. It is useful over coarse textured soils. Potato cultivation benefits from **furrow irrigation** as care has to be taken to prevent the tuber from getting moist. The strips are divided horizontally into furrows and ridges, the latter about 20 cm in height. It has to be seen that the wetted front does not rise beyond 2/3rds the height of the ridges (Sengupta, 1983).

**OVERALL VIEW**

From the above analysis of the various aspects of irrigation types, it may be summarized:

i) With regard to irrigation types in West Bengal, sources of irrigation constitute the main identifying criteria, rather than techniques of water application.

ii) Of all the sources in vogue, canal irrigation emerges as the most important one followed by STW irrigation. In the past, groundwater irrigation was of negligible importance, predominated by tank irrigation.
iii) In general, canal irrigation is confined to the dry western districts of Bardhaman, Birbhum, Bankura, Medinipur West where gentle slopes facilitate canal construction and gravity flow irrigation. It also extends into Hugli district. The excessive monsoonal discharges of the western plateau rivers along with the terrain form congenial settings for harnessing electric power. Tank irrigation is also characteristic of this terrain. Groundwater has been tapped through STW's and BTV's along the humid, eastern parts of West Bengal as in Murshidabad, Nadia and Hugli districts where extensive and thick deposits of alluvium prevail. River lift irrigation is prevalent along the old alluvium and mature riverine tracts of Maldah and W. Dinajpur districts. Here lack of other sources account for this.

iv) Regarding techniques of water application both traditional lifting apparatus like 'dongas' as well as power operated water pumps are in use. The latter is a more recent introduction but more costly.

v) With respect to field methods of irrigation, the objective is to attain maximum water use efficiency. Hence different methods prevail for the varied crop types with due consideration being given to terrain and soils.
Pl 51. Extensive marshy pockets created by seepage water from subterranean fracture zones, Medinipur Dist

Pl 52. Accumulated seepage water being channelised for irrigation, Medinipur Dist
PI 53. Reservoir seepage water being used at Mukutmanipur village for irrigation.

PI 54. Accumulated urban sewage being used for irrigation at the outskirts of Durgapur town.
55. Sewage water being channelised for irrigation.

56. Traditional dongas being used to lift water for irrigation.
"The DVC was bom to meet a challenge - a herculean task of converting a 'valley of sorrow' into a 'valley of prosperity', by taming the turbulent river Damodar ..... When a person now looks at a prosperous farm in Bardhaman or a patch of young forest in the hills of Hazaribagh, he is possibly not aware that for those pleasing sights he owes all thanks to the DVC ..... The once destructive waters now help in raising two or more crops in a year instead of the erstwhile one uncertain crop. DVC's role in fostering greater productivity and socio-economic development extends far beyond its dams and irrigation canals. Its commitment to prosperity encompasses the well being of Lakhs of people, helping to enrich their lives".

- DVC, INFORMATION DEPARTMENT

"Power threshers whirr in remote villages of West Bengal for the newly harvested wheat crop, shallow tubewells turn arid areas into green pockets and there is an increasing demand from the peasants, specially small farmers, to know more about pesticides, pumps, fertilizers and high yielding variety seeds".

- THE STATESMAN, 15.4.1970