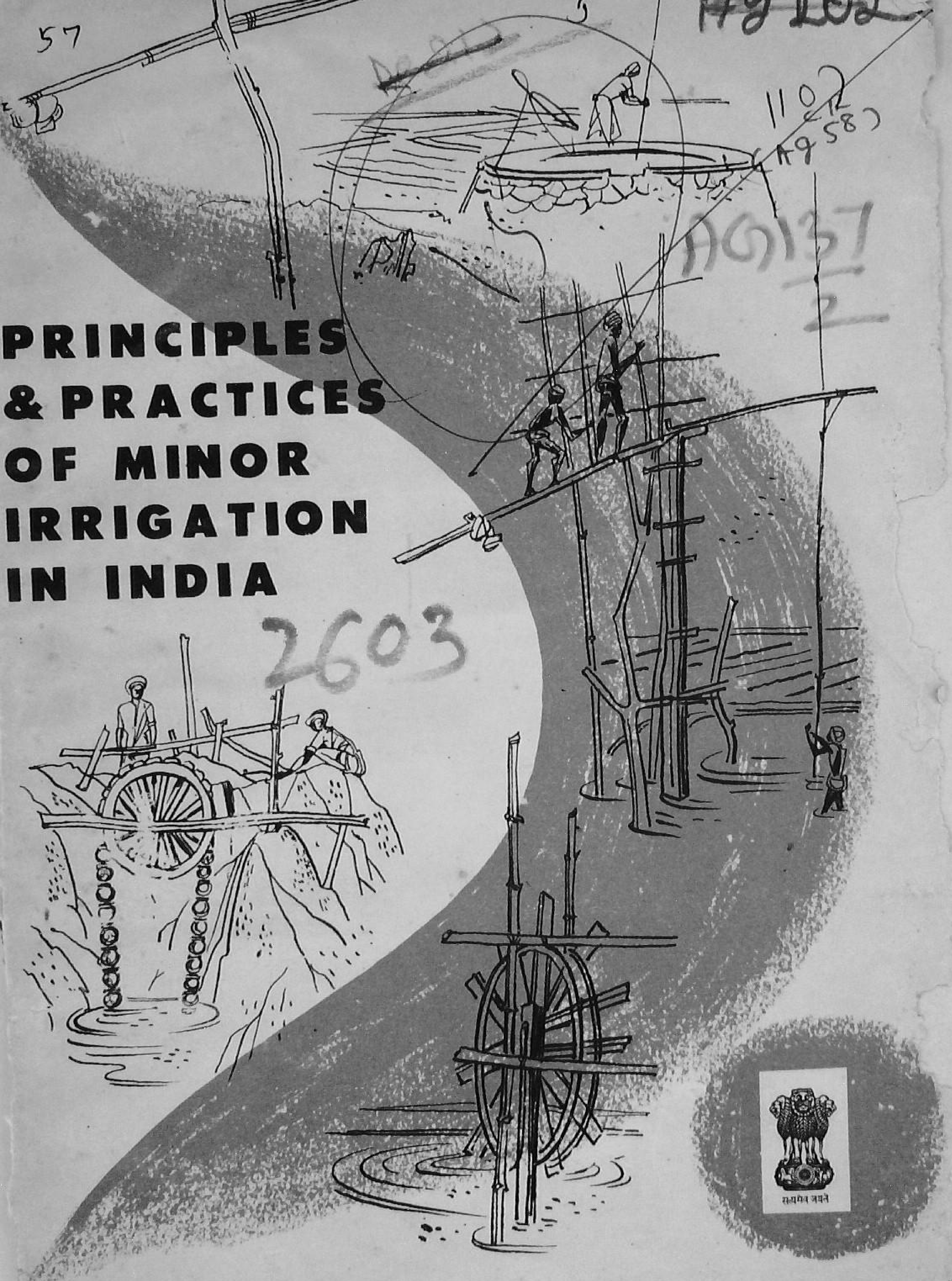
PRINCIPLES & PRACTICES OF MINOR IRRIGATION IN INDIA



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PRINCIPLES AND PRACTICES OF MINOR IRRIGATION IN INDIA

MINISTRY OF COMMUNITY DEVELOPMENT
NEW DELHI

July 1957

Printed at
The Coronation Printing Works, Fatehpuri, Delhi-6.

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OF
MINOR IRRIGATION IN INDIA

PREFACE

When the earlier publication of this series "Manual for Minor Irrigation" was being brought out, it was intended to include two more chapters, viz. "A Journey Through Northen India" and "A Trip to South." These chapters were to give broad principles of minor irrigation in the various parts of the country. As the publication was being delayed and in view of the fact that the Manual was to be kept of a reasonable size, it was finally decided to omit these chapters.

The present publication aims at bringing out the features of 'Minor Irrigation' as practised in different tracts in a more elaborate and comprehensive form. Individually or singly, an irrigation work planned and executed by a simple unskilled farmer would perhaps be too insignificant to attract the attention of a hydraulic expert. But when viewed in a broader context it would prominently come out as a part of some well organised campaign—the struggle between man and water for the benefit of land.

To imagine that the intricate practices followed in the various parts of a vast country like ours could be scribbled through in a few pages would be very presumptuous. But if we could succeed in getting glimpses of a work here, a method followed there and a practice adopted elsewhere, we may, perhaps, fill in the blanks and discover the unified laws which guide the common farmer in the conservation of soil moisture. With all its incompleteness and superficiality of description if this book could succeed in stimulating some interest and thinking from this view point, it would have served its purpose.

In producing this work, the writer has freely made use of the notes which he recorded during his tours to the Community Projects and National Extension Service areas in the various States. Almost everything that appears in these pages is from a personal knowledge. The writer would feel greatly obliged to readers for any suggestion, that they may like to offer for making the book more useful and interesting.

To make the illustrations complete two of the photographs (viz plates 1 and 9) have been reproduced from the earlier publication.

D. S. Sinha

New Delhi,
April, 1956.

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CHAPTER I

IRRIGATION PRACTICE IN THE ALLUVIAL PLAINS

The fertile plains of the Indo-Gangetic valley have a very extensive canal system. Specially in the Punjab and western U. P. almost all the big rivers have been harnessed and their waters diverted to irrigate the Doabs. River irrigation here has almost reached to saturation—so much so that the subsoil water level in some tracts has gone up to the extent of causing water logging as a result of excessive irrigation.

In areas not served by the U.P. and Punjab canals ground water is the main source of irrigation. This water is lifted through wells, tube wells etc. which form the bulk of minor irrigation works in these regions. Water from these sources is mainly used for irrigation of rabi, e. g., wheat crop and cash crops like sugar cane. The various methods by which ground water has been tapped are briefly described in the following paragraphs.

1. **State Tube Wells** : These came into existence about twenty years back. A complete description of this class of wells and how they draw their supplies from confined water below a confining formation is described in an earlier publication. (CPA series 23—Manual for Minor Irrigation Works—pages 81-88).

The State-run tube wells have roughly a discharging capacity of 1½ cusecs to 2 cusecs (30 to 40 thousand gallons per hour). They are all operated by electricity which is available at As. 1/6 to -/2/- a unit for the purpose. Originally, one cusec tube well used to cost Rs. 11,300/- at pre-war rates. The cost rose steeply after 1942-43 and each tube well project then cost Rs. 27,000/-. The rise continued and the cost at present is Rs. 37,000/- and above for 1.5 cusec tube well. It costs Rs. 39,000/- with a diesel engine pumping set.

The tube wells have been sunk to depths which sometimes exceed even 500 ft. and tap about 90-100 ft. of water-bearing sandy strata. The depression at peak discharge ranges from 6 to 12 ft. The common size for the strainer and blind pipes is 6″ to 8″ in diameter surrounded by gravel, the overall diameter of the gravel packed wells being 24″-27″. The

View of tubewell pumping station in Northern India.

cost of tube well water works out to Rs. 1/6/- to Rs. 1/8/- per acre inch, i. e., for 22,000 gallons. On tube wells it is generally possible to arrange volumetric sale of water. For example wheat irrigation requires about 3 waterings, each 3 inches to 5 inches in depth—total say 12 inches. The cost at Rs. 1/6/- per inch would be Rs. 16/8/-. In the State of Uttar Pradesh, cheaper assessment has been planned and the cost of tube well water has been kept at par with that of canal water, i.e., Rs. 11/- per acre for wheat irrigation.

In the Punjab and Pepsu, water from the tube wells is being charged for, on a volumetric basis. The rate corresponds to four annas per unit of electricity consumed or about Rs. 1/8/- per acre inch. For wheat irrigation, the rate would thus work out to Rs. 18/- per acre. Against this, the charges for canal water are Rs. 6/- per acre. The disparity between the cost of canal and tube well water is to some extent, coming in the way of quick development of irrigation from the tube wells.

The tube wells in the Punjab and Pepsu are of two types, one for purely supplying irrigation water and the other for de-watering the water-logged areas. For example, the Jagadhari tube well scheme comes under the latter category. Water is continuously pumped out from the water logged areas and thrown back into the main canal for irrigation lower down. The main purpose is that of de-watering the water-logged area and irrigation is only incidental. The tube well scheme in practically the whole of the Khadar area is an extension of the Jagadhari tube wells. Wherever canal irrigation has resulted in a substantial rise in the subsoil water level thereby threatening water logging, it has been proposed to stop canal irrigation and gradually replace it by tube well irrigation. By this arrangement, the trouble of water-logging would cease and at the same time the areas would continue to receive irrigation facilities.

In Punjab and Western U. P. a duty of 400 acres to the cusec is assumed for irrigation from tube wells. Allowing 80 per cent intensity of irrigation area attached per cusec of the tube well is 500 acres or 750 acres for one and a half cusec tube well. The duty is thus much higher than that obtained on canal irrigation for obvious reasons.

In Bihar the tube wells mainly do paddy irrigation. The basis adopted for recovering the water charges is, in effect, volumetric but every cultivator has to pay a fixed charge of Rs. 15/- per acre. This rate is meant to cover the cost of irrigation of 5 waterings—in all 4 lakh gallons are consumed which means 18 acre inches of water. This rate is payable by the cultivator irrespective of whether he takes one watering or five waterings.

Compulsory irrigation of paddy in the above manner has been found to be somewhat costly and cultivators have shown a tendency to withdraw from tube well irrigation. Even these high rates do not cover the full cost of irrigation as 18 acre inches of water may cost as much as Rs. 25/- to Rs. 30/-. Whenever the cost of water is high, such as is the case with tube wells, it may neither be practicable nor expedient to have the system of compulsory irrigation—only actual water consumed could be charged for.

2. **Private Tube Wells** : The tube wells sunk privately are of smaller sizes. The depth of boring ranges from 150 ft. to 250 ft. The strainer pipe is usually 4″-6″ in diameter with gravel packing all round (total diameter of the bore being 8″). The delivery is 4″ and the total discharge ranges from

10,000 to 15,000 gallons per hour. Where power is not available, centrifugal pumps driven by 8-10 H. P. diesel oil engines run the tube wells. The total cost of sinking such a tube well is about Rs. 8,000 to Rs. 10,000 inclusive of the cost of engine. Area irrigated from each such unit varies considerably depending upon several factors. Anything between 50-100 acres is irrigated from each such tube well. Generally, the owner irrigates his own land but sometimes he sells water to other cultivators also. In these tube wells boring is done approximately up to 100-150 ft. and within this depth it is generally possible to tap about 40-50 ft. of good water bearing sandy strata.

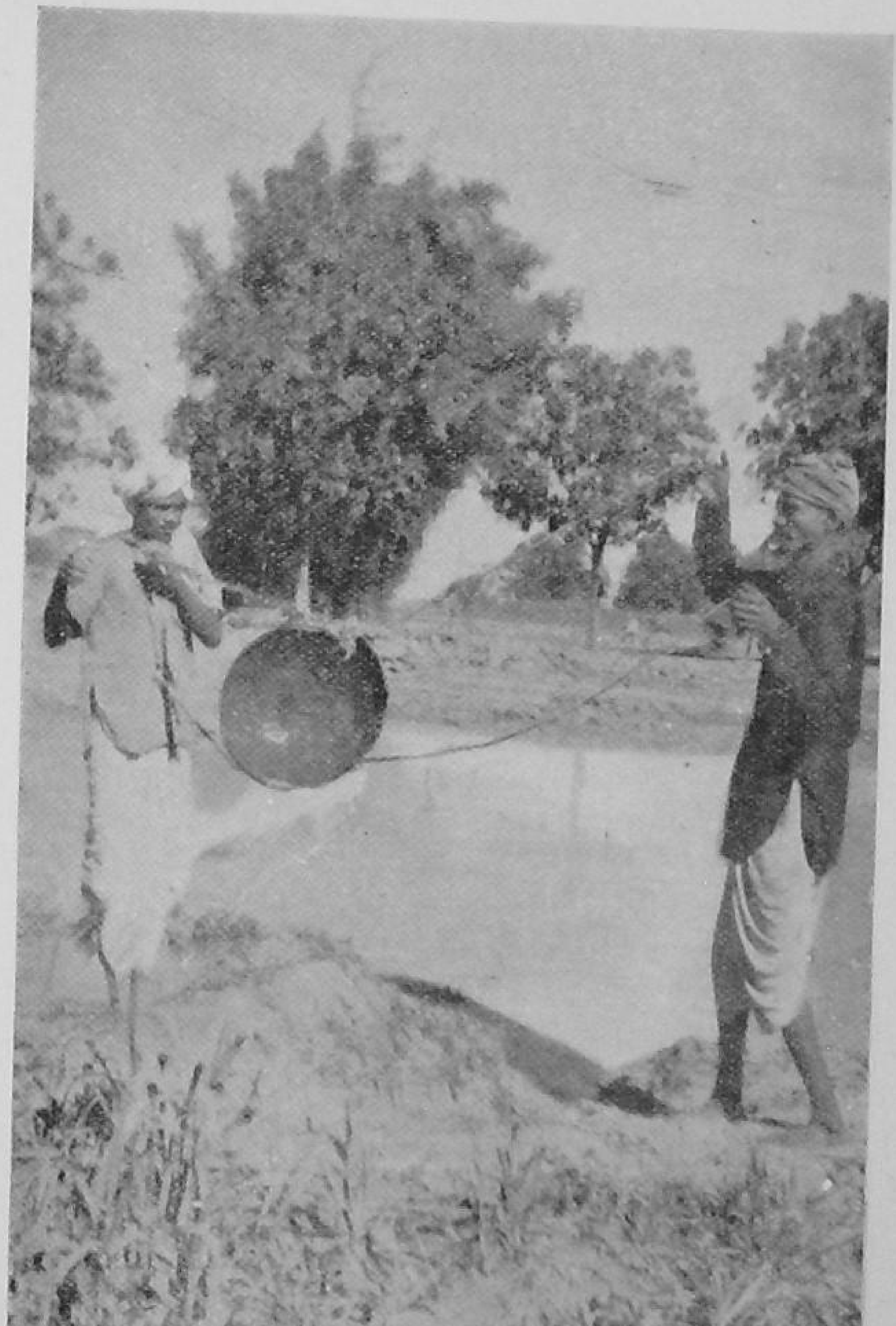
There is another type of tube wells sunk by private irrigators—these are the cavity tube wells. In this case the bore pipe extends to a depth of 60-70 ft. and pierces through 10-12 ft. of good dependable clay below which cavity is developed. 7½-10 H. P. oil engines with pumps are directly fitted to the top of the bore pipe. These tube wells yield a discharge of 8,000 to 10,000 gallons an hour. Maximum draw down noticed varies from 4-6 ft.

In some areas cultivators have joined hands and installed tube wells on a co-operative basis. In Ambala (Punjab) and Meerut (U. P.) districts, there are regular irrigation co-operative societies functioning. These societies instal and run the tube wells and are responsible for their maintenance and management.

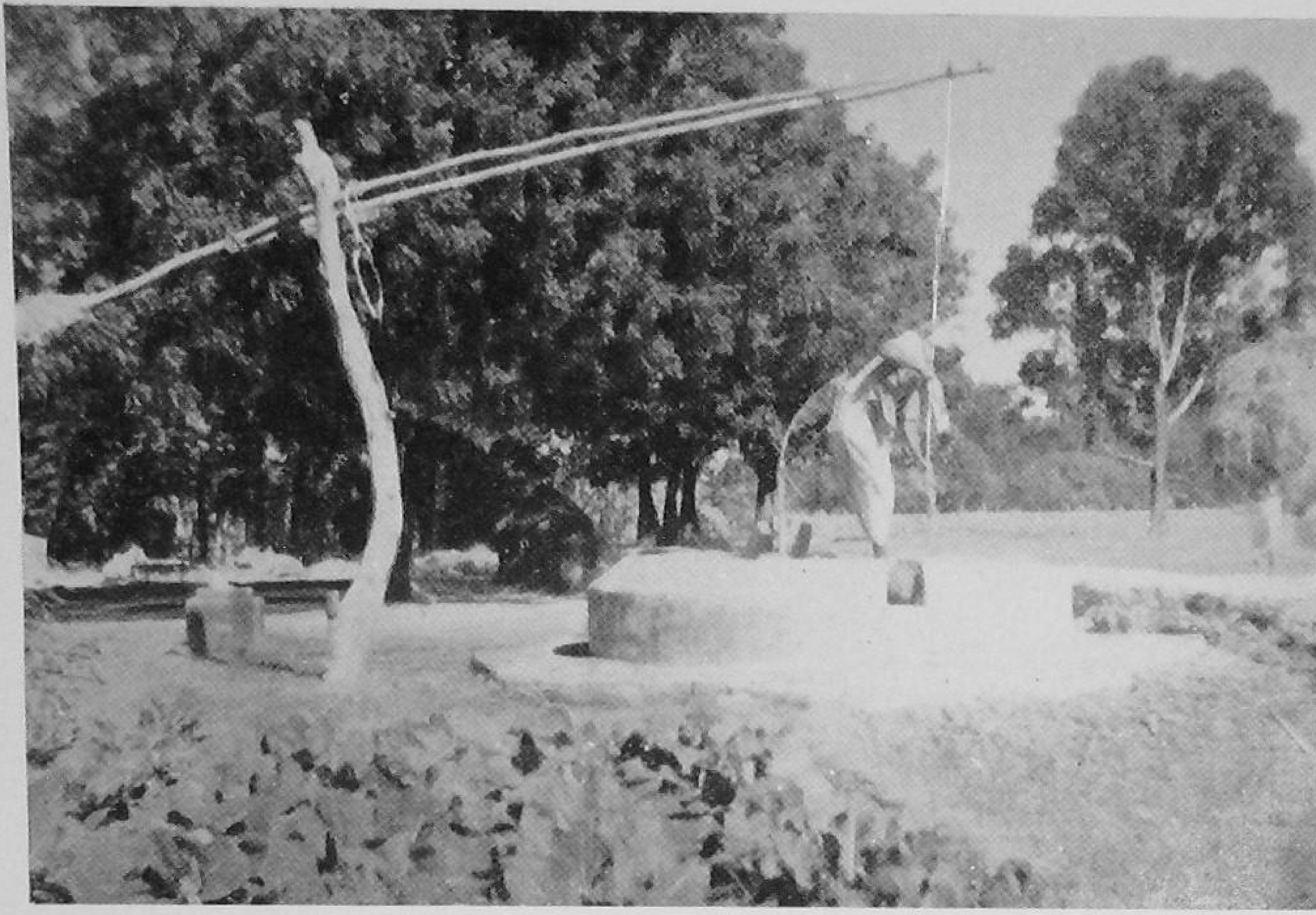
3. **Bore Wells**: Normally, open percolation wells do not have a yield exceeding 1,500 to 2,000 gallons per hour. When the supply is still less, even Persian wheels worked by bullocks or camel would be able to deplete the well completely. The cultivators, therefore, resort to boring whenever they want to use the well for irrigation purposes. Often, this results in a very marked increase in its yield and pumps also could be installed successfully.

Boring is done in two ways. Where a good column of water bearing sandy stratum is met with, strainers are fitted to the bore pipe which increases the yield of the well. Alternatively, if porous stratum is encountered below a confining formation, of good clay, cavity boring is resorted to. Both the methods are successfully adopted depending upon the types of strata struck during boring. The diameter of the bore is usually 3 inches to 5 inches. The depth to which the bore pipe is to be carried ranges anywhere between 20 feet to 150 feet. The expenditure involved in 100 feet bore 5 inches in diameter is Rs. 500/- inclusive of the cost of pipes. Almost every bored well has either a pump or a Persian wheel installed on it.

4. **Methods of Lifting Water**: There are various devices used in Northern India for lifting water for irrigation purposes.



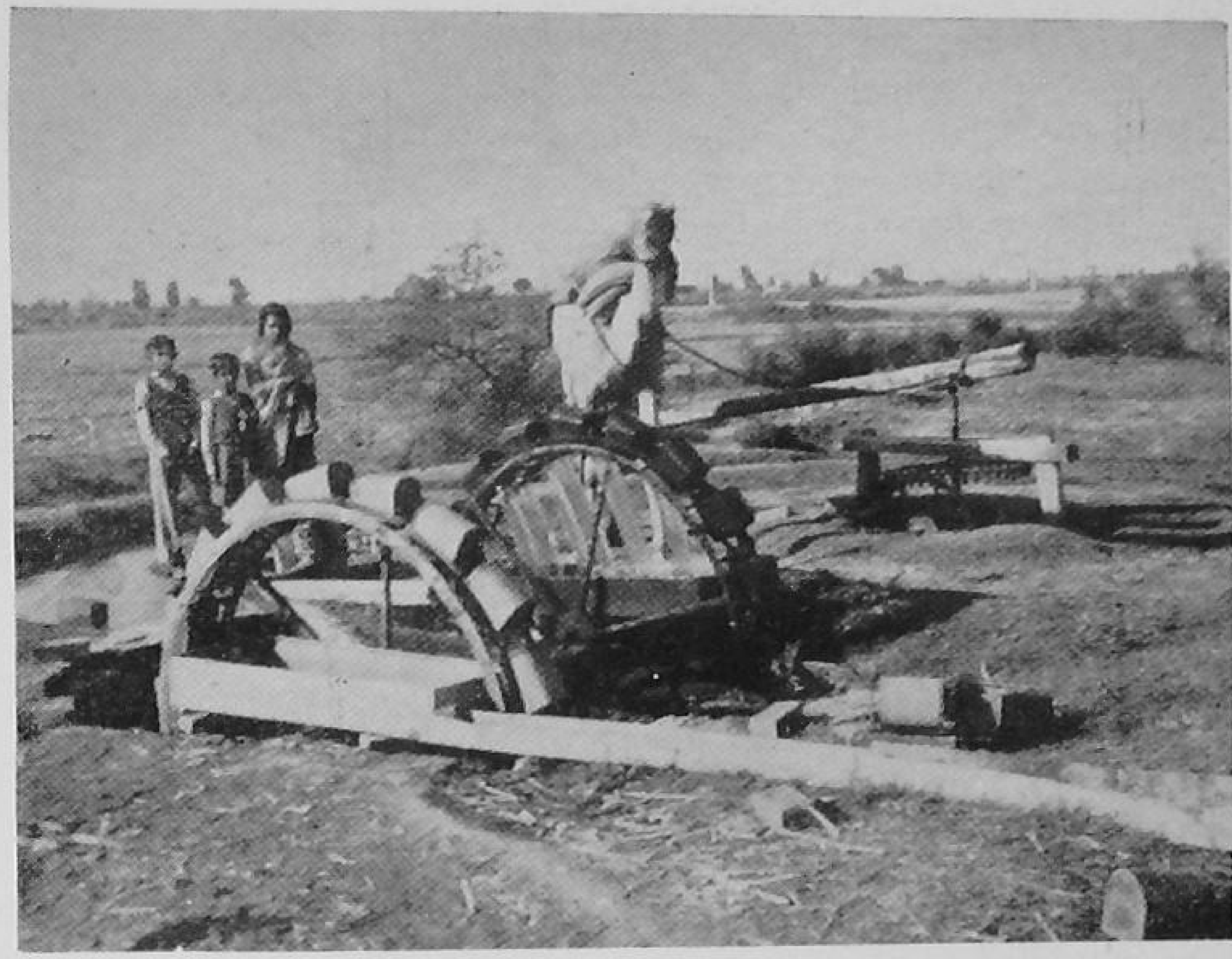
"Dauri" or "Swing Basket" System



Dhenki System

(i) *The 'Dauri' and "Don" System* : These are used when the lift involved is small say 3 to 5 ft. In the former two men lift water to a height of 3-4 ft. by means of a swing bucket. Approximately, 12 gallons per minute are lifted by this method. The 'Don' is an improvement on the 'Dauri' system but uses the lever principle. The receptacle is an oblong bucket of galvanised iron sheet levered at an intermediate point. The long arm is suspended by means of a rope tied to one end and is made to dip into the water. The counter-weight pulls the receptacle and water is lifted by about 4 ft.

(ii) *The Dhenkis of Eastern U.P.:* In the eastern parts of U.P. where the wells have scanty supplies, 'Dhenkis' are in common use. In this, use is made of the principle of lever with a suspended fulcurum and a counter weight. A metallic bucket hangs from the long end of a pole levered on a 'Y' shaped log of wood. The operator lowers the bucket by pulling



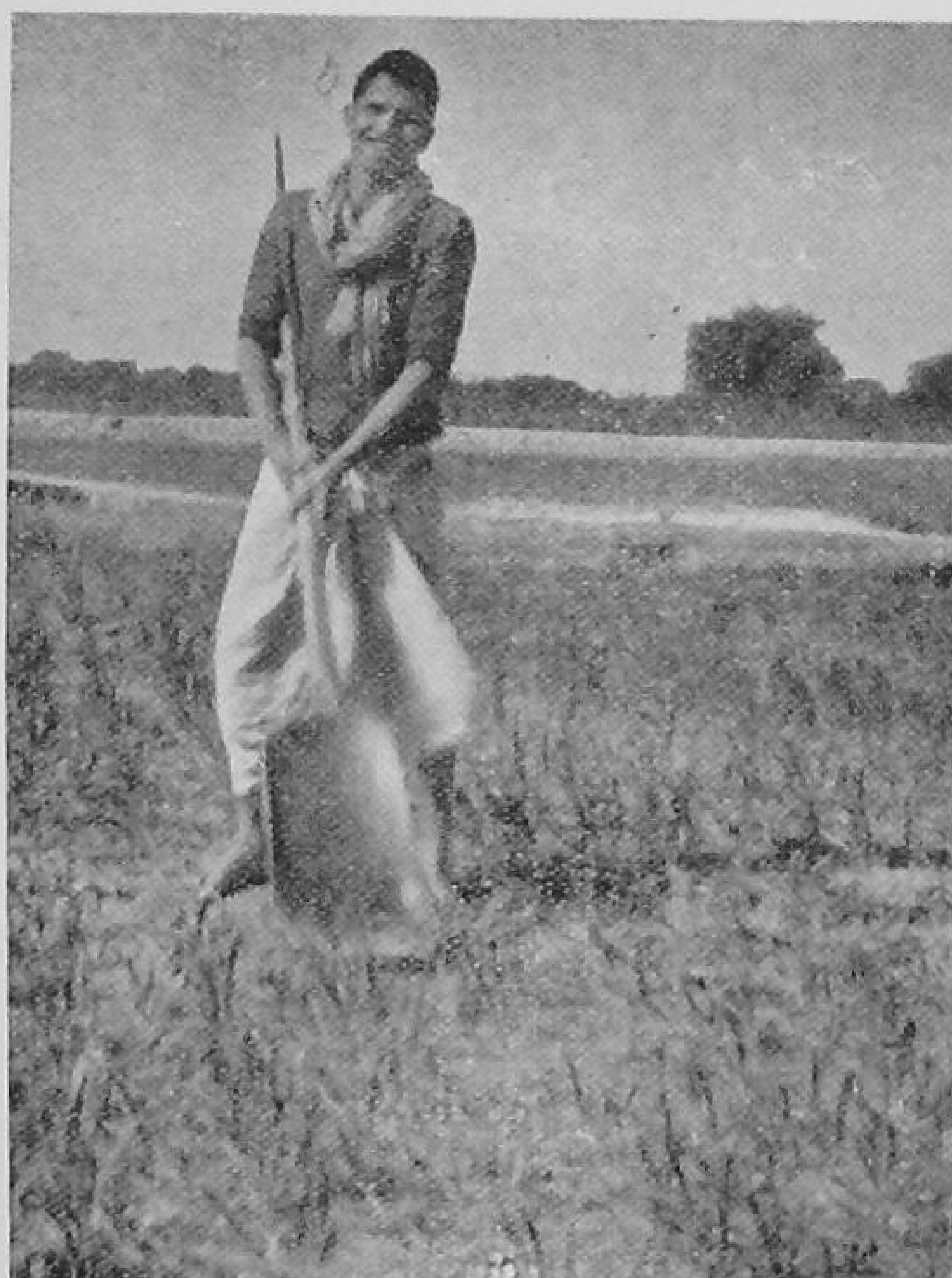
The Persian Wheel worked by a Camel in the Punjab Village

at the rope, the bucket dips into the well and the counter weight raises it up. Water lifted by this method is about 5-8 gallons per minute from a well of normal depth.

(iii) *The "Moat" and the "Persian Wheels"* : On wells with better yield, the devices most commonly used are operated upon by animal power. The Persian wheel and "Moats" come under this category. In the "Moat" system a bullock or a pair of bullocks draws water from the well in a big leather bucket known as the "Moat". While drawing water the bullocks take advantage of the downward slope of the ground on which they move.

The Persian wheel consists of a horizontal metallic wheel about 8-10 ft. in diameter with cocks projecting. The wheel is supported on a vertical shaft which rests on a bearing. The horizontal wheel rotated by an ox or a pair of oxen is geared to a vertical wheel on horizontal shaft to which is also fastened a large vertical wheel supporting metallic buckets. By this device, it is possible to raise 1,500 to 2,000 gallons per hour from wells where the depth of water is 25-30 ft. The cost of a persian wheel ranges from Rs. 500/- to Rs. 800/- depending upon the depth of the well. The well costs nearabout Rs. 1,500/- to 2,000/-. The area served per well is about 5 to 10 acres by persian wheel.

5. **Cropping Practices in Eastern U. P. & Bihar**: In the Eastern districts of U. P. there has been no canal or tube well irrigation till recently. Almost the entire crops are raised under rainfed conditions. During the rabi season, several crops are sown which are irrigated from wells, ponds or jhils but irrigation is very partial. Water lifted from wells or tanks is just sprinkled on the crops and is rarely allowed to flood



Watering of fields by "Hatha" in Eastern U.P.

the fields as under regular flow irrigation. In these districts of U.P. due to shortage of supply in the wells, some of the slowest and most inefficient methods of lifting water are still quite prevalent. The 'Dhenki' as already described, is by far the most common method.

As one proceeds further east towards Bihar, more and more of rainfall is encountered. In the north Bihar, the raging waters of many rivers, when in spate, inundate large tracts of land leaving a frightful trail of destruction, hunger and distress. Kosi is Bihar's "River of Sorrow". These rivers are being gradually tamed with the coming of several major river valley projects.

In south Bihar, the Chotanagpur plateau extends in major portion. Between the plateau and the Ganges river lie the fertile alluvial plains of the Gangetic valley. The main crop here is paddy. Wheat cultivation is also done on an appreciable scale but rice is the predominant crop.

In the Chotanagpur plateau and also in the Santhal Pargnas districts, where soil and rainfall conditions are similar, paddy is mostly grown as an unirrigated crop. Due to rainfall of over 50″ the low land does not require any irrigation and it is always possible to grow paddy here without any irrigation. In the midland, it is not safe to grow the good variety of paddy without irrigation facilities. The October rains occasionally fail and without irrigation this paddy cannot be grown successfully. The cultivators, therefore, take to early varieties of paddy, the yield from which is much less. In the high lying areas which become dry even during short breaks of rainfall only an early variety of paddy is grown under unirrigated conditions. Even there the crops suffer for want of moisture when the rains fail during the later part of the crop season.

In certain parts of the Ranchi districts, where the river beds have been reclaimed and where moisture is available, all the year round, a 2-3 months duration crop of paddy is grown in addition to the regular crop. This former variety is sown in March and is harvested in June. Its roots and stems after harvesting act as manure for the next crop.

In the Shahabad district, where irrigation facilities are available from the Dehri canal system, irrigated paddy is grown in the entire commanded area. In the bed of the 'Ahars' which retain sufficient moisture and where the soil is clavey wheat is grown as unirrigated crop. Wherever irrigation facilities are available from wells and tube wells, sugar-cane is extensively grown. The minor irrigation systems practised in South Bihar have been broadly described in the following paragraphs.

6. **Bunding of Rivers and Streams in South Bihar :** In the Shahabad district, the cultivators occasionally practice irrigation by throwing earthen bunds across rivers and streams just after the cessation of monsoons. The flow water in the river is diverted to the fields through irrigation channels for the last watering of the paddy crop. These bunds are sometimes washed away due to untimely floods. Also, when there is scarcity of rainfall, the streams do not carry sufficient water and the benefit is limited to much smaller areas. The Suara river at Bhabua and the Kau river in the Sasram Sub Division used to be bunded in the above manner. In the latter case, a weir has been constructed by the Irrigation Department at a cost of Rs. 4 lakhs. A half mile length channel taking off from the anicut joins the old cultivators' channel system. Irrigation and distribution of water beyond this point is managed by the beneficiaries.

Similarly in the Gaya district the local people used to construct the Chariari Bandh across the Jamuna river and take the irrigation water through the Dasoi-Supi Pyne. About 6,000 acres of land used to be irrigated from this Pyne. The Bandh got breached or deflanked every year due to flood waters. Subsequently, the Irrigation Department built a permanent weir 100 feet in length along with irrigation channels on either side at a total cost of Rs. 8.27 lakhs. The irrigable area from this scheme is 9,000 acres and the cost per acre works out to Rs. 92/-. This is comparatively a cheaper scheme as costs of similar work undertaken in this tract are as much as Rs. 200/- per acre.

7. **"Pynes" of Chotanagpur :** These are diversion channels taking off from streams of catchment ranging from one to three sq. miles. They divert the stream water into the fields for irrigation purposes. Generally, an earthen bund is thrown across a valley. The "Pyne" takes off from the upstream of the bund and the flow water diverted into it. The surplus water not required in the "Pyne" escapes through a waste-weir suitably located.

The "Pyne" is generally a high level channel, its bed being at the sill level of the escape-weir or slightly lower. The idea is to have a large command. The storage of the tank formed by the bund is small and is almost ineffective except that the land, lying just below, receives benefits of seepage. In very rare cases, is the storage utilized for direct flow irrigation. The "pyne" fed by the flow water of the stream is often a long length channel. In its passage it picks up the seepage and also the direct flow from the catchment it intercepts. Quite often it passes at the foot of hillocks from which there may be heavy seepage. All this water flows into the "pyne". It is, however, not infrequent that during floods, the "Pyne" gets chocked with silt and flood water. In absence of suitable and adequate relieving arrangements, the embankment of the "Pyne" gets breached. A relieving weir of proper dimensions which may be able to cope up with the flood discharge from the intercepted catchment would, perhaps, improve the functioning of the "Pynes".

Water from the "Pyne" is generally used for irrigation of the paddy crop. Since "Pynes" entirely depend upon the flow water and cannot draw upon any storage, they are unable to protect the crops when there is a long break. A big sized "Pyne" which is able to carry large quantities of flood water also helps a good deal in the conservation of soil moisture.

The "Pynes" from the Dighal Pahari tank in the Ranishwar Community Development Block and Raghunathpur and Ratu tanks in the Ranchi Community Project are examples of this kind of irrigation. In none of the above works, do the "Pynes" draw upon the storage of the tank, neither is there much direct flow irrigation from the stored water. As the embankments are porous and rest on porous soil, there is lot of seepage which keeps the land downstream wet for long periods. The Dighal Pahari tank is probably being remodelled as a storage-cum-diversion scheme under the Community Project Programme. The Raghunathpur tank was constructed as a Grow More Food work earlier and the Ratu tank belongs to the local Zamindar. The "Pyne" from this latter tank was repaired under the G.M.F. scheme but its banks have breached due to reasons stated in the foregoing paragraph.

8. **"Ahars" of the Shahabad District :** The "Ahars" are long length earthen bunds constructed across side long ground for catching the rain water. The slope is, however, very gradual and the land generally gives the appearance of being flat. The "Ahars" submerge large areas of land on the upstream side though the depth of water is small. The paddy

sown in the submerged area is of the water resistant variety. The yield from such paddy is small but the cultivators can raise a good crop of wheat in the submerged area during the winter season without any irrigation. The submergence actually benefits the cultivator quite a lot. Not only is the actual submerged area benefited but there is a general increase in the moisture content of the land further upstream due to obstruction created in the free flow of water.

Further, the water stored in the 'Ahars' is let out for irrigation of the paddy fields down below during the later part of the crop season. The quantity of water stored is small and the benefits from actual flow irrigation are limited. Sometimes when the fields lying upstream of the submerged area get dried up for want of timely rains, water of the 'Ahars' is lifted up and sent to these fields. Since the lift involved is small and also the quantity of water required little, it is generally possible to protect the crop upstream of the submerged area from the 'Ahar' water without much cost.

On the whole, the 'Ahars', though crude in construction, serve the very useful purpose of conserving moisture in the land upstream. They are definitely more effective sources of water than the irrigation ponds of Chotanagpur (described below). Their function is similar to that of submerging tanks. (See Chapter V).

9. **Irrigation Ponds in Chota Nagpur and Santhal Parganas :** These are small storage tanks constructed across valleys of small catchments of 50 acres or less and rarely exceeding 100 acres. The bund is constructed without a puddle trench or a core of retentive material. The soil is almost everywhere murrum and the tank embankment is constructed of this porous earth.

The benefits of these storage tanks are limited though collectively they help a good deal to conserve the soil moisture. On account of very small catchments and inadequate storage and also because the tank embankment and the subsoil underneath are not sufficiently impervious, these tanks do not retain much water at the time of real need, and are able to correct rainfall irregularities of very short duration. When there is a long break, they would offer little protection and may not be of much use.

CHAPTER II

KUHLS OF THE HIMALAYAN HILLS

1. **Kuhls of Himachal Pradesh :** In Simla and Kumaon hills most of the agriculture is done on the hill slopes. The level plots are few. Land preparation here is very difficult but the people are hardy and have managed to reclaim large parts of this mountaineous country. Hill slopes are cut into steps and each narrow strip of flat land is suitably bunded. This is known as terracing. The bunds are usually low but are good enough to arrest the free flow of water. When the bunds are reasonably high a regular depth of water is maintained in the fields. These bunds are made of boulders and

Terraced Cultivation in the Himalayan Hills sometimes a combination of earth and boulders. Average rainfall in these hilly tracts ranges from 40″ to 60″. Both rabi and khariff crops are grown in the terraced fields. Paddy is the main irrigated crop.

Irrigation is done from small channels which tap the water of perennial streams. The hill people call these channels 'Kuhls'. Travelling through these hilly regions, one could notice the 'Kuhls' from a long distance carved out on the hill slopes sometimes in a most zigzag manner. In their course, the 'Kuhls' are fed by many hill springs, and the flow increases. The bed slope in the valley is so steep that the 'Kuhl' and the main stream spread out within a short distance of the take-off point. Sometimes, the 'Kuhls' before being used for irrigation, drop their water into flour-mills and run them by the power thus generated. Wherever the flow of water is great one could notice a cluster of flour mills worked by these 'Kuhls'.

There are no controls at the head of the water channels nor are there any diversion bunds across the streams. The bed of the 'Kuhl' is kept flush with the bed of the main stream and sometimes even lower than that. Due to steep fall in land there is practically no loss of command. Occasionally a small boulder bund is erected across the stream for diverting the water into the kuhl. The soil is rocky and the 'Kuhls' do not show any tendency of river formation when the flood water enters them. When the kuhls do not leak, specially in the head reach, area irrigated from them is often quite considerable. The duties obtained are sometimes better than the canal duties. This is because field to field distribution of water in the terraced fields is very closely regulated by the cultivators. A cusec of water is able to irrigate as much as 150 to 200 acres of land.

All these 'Kuhls' have been constructed by private enterprise as a result of people's own efforts and are owned by them. Once water is discovered by the hill people, they would go to any extent to make use of that water. It is not uncommon to find 'Kuhls' constructed sometimes along very difficult alignments. The aqueducts that are constructed out of the trunks of trees, spanning sometimes deep gorges, or carrying water along the vertical face of a rock, are feats of rural engineering. In the plains one would rarely think of constructing channels through such difficult reaches.

The hardiness of these people in their attempt to tap the available water in these difficult regions has to be seen to be believed. In an isolated village of the ex-Bilaspur State, the Sutlej river takes a sharp bend which is called the 'Karahi Bend'. The local hillman here has made use of the available water power from streams by instaling 4-5 flour mills. These serve the needs of a number of neighbouring villagers Across the deep Sutlej river, he has constructed a rope bridge. A strong steel wire rope, suspended from which is a crude. wooden trolly spans the river. The trolly is worked by means of a string. The villagers on the other side cross the river one by one and thus avail of the flour mill. This is just an example of the general hardiness and enterprising nature of these simple hill-folks.

2. **The small tanks of Kumaon Hills :** In these tracts, irrigation water for paddy is needed most during raising of seedlings in May and transplantation operations in June-July. At this time of the year, the flow in the Kuhls is very scanty. Often the water is so little that it dries up in the 'Kuhls' and does not reach the field.

In the Kumaon hills, the cultivators have resorted to construction of small pucca masonry reservoirs. The inflow from a local spring instead of being diverted in a 'Kuhl' is collected in a small tank constructed for the purpose. This is built in masonry below ground level but at some high point. An outlet leads the water from the tank into a 'Kuhl' and thence into the field. The tank capacity is such as would enable it to store about a week's inflow. It, however, gets emptied in just 4 to 5 hours. The result is that water flows out into the 'Kuhl' with force and is able to irrigate the nursery successfully. Every acre of nursery gives seedlings for about 20 acres.

Subsequently, when the early showers occur and the flow in the 'Kuhls' increases, these small tanks serve the useful purpose of supplying adequate irrigation water for transplantation. During that period the tanks get filled up in just one or two days. The increased quantity of water spreads on a much larger area and successfully irrigates the transplanted crop. Although with the first showers the flow in the 'Kuhls' increases yet it is not sufficient for direct feeding of the 'Kuhls' without the reservoir.

A tank of this type constructed in the Rawain-Nowgawn Block cost Rs. 6,000/- of which Rs. 1,000/- was subsidized by

Government. The tank is about 50′ long x 30′ wide x 15′ deep.

3. **State irrigation works in the Doon valley:** Wherever big rivers are tapped in their head reach, it is not the practice to construct diversion weirs even in State-owned works. Here the slope is very steep and the rivers carry large quantities of sand, shingle and boulders. Apart from the fact that he cost of construction would be high, rolling down of this heavy bed load would endanger the safety of these works. Also, obstructions in these stages of the river flow are likely to create unstable condition upstream.

The Katapathar canal system in the Doon valley maintained and managed by Government is a work of this kind. It is over 100 years old and is lined in a major portion. The canal diverts the Jamuna water although there is no permanent diversion weir. There is a head sluice which controls the feeding of water into the canal. The diversion arrangement is temporary and consists of boulder crates. Rs. 10,000/- are spent every year on this work. Only a part flow is diverted into the canal, which is sufficient to irrigate the 14,000 acres of land under command of the K.P. canal system. As the canal follows almost the bank line in the head reach, it is always exposed to damage by the river current when in floods. In 1924, when the river started eating the banks, stone spurs projecting at right-angles to the banks were constructed to protect the canal. Some of these spurs require heavy maintenance as they are frequently damaged during floods. Also more and more new spurs have to be constructed and approximately Rs.30,000/- is spent on the spurs every year.

4. **Expansion of irrigation from Kuhls :** Quite often the management of 'Kuhl' water is not a very easy job with the result that optimum use of water is not made of.

A cultivator generally digs a 'Kuhl' to serve his own plot of land. Though more water is available and by extension of the 'Kuhl' additional area could be brought under irrigation, the owner of the lower land is not able to come to terms with the owner of the upper land. Often the latter demands heavy compensation from the former because he believes that the owner of the land lower down has been saved the cost of construction of the 'Kuhl' in the upper reach. He sometimes claims the entire cost of his 'Kuhl' before giving permission to the owner of the lower land for extension.

Also due to local jealousies and rivalries, a person in the upper reach does not like his neighbours lower down to enjoy the benefits of irrigation. Similarly, there are jealousies between one village and another. If a 'Kuhl' serves the needs of one village, quite often it would be reluctant to allow the 'Kuhl' water to be taken to the lower village even though plenty of water may be available. It would generally be argued that if water is allowed to the lower village, the upper one would suffer.

Due to poverty also, the villagers are not able to invest huge sums of money on digging of costly 'Kuhls'.

Above are some of the causes which come in the way of optimum utilization of water from these 'Kuhls'.

In the past, the State Irrigation Departments have had very little to do with the management of 'Kuhl' irrigation. Only recently, the States of Uttar Pradesh, Punjab and Himachal Pradesh have undertaken the construction of new 'Kuhls' and renovation and remodelling of several old 'Kuhls'. The remodelling work generally consists of lining the irrigation channels in the leaky reaches because leakage of water in such reaches is the biggest defect in the 'Kuhls'. Leakage also takes place close to the cross-drainage works. Here also properly designed masonry works have gone a long way in improving water conveyance and thus make additional supplies available. The cost of renovation and remodelling is generally between Rs. 75/- to Rs. 100/- per acre of the irrigable land. The general policy so far has been to renovate and remodel old 'Kuhls' but as yet the construction of new 'Kuhls' has been taken up on a very small scale. Some of these newly constructed kuhls could be seen in the Mahasu and Sirmur districts of Himachal Pradesh. Government investment on these works has been in the neighbourhood of Rs. 150/- to Rs. 200/- per acre. Where the channels follow a difficult alignment, the costs go up to Rs. 300/- per acre. 'Kuhls' constructed as State-managed works or on a co-operative basis would be able to extend irrigation in much larger areas where due to local factions and quarrels, the available water is not being fully utilized.

5. **The Kashmir Valley Irrigation in the Ladakh plateau :** About 80 to 90% of irrigation in Kashmir valley is done from privately owned sources. In the recent past the Irrigation Department either independently or through the agency of Community Projects Organisation have been taking

up improvements and remodelling of the existing irrigation canals with the help of Government finances. Some miles away from Srinagar could be seen timber drainage crossings recently built. Canal water is carried across the drainage through a timber acqueduct. The acqueduct is supported on wooden piles and is made watertight by sannhemp. Such works are beyond the capacity of the local people. These have greately improved water conveyance as previously lot of canal water used to be lost at the crossing.

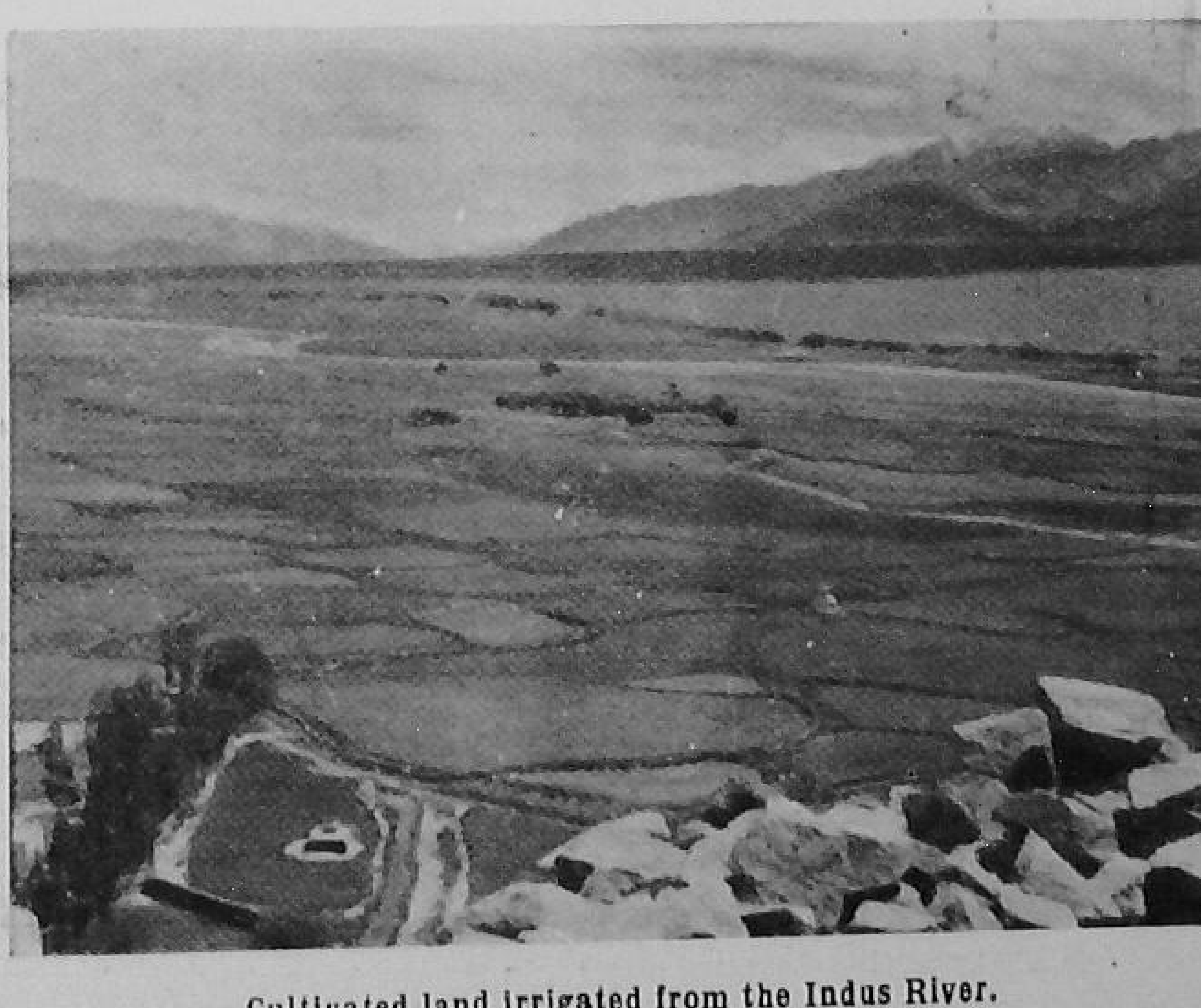
Similarly in the Badgam Community Development Block remodelling of two big canals taking off from the Sukhnag river is being done by the Irrigation Department. These canals have hitherto been maintained and managed by the people. One of these is the Larkuhl which has a carrying capacity of over 300 qusecs of water. The other water channel is the Ahji canal which is slightly bigger than the Larkuhl. Masonry head works would be constructed, the channel resectioned and some type of lining provided in the porous and leaky reaches.

Irrigation in Ladakh—The Ladakh district is located between the Western Himalayan mountains and the Karakoram range and is in the rain-shadow region, the annual rainfall being 2 to 4 inches. The average elevation is 11,500 feet. The Indus river flowing between these two mountain ranges traverses this district. The cultivated land lies on the fringe of the river bank or at the foot of the snow-clad mountains. The soil consists of disintegrated and crumbled particles of granite which at first sight appears to be quite unsuitable for cultivation. It is, however, built up in the course of a few years by the application of composted manure and silt from the hill torrents. Wheat is the richest food crop but barley and grim are also grown in inferior lands. Unlike other parts of the country where wheat is essentially a Rabi crop it is grown in Ladakh during the Kharif season. With low temperature, favourable irrigation supplies and practically no humidity in the atmosphere the conditions are most conducive to the growth of wheat crop during the period April to September.

There are two main sources of irrigation water viz. (a) Water from the melting snows and (b) The Indus river water.

(a) Water from the melting snows :—At places there are thick deposits of snow on the southern face of the mountains. This snow starts melting near about May, and gives rise to flow in the streams. During June and July maximum flow occurs and after middle August the flow decreases reaching a minimum near about September. In the period of maximum flow wide fluctuations occur during day and night. Since melting takes place during day time only, as soon as it ceases during the cool hours of the night the flow in the streams also diminishes. These fluctuations are very wide and are easily noticeable by the local people. Water from these streams is taken to the fields through an elaborate system of water channels. These resemble the kuhls of Himachal Pradesh, although the land here is comparatively flat. Quite often each kuhl is provided with a small tank in its head reach. This tank collects the excess water during the time of peak flow in the day. When the discharge decreases the tank water is diverted into the kuhl. It, thus, serves the useful purpose of absorbing fluctuations in the stream flow resulting from melting and non-melting of the snow at the source. In years of less rain and snowfall, the reservoir also collects excess flow during June and July which is utilised subsequently when the stream flow dwindles down.

(b) Irrigation from the Indus River :—The Indus river flows here at a fairly steep gradiant ranging from 1 in 300 to 1 in 500. Water channels taking off from the river are excavated at a flatter gradiant and irrigate the patch of land between the river bank and the channel. Water in the river is headed



Cultivated land irrigated from the Indus River.

up by the construction of a temporary low boulder weir. No control exists at the head of the channel. Any water in excess of its carrying capacity is allowed to flow back into the river by breaching the river side bank of the channel. These irrigation channels are sometimes quite big and carry as much as 15 to 20 qusecs of water irrigating 600 to 1,000 acres of land. The cultivators maintain these channels in a neat condition. Regular banks have been provided and if the land is not very uneven the channels follow regular alignment. Each village has its own water channel. It is not uncommon to see two and sometimes three independent channels flowing close to each other but taking off independently from the Indus river. This is done for facility of maintenance. The members of each village have co-operative rights in the use of these channels and are keenly interested to maintain them properly. Not only are these kept in neat condition and in proper section, but some of the irrigation crossings constructed with local materials could easily be classed as feats of rural engineering. Between Tikzey and Rambirpur villages some aqueducts, super-passages and road crossings have been constructed by the local people with Government assistance. The aqueduct consists of wooden beams resting on timber abutments. Over the beams is laid earth mixed with small grass. The irrigation channel is carried across this, its embankment being suitably protected by boulder pitching. These crossings carry the channel water and not a

Aqueduct carrying the canal water. In the background is also the Road Bridge on the drainage.

drop of water leaks into the drainage below. All these are commendable works and speak highly of the skill and ingenuity of a people almost completely cut off from the rest of civilisation.

CHAPTER III

WATER UTILIZATION IN THE ARID ZONE

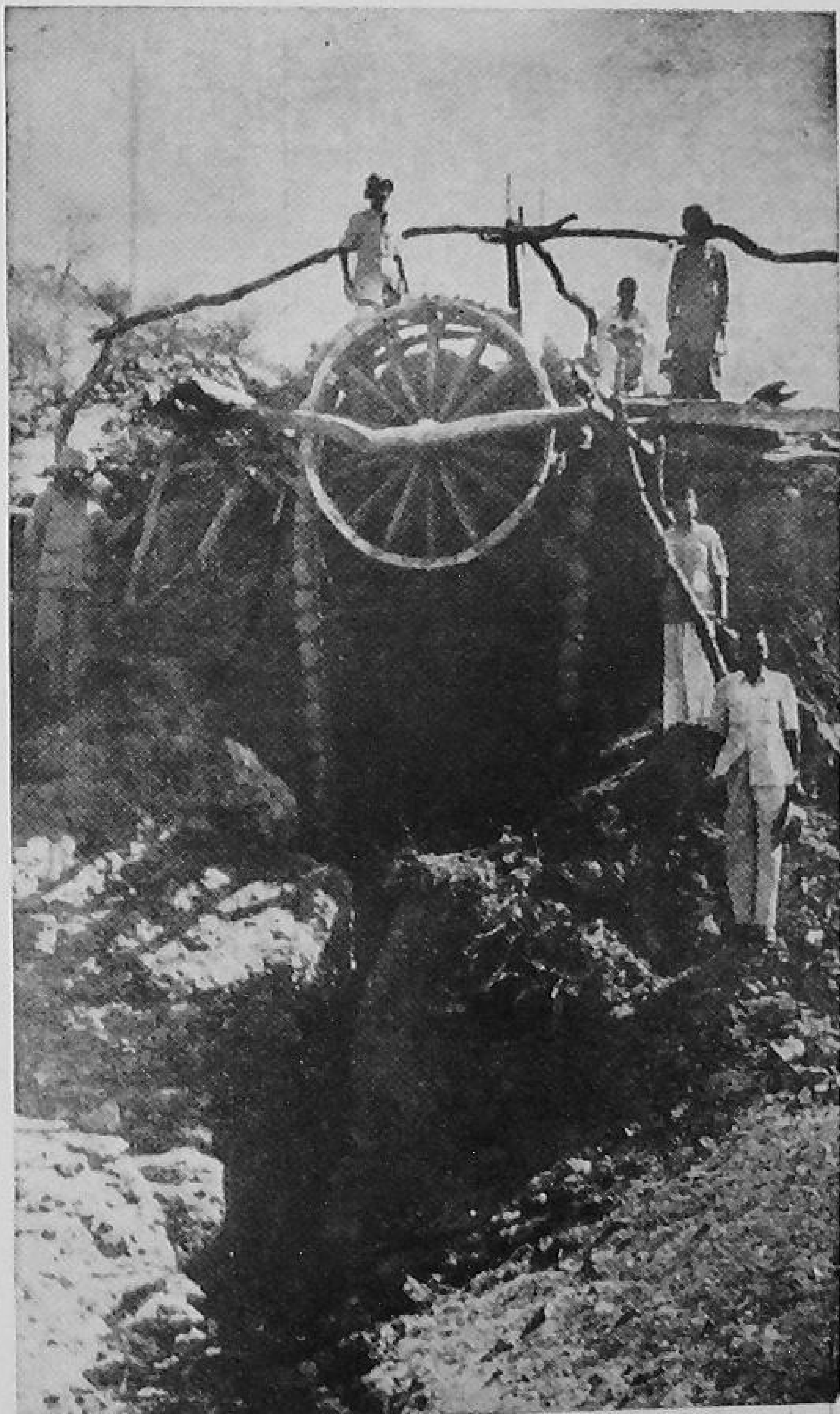
1. **Deep wells of Bikaner and Jodhpur :** These are the dry parts of Rajasthan where the rainfall is just a few inches. In the north, there is the desert area of Bikaner where subsoil water is very low, viz. 120 ft. below ground level. Due to availability of canal water, wells are not used for irrigation. The Gang canal which brings the Sutlej water from Ferozepur is the main source of water supply here.

As we go south east, there are no canals. Although the ground water table is very low, wells are the only source of irrigation. Thus in the Nagore district of Jodhpur Division, wells make an appearance even though the ground water table is about 150 ft. below ground level. Due to proximity of the Sambhar lake, water struck is saline in the adjoining area and is unfit for irrigation. Further east, water is sweet and is quite suitable for irrigation purposes.

Although during excavation of wells, water is struck at about 150 ft. depth, sandy layers interspersed with layers of clay are met with much before this. In such reaches, the practice while sinking a well is to construct a steining of brick in mud to retain the sandy backing. Where the soil consists of a fair proportion of clay, no such steining is made. The local people dig the well right up to the bottom in this manner till water is struck. After that the well curb is placed in position and a steining built from the bottom. Further excavation of the well is done by sinking this masonry steining and bailing and scooping off the mud and water from underneath.

A deep well like this constructed in the above manner would normally cost Rs. 7-8 thousand. But people are so hard-working that a loan of Rs. 2,000 from Government is good enough to induce them to sink an irrigation well. The cultivators mould and burn their own bricks at site of the well; they collect and bring the kanker also at site and burn it to get lime. The members of the family provide the manpower for excavating the well. It would thus appear that very little cash is needed to sink the well and it comes up simply by productive use of the available manpower. The yield from the wells varies from place to place but is rarely more than a thousand to two thousand gallons an hour.

2. **The wooden Rahat :** As different from the Persian wheels of the alluvial plains, using metallic buckets, the wooden Rahat is commonly used in Rajasthan. On these Rahats earthen jars supported on a large vertical wooden wheel are used. One reason for the use of this kind of device is the great depth at which water is struck. The bullocks find it comparatively easier to work on the wooden Rahats which use earthen jars and which are, therefore, lighter.



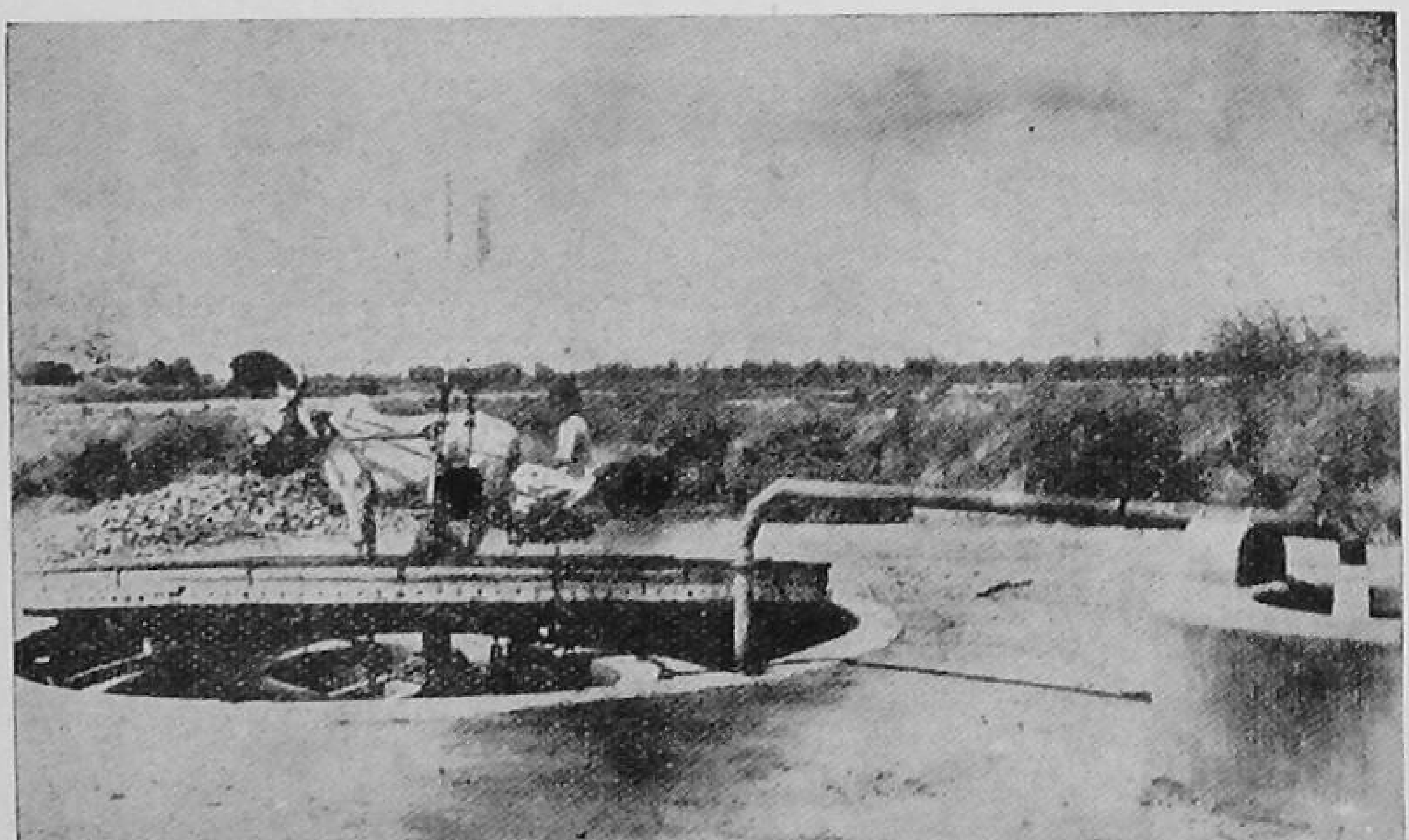
The Wooden Rahat with Earthen Jars Installed on a Well in Bali Community Development Block (Rajasthan)

However, the cheapness of the device is an equally important reason. Wood is available locally and the local carpenter shapes it into Rahat. The cultivator moulds his own earthen jars and on the whole very little of cash investment is needed. Even though the device evolved may be crude, more expensive in the long run and also expensive to operate, it does not cost much cash money to the cultivator although the cost of labour and materials would amount to Rs. 300/- to Rs. 400/- as against Rs. 600/- for a metallic Persian wheel. This aspect of rural economy has to be fully kept in view before the prevalent practices—however crude these might be—could be thought of being replaced.

Whenever the wells are charged by flood waters of the neighbouring streams, the supply is plentiful. In such cases, maximum use of the well water is made by the Rahats. This is rendered possible by employing 6 pairs of bullocks instead of a single pair and working the Rahat all the 24 hours. One pair works at a time and changed after every hour.

With the availability of cheap credit facilities from Government, cultivators have been encouraged to instal pumping sets wherever wells have got good yield.

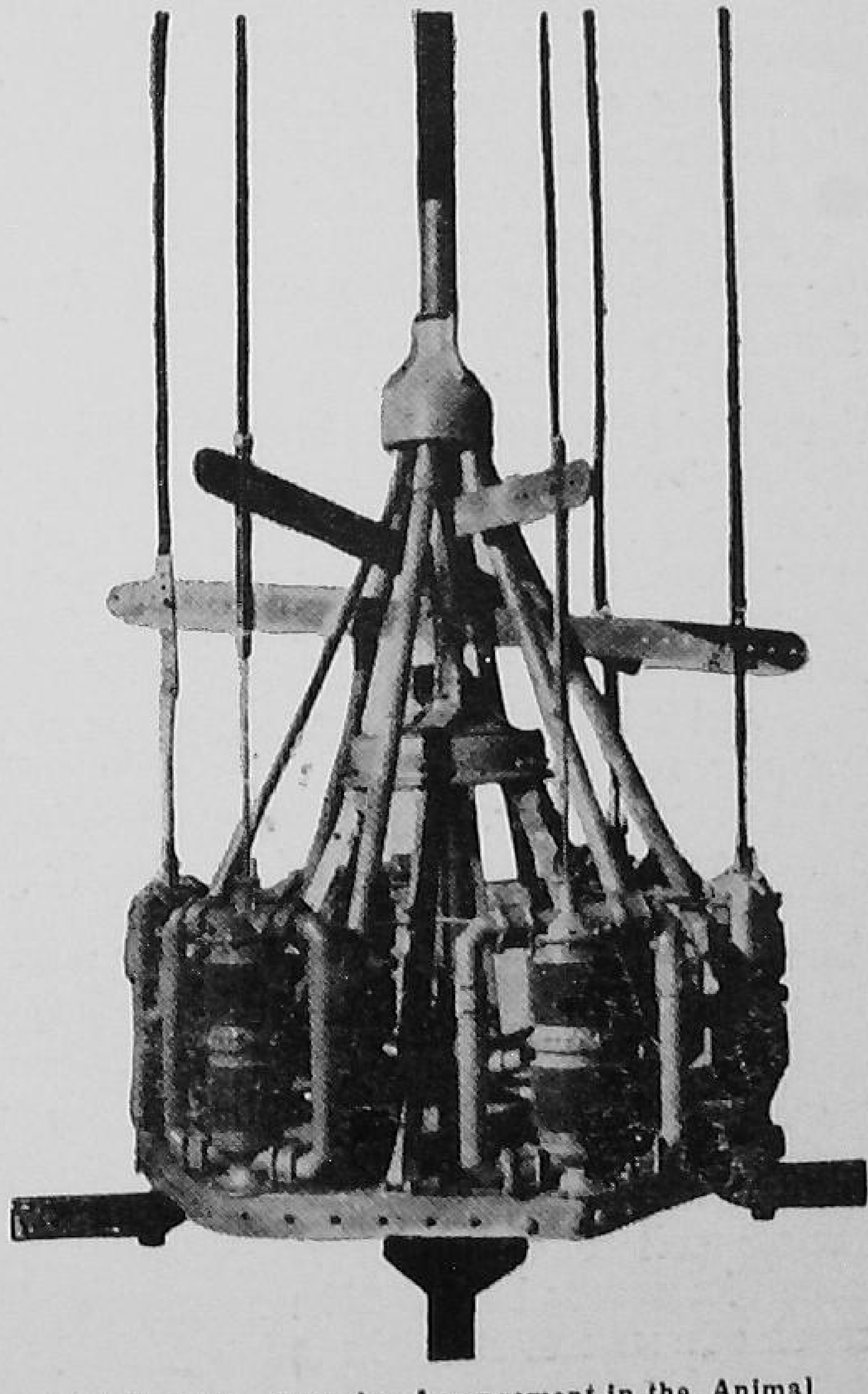
3. **Animal body weight water pump of Takhatgarh and other devices :** In one of the villages of Rajasthan, namely,



The Animal Body Weight Water Pump at Takhatgarh (Rajasthan).

Takhatgarh, a local man has invented and installed what is called 'Animal Body Weight Water Pump'. It is an interesting device for harnessing the bullock power for pumping water from a well. A big and heavy circular disc rests in a tilted position over the top of a well. The spokes of this disc are connected by means of iron bars to the plungers of a pump installed lower down. The bullock walks round and round on the periphery of the disc and, as the wheel changes its position of tilt, the plungers are successively brought into operation moving up and down one after the other. The pump thus starts working.

In this arrangement, there are no moving parts except the pump plungers with the result that the pump works at a high efficiency. One bullock does the work of two without



Details of the Pumping Arrangement in the Animal Body Weight Water Pump getting tired. In fact, observations taken show that one bullock is able to lift 3,300 gallons of water per hour against a head of 55 ft.

The main disadvantage of this device is its capital cost. It has not yet been patented but it is understood that it can be manufactured in about Rs. 2,500/-. This again would be beyond the capacity of the common cultivator to pay. Added to this would be the disadvantage of the complicated mechanical parts, and if anything goes wrong with the pumps or other moving parts, the cultivator would again be stranded.

There is yet another device invented by a local resident of Ajmer. A bullock operates upon a mechanical device resembling that of a Persian wheel and sets in motion a pair of ropes which has no earthen buckets fastened to it. As the rope circulates round and round, it draws water by surface tension and a good quantity of water is lifted. The rope is held in position at its lower extremity by a heavy pulley without any axle. It may be an improvement over the Persian wheel as it eliminates the energy required for lifting the buckets. It is, however, not as efficient as the 'Animal Body Weight Water Pump' as described earlier.

In Ajmer an improvement has been made in the existing moat system for drawing water from the wells. This is to employ double pair of bullocks with a single rope and a moat. One pair moves down the slope and as soon as the moat full of water reaches the ground, the rope is disengaged from this pair of bullock and it slips back to the well by the help of the moat itself. At the well it is attached to the other pair of bullocks and the first pair moves back up the slope but without rope and replaces the second pair. By this arrangement, two pairs of bullocks draw water alternately and do not easily get tired.

4. **Tho sub-surface dams or 'rapts' of Ajmer :** Ajmer is centrally situated in the Rajasthan desert where there are numerous tanks constructed some hundred years back. With precarious rainfall these tanks fail to fill in many years. In some cases, the feeder nallas which used to bring water have disappeared into sand hills and now bring practically no water. Whatever water collects in the tanks mostly escapes underground through its porous basin. These tanks have, therefore, not been much of a success as works doing direct irrigation.

But one advantage of these tanks has been that they have immensely benefited the wells by augmenting ground water supplies. Almost all the wells in the locality where the tanks exist have permanently benefited. Similar works in the form of storage tanks or subsurface dams commonly known as 'Rapats' are in great popular demand. One could see temporary bunds of earth and boulders constructed across nallas for the sole purpose of increasing the ground water supplies.

In the recent past, a number of weirs across streams have been constructed some by private enterprise but quite a few by Government. The 'Rapats' are mainly intended to arrest the gradient of surface and subsoil flow by making the river bed flater. This results in increased percolation of water into the subsoil with consequent increase in the yield of wells. The water standing beyond the weir also helps to charge the ground water supplies.

5. **The tanks of Udaipur and Jodhpur :** On both sides of Arravali range, there are a number of valleys which provide suitable basins for tank construction. Although the rainfall here is not much (only about 20″), these tanks store whatever inflow is received from the catchment and serve as valuable sources of irrigation. In both Jodhpur and Udaipur Divisions, a number of beautiful irrigation tanks have been in existence for a long time. In the Jodhpur Division, the Jawai dam which is a major irrigation reservoir, has been recently constructed. These being dry areas, where crops requiring heavy irrigation cannot be grown, only rabi irrigation is done from these tanks. Kharif is cultivated as a catch crop wherever possible depending upon the rainfall. The tank duty for rabi crop is taken as about 10 to 15 acres.

The Pali district in Jodhpur Division and Udaipur district in Udaipur Division have a number of major irrigation tanks. These are reinforced by a large number of minor tanks. South of Udaipur is the Dungarpur district. Here, two minor tanks of fairly good size, viz., Gajpur and Bilpan are under construction in the Dungarpur Community Development Block. The Gajpur tank with a catchment area of 17 sq. miles and capacity of 119 million cu. ft. is costing Rs. 2.67 lakhs. Area proposed for irrigation is 1,600 acres. The Bilpan tank has a catchment area of 7.4 sq. miles and a capacity of 99 million cu. ft. Its cost is Rs. 1.3 lakhs and the area proposed for irriga- is 800 acres.

In these regions it is a common practice to construct embankment with a central core of masonry with earth fill on either side. The core wall is carried several feet below the bed and located preferably on rock so as to intercept any possible infilteration through the subsoil.

6. **Irrigation in Kutch :** Although sufficiently far removed from the desert regions, Kutch is on the whole a dry country. The rainfall is very small ranging from 10″ to 12″ a year. Wet crops, therefore, are usually not grown except where good irrigation facilities are available. Bajri is the main kharif crop. Where irrigation water is available, Bajri is a regularly irrigated crop. In this dry country, irrigated Bajri always yields a bumper crop and at no stage is there the risk of its being damaged by heavy rains. It is a common practice here to supplement tank irrigation with well irrigation specially for the Bajri crop. Land here is both sweet and saline and wells also have sometimes sweet and sometimes saline water. For Bajri crop it is said that alternate irrigation by sweet and saline water considerably increases its out-turn and also improves its taste. On sweet land, therefore, if there be wells with saline water alternate waterings by tank and wells is supposed to be very beneficial to the crop. The main sources of irrigation are tanks and wells.

(i) *Minor Tanks* : In Kutch there is a central plateau with a number of parallel ranges of decreasing height. Each range is actually a table land with projections at the edges and out crops of high land here and there. The rivers, flowing both towards north and south, in their passage, pierce through the several ranges giving rise to gorges. These gorges with a spread out basin on the upstream side provide ideal sites for irrigation storage reservoirs.

Although this State is so small and has limited resources, a large number of irrigation tanks have been constructed both by Government and the people. Due to low rainfall, cultivators are very much water conscious and have shown great initiative and enterprise in constructing a number of private irrigation works.

The Government-owned tanks are of all sizes—major and minor and many of them are of comparatively recent origin. In the State-owned tanks, the catchments range from one sq. mile to 90 sq. miles. Bhuj, Kalyanpur and Tara are some of the bigger tanks. Two major irrigation tanks Kaila and Gajor taken up under the first Five-Year Plan are nearing completion. Their capacities are 459 and 348 million cu. ft. and they tap 65 and 52 sq. miles of catchment respectively. Their costs are Rs. 14.2 and 12.6 lakhs respectively, and the areas proposed for irrigation are 6,870 acres and 5,222 acres. The costs per acre work out to Rs. 206/- and Rs. 240/- respectively.

Most of the reservoirs have earthen dams but a few masonry dams have also been constructed. All these tanks are designed to store 50 per cent over and above the average annual yield from the catchment. The idea is that in a dry country like Kutch, it is considered worthwhile to store the extra run off coming during wet years and put it to use for irrigation.

Then there are the minor tanks owned privately. Under the G. M. F. scheme a number of minor tanks were constructed by private individuals. Loans are advanced from the G.M.F. funds to the extent of Rs. 200/- per acre of the area irrigable from a Project. Of this 25 per cent is subsidized by Government. These tanks, though small in size, have served the very useful purpose of reaching the irrigation technique to the village and making the cultivator tank minded. Construction of most of these works is initiated by the cultivators themselves. Some skeleton survey is done by the Irrigation Department and rough estimates prepared. The loans are sanctioned after scrutiny by the local irrigation officers. Work is done by the people themselves under some technical guidance from the Irrigation Department. A set of rules and specifications and broad features of constructional details of a tank have been freely circulated and no difficulty is experienced in executing these works. All these tanks are small in size, their catchment area ranging from ¼ sq. mile to just over one sq. mile and capacity from one to 10 m. c. ft.

(ii) *Wells*: In the sub-plateau regions, wells from an important source of irrigation water. At some depths below the ground level soft rock white in colour is commonly met with. This is calcarious sand-stone and is locally known as 'Sag'. It is a very porous stuff and can be crumbled by hand into particles which resemble porous sand. Some cohesive material keeps the particles together but without depriving the solid stuff of its porousity. The 'Sag' is an excellent storer of ground water and almost all the wells in the region receive their supplies from these strata.

Due to uncertain subsoil formation 'Sag' is often struck at great depths and sometimes it is not met with at all. In the latter case, wells fail and the water supplied from such wells is very scanty. The subsoil water level is also generally low and ranges from 40 to 80 ft.

Where the yield from the wells is poor, boring has been successfully resorted to. Unlike in sandy strata, bore holes drilled through 'Sag' formation do not collapse and, therefore, do not need any strainer pipe. The cultivators have, however, been advised to put in short lengths of pipes at the mouth of the bore, projecting a foot or so above the well bottom. This is to prevent blocking of the mouth from debris from the top or sides.

An interesting feature of the wells here is the horizontal boring in the 'Sag' strata as resorted to by the cultivators themselves. Such a practice is probably not followed in any other part of the country. With their own crude tools consisting of bore pipes in lengths of 8-10 ft. cultivators have managed to drill horizontal holes by simple percussion in lengths as much as 90 ft.

Wherever it has been possible to tap good ground water supplies, pumps have almost immediately made an appearance. As the spring water level is generally low, the cultivators have to use lot of man and animal power for drawing water from the wells. They, therefore, find it convenient to instal pumps. Since most of them are also skilled workers, maintenance and operation of the pumps is comparatively an easy task for them.

From wells sometimes the progressive cultivators grow and irrigate wheat and also paddy. Even though paddy requires heavy irrigation and cost of lifting water from great depths is quite high, the cultivators are able to raise such crops at economical rates by employing scientific methods of farming. Wherever, therefore, good land is available and the facilities exist for proper manuring and irrigation, cultivators have taken to growing richer varieties of crops like wheat.

CHAPTER IV

IRRIGATION IN THE HUMID AREAS OF THE EAST

1. **The Cropping Practices :** In most parts of Assam, the main crops are grown during the kharif season, and among kharif crops paddy is the most important one. Two classes of paddy are grown here. They are *Aus* or *Ahu* paddy, i.e., autumn paddy and *Sail* or *Sali* paddy (i.e., winter paddy). The former is a periodical four month crop and is sown any time from March to May. The latter is a seasonal crop and is sown in June-July. It is harvested in November. Only in a small percentage of the paddy area, *Aus* is grown as a double crop in the *Sali* land.

Another class of paddy, namely boro-paddy (spring crop) has recently been introduced in this State. It is grown in and round about the low lying land which remains water logged for major part of the year. Being a crop of the spring season, it is of great importance in the flood affected area.

In the hilly regions of Assam, the method of cultivation is out-moded though the tribal people have recently taken to more scientific practices in the plains. The hills covered with forests are not rocky but consist of good fertile soil which can easily be cultivated. The tribes cut and clear the forests and burn the undergrowth. The burnt stuff serves as manure and paddy is sown. After one or two years, the soil ceases to respond and the tribes shift to another hill. This is known as shifting or "Jhum" cultivation. The practice is extremely wasteful and has resulted in considerable deforestation.

2. **The Dongs & "Bunds" of Assam :** The rainfall in the Assam hills ranges from 70″ in the Darrang district to about 125″ in the Garo hills. Normally this rainfall should be good enough for the paddy crop. All the same, in the foot-hills, large areas of flat land could be seen traversed by a network of irrigation channels—the Assamese call these channels 'Dongs'. The need for irrigation water arises from the fact that the land being at the foothills, slopes steeply and water cannot stay in the fields. Also, the soil is very porous and whatever water is trapped, escapes underground. Even during short breaks, therefore, the fields would remain practically dry and need irrigation water.

The cultivators' channels or the 'Dongs' as they call it take off from the hill streams, most of which are perennial. A 'Bund' consisting of bamboos brush wood and earth is constructed across the stream and water diverted through the channel. These diversions are washed away from year to year and often several times a year. At many places hollow bamboos could be seen projecting out from the 'Dongs'. The 'Dong' water flows into the field through these bamboo outlets and the need for cutting the 'Dong' bank does not arise. The whole arrangement is very neat.

During the rainy season, the flood water in the parent streams has a tendency to rush into the 'Dong' as no control exists at its head. In course of time, it deepens and widens. In the early stages, the 'Dong' loses its identity among the several streams and it becomes difficult to distinguish between a 'Dong' and a rivulet. Water from the 'Dong' ceases to flow into the fields by gravity and the tribes throw cross-bunds in the 'Dong' to head up water. Later, when the 'Dong' is scoured still more, the main river sometimes changes its course —the 'Dong' becomes the river and the original river gets silted.

From the changed course of the river, cultivators dig more and more 'Dongs'. This goes on and on like an unending process. The parent streams become dead and quite often the local drainage gets disturbed.

In spite of all its technical faults, the 'Dong' today is the very life of wet cultivation in the Assam hills. The tribes who had so far been accustomed to 'Jhum' cultivation have clearly recognised the benefits of wet cultivation and are descending down the plains in numbers clearing and uprooting forests and reclaiming land for irrigated cultivation.

For encouraging irrigation from 'Dongs' and 'Bunds', the State Government have been offering liberal subsidies to the cultivators. For every new work Government give a subsidy of 50% of the total cost while for repair work 40% is given.

All these works which are necessarily of a temporary nature are executed by the beneficiaries themselves. Government broadly ensure that works are properly carried out and that the area proposed to be benefited is actually brought under irrigation. It roughly costs Rs. 6/- to Rs. 10/- for providing irrigation facilities to an acre of land in the above manner. The benefits, however, last for only two to three years after which the work has again to be reconstructed.

In respect of State Irrigation Works which are of a recent origin, the capital cost goes up to Rs. 30/- to Rs. 60/- per acre of land brought under irrigation. These works have regular diversion weirs, sluice heads and gravity canals (para 5). The benefits from these works would be of a permanent nature.

A perennal stream from the hills is not the only source of water supply for the cultivators' 'Dong'. There are minor storage tanks also constructed across small valleys As the rainfall is very heavy, the tanks after supplying the irrigation water, fill up quickly again. Irrigation progresses and even very small 'Dongs' are able to irrigate substantial areas. In technical language, these would be called 'Low Percentage Storage Reservoir'. The capacity is small while the run-off is large.

3. **'Thingels' and 'Lowkhongs' of Manipur :** In the Manipur State, irrigation is practised somewhat on the same lines as in Assam. The diversion consists of temporay bunds of earth boulders, bamboos and tree trunks across the river. These are locally known as 'Thingels'. The water channels which take off from the upstream of the 'Thingels' are called 'Lowkhongs'. Irrigation channels often run at random and do not command the land by gravity. Water has to be headed up by putting cross-bunds before it could be led into the fields. Like Assam, here also it is not uncommon to find rivers changing their course through the irrigation channels.

4. **Irrigation of Terraced Cultivation in the Naga Hills:** In this picturesque country of the Naga hills, very improved methods of cultivation are practised. Unlike the 'Jhum' cultivation, so common in Assam, land on the hill slopes has been terraced on an extensive scale. Regularly constructed and well aligned channels bring the spring water in the fields for irrigation. These channels closely resemble the 'Kuhls' of Himachal Pradesh which irrigate the terraced land on the hill slopes.

In his book "The Naked Nagas," Chistoph Furer Ivon Haimendorf has beautifully described irrigation of terraced cultivation in the Naga hills in the following words :—

"The Angami is expert in constructing terraced fields and irrigation systems. For thousands of feet the mountain slopes are divided into terraces, many as wide as fifteen or twenty feet, others merely narrow strips. Reinforced by walls of pebbles and plastered with mud, these terraces are well able to withstand the torrential rains of Assam. Every rivulet on the mountain side is captured, and the water led through long channels to flood the terraces, for during the whole of its cultivation the rice must be kept under water. The water flows down from one terrace to the one below, and a complicated system of water—rights governs the distribution of the precious liquid; the share in a spring can be bought in exactly the same way as a field. Nocturnal theft of water, by illegitimate tapping of the channels, often causes quarrels that ultimately come before the Deputy Commissioner's court in Kohima. The maintenance of the terraces is an endless work, for each one must be levelled with the greatest care, so that the water may lie at a uniform depth; water that is not needed for one terrace is conveyed through channels to the next, but across the face of the rocks, or wherever the ground is uneven, it is carried in aqueducts of bamboo."

5. **Some Suggestions for Improving the Technique of Minor Irrigation in Assam :** It has been stated earlier that irrigation from Dong and Bund is somewhat uncontrolled and the irrigation channels after sometime show tendencies of river formation. The behaviour of Assam rivers is most unpredictable due to the heavy silt load carried by them. As such it is somewhat difficult to lay down any hard and fast rules for controlling the Dong and Bund system of irrigation in these tracts. A very close study of the silt load of these rivers is being carried out and it may then be possible to devise specific remedies for controlling these systems. However, on smaller channels some controlling devices could be provided. For example in some cases where rivers do not show much meandering tendencies, some kind of sluice control at the head of the irrigation channel would enable it to carry a fixed quantity of water. The bed slopes in the channel could also be restricted in some cases so as to prevent carriage of large quantity of sand and its eventual spreading on the fields.

CHAPTER V

THE TANK SYSTEM IN THE CENTRAL AND SOUTHERN INDIA PLATEAU

1. **The Multiple Paddy Crop :** Hyderabad and coastal regions of the East come within the influence of North East monsoons. This combined with hotter climate and less severe winter is conducive to the growth of a second crop of paddy and sometimes even a third crop. North of the Godavari river, i. e., in Madhya Pradesh, second crop of pady is unknown but South of this river, as we enter the Hyderabad State, it is a common practice to grow two crops of paddy.

Wherever water is available in the tanks during the winter season, the second crop of paddy, known in Hyderabad as the *Tabi* crop (i.e., the winter crop) is invariably grown. The first crop which is grown during the rainy season is called the *Abi* crop. The *Abi* is a 5 month crop. It is also seasonal, i. e., if its sowing is delayed beyond a certain time, it has to be given up altogether. The cultivators in that case have to take the chance of raising second crop (*Tabi*) which also is seasonal and is to be sown only at a particular time of the year.

The out-turn of the *Abi* crop is more than that of *Tabi* and its water requirements by way of irrigation are also much less. Thus for '*Abi*' crop water is allowed in the irrigation tanks at the rate of one million cubic feet for 6 acres, while for *Tabi* crop the same quantity of water is needed for 3 acres. The '*Tabi*' crop is, however, of a much finer variety and fetches better cash value. Whenever, therefore, there is the slightest possibility of getting irrigation water, a cultivator invariably grows the *Tabi* crop in a small portion.

In the west coast also, due to extremely wet conditions, multiple crop of paddy are grown. A description of this appears elsewhere (See Chapter VI).

2. **Series Tanks of Hyderabad :** The topography of Hyderabad and also Mysore is well suited for the construction of storage reservoirs. Telingana in Hyderabad where

most of the irrigation tanks are located is aptly known as 'The Land of Thousand Tanks'. Almost all the irrigation districts lie in this part of Hyderabad.

A special feature of the tanks in these tracts is their construction in series, by bunding the same valley at several points. The surplus water escaping over the wasteweir from one tank feeds the tank lower down and so on. Not only does the surplus water escape into it but the irrigation water from the fields under the upper tank, whatever of it seeps through the subsoil, also flows into the lower tank. Due to porous nature of the soil and sloping terrain of land, often large quantities of water are drained into the lower reservoir in this manner. This has the effect of improving the tank duty. Specially during the *Tabi* (dry crop) season, when the waste-weirs do not surplus, the effect is quite marked. The result would be somewhat similar in a system consisting of a series of anicuts across the same river or a combination of tanks and anicuts in the same valley. The series irrigation has the effect of improving the overall outlet duty of the system since water which escapes into the river after irrigating the upper field is picked up by the anicut lower down.

The series tanks have both advantages and disadvantages as compared to bigger tanks constructed across a single point in a valley. The main advantage of series tank irrigation is that the benefits of irrigation are distributed over the water-shed itself. In a big storage tank the catchment area does not derive any benefit and the entire irrigation is localized down-stream of the tank. In the series tank, the catchment of a minor tank is actually the ayacut (the commanded area) of an upper tank. As one motors down through Telingana, it is an interesting sight to see tanks on each side of the road, the upper tank draining into the lower tank and good cultivated land lying in between. Sometimes, when the land slopes upward steeply, one could see a chain of tanks the upper one feeding the lower. The other advantage as has already been mentioned, is the better use of stored water because the residual water after irrigation, which would otherwise go waste, finds its way into the lower tank. Very little water is thus lost by seepage and there is an overall improvement in the tank duty.

The main disadvantage of series tank is the breaching of the whole system during heavy rains. If due to excessive floods any tank in the chain breaches, the tank lower down is unable to bear the strain of the rushing waters from above and it also breaches. This continues on and the whole system downstream of the first breached tank breaches. This is why if any of the tanks in a series is not in a state of proper repairs, it would be desirable to breach it. Otherwise, if water is allowed to be stored therein, its subsequent breach would endanger the safety of all the tanks in the series. The remedy to this would perhaps lie in providing adequate flood storage by keeping the maximum water level sufficiently above the full tank level. This would enable the tank to absorb the impact of water reaching from the breached tank above.

While designing the series tanks, the common practice is to take the whole of the free catchment and only one-eight to one-sixth of the bunded catchment into consideration for purposes of determining the yield, flood influx etc. etc. For designing the wasteweirs of these series tanks, it may be desirable to treat the whole catchment as free. This would, to some extent, obviate the dangers of breaches occurring in the whole system, from a breach in a single tank. Theoretically, however, since each tank has a moderating influence on the floods, it would not be quite correct to have a surplusing arrangement as if the whole catchment were free. Another remedy would be to provide breaching section in one or both the flanks. When an upper tank breaches, the rushing water would be disposed of through the breaching section of the lower tank without causing any appreciable damage to the whole bund.

3. **Maintenance and operation of minor tanks in Mysore :** In this State, there are big and medium size reservoirs maintained by the Irrigation Department. In addition, there are a number of minor tanks maintained and managed by the Revenue Department. The latter are further sub-divided into major tanks and minor tanks. The tanks which yields a revenue in excess of Rs. 300/- are classed as major tanks and those yielding less revenue are classed as minor tanks.

The unit for capacity of an irrigation tank here is taken as 6-acre feet of water, i.e., under dry conditions, an acre of paddy would require 72″ depth of water for its maturity. Area irrigated from each unit of storage would depend upon—

(a) the actual rainfall, and also

(b) the number of fillings for which the tank is designed.

As both these factors vary from place to place, no fixed tank duty is adopted.

The responsibility to maintain these tanks in good condition is upon the *Atchkatdars* (i.e., beneficiaries). If they fail to maintain the tank, Government carry out the necessary repairs at their cost and the amount is recoverable as a revenue demand. If due to continuous neglect, the tank gets breached, its restoration is carried out under the provisions of the minor Irrigation Act. According to this Act, when a tank has to be restored, an estimate is prepared for its repairs by the Irrigation Officer and the amount notified to the beneficiaries. If they agree to contribute one-third of the cost, Government meet the remaining two-third cost and the work is carried out. The one-third cost is generally recoverable from the cultivators as a revenue demand.

In an already restored tank, the responsibility for maintaining the masonry works like the sluice and the wasteweir rests with Government and not with the *Atchkatdars*. The latter are required only to maintain the earth-work in the tank bund intact. Desilting of the tank basin is also not their responsibility. Repairs to the masonry works are expected to be carried out from a fund known as the "Irrigation Cess Fund" (I.C.F.) to which the *Atchkatdars* are required to contribute to the extent of one anna per rupee of the land revenue payable by them. The water rate is merged in the land revenue which varies from Rs. 4/- to Rs. 6/- for wet land and Rs. 1/- to Rs. 1/8/- for dry land.

Improvement to tanks and channels here cost near about Rs. 100/- per acre of the irrigable area. The cost of restoration of breached tanks goes up to Rs. 600/- per acre. The works of improvement and restoration under the minor irrigation programme receive priority over the construction of new tanks and new pick-up weirs on account of the high cost of the latter. Thus, the new tanks cost Rs. 1,000/- to Rs. 1,500/- per acre in the 'maidan' area. Similarly new anicuts and new pick up channels cost Rs. 600/- to Rs. 800/- per acre.

4. **The tank-cum-anicut systems :** The rivers which traverse the plateau of peninsular India come under the influence of both the monsoons—in the upper reaches of the catchment South West monsoon predominates while in the lower reaches, the North East monsoon is more effective and maximum floods occur during November. The result is that

as we approach the coastal zone, copious flow is always available in the rivers during the irrigation season—June to January. This forms the basis of anicut system of irrigation in South India. Masonry diversion weirs are constructed across rivers, often in series across the same river for diverting its water for irrigation purposes.

Due to failure of one or both the monsoons, specially, the North East, the river flow sometimes fluctuates within very wide limits and irrigation suffers. Assistance is taken from a series of tanks, reservoirs and sometimes big lakes constructed in the upper reaches of the catchment which store the flood water from the South West monsoons. In times of needs, this water is let out into the river and is again picked up by the anicut system. This results in assured supplies being available even in the dry years.

Alternatively, the anicuts themselves spill the flood water into a system of high level channels which feed a number of small tanks at their tail end. The flood flow of the river which would have, otherwise, run waste over the anicut is stored in such tanks.

When these local tanks, meant essentially to absorb fluctuations in the river supplies and thus stabilize irrigation, get silted up, recourse has to be taken to construction of bigger reservoirs. Almost invariably in Madras and Travancore-Cochin, the original irrigation system consisted of a number of minor tanks fed partly from their independent catchments and partly from the diversion of river water by anicuts. In course of time, the minor tanks silted up and lost their storage. Only the flow water in the river was available for irrigation and tanks functioned simply as passages for canal water. In years of scanty rainfall the river supplies were insufficient and a major reservoir had to be constructed in the head reach of the valley for stabilizing irrigation in the original ayacut (commanded area). Later on, when silting occurred in the minor tanks or there was continuous failure of rainfall, a second reservoir had to be constructed. Although these reservoirs were meant to provide additional supplies also to meet the irrigation needs of the expanding ayacut, the fact, however, remains that the continuous silting of the minor tanks has resulted in the loss of very valuable irrigation storage. It has also adversely affected the local distribution of water especially in the tail areas. For the cultivators in the tail areas, the minor tanks are a valuable asset from both points of view and they are always most anxious to get the tanks de-silted and restored.

Examples of anicut-cum-tank irrigation and the manner in which the major reservoirs recondition their operation, could be seen almost everywhere in South India. Thus before the construction of the Periyar reservoir, a thin stretch of land on either side of the Suruliyar river known as Cumbum valley was under irrigation from a series of about 15 anicuts across the river. Similarly, a portion of the Periyar delta used to be irrigated from a series of tanks both big and small which had independent catchments. With the construction of the Periyar reservoir, both the Cumbum valley and the minor tanks now form a part of the Periyar system.

The anicuts and the channels irrigating the Cumbum valley were remodelled and improved and there was expansion of irrigation in this area. The minor tanks in the Periyar delta have had somewhat a different fate. Some of these tanks are owned by Government and some by Zamindars or private individuals. The former are classed as 'A' tanks and the latter as 'B' tanks. These are further subdivided—under one category are included those tanks which are big in size and have independent catchment of their own. Such tanks would effectively contribute to the water supply in the Periyar system. Under the other category are the small size tanks which have no appreciable catchments of their own and which would, therefore, simply serve as passages for canal water. The former are classed as 'A-1' and 'B-1' and the latter as 'A-2' and 'B-2' tanks. With the coming up of the periyar irrigation system, it was decided to maintain the 'A-1' and 'B-1' tanks as an effective part of the Periyar system—the former by Government and the latter by private owners. If the latter failed to maintain the works and the tanks went out of repairs, Government would undertake to restore such tanks at owners' cost. Regarding 'A-2' and 'B-2' tanks, Government were, at one time, contemplating to breach them and allow the land in the tank beds to be cultivated. As there was lot of opposition, the 'A-2' and 'B-2' tanks were left as they existed. The private individuals were permitted to maintain them if they so desired but Government would not spend any money on those works.

The small channels of the Periyar irrigation system either pass through the small tanks (A and B) or tail in them. With the presence of these tanks not only is additional storage available but the distribution system functions very efficiently. The main channels fill the tanks and the cultivators take water from them as and when required. The result is that the working duty is very high. It is of the order of 90-120 acres per cusec as compared to 30-40 acres per cusec in the Cauvery delta of Tanjore district.

In the recent past, restoration and improvement of these minor tanks and their proper maintenance has assumed special importance in view of the rising costs of new irrigation works. As in Mysore the new works in this part of the country also cost anything from Rs. 800/- per acre to Rs. 1,500/- per acre. In the case of minor tanks it is possible to effect improvement and restoration in Rs. 150/- to Rs. 500/- per acre.

In the dry parts of the Salem district, there are a number of small tanks which get their supplies from channels taking off from anicuts built across adjacent streams. The independent catchment of these tanks are not big enough to feed them to their full capacity.

5. **Irrigation in the Cauvery Valley :** The Cauvery irrigation is at present one of the most perfect systems in South India. The physical features, the rainfall conditions and the cropping practices in this valley are typical of the drier regions of the peninsular India. A description of minor irrigation practised in this valley, its subsequent development and merger with the major irrigation reservoir systems, would perhaps give a clear picture of the practices followed in the whole of this region :—

(i) *Coorg :* The head reach of the Cauvery valley lies in the State of Coorg which is at the Southern extremity of the Western ghats. With its numerous coffee plantations, pepper and cardamom gardens and terraced paddy fields, this is a beautiful and picturesque country. Rainfall is very heavy (80″-150″) and the well drained conditions here are most conducive to the growth of coffee. Paddy is the main food crop grown under wet conditions. Here the duration of the crop is longer than in Mysore and Hyderabad. Harvesting takes place by the end of December. Generally, only one crop is raised. People are fairly well off with a single crop and are not bothered about raising a second crop. Apart from this, the long duration paddy crop leaves very little time for any second crop.

Irrigation here has been practised on a small scale for the past several years. It is mainly confined to the rain-shadow regions of low and uncertain rainfall. Some of the works constructed as long back as 60-70 years are still functioning satisfactorily. These mainly consist of low level diversion weirs across streams built for the purpose of diverting their water into the paddy fields. The hills absorb lot of rain water which regenerates either as stream flow or in the form of springs after the cessation of rains. Most of the streams in this region, therefore, carry large quantities of flowing water late in the dry season even though their catchments may be small. The irrigation capacity of diversion works across the stream is limited more from considerations of non-availability of land rather than non-availability of water. Seeing these channels and the terraced fields along the hill slopes, one is reminded of the Kuhls and similar paddy fields in the hilly regions of Northern India.

Some of the old works could be seen in the Aigoor village (19 miles from Mercara) and another village in South Coorg (14 miles from Mercara). The former consists of a masonry anicut, 75 ft. in length and is over 40 years old. It was constructed by the old State Government. It irrigates an area of 500 acres though lot of excess water is available. The other work is called the Abhyath Mangla anicut. It is about 60 years old. A channel, 4 miles in length takes off from the anicut and irrigates 300 acres. Both these anicuts have one or two openings fitted with a single row of wooden plank shutters, which function as scouring sluices. In the sluice controls also at the head of the irrigation channel, plank shutters have been used for controlling the supplies. Since water is available in large quantities, very water-tight arrangements are not needed and a single row of plank shutters serves the purpose. On account of rocky bed, protection works downstream of the anicuts are usually not required.

There are a number of other similar structures some of which have collapsed and some are in a state of disrepairs. The Minor Irrigation Department in Coorg has recently started an extensive programme of repairing these works and constructing a number of new works on somewhat similar lines. On these works Government investment is in the neighbourhood of about Rs. 50 to Rs. 75 per acre.

Where permanent structures do not exist, the cultivators divert water by throwing temporary earthen bunds across the streams. Often these bunds are washed away much before water reaches the cultivator's fields and irrigation suffers.

In addition to diversion works, there are a number of small irrigation tanks. Their storage capacity is small but the area served by each tank is sometimes quite large. The reason is that these tanks are built across perennial streams or are fed by seepage from the adjoining hills. Water continues to flow into the tanks long after the rainy season. Essentially, these are also diversion works and their storage is not so effective as the perennial flow which is tapped by the tank. Many of these tanks have gone into a state of disrepair and water escapes into the valley without doing any irrigation. The Minor Irrigation Department have taken up the restoration of these works also.

(ii) *Mysore:* Leaving the Ghats, the Cauvery enters the State of Mysore. The Southern half of the State lies in the Cauvery basin. The Western ghats which form the boundary of Mysore, fall within the water-shed of the Cauvery river.

The tract stretching down the Ghats covers a hill forest area and is known as 'Malnad'. Like Coorg, rainfall here is heavy and ranges from 100″ to 200″. All the water from this tract is brought into the Cauvery river through its tributaries, Hemavathi, Lakshmana Tirtha and the Kabini, which also have their source in the Ghats. At the junction of Cauvery with the first two tributaries, is located the famous Krishnarajsagar reservoir of Mysore. As we proceed further East, we reach the Maidan portion of the Mysore State. This is the rain-shadow region and the rainfall here is much less. It varies from 25″ to 40″, almost the whole of which is during the period from June to October.

Wherever irrigation facilities are available, paddy is the main crop. Ragi is also an important food crop and is grown under rainfed conditions. Here paddy is slightly a longer duration crop than in the neighbouring State of Hyderabad, i. e., harvesting takes place 2-3 weeks later and not earlier than the end of November or first week of December. Unlike Hyderabad, the practice of raising a second crop of paddy, i.e., during the winter season, is not common here. The reasons are that this tract is not within the zone of the winter monsoons and also due to late harvesting of the first crop, very little time is left for the second crop. Apart from paddy, commercial crops like sugar-cane and areca are also grown where irrigation facilities are available.

In this region of the Cauvery valley, irrigation is practised both by tanks and anicuts. The tanks in existence are of all sizes. A description of these appears elsewhere (paras 2 & 3).

The anicut system is equally common. The Kattepur anicut, the Chamaraja anicut across the Cauvery river, the Himagiri anicut and the Mandagore anicuts across the Hima-vathi and the Hanagood anicut and Siriyur anicut across the Lakshmana Tirtha are some of the main anicuts upstream of the Krishnarajsagar reservoir. Channels take off generally from both sides of the anicut and irrigate a thin strip of land between the river and the channels. Paddy is the main crop grown in these irrigated fringes of the river bank. A number of such anicuts exist all along the course of the Cauvery river. There are similar anicuts across the Bhavani river also—a tri-butary of the Cauvery which is joined by the former lower down. Periyakoduveri anicut and the Kalingarayan anicuts are the two main works irrigating narrow stretch of land close to the Bhavani river. Both these irrigation systems now form a part of the Bhavanisagar irrigation system.

With these anicuts in the Cauvery valley is closely asso-ciated the name of Sultan Tipu, one of the best rulers of eighteenth century decadent India. Scripts bearing his name could be seen on the archeological remains close to the site of the Kalingarayan anicut across the Bhavani river near Erode. Following is an English translation of a stone-inscription dis-covered at site of the Krishanrajsagar reservoir :—

"1794 A.D.

Yafttah

In the name of God, The Compassionate, The Merci-ful. On the 29th of the Solar year Shadab, 1221 (one thousand two hundred and twenty one) dating from Mowlood of Mohammad (May his soul rest in peace) on Monday at Dawn before sunrise under the auspices of the Planet Venus in the constellation Tarus, Hazarath Tippoo Sultan, the shadow of God, the Lord, the Bestower of Gifts, laid the foundation of the Mohyi dam across the river Cauvery to the West of the capital, by the Grace of the God and the assistance of the holy prophet, the Caliph of the worlds and the Emperor of the Universe. The start is from me but its completion rests with God.

On the day of commencement, the Planets, Moon, Sun, Venus, Neptune were in the sign Aries in a lucky conjunction. By the help of God, the most High, may the above mentioned dam remain till the date of resurrection like the fixed stars. The money amounting to several lakhs, which the God given Government has spent solely for the service of God. Apart from the old cultivations, any one desirous of newly cultivating the arable land, should in the name of God, be exempted from various kinds of productions, whether of corn or fruit, of the one fourth part levied generally from the subjects. He will only have to pay three fourths of it to the benign Government. He, who newly cultivates the arable land himself, his posterity and other relatives will be the masters of the above as long as earth and heaven endure. If any person were to cause any obstruction or be a preventor of this perpetual benevolence, such a human being is to be regarded as the enemy of mankind as the accursed Satan and a Sperma Lommis of those cultivators, nay of the entire creation."

The tanks and anicuts individually or jointly form the basic system of minor irrigation in this valley. Originally, there were no major works in existence. Later years saw the construction of three major resorvoirs, Krishnarajsagar, Mettur and Bhavanisagar. Both the Krishnarajsagar and the Mettur systems, each tapping the Cauvery water, were inter-State projects. It was after a long time that an agreement was reached between the Governments of Mysore and Madras. According to this agreement, the Mysore Government have to release from the Krishnarajsagar reservoir whatever quantities of water are received each day from May to January every year. The Krishnarajsagar reservoir is permitted to hold only such quantities as are in excess of the above limit of discharge fixed for each day. These are based on the irrigation requirements in the Madras territory before the construction of the dam.

The Krishnarajsagar reservoir is essentially a hydro-electric scheme though irrigation in a large area is also one of its important functions. Prior to the construction of the K. R. reservoir, there was a hydro-electric station at Shivasmudram where there is a big drop in the bed of the Cauvery river. Due to limited flow in the river, the station could generate only about 13,000 H. P. From the storage of the K. R. reservoir it is possible to increase the summer supplies several times and in consequence the generating capacity of the station at Shivasmudram has been stepped upto 60,000 H. P. This is the main objective of the K. R. project. The second object is to utilize a part of the storage for irrigating about 1,25,000 acres in the Mandya district of Mysore. A high level canal now known as Viswasheshwariya canal takes off from the reservoir for the irrigation of this tract.

(iii) *Madras :* After leaving the Mysore plateau the river enters the sub-mountainous districts of Salem and Coimbatore in the Eastern ghats and thence into the plains. At the point where the river leaves the mountainous country and enters the plains, the Mettur dam has been constructed. This is a big irrigation storage reservoir which supplies water for irrigation of the Cauvery delta. Like the Krishnarajsagar, this project was also concieved quite a long time back. The scheme could not, however, be taken up till an agreement had been reached between the Government of Mysore and Madras regarding the apportioning of Cauvery waters. The main objective of the Mettur dam is to stabilize irrigation in the Cauvery delta and also to moderate the floods in the Cauvery river. In addition to fulfilling the requirements of the Cauvery delta, lot of additional area has also been brought under irrigation. The Cauvery delta irrigation system headed by the grand anicut is several miles away from the Mettur dam. Water from the dam is released directly into the Cauvery river and is again picked up by the anicut system of the Cauvery delta. The reservoir supplies the irrigation requirements of 13.5 lakh acres in the Cauvery delta system. As stated earlier, the reservoir acts as a flood moderator in times of heavy floods. Provision also exists in this dam for generating hydro-electric power. Although the Mettur dam is situated in the Salem district, its waters do not benefit any portion of this bare and rugged country. Recently, a scheme has been conceived to dig out a canal just downstream of the Mettur dam for irrigating portions of the Salem district. Work on this is about to be completed shortly.

The tract from the point where the Cauvery enters the plains is under the influence of the North East monsoons and heavy floods occur usually in November. Water is brought into the Cauvery river from its chief tributaries Bhavani and Amravati which have their source in the zone subject to North-east monsoons. The Bhavani valley consists of a bare and a rugged country. Except for a few pockets in a narrow fringe near the river, the soil is suitably described as shallow, light, gravely loam.

The North east monsoons are generally weak and sometimes very uncertain, the total annual rainfall being in the neighbourhood of 25″ to 30″.

The lower Bhavani reservoir has been constructed across the Bhavani river just below its confluence with Moyar. The Bhavani joins the Cauvery about 50 miles downstream. Being in the same valley, irrigation under the Bhavanisagar reservoir is closely linked with irrigation in the Cauvery delta of the Tanjore district.

Till recently, the cultivator in the South has been associating irrigation only with the paddy crop and practically no attention was paid by him to the raising of lightly irrigated crops like Ragi under irrigated conditions. In many of these big projects, it has been the policy of Government to encourage dry crop cultivation under wet conditions.

Before the construction of the Bhavanisagar reservoir, irrigation was mostly practised from wells. The area under wells was mostly sown with dry crops of millets and pulses like cholam, cumbum, ragi and cotton. These crops are grown in this tract both under irrigated and dry conditions. Due to constant failure of North east monsoons during the past few years, the out-turn from the unirrigated crops has been extremely poor. The crops under irrigation from wells also suffered badly because the yield in the wells had considerably diminished due to poor rainfall.

The water stored in the Bhavanisagar reservoir is mainly intended for the irrigation of dry crops. Wet cultivation like paddy would be confined to the original area under the two anicuts, viz., Periyakoduveri and Kalingarayan. Issue of water from this reservoir has been so timed as not to allow growing of wet crops in the ayacut.

Cultivators, however, wanted to instal and have actually installed pumping sets on the wells for growing wet crops. The Irrigation Department argued that by installing power pumps the cultivators will actually be pumping out the canal water. Not only would the emphasis on growing of dry crops under irrigated conditions thereby diminish but also irrigation in the tail areas would suffer. With the opening of the Bhavani canal, the water level in the wells rose by about 10-15 ft. almost everywhere. If water were allowed to be pumped from such wells, it would be only at the risk of losing flow irrigation in the ayacut lower down. Cultivators who have been irrigating only 2-3 acres of uncommanded land from the wells would, after the installation of pumps, be in a position to irrigate 7 to 8 acres of such land where canal water would not normally flow. The natural result would be the expansion of lift irrigation at the cost of flow irrigation. The Irrigation Department have, therefore, imposed several restrictions and rightly too, upon the pumping of water from the wells located within the ayacut of lower Bhavani reservoir. This was very necessary as otherwise the programme of emphasizing dry crop cultivation under irrigated conditions could not be successfully carried out.

As the Cauvery and its tributaries emerge out of the sub-mountainous districts of Salem and Coimbatore, the valley opens out into the coastal plains of the Tanjore district. A brief description of the irrigation practices here is given elsewhere (Chapter VI).

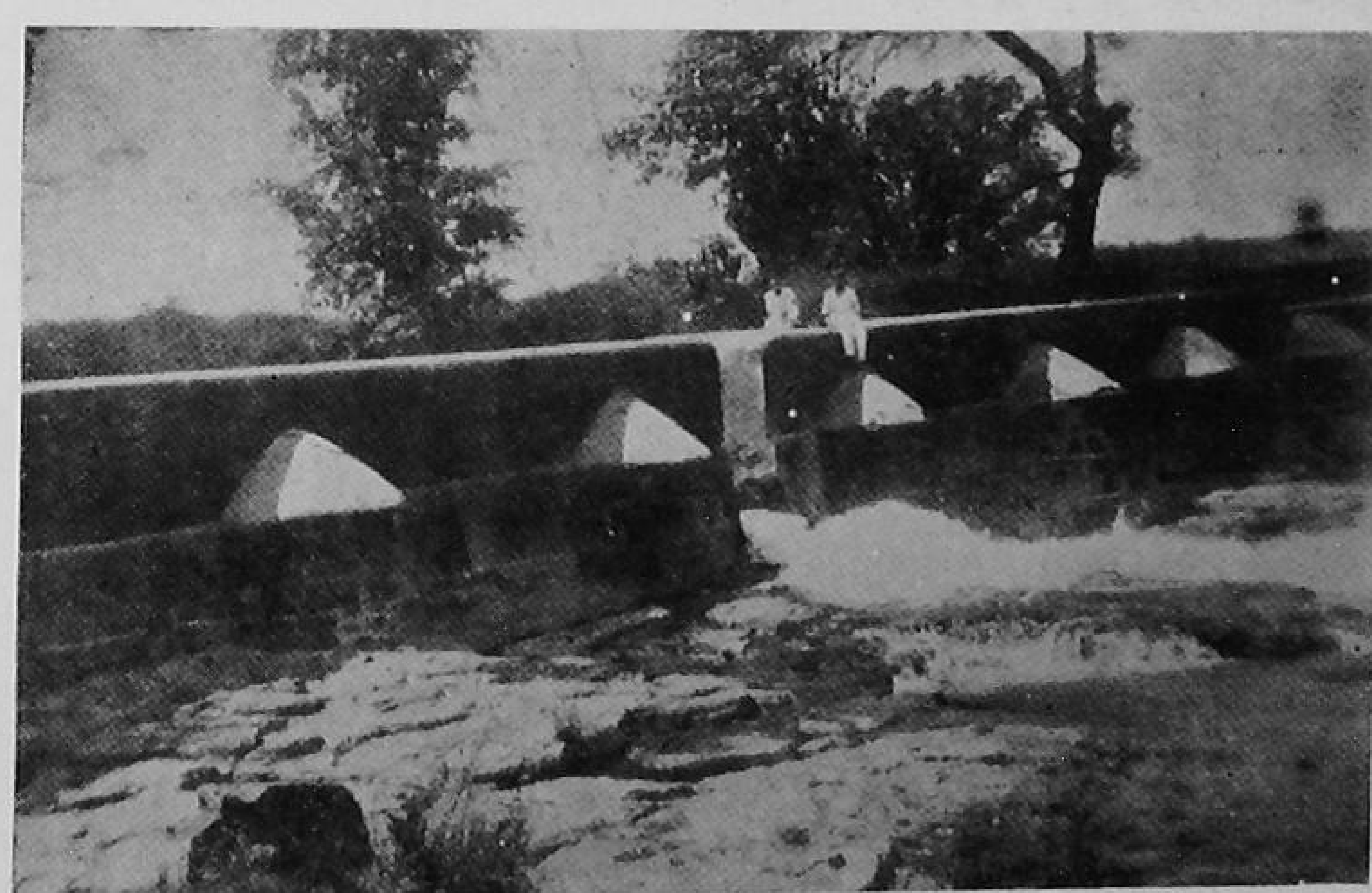
6. **Pat system of Irrigation in Madhya Bharat :** This system of irrigation is practised in the sub-mountainous tract of the Narbada valley at the foot of the Satpura range. The de-composed black trap overlying the mountain ranges in the upper reaches or underlying the rich black cotton soil lower down possesses some peculiar characteristics. It absorbs and retains rain water and forms almost an inexhaustible source of water supply. In the upper regions, water thus absorbed is regenerated as stream flow during the open season. This has given rise to a number of perennial streams and rivulets which form the main source of irrigation in this area.

An earthen bund is thrown across the stream after the rains and water headed up. Small gradient flow channels taking off from one or either side of the bund, divert this water into the Rabi fields. This is known as the 'Pat' system of irrigation in this tract. On account of good slope in the land, command is easily available within a short distance of the diversion bund. A number of such works, some in a state of disrepair and some in actual operation could be seen in the Nimar districts of

Madhya Bharat and Madhya Pradesh. The following extract from the gazetteer of the Khandwa district (Madhya Pradesh) would be of interest :—

> "In the centre of the Khandwa Tehsil irrigation by channels is occasionally practised. A dam of palm trunks and mud (called 'pat') is thrown across a small stream and an open earthen channel leads the water into the fields, the owners of which combine to construct and repair the dam. It is repaired after the rains have ceased, when there is still a small flow of water in the stream, and is used to irrigate spring crops. Forsyth ascribes the introduction of this method to the Mughals as it is common in Afghanistan and in Muhammedan countries."

During the late Holkar State regime, a number of masonry diversion weirs were constructed to replace the temporary bunds. The Surana weir, Ponwalanalla minor irrigation weir (Madhya Bharat) and the Abna river anicut at Kharwa (Madhya Pradesh) are examples of this kind of construction. Most of the old diversion weirs have been out-flanked because they used to block practically the entire waterway. The weir walls were provided with only one or two openings 4 to 5 ft. wide and were constructed right up to bank level and sometimes up to the high flood level. Outflanking was thus sure to occur.



Abna River Anicut at Kharwa in Khandwa Tehsil (Madhya Pradesh)

It appears attempt was made to get the command as close to site of work as possible. The bed slope in most of these hilly streams varies from 1 in 200 to 1 in 300 which is also roughly the land slope on either side. Since a bed-grade of 1 in 800 to 1 in 1,000 would be sufficient for the irrigation channel, command would be easily available from low level diversion weir within half to one mile of the headworks. The purpose would, therefore, be easily served by having low level diversion weirs. As more and more of these types of works are taken up, progressive improvement in the design is noticeable. Most of them can cope up with the high flood discharge in the river and those which cannot, are being provided with suitable surplussing arrangements so as to prevent their outflanking.

These diversion weirs are costing in the neighbourhood of Rs. 200/- to Rs. 300/- per acre of land brought under irrigation.

7. **Tanks of Central India :** In Madhya Pradesh the irrigation tanks are essentially meant to give protective irrigation to paddy crop. Here large areas under paddy are sown under the broadcast system. Transplantation is done in a limited area and it is not the common practice to issue irrigation water for transplantation operations. Instead the paddy fields

The Tank Work in Rajpur Community Project (Madhya Bharat) showing the excavation of Puddle Trench.

are ploughed when the crop is 8 to 9 inches high and rain water has collected in the fields. This operation is locally known as "Biasi". It is a crude method but has the effect of transplantation.

With a rainfall of 40 to 50 inches not much irrigation is needed till the end of August. In September there is often a break while in October rains fail frequently. At this time irrigation water is badly needed and the irrigation systems here serve the useful purpose of correcting rainfall irregularities during the months of September and October. In northern districts of Madhya Pradesh which have heavier soil and are fit for double croping, Rabi irrigation is also done from the water left over in the tanks.

Because of good rainfall water required for irrigation of the Kharif crop here is far less than in the adjoining State of Hyderabad or southern regions. The tank duty obtained on irrigation works in these parts is about 15 to 20 acres per million cubic feet of storage. Since irrigation is done during the monsoon season the tanks are generally designed for two fillings. It costs about Rs. 300/- to 400/- to protect an acre of land by tank irrigation. For repairs and improvement of the existing tanks the cost is generally Rs. 100 to 150 per acre of land benefited.

In Orissa the rainfall is heavier and the crop requires still less water. Here also irrigation is of a protective nature. On account of heavier rainfall and less water requirements the capital cost of irrigation per acre in these regions is somewhat less ranging from Rs. 200 to Rs. 250. A duty of 25 to 30 acres per million cubic feet storage is obtained on these tanks and they are designed for 2 to 3 filling.

8. **The Bandharas of Bombay :** In the Nasik and Khandesh districts of Bombay, irrigation from Bandharas is practised. These are low level diversion weirs across steams for irrigating land on either side of the river. Malegaon is well known for its irrigation systems from the Mosam river. Water of this river is used by putting well-designed diversion bunds at several points. These districts have rainfall of about 30″.

Till lately, the Bandharas were intended for irrigation of only the post-monsoon crop. The irrigation capacity of the Bandharas was, therefore, determined from the winter flow available in these streams. The present practice aims at making maximum utilization of both the monsoon and the post-monsoon flow in the rivers. The result is that irrigation capacity of these works is now much more than what it used to be.

During the monsoon season, mainly the food crops are irrigated including the dry crops. Although the discharge in the streams fluctuates within wide limits, depending upon the actual incidence and intensity of rainfall, the irrigation capacity of these works does not vary to the same extent. The reason is that the canals from Bandharas are now generally designed to carry much larger quantities of water than the post-monsoon flow. Since the discharge fluctuates, the canal supplies also fluctuate, but the total quantity of water delivered in the field during the whole monsoon season does not appreciably vary unless the total rainfall is much below the normal. So long as the total quantity of water delivered during the crop season is sufficient, variations in the depths of watering do not have much effect on the irrigation of dry crops. For these reasons, it is now commonly advocated to design the canal systems from Bandharas for maximum flow in the stream as long as land under command is available.

The soil condition of these two districts also has the effect of stabilizing the fluctuations in the stream flow during the monsoon season. Because of sufficient thickness of the soil cover and its retentivity, a substantial portion of the water diverted during periods of peak flow is stored therein. When the river supplies are low, the water stored in the soil, supplies the necessary moisture for the growth of the crop.

During the Rabi season, of course, the area under direct irrigation is determined only from the post-monsoon flow. Here again, flooding is often resorted to and advantage is taken of the retentive nature of the soil. Just before the Rabi season starts, the area is flooded from water diverted by the Bandharas. The moisture retained in the soil after flooding, supplemented by direct irrigation, supplies the necessary water requirements of the Rabi crop.

It is a common practice to construct Bandharas in series across the same stream. The effect of diversion of water by these series of Bandharas is to flood and saturate the whole valley with moisture. Virtually, it amounts to the storage of water in the soil, which would have otherwise run waste into the stream. Also, water stored in the soil helps to strengthen the post-monsoon flow and thus make more water available for direct irrigation during the rabi season. It is obvious that this storage would not be possible if the soil cover is not of sufficient thickness and is not retentive.

Kolhapur and Belgaum districts have similar soil and rainfall conditions and in these districts also, the scope for Bandhara irrigation is very great. In the Satara and Poona districts where the rainfall condition is similar but the soil is neither retentive nor of sufficient thickness, much possibility for Bandhara irrigation does not exist.

9. **Submerging tanks :** This system of water conservation is peculiar to the Central India tracts and could be seen in the Kotah district of Rajasthan, in the Gird district of Madhya Bharat, the Sagar and Jubbulpore districts of Madhya Pradesh and the Jhansi district of Uttar Pradesh. All these areas are contiguous. In the Jhansi district, these works are popularly known as 'bundhis'.

Ordinarily, the tanks do not do any direct irrigation. They benefit the land by submergence. 'Bundhis' consist of earthen embankments thrown across side-long ground. During the rainy season water is stored upstream and the land gets submerged. If the land slope is gradual, often large areas get submerged even by low embankments. In the case of big embankments, impounding big catchments, the surplus water is allowed to escape through a masonry waste weir generally located in one of the flanks. After rains water is let out and the tank bed released for cultivation.

In all these tracts, the soil is generally black and contains substantial portion of clay. This enables it to retain moisture for a long time and it is possible to grow a good crop of wheat therein without any irrigation. The other advantage of submerging the land in this manner is that the first floods bring lot of silt with them which acts as a rich manure. So, also, growth of weeds is arrested and whatever weed already exists, dies off. The dead weeds greatly enhance the manurial value of the soil. A third and a very important advantage of the submerging tanks is the soil conservation. By preventing free flow of water across steep gradients, the agricultural wealth of the soil is permanently conserved.

In the Jhansi district, the 'Bundhi' system of irrigation dates back to very olden times. Many of the old 'bundhis' are still in existence and function properly. Early this centuary, when there was famine almost all over the country, a number of these 'bundhis' some of them quite big, were constructed by Government as a famine-relief measure. After recovering a small proportion of the cost of construction, Government handed over these 'bundhis' to the local land holders. The 'bundhis' in this district are thus now held singly or jointly by the cultivators with the exception of a few which are owned, maintained and managed by Government. When the 'bundhis' are maintained by the Irrigation Department, a water rate of Rs. 4/- per acre of the submerged area is charged from the cultivator. When the 'bundhis' are owned singly, the owners generally maintain these in proper order except when they find it beyond their means to repair a breached 'bundhi'. Where, however, a 'bundhi' is owned jointly by a number of cultivators, proper maintenance is almost impossible and the 'bundhis' go into a state of disrepair. This is due to lack of co-operation among the villagers.

When the land slope is gradual the Bundhis cost Rs. 100/- per acre of land submerged. When, however, the slope is steeper, the cost goes up to Rs. 150/- to Rs. 200/- per acre.

Similar 'bundhis' could be seen in the Kotah and Bundi districts of Rajasthan. Often large catchments are impounded and the bunds have regular wasteweirs and sluice gates, the latter being provided at the deepest point to drain out the water. Quite a large number of these bunds could be seen in the Saugor and Jubbulpore districts of Madhya Pradesh. Like the Jhansi district, here also, several big bunds were constructed during the famine of 1905 as a relief measure.

Sometimes the water stored in the submerging tanks is utilized for irrigation of paddy crop lower down. Generally, the soil texture and rainfall conditions would determine the feasibility of both the crops being grown in the same tract, i. e., wheat on the upstream side and paddy on the down-stream side. The difficulty that is usually encountered is that the tank bed has to be emptied a few weeks before the sowing starts. If irrigation is needed in the paddy fields at this particular time, due to break in monsoons, the water stored above could be advantageously utilized for irrigation of the paddy fields lower down. But if break occurs later on, i.e., after the tank has been emptied, such tanks would not offer much protection. In the Gird district of Madhya Bharat, it is a practice to submerge land upstream for wheat cultivation and simultaneously do paddy irrigation downstream of the tank bund. This is not so in Kotah district of Rajasthan and the Western part of Sagar district in Madhaya Pradesh. In Sagar the soil is perhaps not suitable for growing paddy while in Kotah, the rainfall is not sufficient for the paddy crop. Similarly, the 'bundhis' of Jhansi are also not used for doing any direct irrigation.

10. **Flood Irrigation in Madhya Pradesh** : In the wheat zone of Madhya Pradesh, it is generally not the practice to have bunded fields as is the case in paddy tracts. In some districts, however, of Madhya Pradesh, viz. Jubbulpore and Hoshangabad, wheat fields are invariably bunded. This area constitutes what is locally known as the 'Haveli Tract'. The main intention of bunding seems to have been to prevent soil erosion because of the heavy rainfall here.

Later on, the cultivators taking advantage of the bunded fields took recourse to artificial flooding. This is achieved by throwing temporary earthen bunds across streams and sometimes big rivers during the monsoon season. Generally, the first floods are diverted into the fields after which the bund across the river breaches. Spreading of flood water, sometimes on a large tract of land, takes place in a short time, viz. in the course of just a few days.

Flooding of bunded rabi fields in the above manner has several advantages. In the first place, the soil with 1′ to 1½′ depth of water permanently standing on it, gets saturated with moisture and remains so during the whole of the monsoon season. The result is that after the rainy season when the fields have been emptied of their water, bumper crops of wheat could be grown without any irrigation. The effect is the same as that of submerging tanks described earlier. The second advantage is that, with the diversion of the first floods on the land, lot of silt is brought which acts as a rich manure. There is yet another advantage. Under natural rainfall conditions, weeds have a tendency to grow because the fields get water gradually and in stages which helps their growth. By suddenly flooding the land with a foot depth of water and sometimes more, the weeds die down and their further growth is arrested. The decayed stuff also serves as manure.

Sihora regulator in Jabalpur district (Madhya Pradesh) which does flood irrigation.

Above are the several advantages of artificial flooding but when flooding is uncontrolled, the field bunds break and sometimes large scale damage takes place. Recently, attempts have been made to have controlled flooding. The regulator in Sihora, 25 miles from Jubbulpore, is a work of this kind. It has been constructed across the Bah nalla (having a catchment are of 35 sq. miles) and has been provided with double rows of plank shutters. The planks have handles attached to them and they could, therefore, be taken out even during floods by means of chains provided with hook at their end This regulator is able to flood 5,000 acres of compact block of rabi land from year to year. Flooding has thus been achieved here at a cost of about Rs. 3 per acre.

11. Lift Irrigation from Ground Water in South :

(i) *Wells* : Where tank or anicut irrigation is not available, ground water through open percolation wells is made use of. When the wells have good supplies, wet crops are grown but when the supply is scanty only dry crops are raised. Sometimes the wells are situated close to a tank and in consequence have plenty of water supplies. Such wells are used either for supplementary irrigation of paddy when the supply from the tanks is deficient or for independent irrigation of paddy. In other places, where the ground-water supplies are insufficient for paddy, cultivators generally grow ragi, cholam and other dry crops under light irrigation.

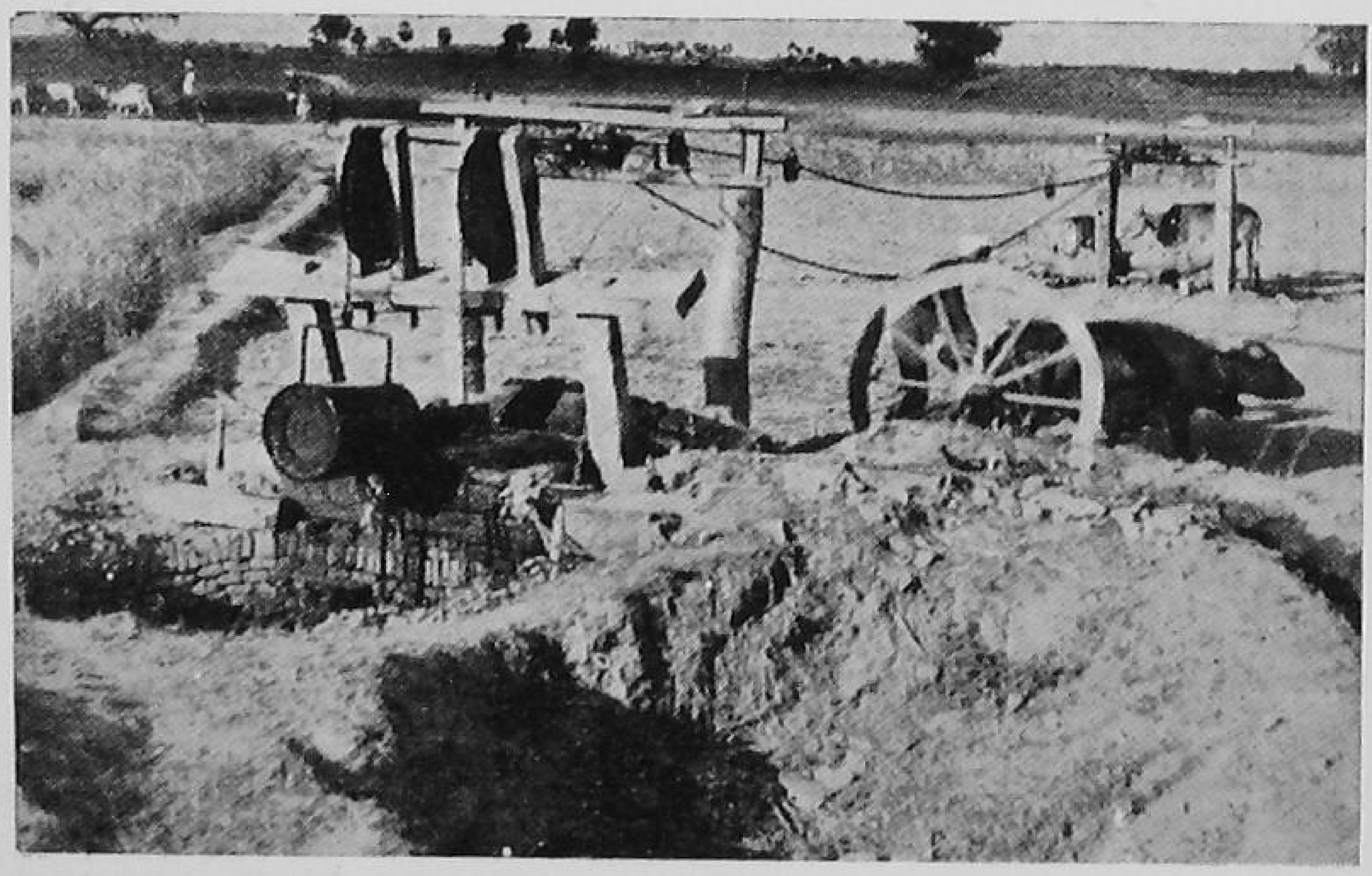
In the Madurai district, on the periphery of the periyar delta, and outside the command of its canal, well irrigation is extensively practised. In these tracts, wells receive their supplies from fissures in rocks where permanent springs may also exist. In the subsoil, rock is struck at a depth of 10 to 20 ft., the top layers consisting of gravely earth. This earth is generally non-water bearing and excavation has to be done in rock for assured supplies. It is not the practice here to construct circular wells. The excavations are generally rectangular and are sometimes very big in size—as much as 90 ft. × 90 ft. The intention in constructing such big sized wells is not to tap large exposed surface of water bearing strata because the supply is only from isolated springs. The main purpose is to create storage. The discharge available from the springs is small but since storage is available, water continuously collects in the wells. When power pumps work on such wells, much bigger quantities of water can be drawn from it than the normal capacity of the springs feeding the well. Irrigation of larger area is thus rendered possible, i. e., the full 24 hour inflow into the well (or even a longer period inflow, if the watering timings are far apart as would be the case with dry crops) is picked up by the power pumps working for much shorter duration and full use is made of the available supplies.

For augmenting the yield of these wells, boring is often resorted to. The bore holes are generally 3″-4″ in diameter and are 100-150 ft. deep, most of which is in rock. These tap additional fissures which results in increased yield. An idea of the yield of these wells, their irrigation capacity and the cost could be had from some of the wells in the Madurai district. The details are given below :—

(i) A well 90 ft. × 80 ft. × 48 ft. deep had 18 ft. of water. A 10 H. P. pump installed on this well was able to pump about 8,000 to 10,000 gallons of water per hour against a lift of 48 ft. With this big storage available in the well, the pump works successfully for 10 hours a day. The total cost of the installation including the cost of the well is Rs. 40,000. It irrigates 50 acres of wet and 30 acres of dry crops. The soil here is clayey and hence somewhat less water is needed for irrigation.

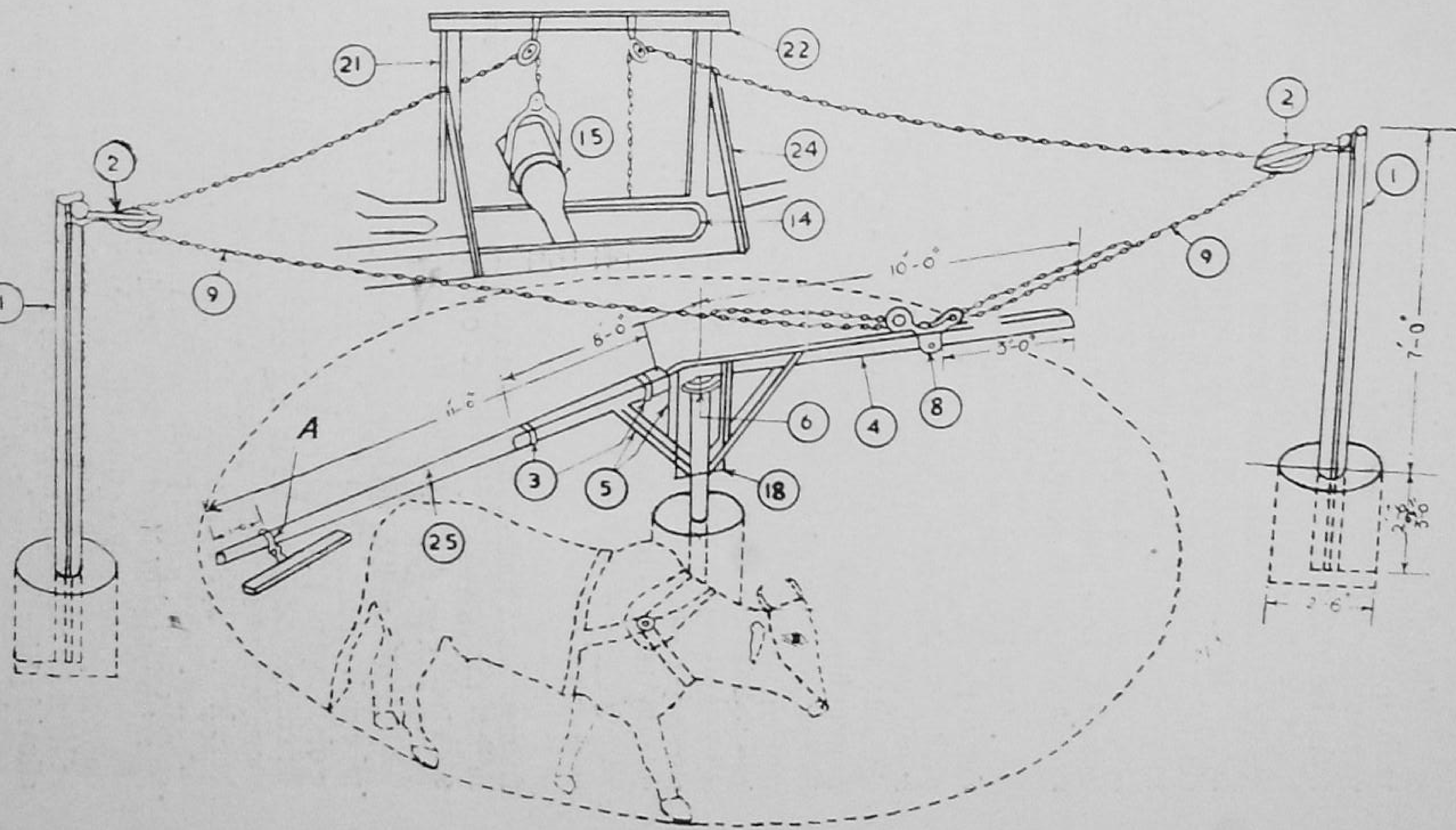
(ii) Size of the well is 33 ft. × 30 ft. The subsoil consists of 4 ft. of murrum from the top, hard gravel up to 12 ft., then granite up to 30 ft., and after that hard rock. Two bore holes were sunk in the well 97 ft. and 110 ft. from the ground level. A 5 H. P. pump electrically operated has been installed on it. The total cost of the well, the pump and the bore holes is Rs. 11,500/-. Prior to boring, the 5 H. P. pump used to exhaust the well in half an hour. After sinking of the two holes, about four hours supply for the pump is available. The well irrigates four to five acres of dry crops like Ragi, Cholam etc. requiring two waterings a week.

In addition to pumps, manually operated lifts are also commonly used. In the Coimbatore district, the circular mhote system is an interesting device. It consists of rope and pulley arrangement with a central rotating lever operated by two bullocks as shown in figure 1. It employs two buckets of 16 gallons capacity each. These buckets are held up and go down alternately so that at no time the bullocks are required to pull both. This circular mhote is suitable only for short lifts not exceeding 12 ft. Capacity of this mhote is about 3,500 gallons per hour.



Circular Mhote system in South India

IMPROVED CIRCULAR MHOTE



(iii) *Tube Wells :* Irrigation from ground water by tube wells has also been attempted in some parts of this sub-mountainous country. These tube wells are quite different from those sunk in the alluvial plains of northern India. In the latter case, the discharge from the tube wells depends mainly on the extent of water-bearing strata tapped. The larger the water bearing strata, the more would be the discharge. In the former case, boring is through rock. The supply of water to the tube well is through the fissures or some local springs. It would, thus, appear that water source in tube well sunk in rock is not much different from that of a simple well dug in similar formation.

The increased discharge in such a tube well is mainly due to the depression head maximum being limited by the peak discharge of the springs. If water is pumped from such a well, the water level depresses and even though the crossectional area of the fissures through which water flows into the tube wells may not be much, the discharge through it considerably increases as the depression becomes greater. This is the main difference between the tube well sunk in the alluvial plains and that sunk in rocky formation. In the plains it is not considered desirable to exceed the depression head of 12-15 ft. as the increased velocity in the ground water flow due to increased depression head is likely to disturb the sand particles. In the tube wells sunk in rock, there is no such danger and advantage is taken of the depression head for obtaining the increased discharge. As mentioned earlier, the maximum discharge of the springs limits the greatest yield that could be obtained from such wells.

A tube well of this type exists at Gandhigram. In this tube well a depression head of as much as 60-70 ft. occurs for a discharge of 4,000 gallons per hour from the 3″ bore pipe. Of course, the discharge is augmented to a great extent by more fissures and more springs struck along the depth of the bore hole. The total cost of this tube well is Rs. 5,000/-. A 5.3 H. P. submersible pump has been installed at a depth of 80 ft., i. e., below the depression level and the housing pipe has been carried up to this point. No pipes are needed lower down as the entire boring is through rock. There is no danger of its sides collapsing as is the case with bore holes sunk in the alluvial plains.

12. **Wells of Central India :** Unlike in the case of rock

wells in the South, the yield in the wells of Central India is augmented by blasting of the well-bottom. The geology of this tract differs from that of the South in as much as the rocks here dip more towards vertical. If holes are drilled in the well-bottom, it is possible that not even a single fissure may be tapped. This is the reason why blasting of the well bottom is considered to be a surer operation for increasing the supplies. It exposes several water bearing fissures and at the same time increases the storage capacity of the well.

Air compressors are commonly used for blasting the rocky bottom of wells. Generally, in a 10 ft. diameter well, 4 holes each 2½ ft. in depth, are drilled by means of the air compressor. The rate fixed by the Agricultural Department for drilling operations is Rs. 3/- per running foot. The cultivator is required to pay Rs. 9/6/- for each hole drilled to a depth of 2½ ft. This includes the cost of fuses and gelegnite by which blasting is done. After the first layer of 2½ ft. has been blasted in this manner, the air compressor moves to another well. The owner of the first well removes the blasted rock and debris by his own labour. After the compressor has blasted some more wells in this manner, it returns to the first well for repeating the operations unless the yield in the well has already increased due to the blasting of the very first layer. The compressor is generally able to drill about 40 such holes in a day. The number of wells, thus covered depends upon the actual depth to which it is blasted. The cultivators have to spend anything from Rs. 200/- to Rs. 500/- for deepening their wells in the above manner for the purpose of increasing the water supplies.

CHAPTER VI

MINOR IRRIGATION IN THE COASTAL PLAINS

1. **The cropping practices on the west coast :** In the narrow strip of land between the Western ghat and the sea coast, the South west monsoons are very active and give rise to heavy rainfall. It is of the order of 100″-150″ although it decreases in intensity in the extreme South where the rainfall is only 70″.

In the northern half of this coastal belt, the rainfall is almost entirely from the South west monsoons during the period June to October. As we proceed South, the area partly comes within the influence of North-east monsoons also. Showers are received from these monsoons during the months October to December to the extent of about 10″ to 15″. Some rainfall is also received during the summer season from January to May.

The cropping practice follows the pattern of the rainfall. In the northern regions of the coastal belt paddy is the main crop grown during the kharif season. Where there are no irrigation facilities, the land generally remains idle after harvesting of paddy. The land becomes quite dry and it is not possible to grow any rabi season crop.

The southern half of the coastal belt could be roughly divided into three parts :—

(i) First is the highest portion of the valley where there is neither flow nor lift irrigation. The soil is porous and the land slopes down steeply with the result that the subsoil water escapes into the valley. This class of land in absence of any irrigation facilities is, therefore, suitable for the raising of a single crop.

In the extreme south which falls within the Travancore-Cochin State, the south-west monsoon decreases in intensity. Here dry crops like tapioca are grown on the hill slopes while in the foot-hills a single crop of paddy is raised during the south-west monsoon period. Owing to the peculiar lie of land and no rainfall from the north-east monsoons, very little moisture is retained in the ground and here too it is not possible to raise a second crop of paddy.

(ii) Lower down the valley towards the east is what may be termed 'Midland'. Here the ground is even and flat. Paddy is the main crop ; other cash crops are also grown in the high lying areas. Advantage is taken of both the north-east and south-west monsoons and two crops of paddy are grown. The first one is sown dry in the month of May and is harvested in August-September. The second crop is sown in the month of September and is harvested in January.

Due to late south-west monsoons the first crop occasionally suffers. The second crop suffers quite frequently due to inadequate north-east monsoons.

(iii) Finally comes the strip of land very close to the sea-coast and just a few feet above the sea level. Where the land is not affected by salinity of the sea water, often three crops of paddy can be raised. The ground here is generally wet even without irrigation and with slight assistance it is possible to raise a third crop of paddy.

Sometimes the first crop cannot be grown at all in lands very close to the river bank due to continuous submersion by the flood water from the river. In the south Kannada district, such land is locally known as 'Padli land' and here it is possible to raise the second and third crops only. The second crop is locally known as 'Suggi' while the third crop is known as 'Kolake'.

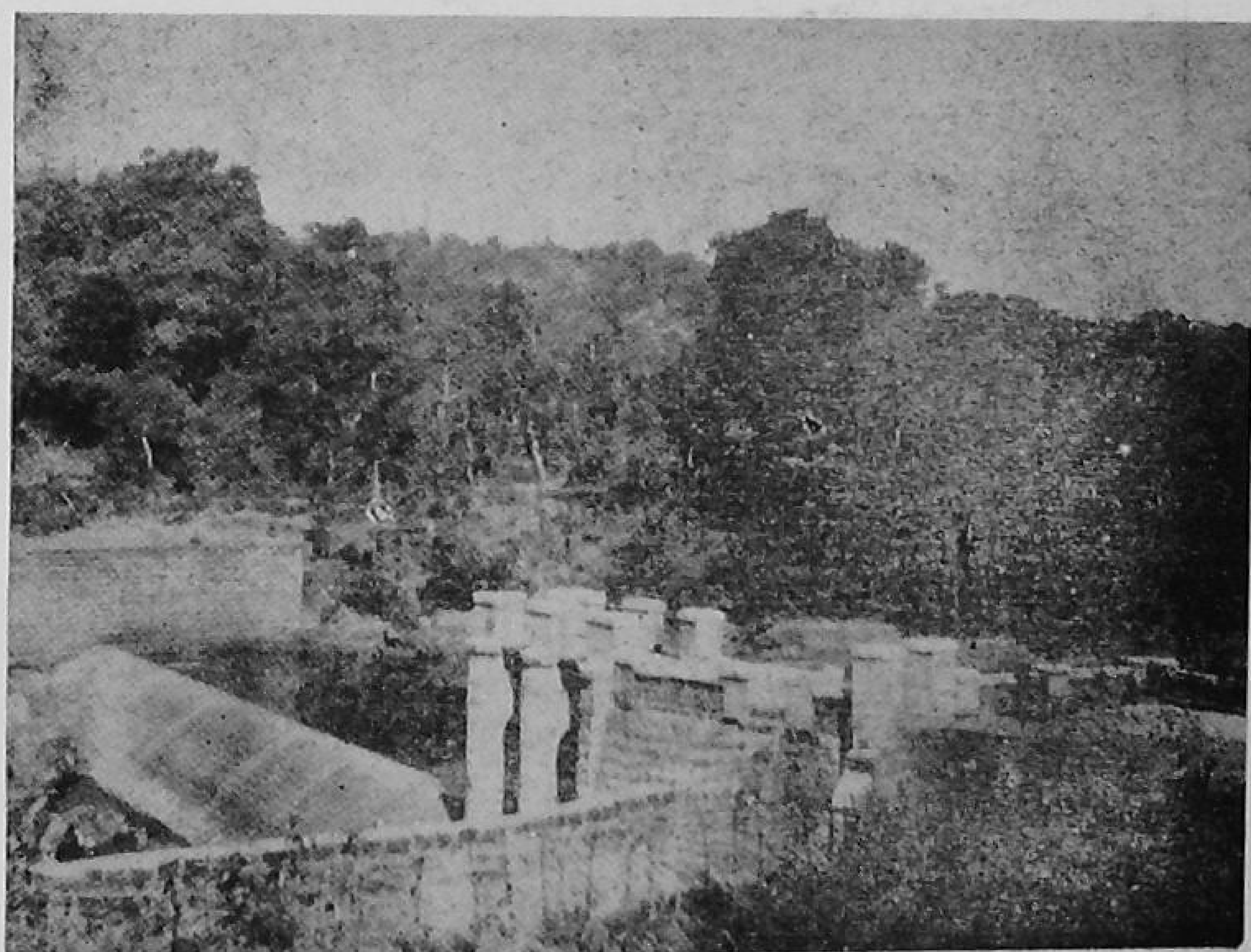
Very close to the sea coast, the subsoil water including the water in the streams and back waters is generally saline owing to the ingress of salt water from the sea. Coconut is the main crop here. It does not require much irrigation except light watering during the summer months. Paddy is also grown but not on a very large scale. It is sown during the south-west monsoon period when the effect of salinity is much less but not before the first floods are over ; otherwise it is likely to suffer from submersion. This crop does not require any irrigation. The paddy grown here is of the saline resistant variety.

2. **Irrigation in Mangalore and worth Malabar :** In the northern portions and in the areas close to the foot-hills, sometimes the 'Bandhara' system of irrigation (described earlier) is practised. Due to heavy rains from the south-west monsoons this is generally not found necessary. The streams in this tract are all rainfed and do not carry any perennial flow. However, many of these have some flow at the end of the rainy season and this is made use of for protecting the paddy crop whenever any shortage of rainfall is experienced at the end of the crop season. The 'Bandharas' here, however, have a limited utility because when the rains fail, the streams also carry little water and irrigation suffers.

In the 'midland', the south-west monsoons are rarely known to fail and almost every cultivator is sure to grow the first crop of paddy successfully. However, occasional supplementary irrigation is resorted to whenever there is deficiency of rainfall. If regular showers from the north-east monsoons are received, no irrigation is found necessary even for the second crop during the period October to middle of November

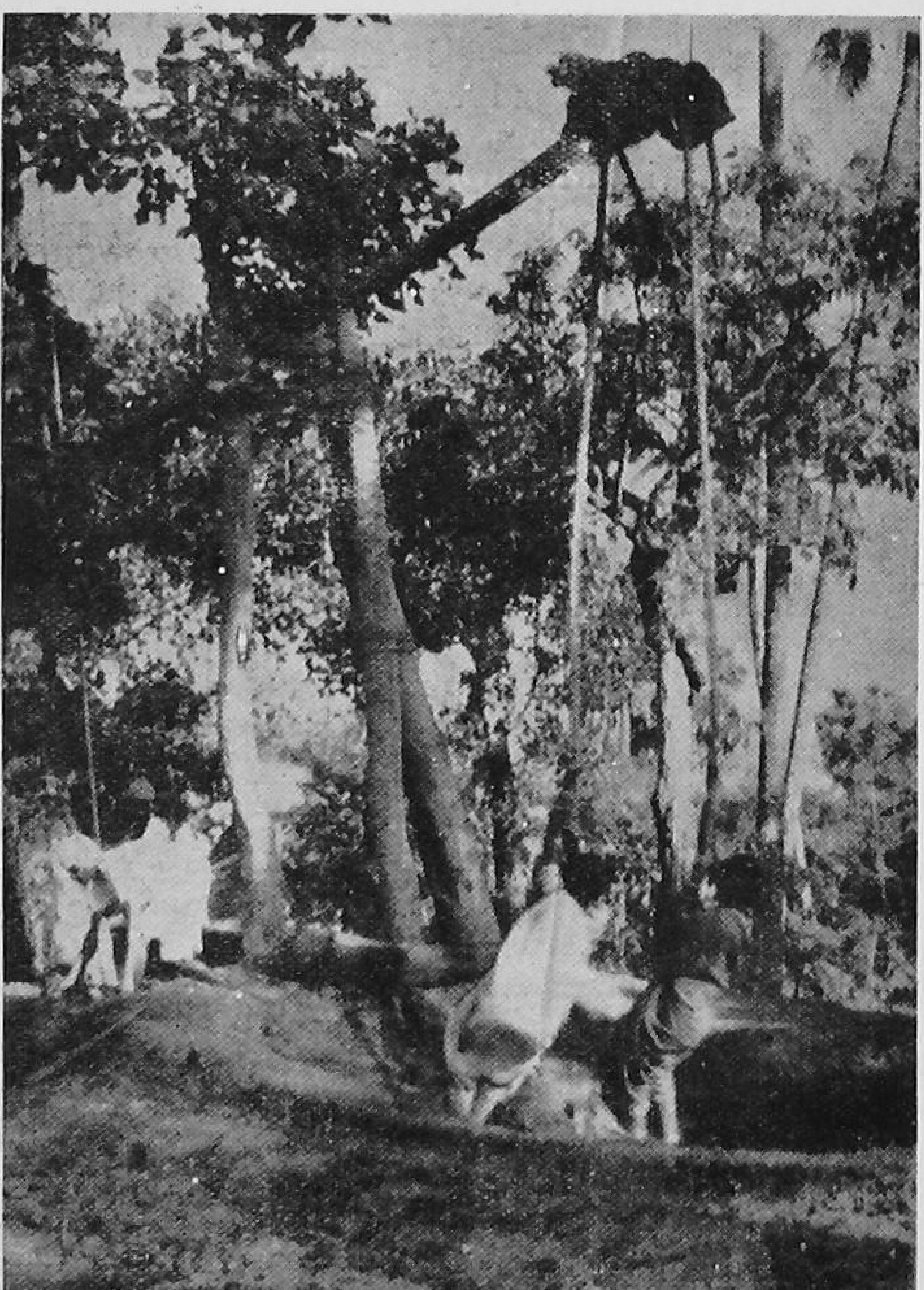
A Mud 'Katta' (Earthen Dam) across a River in Mangalore but during the remaining months, assistance of irrigation water is always needed. If, however, north-east monsoons fail and this is not very uncommon, irrigation water to the extent of about 8″ per month during the entire crop period is found necessary.

For this purpose, the river or stream water is diverted. This is done by constructing earthen dams across the rivers soon after the cessation of the south-west monsoons. In Mangalore, these dams are called 'Kattas'. They consist of earth mixed with dry grass and brush wood and are sometimes quite big in size costing as much as Rs. 20,000/-. This expenditure has to be incurred from year to year as during the subsequent flood season, the earthen dams get washed away. In about half the midland, where second crop is grown, water thus diverted from the river, flows by gravity. In the remaining half water has to be bailed out—the lift varying from a few feet up to 10 feet. Cultivators who are far removed from the river or any irrigation channel but who posses low lying land, dig wells or small ponds locally. Due to heading up of water in the river, and also due to the fact that the ground is charged with moisture soon after the rains, water is usually struck at shallow depths.



Shiriya Aniout in Mangalore to replace a Mud 'Katta'.

The lifting device is quite interesting in which use is made of manpower and not animals. Water is bailed out at a much faster rate than is normally possible by the ordinary "Dhenki" arrangement adopted in the eastern Uttar Pradesh and Bihar. Like the "Dhenki", here also a wooden pole levered at an intermediate point at the top of a V-shaped wooden post is used. At the water side extremity of the



Method of lifting water in Mangalore.

wooden pole is suspended the water bucket by means of a bamboo and not a rope as in the 'Dhenki' system. At the other extremity of the wooden pole is tied a cross piece from which hang two or three ropes. Each rope is held by a man or a woman (generally, two adult females and one male operate this end). Vertically below the ropes is a pit 3-4 ft. deep. Three persons standing on the ground and holding the ropes jump into the pit thus lifting the bucket full of water. Though the jump is from a height of only 4 ft., it results in an impulsive force being applied to one end of the levered bamboo pole and the bucket full of water rises quickly. The man at this end, standing close to the well has just to guide the lifting pole and it comes up very quickly to the ground level. The persons in the pit ascend a flight of steps and take up their position again on the ground. The man at the other end lowers the bamboo pole from which the bucket is suspended thus dipping it into water. The process is repeated. It would be seen that four persons are employed in working the well in the above manner as against a single person employed in the 'Dhenki' but the rate of lifting water is also correspondingly increased in the former case.

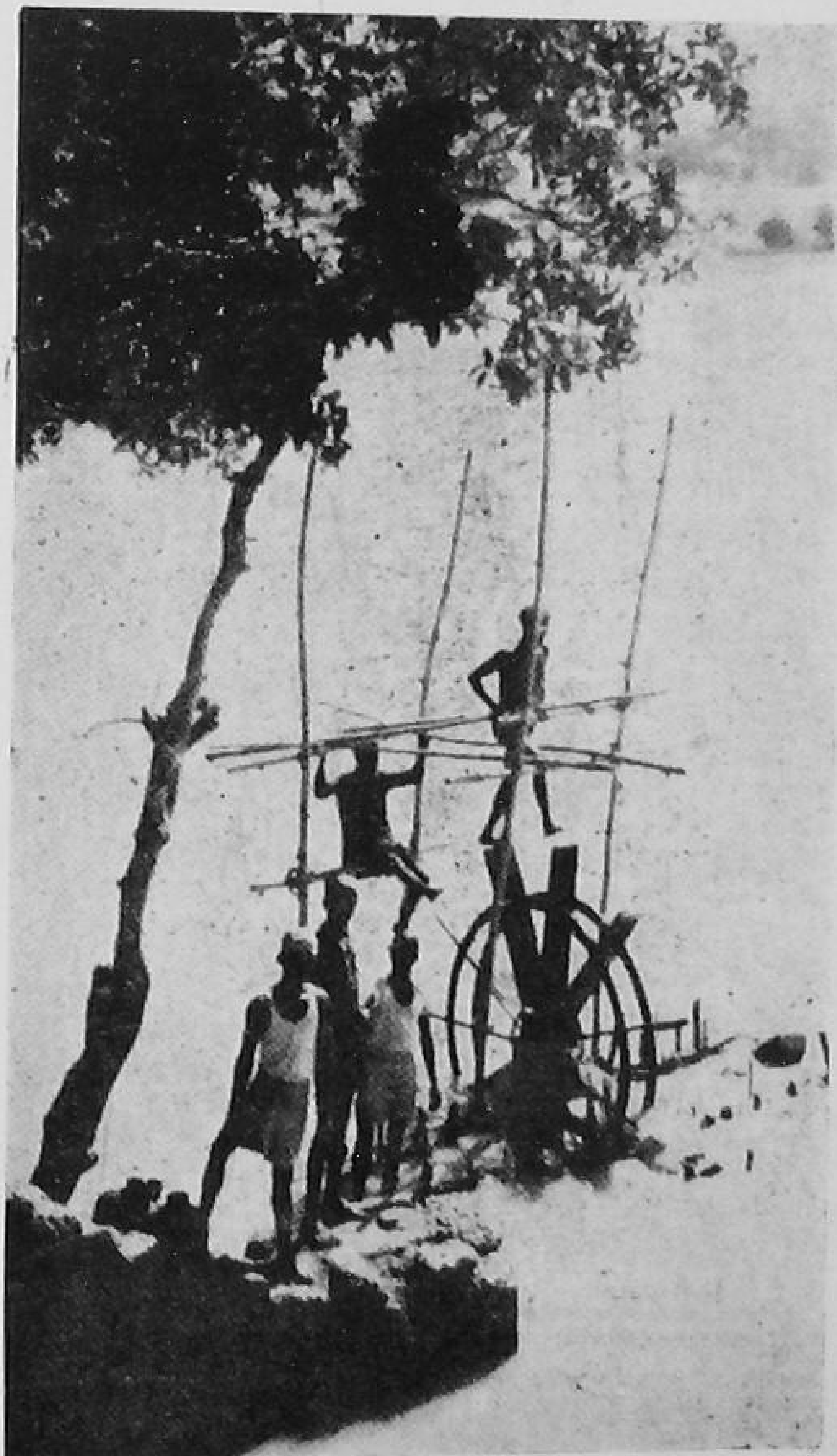
In the land very close to the sea coast, but which is free from the ingress of saline water, irrigation is practised on the same lines as in the midland, the difference being that less water is needed for growing the corresponding crops and almost everywhere it is possible to raise three crops of paddy. Also the lift is very small. For bailing out water a tripod is erected over the pit containing water. A cross-piece is tied horizontally to two legs of the tripod and very close to its top. From this cross-piece are suspended one, two or three spoon shaped wooden bailers by means of ropes. The number of these bailers depends upon the quantity of water to be lifted. Each bailer is worked by a single man standing in the pit. Water is lifted from the pit by about 2-3 ft. by working of the bailer. It resembles the 'daun' and 'dauri' systems of northern India.

In the north Malabar coast (the ex-Cochin State) both gravity irrigation and lift irrigation are practised. Under gravity irrigation are the reservoir and diversion weir systems. Most of the gravity irrigation schemes are of very recent origin and are major irrigation projects, e.g., Vaghani, Pichi and Chalakudy. The first two are reservoir schemes and the last one a diversion scheme across the Chalakudy river.

Under lift irrigation, a number of such schemes have been executed during the past few years under the Intensive Cultivation Scheme. Due to difficult topography of land and high costs of transmission of water across long distances, lift irrigation compares quite favourably with flow irrigation since, in the latter case, the ayacut is localized and is within a short distance of the pumping station. Due to availability of cheap electric power and good stream flow close to cultivated land, presence of subsoil water within shallow depths and due to small land holdings, pump irrigation is extremely popular in

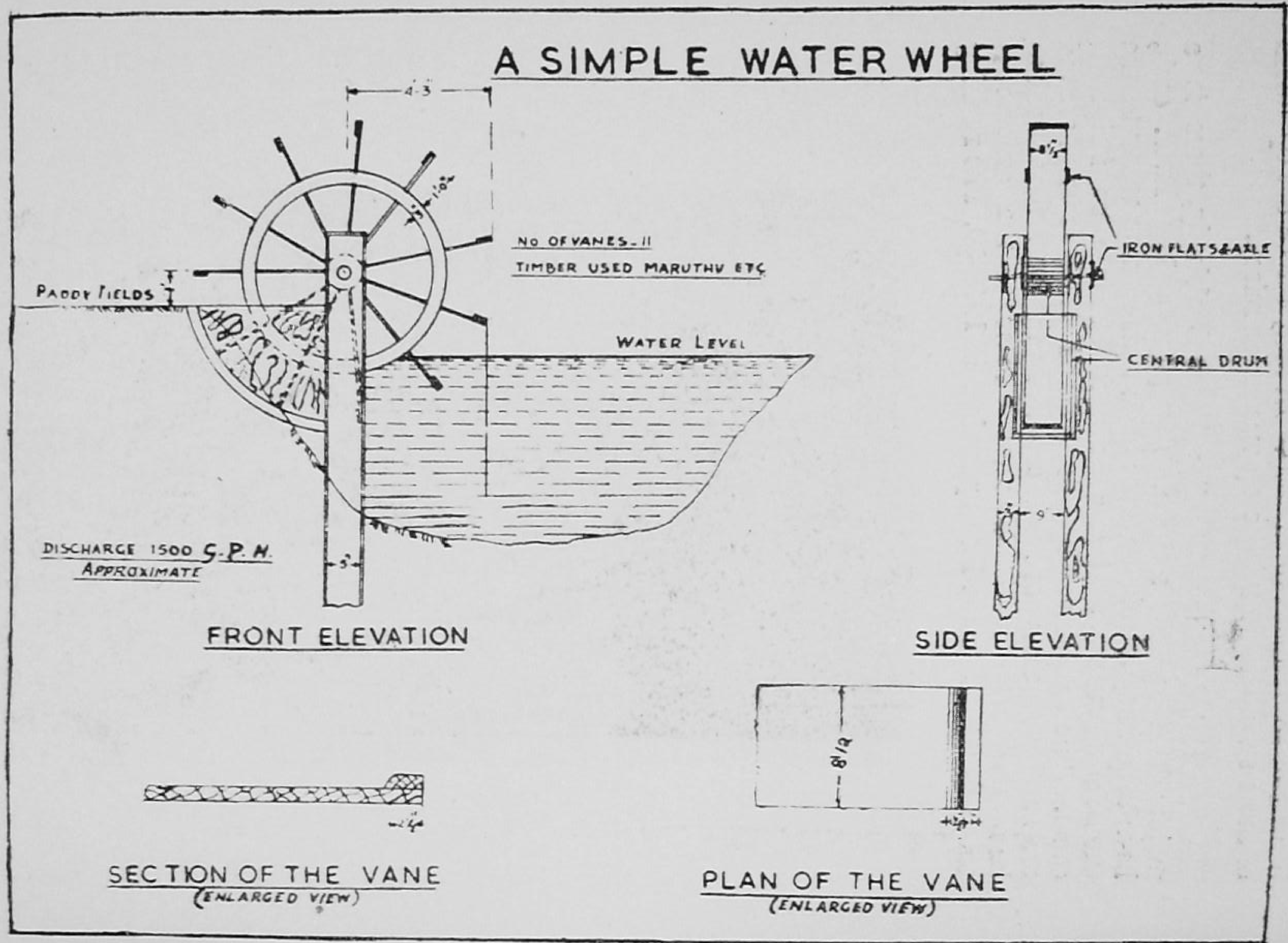
Low Lift Irrigation Device in North Malabar this area. All these lift irrigation schemes are mainly for the benefit of second and third crop. In fact, before the operation of these schemes, no third crop was being raised.

At Kalady about 16 miles from Chalakudy, there is a major lift irrigation scheme. Two pumps, 100 H. P. each, have been installed on the river bank which pump water to the extent of 20 cusecs against a lift of 22 ft. into an irrigation canal. The area served by this scheme is 1,025 acres of second crop and 800 acres of third crop. In the past there used to be no third crop at all. The total coast of the scheme is Rs. 1,94,000. It came into operation in 1949-50. The running



A Simple Water Wheel in North Malabar

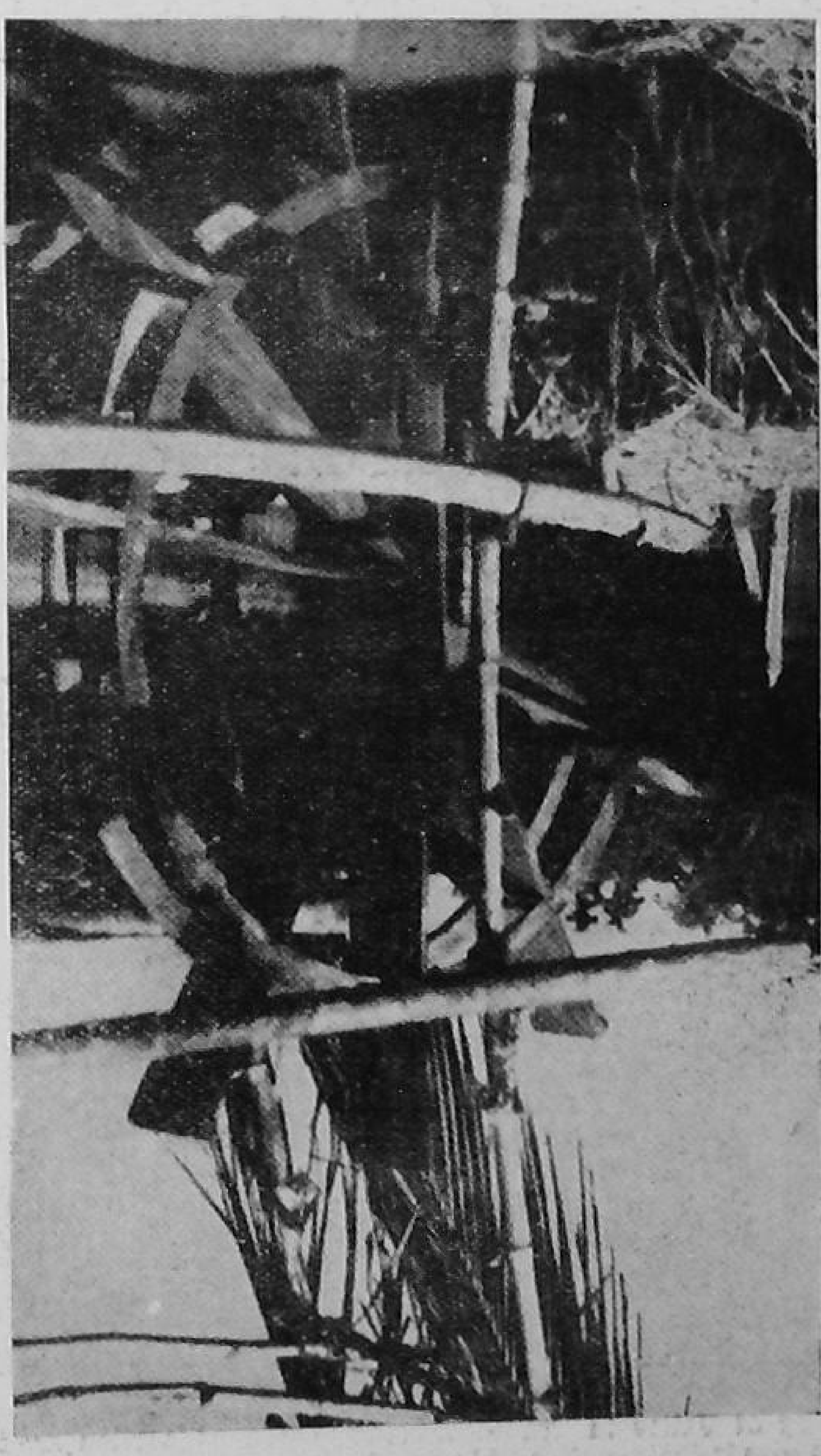
Fig. 2



A SIMPLE WATER WHEEL
4-3
1-0
NO OF VANES - 11
TIMBER USED MARUTHU ETC
PADDY FIELDS
WATER LEVEL
DISCHARGE 1500 G.P.H.
APPROXIMATE
FRONT ELEVATION
IRON FLATS & AXLE
CENTRAL DRUM
SIDE ELEVATION
SECTION OF THE VANE
(ENLARGED VIEW)
8 1/2
PLAN OF THE VANE
(ENLARGED VIEW)

costs of irrigation work out to about Rs. 30/- per acre. The State Government have been contemplating levy of a cess of Rs. 25/- per acre, no betterment tax being charged. The scheme would, therefore, be operated on a subsidized basis.

For shallow lifts of 4′ to 6′, wooden water wheels operated manually are extensively used. The sketch vide fig. 2 and the photographs show the arrangement. It consists of a central drum held between two vertical pieces and capable of being rotated in a vertical plane along a central iron axle. From the drum the water vanes project radially and are held



Enlarged View of the Water Wheel

in position by two flat iron rings one on either side of the set of vanes. A cross-piece 2½″ wide is attached to each vane at its tip. With the rotation of the wheel, water is bailed out to a lift of about 4 ft.

The actual lift of such a wheel depends on its size and may be taken as about one-third of its diameter at its maximum. Wheels up to 12 ft. diameter are used in stages up to three for increased lift. The small wheels are operated by one man but big wheels are operated by several men sitting one above the other on bamboo frames.

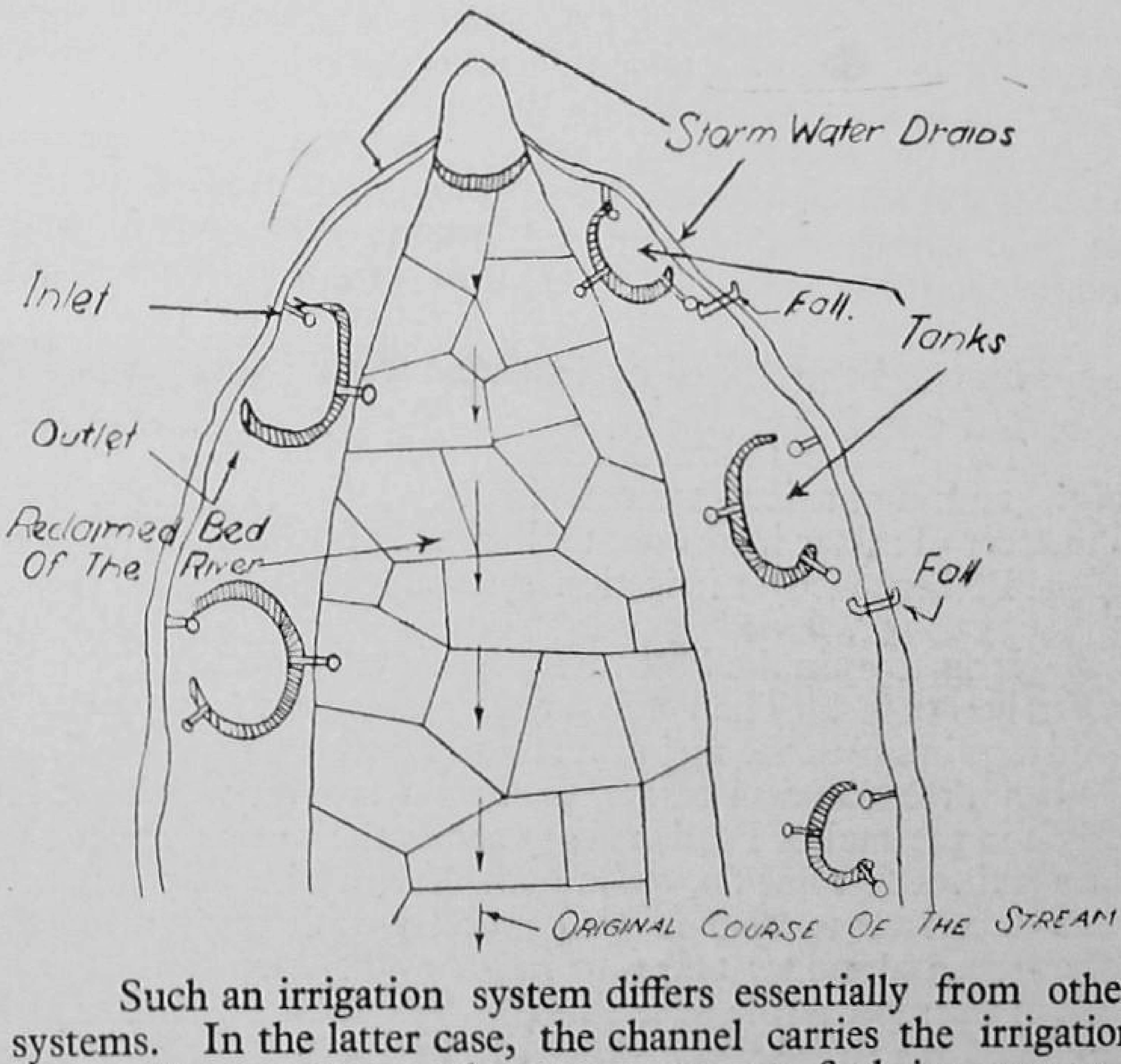
3. **Series Bunding of Valley in Travancore :** Further lower down the Malabar coast, irrigation from small tanks is a special feature peculiar to this tract only. From the very start of a valley, there is a small tank. The drainage water coming from the hills is intercepted by high level storm water drains dug on either side along the slopes of the valley. The tank in the head reach of the valley also spills its surplus water into the storm water drains. The main drainage line in consequence disappears thus making the deepest portion of the valley available for cultivation. The storm water drains, in turn, feed a chain of small irrigation tanks which

Series Bunding of Valley in Travancore (In the deepest portion are the paddy fields with irrigation channel in the background and cocoanut and banana trees on the slopes).

have an earthen bund on at least three sides. Any excess water coming into these small tanks flows back into the storm water drains through an outlet pipe which is fixed at a slightly lower level than the inlet pipe. In addition to the inlet and outlet pipes the tank has an outlet at a lower level to let out the irrigation water.

As one proceeds lower down the valley, the storm water drains become bigger and bigger in size. These have been provided with proper falls and road bridges and are regularly maintained as a part of the minor irrigation system. The sketch vide Fig. 3 shows the arrangement. To sum up, the main stream is trained to change its course. Instead of allowing it to follow the deepest valley line, it is made to flow into canalized high level storm water drains.

Fig. 3



Such an irrigation system differs essentially from other systems. In the latter case, the channel carries the irrigation water allowing the surplus storm water to find its own way into the natural drainage. In the present case, it is just the opposite in which the storm water is trained to flow into regular canalised drains. The practice has been in force since ages. The great advantage of such a system is that the lowest land along the drainage line, which is richest in the whole valley, is available for cultivation.

River bed cultivation is not the sole and only advantage. Training of the valley in the above manner helps a great deal in the conservation of soil moisture and this in fact, is its bigger advantage. The floods which used to be drained out in a short time due to the steep bed-slope in the parent stream would now recede very gradually on account of the flat gradient of the storm water drains. The result is a general saturation of the valley with moisture. In consequence, the ground water plane not only rises but its slope becomes flater. One important result of this is that the 'midland' also becomes fit for wet cultivation due to its increased moisture content. Also, regeneration of flow in the storm water drain during a break is much more than what it would have been in the parent stream on account of the flater gradient of the ground water plane. This flow is also profitably utilized for direct gravity irrigation of the 'midland' lower down.

4. **The Minor Tanks Near the Cape :** Further south as we approach the end of our land, the two ghats close and the topography changes. The land opens out into a flat and continuous stretch of paddy fields. Rainfall here is less and crops have to be protected by irrigation water.

The practice followed here is somewhat similar to that of the tank-cum-anicut systems in South India. There are a number of minor irrigation tanks some of which form part of the Puthen Kodyar irrigation system.

Irrigation in the Puthen Kodyar system dates back to several centuries. The Paralayar river along with its tributary Kodyar, has been the main source of its water supply. The Puthen diversion dam across the Paralayar river which has its origin in the ancient Pandyan dam across the same river, came into existence some 200 years back. With the help of this dam the river water used to be diverted through a system of canals and minor tanks to irrigate the Nanjinad Taluk, one of the most fertile tracts in the Travancore State. Later on, when the river supply proved to be inadequate, this work was followed by the construction of the Kodyar dam at the end of the last century. The Kodyar reservoir consists of masonry dam across the Kodyar river at Pechipara. Its water is led through an irrigation channel and dropped into the Paralayar river, just upstream of the Puthen dam to be picked up again by the later's canal system. The Kodyar reservoir actually supplements the flow of the Paralayar river and the two systems function jointly. During years of scanty rainfall even this combined system has failed to meet the irrigation requirements of the commanded area. Specially during the second crop period shortage of water has been experienced quite frequently. The Perinchani dam across the Paralayar river is intended to supplement the supplies of the Kodyar-Puthen system.

Many of the minor tanks which form a part of the Puthen-Kodyar Perinchani system have got silted up and have practically lost their capacity. This has been another reason for the continued shortage of water under this canal system necessistating construction of one reservoir after another in this valley. The silted up minor tanks serve only as passages for canal water and possess very little storage.

The functioning of the system would be greatly improved if somehow the capacity of these minor tanks could be restored as it would effectively increase the capacity of the system as a whole. Like the minor irrigation systems of South India, these tanks also serve the very useful purpose of correcting irregularities in canal supplies.

5. **Tube Wells in the Sabarmati Valley :** In the lower reaches of the Sabarmati and Saraswati valleys, slightly away from the sea coast, good ground water is available and irrigation from tube wells is extensively practised. In most of these tube wells it is possible to tap about 90 ft. water bearing strata in a total depth of 350 ft. Each tube well has a discharging capacity of 25,000 to 35,000 gallons per hour and the draw down ranges from 6 to 15 ft. Irrigation water from State managed tube wells is supplied on a volumetric basis. Generally, the rate per hour is fixed for a particular tube well, e.g., Rs. 2/7/- per hour from tube well of 25,500 gallons per hour capacity. This works out to about a rupee per 10,000 gallons. In addition, a cultivator has to pay three annas per rupee of the water charges as an additional cess. For raising of cash crops like "ziru", Government originally charged additional Rs. 60/- per acre for supply of water from State managed tube wells. As this resulted in people with-drawing from the tube well water, Government have since brought down this additional cess considerably. The tube wells are in operation for about 4 to 5 months in the year. The total number of hours

a tube well may work during the year varies considerably and in some cases, it is as low as 400 hours in the whole year.

Under the North Gujrat Tube Well Scheme, more tube wells would be sunk in these areas and also in the Mahi river valley.

6. **Irrigation in the Godavari delta districts—Filter points and Tube Wells :** The delta districts of Godavari and Krishna rivers are intensively irrigated from their respective canal systems. One, two and sometimes even three crops of paddy are grown here.

The first freshes in these rivers are received at the end of June or early July and the canal is immediately opened for raising seedlings for the summer crop of paddy. Transplantation is completed by the end of July or middle of August and the crop is ready for harvesting by the end of November After the first crop period, supplies in these rivers dwindle down. Whatever water is available is used for growing of the second crop of paddy. The area under this crop is divided into two classes—in one water is supplied every year while if the other the area sown and irrigated changes from year to year both in extent and locality, depending upon the availability of supplies in the rivers. A notification is issued after the monsoons indicating when canal water would be available for the second crop. Such areas, therefore, necessarily grow the second crop by rotation.

To meet this deficiency in river supplies the local people have reinforced these major canal systems with a number of their own minor irrigation works. These cultivators of the delta districts are very enlightened people. In the Godavari district they have done excellent work by establishing several irrigation co-operative societies (Chapter VII) mainly for the purpose of raising a second crop of paddy and also growing cash crops.

Under these minor irrigation works the following sources of water have been tapped :—

(i) Firstly, there are a number of small tanks, some in derelict condition, located on the periphery of the delta area. Quite a few of these tanks have insufficient catchments and are unable to collect water even for the first crop. During the rainy season when the requirement of paddy in the delta area is not much and the canal continues to run full supply, the extra water not required for irrigation, is pumped up and stored in these tanks. The canal water is reached to the pumping station through the cross drainages that intercept the canal. During the rainy season, these drains bring the rain water and drop it into the canal which is provided with a relieving weir corresponding to each inlet. Being in the delta area, the drains have a very flat gradient and can be made to function in either direction. When, therefore, canal water is required to be pumped for feeding the tanks it is let out in these drains on the upstream side which lead it to the pumping station.

By pumping water in the above manner, supplies are assured for the first crop in the ayacut under the tanks and also a second crop is raised from the water left over. In fact, pumping from the canal is continued up to December (i.e., up to the transplantation period of the second crop during which period much water is not needed). Water stored in these tanks is subsequently used for gravity irrigation of a second crop of paddy.

(ii) *The Drain Water :* Secondly, thrre is the drain water which also is pumped for irrigation. During the rainy season and even afterwards a number of drains carry lot of flowing water. This water is being pumped either into regularly constructed irrigation channels or in the already existing channel systems.

The use of water in the drains which lie outside the command of the Godavari delta system is mainly confined to growing of the first crop since much water is not available in these drains during the winter months. But in the delta area, where the ground is charged with moisture, the drains carry a good flow. Water pumped from these drains is used for raising seedlings for the first crop (as the canal supply is low and delays the transplantation operations), meeting any deficiencies of irrigation water for this crop and giving assured supplies for the second crop of paddy from year to year so as to make the latter a regular and not a rotational crop.

(iii) *Filter Points :* In the area served by the Godavari delta system, sand is met with just below 8 to 10 ft. of soil. As this is the delta region and also the land is heavily irrigated, the ground always remains fully charged with water. Here small strainer tube wells locally known as 'filter-points' have been successfully installed.

The total depth of the filter point is generally 35-40 ft., the pipe diameter is 3″ to 6″ and the strainer is provided in a length of 7-10 ft. Each filter point including the electric motor, pump, strainer and pipe etc. costs about Rs. 2,500/- to Rs. 3,000/-. The capacity ranges from 5,000 gallons per hour to 9,000 gallons. About 10-15 acres of land are served from each filter point.

(iv) *Tube Wells :* In the Eleru river basin of the Godavari district, there is an extensive channel system which draws its supplies from the Eleru river. This is a hilly stream and carries water for 8 months in the year. During remaining part of the year, water for irrigation is drawn from tube wells. Essentially, these are cavity tube wells, no strainers being used. Good water-bearing sandy stratum is struck at about 80-100 ft. depth with overlying strata of hard dependable clay. As is well known such formation is most conducive to the development of cavity tube wells. The cavity is developed by ordinary centrifugal pumps. Generally, 6″ diameter pipe is sunk and 3-4 cart loads of sand are pumped out during the development operations. The wells yield a constant discharge of 6,000 gallons and above. As power is yet to reach this area, the pumps are run by diesel engines. In summer the water level in the bored pipes goes down to about 8-10 ft. below the ground level but during winter and rainy season the pipe generally overflows. The cost of each tube well is about Rs. 3,000/- and it is able to irrigate 20 acres of land.

In each plot of 20 acres, there is sugar-cane in about 8 acres which is sown in rotation with paddy. Normally, the first crop of paddy receives irrigation water from the Eleru river canal system which runs for 8 months in the year. Irrigation from the tube wells is confined to 4 dry months during which water is supplied to sugar-cane, plantains, garden crops and the second crop of paddy. With this cropping arrangement, the cultivator, here, has found the tube well irrigation not only economical but a positively paying proposition.

7. **Ground water utilization round about Madras :** The southern part of the eastern coast comes mainly within the zone of the north-east monsoons and summer rains become scanty. As mentioned earlier (chapter V), the rivers flowing towards the east coast being within the influence of both the monsoons carry flowing water for the entire duration of the irrigation season. This factor is most conducive to irrigation from the anicut systems at the head of the deltas of the various rivers. The anicuts across Pennar, Palar, Vellar and a few other rivers have well established irrigation systems in the delta of these rivers. Like the tank-cum-anicut irrigation in South India, here also large number of minor irrigation tanks reinforce and help to stabilize anicut irrigation.

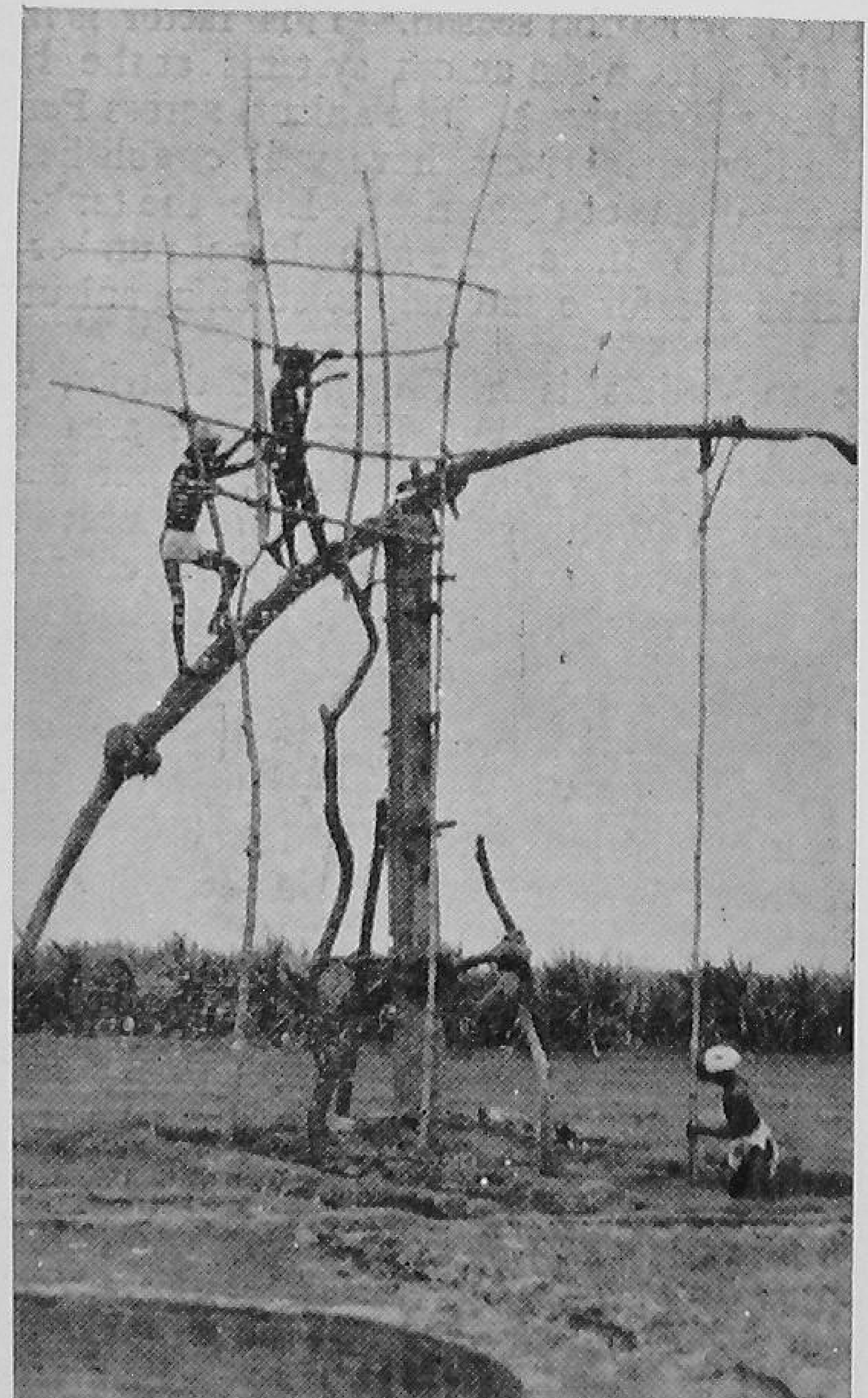
Close to Madras is the Chingleput district, where there are no major irrigation works. Here a large area is irrigated from minor tanks and wells. The district is particularly suited to tank irrigation. Well irrigation is also practised mainly to supplement tank irrigation. Although the entire area under paddy is irrigable from the system of storage tanks but due to their uncertain filling supplemental irrigation from wells is almost always required.

The subsoil water is not more than 10-15 ft. below ground level. Wells are made big in size so as to have adequate storage. Water received in the wells is sometimes from springs and sometimes from seepage from the sides and bottom. Many of these wells are located in the commanded areas of the tanks and draw the water seeping therefrom through the soil. Electric motors with pumps have been installed on a number of these wells.

Land on a small scale is cultivated entirely from well irrigation. This is an expensive practice on account of heavy water requirements of the crops but the cultivator still chooses to do it mainly for the purpose of getting gainful employment.

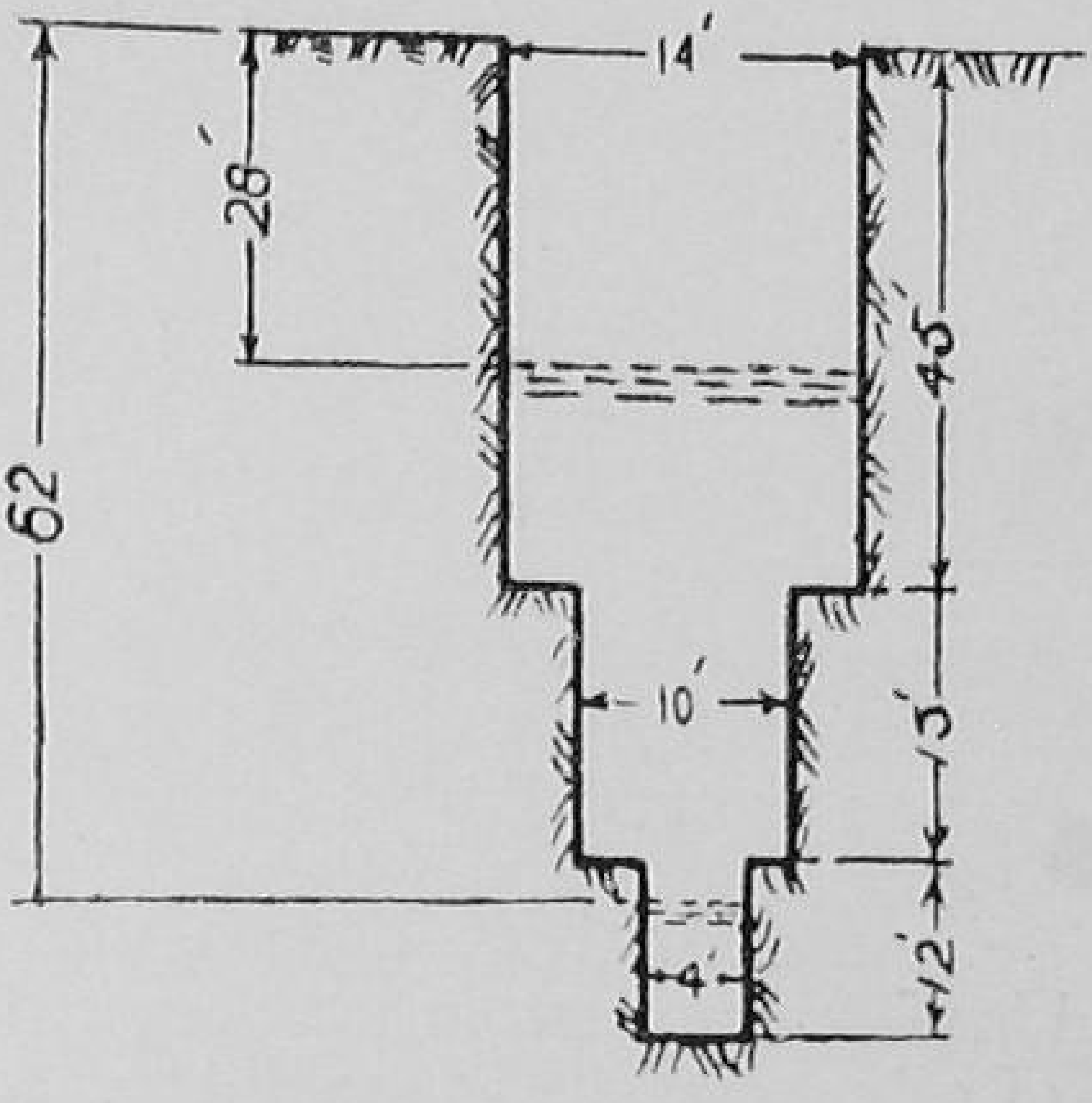
The method of lifting water from wells on the east coast is slightly different from what it is elsewhere. While the same arrangement of a wooden pole levered at an intermediate point to a vertical post is employed, and a bucket suspended from its water side extremity, on the other side there are no persons pulling the pole from this end and neither is it loaded at that end (like in the Dhenki system). Instead a man continuously keeps on walking to and fro on the levered pole and close to the fulcrum with the result that the bucket is alternately dipped and lifted.

In the Tirumallur and Kadambathur Talukas of Chingleput district, lift irrigation from wells is extensively practised. In fact, there is evidence of over pumping as the



Lifting of water on the east coast,

subsoil water level has gone down by about 20-25 ft. during the past 10 years. Continuous droughts during the last few years are also partially responsible for the lowering down of the ground water table. Description of a typical well is given below :—



The well has a diameter of 14 ft. and is 45 ft. deep. It was dug 15 years back when the water level was 28 ft. below the ground level. An oil engine was installed and water level went down to the bottom in the very first year. Five years later an inner well was dug about 15 ft. in depth from the bottom of the original well and a 10 H. P. electric motor was installed. The inner well also got completely depleted in the next 5-6 years. Two years back a third well 4 ft. in diameter was dug within the inner well to 12 ft. depth from the bottom of the former. The pump now works 17 hours a day on the well and the water level stays at 2 ft. below the bottom of the second inner well, i.e., 62 ft. below the ground level.

Above is a clear case of over pumping and it is sure to cause permanent damage to the water bearing capacity of the subsoil. In this tract, several wells are situated very close to each other and always there is mutual interference. Lack of rainfall has aggravated the trouble.

In the Kadambathur Taluk of the Chingleput district, a very interesting method of irrigation is practised. A river Coovom by name, flows through this area. The whole tract is sandy formed of the river deposits. A channel taking off closeby, though not joined to the river, is reported to have been dug in the past. It used to receive its supplies from the springs in its side and bed and the water level used to be so high that previously it could do flow irrigation lower down. The springs receive their supplies from the flood water of the Coovom river percolating into the subsoil. During the past some years, lots of pumps have been installed on the banks of Coovom and also on the spring channel with the result that the subsoil water level has gone down by about 10-12 ft. In the spring channel, water has gone down to a few feet below its bed and now it cannot do irrigation by gravity. A well has been sunk in the head reach of this channel and two pumps run by 12 and 14 H. P. engines have been installed. The well has got a good yield due to functioning of the spring channel as a gallery well having a large exposed surface of water bearing formation. The arrangement will be irrigating a large area successfully.

The subsoil water level in these tracts could possibly be raised and in fact restored to its original level by the construction of subsurface dams suitably spaced across the Coovom river. This will arrest the quick flow of surface and subsurface water and in the process the ground water will be recharged.

CHAPTER VII

IRRIGATION THROUGH CO-OPERATION

1. **Irrigation management :** Any extensive irrigation system in our country is almost always a State-managed enterprise. Except for very small irrigation sources owned individually on a private basis (e.g., wells), irrigation is a service rendered by the State. We rarely hear of irrigation companies or water societies managed privately. One of the important aims of Minor Irrigation Programme in the Community Projects has been to develop co-operative irrigation. The formation of these Co-operatives would enlist people's participation to a greater extent and is sure to stimulate water consciousness among the cultivators.

Doubts have been occasionally raised as to the efficacy of a service like irrigation through co-operation. The efficient functioning of the irrigation co-operative societies in some parts of the country like the East Godavari District (Andhra) should, however, serve to dispel such doubts.

2. **Societies for flow and lift irrigation :** For successful planning of irrigation co-operative societies, it is necessary to recognise certain distinctive features of irrigation enterprises. As is well-known, there are two categories of irrigation works-lift and flow. In lift irrigation since the service reached to an individual is well defined and is in strict proportion to the recurring expenses, it is somewhat easier to join the people together for a co-operative irrigation society.

In a flow scheme, the main effort is needed to build the work in its initial stage. Once it is completed, it starts functioning from year to year except when its maintenance gets neglected. If, therefore, people join hands to construct a tank, it would essentially be a building or a tank constructing society and would hardly remain an irrigation society.

Construction of a tank generally involves detailed surveys and investigations by a technical organisation like the Public Works Department. Further, such works often necessitate permanent changes in the land system. Thus land submerged in a tank has to be acquired. Private persons cannot take possession of such land. Also because of the permanent benefits, the land value rises and Government have often to enhance the land revenue in some form.

The above become the primary things to be tackled while its actual running and operation remain secondary. When the former are got done through Government agency, the cultivator supposes that the rest of it also would be taken care of by Government. This is one of the main difficulties that has been encountered in the past whenever decentralisation of maintenance of minor irrigation works was attempted like in Mysore and Travancore-Cochin. Even though beneficiaries have been made responsible by legislation for the maintenance of minor works in these States, it has not been possible to enforce this. What happens is something like this. If 10 beneficiaries are jointly responsible for the upkeep of a tank and one man withdraws, i.e., he does not fulfill his obligation in the maintenance operations, he feels he would still get water if the remaining 9 keep the tank in order. The argument is followed by others also and ultimately the tank is completely neglected and goes into a state of disrepair. All this takes place gradually. The beneficiaries realise their mistake when it is too late and naturally they have to fall back upon Government for its restoration.

However, irrigation co-operative societies for the maintenance and management of flow irrigation schemes have made an appearance in the recent past. In the Kolhapur Community Project, some of the 'bandharas' are managed on a co-operative basis. Even in the past, irrigation from Mosam river in the Nasik district (Chapter V, Para 7) has been maintained and managed by the ryots themselves as a co-operative enterprise. This is a very old system and has been functioning quite successfully. In the Himalayan hills of Himachal Pradesh, Kuhl irrigation is also practised on a co-operative basis.

In a lift irrigation scheme, the working is different. In these schemes, running and maintenance of the pumping plants become the primary concern of the beneficiaries. The actual installation is comparatively an easy task. If some individuals subsequently show tendency to withdraw, they lose the water also because only that quantity of water is pumped as is actually required.

The lift irrigation installation on the Thulia Bhaga drain in the delta area of the Godavari District (Chapter VI, para 6) is a typical Irrigation Co-operative Society. On its right bank there are two pumping stations, one provided with two units of

50 H.P. pumps and the other with a single unit of 40 H.P. pump. On its left bank also there is a pumping station with one unit of 50 H. P. pump. The total area served is 1,000 acres of paddy in which 500 acres is generally sown with sugar-cane by rotation. The capital invested by the beneficiaries jointly is Rs. 75,000 on the pumping stations. The cultivators raise the second crop of paddy and also a perennial crop like sugar-cane every year on payment of a rate of Rs. 25 per acre to the society. Their monthly expenditure works out to Rs. 1,200 to Rs. 1,300 and for the entire duration of the second crop period, it is Rs. 4,500. Thus by collecting Rs. 25/- per acre, they expect not only to meet the working expenses but also to build up a depreciation fund for replacing the present plant after this is worn out.

Details of land holding and the number of persons who have participated in the enterprise are as follows :—

Land holdings	*No. of persons*	*Total acreage*
Below 5 acres	305	687
Between 5 and 10 acres	27	214
Above 10 acres	13	189
Total	345	1,090

3. **Causes of failure :** Why is it difficult to establish irrigation co-operative societies and when established why do these fail ? The basic difficulty of personal ownership strongly asserting and dominating all other interests is true of irrigation societies as it is true of all other co-operative societies. It is not uncommon to hear of three brothers jointly owning a well but each having a pump of his own even though a single pump could fulfill the needs of all the three. Bickerings and fueds in the village bring out the personal factor still more prominently. Another cause responsible for the disintegration of the society is that the more shrewed persons dominate the interests of the smaller and less resourceful cultivators. In fact, it becomes the show of the dominating person or persons and smaller share-holders have little say in the management. In course of time, they withdraw and the society fails.

Irrigation co-operatives are normally formed in one of the two ways. If the cultivators are experienced in the technique of irrigation and are water conscious, they form the society themselves. Otherwise, it very often becomes necessary to organise the works departmentally and then hand these over to the beneficiaries to be run and managed on a co-operative basis. This brings up the question of departmental management of lift irrigation schemes. As is well known, lift irrigation is much costlier than flow irrigation. Specially in the case of heavily irrigated crops like winter paddy in South India, the difference becomes very much marked. The most prominent lift irrigation schemes managed departmentally are the tube wells in Uttar Pradesh and Punjab. In Uttar Pradesh, the water rate from tube wells has been brought at par with the canal rate not because it is possible to lift water cheaply but because the U. P. canal system is remunerative and the U. P. Government can afford to run the tube wells at some loss.

In other parts of the country, where there is a big difference between the canal rate and working cost of water from lift irrigation, it becomes difficult to run and manage the works departmentally. For example, the cultivator in Mysore spends Rs. 60/- per acre on power alone (which is cheapest in the country) for irrigation. The installation is owned by him. He spends this amount quite enthusiastically but if Government start a lift irrigation scheme and ask him to pay Rs. 40/- as irrigation charges, he immediately points out that in the neighbouriug district where there is a canal, the cultivator has to pay only Rs. 10/-. Why then should he be made to pay more? He is not prepared to understand the difference between lift and flow irrigation. If because he is not prepared to pay Rs. 40/-, Government were to wind up the installation, he is just not bothered about the loss from no irrigation. The feeling of Government being unfair to him outweighs all considerations of the benefits and dividends that he might earn on the crops even by paying the rate of Rs. 40/- per acre. This is the essential difference between a Government management and a privately owned irrigation source. Such an attitude on the part of the cultivator renders the conversion of a Government managed lift irrigation installation (e. g., tube well) into Irrigation Co-operative Society very difficult.

There is another reason why cultivators are unanxious to form an irrigation society. Irrigation in the past has been a service, rendered by the State, more for humanitarian reasons and for the welfare of the people than for profit motive. In the initial stages, some of the irrigation works were originally started by the East India Company and remained company managed but when these works did not prove successful as commercial enterprise, they were taken over by Government. Except in individual installations, the cultivator always feels that even if the service has to be rendered at a loss, Government are duty-bound to come to their rescue, i.e., they should come and manage it and charge only reasonable rates from the cultivator. There is some justification in this. The fact, however, remains that the cultivator wants Government to run the big installations and charge only a reasonable water rate which may be much less than the working cost. Such conditions, of course, cannot hold good for irrigation co-operative societies where the enterprise has to be run on a self-financing basis and every individual required to pay the actual costs of water.

4. **A Consideration of Remedial Measures :** How can irrigation societies be made to function ? In this connection it may be pointed out that any enterprise embarked on privately must be commercially attractive. The same holds good for co-operative societies. Irrigation, whether by lift or flow, is always profitable but somehow it is not always commercially attractive specially where smaller cultivators are concerned. For using irrigation water in a profitable manner often large capital investment has to be made on land improvement, manual labour etc. The small cultivator is not equipped for this. The rural indebtedness, lack of fixity of tenure, poor marketing facilities etc. discourage him from investing capital sums even though facilities for cheap credit may exist. When, therefore, the societies cannot supply irrigation water cheaply as would normally be the case, the cultivator loses interest and eventually withdraws from the Society.

Some suggestions for making an irrigation society commercially attractive are given below :—

(i) In most parts of the country, Government have been and are still subsidizing irrigation in some form or the other for encouraging food production. Thus the water rate charged is often much less than the cost price of water. Repairs and restoration of minor tanks all over Southern India are being carried out on a subsidy basis. As already stated, U. P. Government lose on tube well irrigation by charging a rate less than the working costs. All this is done not only to encourage food production but also because the cultivators have a rightful share in the several indirect benefits accruing from irrigation. In a similar manner, lift irrigation could also be subsidized for encouraging the formation of co-operative societies. The method suggested is that Government could give some cash contribution to all such societies for every acre of land irrigated from year to year. This cash contribution would vary from place to place and also from crop to crop, the actual cost of irrigation being the determining factor. This subsidy, it is felt, would evoke response and the cultivators would be encouraged to form irrigation co-operative societies.

(ii) Since irrigation by itself is not commercially attractive to the smaller cultivator, by combining other services with it, the venture could perhaps be made attractive. What is meant is that round the nucleus of an irrigation source could be built a multi-purpose co-operative society. There are lots of services connected with irrigation which if made available in a unified manner would make irrigation commercially attractive even to the smaller cultivator. Bunding of land and other improvements connected therewith, procurement of manure, storing and marketing facilities, if all these are combined with irrigation, it is sure to improve the stature of irrigation societies.

(iii) A close association of the co-operative, agricultural and engineering officers with the irrigation societies in the initial stages, would help to put the Society on a sound footing. Our cultivators today, especially the smaller ones neither know the technique of mechanised lift irrigation nor the economics of irrigated crops. Proper guidance in these matters would go a long way in the setting up of these societies on sound lines and would considerably improve their eventual functioning.

CHAPTER VIII

THE MINOR IRRIGATION LAWS

1. Minor Irrigation Acts in the States :

(i) *Punjab, Pepsu and Uttar Pradesh* :—In these states most of tne minor irrigation works like wells, pumps and small unit tubewells are owned and maintained by the irrigators themselves. Government assistance to these works is in the form of loans which are recoverable in easy annual instalments.

Where pumps are installed on Government owned gravity canals, the irrigators are required to pay half the water charges that would be payable for direct gravity irrigation. Similarly, according to the Punjab Betterment Act 1952, the betterment charges on land irrigated from such installations would not exceed half of what would otherwise be payable for flow irrigation.

Minor irrigation like the big tubewells are owned and operated by Government. Charges for the use of tubewell water are made on a volumatric basis in Punjab. In Uttar Pradesh the rates for tubewell irrigation are the same as those for canal irrigation. On account of slow development of tubewell irrigation because of the disparity between canal and tubewell water-rates, the Punjab Government also are contemplating bringing down the tubewell water-rates so as to be at par with the canal water-rates.

(ii) *Bihar* :—Prior to legislation of the new Drainage Act of 1947, construction of irrigation works in the state was being governed by the old canal Act. According to that act such works as were capable of giving perennial water supplies and assured benefits could be constructed by Government. Since, however, cultivators have been doing some kind of irrigation from their own works, even though they are crude and supplies therefrom are not assured, there was a great popular demand for extensive construction of and repairs to such works. Government, therefore, decided to undertake these works and the new Act of 1947 came into force. Assured irrigation from such works was not possible and in most cases like "Ahars" it was difficult to demarcate the exact area which would benefit from year to year. The Act, therefore, does not provide for the levy of water-rate on the benefited area. Instead, it provides for the recovery of the capital cost of construction from the beneficiaries in suitable instalments. The cost is duly notified to the beneficiaries before work is actually started.

Since the legislation of the above Act, lots of works have been constructed under the G. M. F. campaign. In the beginning the G. M. F. works received a subsidy to the extent of 50%. The entire expenditure to start with was met with from Government revenues. Recoveries on account of peoples' share of expenditure were to be made subsequently. In actual practice several difficulties have been met with in effecting these recoveries.

(iii) *Himachal Pradesh* :—Most of the kuhls in this state are owned and maintained privately. Areas irrigated by kuhls are assessed to land revenue at a higher rate. Till recently, wherever Government have been undertaking construction of new kuhls or repairs and remodelling of old kuhls a minimum popular contribution of 25% was a necessary condition. At that time there were no laws by which any water-rate could be recovered in respect of such works. Non-availability of 25% contribution greatly retarded the progress on irrigation works in the early stages.

Government have since enacted the Minor Canals Act. Rules under the Act, however have yet to be framed. According to this Act the minor canals have been divided into two categories—(a) works on which the entire expenditure will be incurred by Government and the eventual maintenance and management would be the responsibility of the state. A water-rate would be levied on the irrigated area (Schedule I). (b) works which would continue to be the property of the irrigators (Schedule II). Their maintenance and management would be the peoples' responsibility and no water rate will be levied. Government, however, have a right to enforce a certain standard of maintenance of these works.

The above enactment would, therefore, help the construction of irrigation works both as a state and also as a private enterprise. In the second class of minor canals (Schedule II) it is understood that Government may give some kind of assistance in remodelling and restoration of works if a minimum popular contribution is forthcoming.

(iv) *Kashmir* :—In the state of Kashmir about 90 per cent of irrigation is done from private sources and only 10% is under Government canals. This is perhaps the one single state where big irrigation systems are maintained and managed by the irrigators themselves through their representative bodies. However, often there are disputes in the use of water and it is not uncommon to receive petitions relating to such disputes. In the previous regime the revenue authorities used to take ad hoc and arbitrary decisions whenever such disputes arose. For the past sometime these applications are now being dealt with by the Chief Engineer. The Kashmir Government have under consideration transferring the control of water to the Chief Engineer Irrigation.

(v) *Rajasthan* :—Here also minor irrigation works like wells and pumps are owned and managed by the irrigators. They do not pay any kind of taxes to Government on account of irrigation.

The minor tanks are, by and large, the property of Government. In the old Jagirdari areas, the Jagirdars used to collect the land revenue from the cultivators which also included some kind of water-rate on account of irrigation from the tank. The jagirdars, however, paid a fixed sum annually to Government. The tanks being the property of the jagirdars, the cultivators were not directly interested in their proper upkeep and maintenance. Also since the Jagirdars did not have any direct cultivation interests, they also did not pay much attention to their maintenance with the result that many of the tanks went out of repairs. Before the resumption of jagirdari the state Government made some efforts by direct negotiations on the spot with the cultivators as well as with the Jagirdars for repairing the tanks. In some cases they succeeded while in others they did not.

With the abolition of the jagirdari, ownership of all these tanks now vests in the state. When these tanks are rehabilitated by Government, a water-rate as also betterment fee are proposed to be collected from the beneficiaries of the land brought under irrigation. The state Government have in view transferring of minor tanks below a minimum size to the local panchayats. The revenues on account of wet assessment in respect of such tanks would in that case go to the panchayats and they would be responsible for their proper upkeep and maintenance. The panchayats could also take loans from

Government for restoration and improvement of breached tanks.

(vi) *Kutch* :—Minor tanks which are owned, maintained and managed by Government are subject to the irrigation laws applicable to state irrigation works. The system of assessment to water-rate here is by the number of waterings and not by any particular crop. Thus, a rate of Rs. 3/7/-is charged for the Bajri crop per acre per watering.

Under the G.M.F. scheme a number of minor irrigation tanks were constructed by private individuals. A subsidy of 25% was available under this scheme. These tanks irrigated the land belonging to owners and also to others to whom the former could sell water at Government rates. The maintenance of these tanks is the responsibility of the owners themselves.

(vii) *Assam*:—Till recently, the state of Assam had minor irrigation works executed through the Agricultural Department only. These mainly consisted of 'dongs and bunds' mentioned earlier (Chapter IV). In these works Government have been paying 50% of the estimated cost for new works and 40% for repairs and remodelling of old works, the balance being contributed by the beneficiaries in the form of labour. No water-rate or betterment tax was to be recovered subsequently.

According to the Assam Embankment and Drainage Act of 1954, the State Government now propose to recover in full or in part the initial cost of the scheme by imposition of betterment cess or water-rate. This is mainly intended for the bigger irrigation works constructed or under construction by the State Irrigation Department. Rules under the Act are still to be framed and it is not known to what extent these rules would be applicable to the Agricultural Department Minor Irrigation Works in which 50 to 60% of the total cost is recovered in the very beginning in the shape of popular contribution.

(viii) *Bombay* :—In this state minor irrigation works like tanks and Bandharas are constructed under one of the following rules:—

(a) According to one, popular contribution to the extent of ¼th and 1/3rd of the cost (of repairs or new construction) for tanks and Bandharas respectively is insisted upon. The balance of the expenditure is met with from Govt. revenues. Irrigators are charged, irrespective of the cost of the minor irrigation works, betterment levy water rates and irrigation cess from the date from which water is given to the cultivators.

(b) According to the other rule minor irrigation works are undertaken by Government with the voluntery contribution of the villagers to the extent of 33 to 50% of the estimated cost of works in cash or labour or both. In such works, expenditure incurred by Government is treated as a loan to be recovered from the beneficiaries. The loan amount together with interest thereon at about 4% are recoverable in ten equal instalments as in the case of Tagai loans from the owner of land under the command of these works and who have contributed towards their construction. These works are not subject to levy of water-rates during the period of recovery of loans. Water-rates, however, are charged in accordance with the rules in force in the Public Works Department after the loan is fully repaid. In order to provide for expenditure on the maintenance of these minor irrigation works, irrigation cess is also levied on the commanded land, after the work is completed and water is made available to the villagers for irrigation.

(c) In backward and poor areas Government expenditure is restricted to 50% of the estimated cost of the work and is treated as revenue expenditure. These works are subject to water rates from the year from which water is given for irrigation and no betterment levy is charged on works costing less than Rs. 50,000/-.

The villagers are given the option of selecting any of the conditions mentioned in (a) or (b). Condition (c) as already stated, applies only to backward areas.

From the above rules it would be observed that even where the entire government expenditure on a minor irrigation work has been recovered from the beneficiaries (condition (b) above) the work continues to be the property of Government because cultivators have to pay the water-rate and the irrigation cess to Government. This is so because all rights in water are supposed to vest in the state. However, this is not the case in states like Assam, Bihar or Orissa where the minor irrigation works even though partly financed by Government remain the property of the irrigators.

Wells and pumps are the property of the individuals and they do not have to pay anything to Government except perhaps the increased land-rate.

(ix) *Madhya Pradesh* :—In this state, minor irrigation works were originally being constructed by private enterprise under the Taccavi-cum-subsidy scheme. The response was not satisfactory and it became apparent that the construction of and repairs to village tanks was beyond the capacity of individual borrowers. To accelerate work on this, departmental construction of and repairs to tanks was started under the Village Project Scheme in 1948. To facilitate working of the scheme, an ordinance was promulgated to enable Government to take possession of village tanks. The C. P. Irrigation Amendment Act of 1948 thus came in force. The Act provides for requisitioning of private tanks in derelict condition to improve their irrigation facilities without the need of acquiring them outright in the first instance by paying large amount of compensation. According to the provisions of the Act the tanks had to be permanently acquired after the expiry of the period of requisition or released from requisition, provided the owner reimbursed the State Government the expenditure incurred on the improvement of the requisitioned property.

Consequent on the abolition of Malguzari, the rights in Malguzari tanks now vest in the state and the need for requisitioning such works does not arise. Tanks owned privately have still to be requisitioned.

Irrigation from minor works owned and managed by the state is done on the same lines as from major irrigation works. The method of assessing the irrigable land to water-rate is by the agreement system. According to this, owners of the land under command of work enter into a long term agreement with the state (generally for a period of 10 years). During this period they have to pay a yearly water-rate whether they take water or not.

Irrigation in Madhya Pradesh being of a protective and supplementary nature often takes long to develop. The cultivators can get some kind of crop under rainfed conditions and are not much interested to enter into an irrigation agreement even though the water-rate is very nominal. To meet the situation another act known as the C. P. Irrigation Amendment Act of 1945 was legislated. According to this, the commanded area under an irrigation work could be declared as compulsarily assessed area thus making irrigation obligatory. Even though the Act was promulgated over 10 years back its provisions have not yet been invoked. Once this comes into force, development of irrigation is sure to be accelerated.

(x) *Orissa* :—Under the G. M. F. scheme a number of minor irrigation works were constructed some by the P.W.D. but mostly by the Revenue Department. In all these works 25% contribution from the people had been made obligatory. Works under private ownership continued to be the property of individuals even after these were rehabilitated. The works which were newly constructed (like the weir schemes) were the property of Government. Irrigation from both classes of works was however, left to the cultivators. Till recently no obligations had been imposed on the cultivator to make use of water available from these sources. It was not known whether the beneficiaries would be required to pay any water-rate or betterment tax or both to Government. It is understood that Government have now in view to survey the commanded areas of these works and assess them as per provisions of the Irrigation Act in force in the state.

(xi) *Mysore* :—The rules for maintenance and restoration of minor tanks have already been described in Chapter V.

(xii) *Hyderabad* :—All irrigation tanks, both major and minor, are the property of the State. Tanks having an ayacut of less than 10 acres are neither maintained nor managed by Government. Where the ayacut is more than 10 acres but less than 50 acres, the tanks are managed by the Revenue Department. Whenever required, special repairs or restoration work is entrusted to the Irrigation Department. Tanks having an ayacut of more than 50 acres are maintained by the Irrigation Department. Where the maintenance costs are less than Rs. 250/- per year the tanks are not maintained annually. These are maintained bi-annually or tri-annually as the case may be.

The channel system is constructed and maintained by Government up to the point where the ayacut is not less than 210 acres. The internal water-course system beyond that point is the responsibility of the cultivators.

The system of maintenance of minor irrigation, and collection of water cess therefrom has been in vogue here for a very long time. In fact, every sheet of water is accounted for and according to the minor irrigation Act whenever any fresh area comes under irrigation due to construction or restoration of a tank the land is immediately assessed to water-rate which is later on merged into the land revenue at the time of next settlement. Once it is known that land is irrigable from some tank it is assessed to water-rate even though the cultivators may fail to reach the water.

(xiii) *Travancore-Cochin* :—According to the Irrigation Act here, Government may levy a cess on any area benefited by an irrigation work—major or minor (tanks having an ayacut of over 200 acres are classed as major tanks and all smaller tanks as minor tanks) constructed, restored or repaired wholly at the cost of Government. Amount of such cess shall not exceed 6% of the total outlay. Such cess usually absolves the ryots, in the case of minor irrigation works, from payment of their portion of the cost of such works, where such payment is otherwise liable and also from the duty of maintaining the works.

According to the same Act when any minor irrigation work is constructed, repaired or restored wholly or partly at Governments' cost it is the duty of the beneficiaries to maintain the work. Notwithstanding the above, Government may undertake to maintain such work and in that case it would levy a cess towards the cost of its maintenance an amount not exceeding 4 chekrums (about two annas and six pies per acre). In such a case it would not be the duty of beneficiaries to maintain the work. These two conditions are interchangeable.

For some parts of Travancore viz Neyyattinkara and Vilavancode, there is a special minor irrigation Act according to which when a minor irrigation work is constructed, repaired or restored, Government will remit, as a matter of grace, one half of the cost of such works but the other half will be paid in 10 instalments by the ryots and no cess will be recovered. This is actually a combination of the above two provisions in the Irrigation Act with the difference that remission is given by Government to the extent of 50% and maintenance by the cultivators becomes obligatory.

2. Need For A Changed Approach :—

A study of the irrigation activities under the G. M. F. compaign during the past some years and of the minor irrigation laws regulating their operation would appear to bring out the following few facts :—

(i) For speedy implementation of the G.M.F. programme it was realised that private enterprise had to be stimulated and encouraged in some manner by which irrigation works could be executed without much undergoing the rigours of detailed technical scrutiny. To that extent the scheme perhaps succeeded. For ensuring that the schemes would be of real use, a minimum of peoples' contribution was also insisted upon.

Although a large number of irrigation works were constructed in this manner, the benefits from such works however have not been near what had been visualised. The initial investment on the part of the cultivator was nominal and he did not take sufficient pains to ascertain the suitability of the scheme put forward by him.

Neither could Government give the attention needed in the proper investigation of these works as they felt the cost minus the subsidy would be eventually recovered from the cultivator. The result of all this has been that a large number of minor irrigation works, quite a few of doubtful utility, have sprung up, but the actual increase in the irrigated areas has not been much. Although the rules were made with the best of intentions and with the definite aim of stimulating activity on an aided self-help basis, the over all result has not been very satisfactory.

(ii) Wherever the execution of minor irrigation under the G.M.F. programme was entrusted to the Irrigation Departments, the progress has been slow, partly because of the non-availability of technical personnel and also because normal procedures of Irrigation Department are lengthy and combersome. However, works executed through the Irrigation Department were of real utility.

(iii) The class of works on which progress was satisfactory and where, useful works have come up are the ones owned and maintained by individuals like wells and pumps. Government investment on these works has yielded really useful results.

(iv) Even though legislation has been existing in some states making the irrigator responsible for the maintenance of minor irrigation works, it has not been possible to enforce it.

(v) In regions where irrigation is of a supplementary and protective character and the cultivator can get some kind of crop under rain fed condition, the development of irrigation has been very slow.

In order to have a more efficient performance of minor irrigation works, introduction of some basic changes in our present systems would appear necessary. These would be on the lines broadly indicated below :—

(a) Since there is a limitation on the class of works coming under category (iii) above (viz lift irrigation by wells and pumps), some method will have to be devised so as to achieve maximum progress on useful works coming under category (i). While Government may continue to give concessions to private enterprise, it appears necessary that the benefits visualised from the works undertaken by private enterprise are actually realised. Perhaps levy of water-rate or a betterment tax or both on a scale lower than that applicable to state managed works from which supplies are assured, would have the desired effect. It would not only help proper development of irrigation from the newly constructed sources but would also ensure construction of works of real utility.

(b) There is no doubt that as the institution of panchayats is gradually built up and strengthened, it should be able to look after the maintenance of minor irrigation works in an effective manner. Till then the desirability of forming Irrigation Associations as an integral part of the Panchayat could be considered. The irrigators or their main representatives would be the members of the Association, and they would be responsible to the Panchayat for the efficient maintenance and upkeep of these works. In short the control (both financial and administrative) which Govt. would normally exercise would now be exercised by the Panchayats. At the same time the interested parties i.e. the irrigators would be directly responsibile for the actual maintenance work. The finances, when necessary, would be provided by the Panchayat since the revenues on account of wet assessment would go at least in part to the panchayats.

(c) The system of compulsory irrigation as visualised in the Irrigation Amendment Act of 1945 in Madhya Pradesh needs to be introduced in all such regions where water is needed only for supplementary irrigation.

CHAPTER IX

ROLE OF MINOR IRRIGATION IN MAJOR RIVER VALLEY PROJECTS

1. **Water Shed Problems in the Planning of River Valley Schemes :** Every river basin has a particular annual run off that could be tapped for irrigation purposes either by major or by minor works. The apportioning of water to these two categories of work has to be properly planned and phased. For example, if it is proposed to construct a major reservoir in the near future. It would not be correct to permit large scale construction of minor tanks in the water-shed unless of course the major reservoir is designed to store only a small percentage of the yield from its catchment.

Similarly, if a large number of diversion works tapping the small tributaries in a river basin are in existence, the actual operation of a major storage reservoir located in the head reach of the valley would be conditioned by the presence of these minor works.

Ground water resources are also sometimes interfered with by the execution of river valley projects. For example, before the construction of the Jawai dam in Rajasthan, the flood waters of the Jawai river used to charge the ground water by percolation. With the construction of the Jawai reservoir this feeding of the wells located on either bank of the river has been obstructed and most of the wells have suffered in their ground water supplies. Here, of course, irrigation from the Jawai reservoir would ameliorate the trouble to a great extent but there is another part of this scheme which if implemented is likely to have some repercussions on the ground water supplies. It has been proposed to divert additional 30 sq. miles catchment in the Jawai reservior because of the inadequate yield from its own catchment. When the diversion is effected, wells in the adjacent valley will have deficient water supplies and the local people are apprehending danger to their wells.

These are simple instances which bring out the important corelationship between major and minor projects. It is almost impossible to separate one programme from the other and lack of appreciation of the minor irrigation programme would reflect adversely in the overall planning of any river valley project. The unit of investigation is necessarily to be a water-shed and not a major or a minor project.

2. **Effect of Minor Irrigation on the Behaviour of Catchments :** With the coming up of minor irrigation works and soil conservation projects on a large scale, it has become necessary to determine their exact effect on the behaviour of catchments as on this would greatly depend the design and operation of major river valley projects. Thus, in course of time, when the minor irrigation works and the soil conservation projects reach a stage of maturity, they would have a direct effect on—

(i) the run off;

(ii) the intensity of peak floods ;

(iii) the duration of peak floods.

Any big reservoirs that may have been constructed lower down would be affected in a corresponding manner. Thus lowering down of the effective yield from the catchment would render a portion of the storage inoperative. Similarly, if the duration of peak floods becomes shorter, the flood absorption capacity provided in reservoir would also be partly rendered inoperative. Both these factors would point to the need of having a certain degree of flexibility in the design of our storage dams.

Lot of research work has been done and is being done on the hydraulic structures but perhaps not much hydrological or hydrographic study of the water-shed has been carried out. The Soil Conservation Board in the Ministry of Food & Agriculture have been carrying out these studies on a small scale in respect of small catchments in the Nilgiri hills with a view to bringing their soil conservation projects on a sound footing. Some of the States, e.g., Madhya Pradesh offer a variety of catchments. In such regions, hydrological study of some sample catchements of varying sizes and also subjecting different catchment to identical conditions of rainfall may give valuable information which would greatly help the design of works.

There is yet another factor to be considered. We have been drawing heavily on the ground water storage and in times to come this drawal is likely to become many times more.

Here also the replenishment is effected by water drawn from the surface run off. The extent of depletion of ground water would, therefore, have a direct bearing on the yield from the catchment. For an accurate forecast of the behaviour of catchment it would, therefore, be necessary to establish the relationship between the yield from the catchment and the extent of depletion of ground water.

3. **Conservation of Moisture in Soil versus Direct Irrigation :** In the preceding pages it may have been noticed that in some areas, the manner of application of water to fields from the cultivators' works is different from what it is in the case of regular irrigation sources. Thus in Assam, the real effect of 'Dong' and 'Bund' irrigation is not merely to divert the flow water. The bunds periodically divert a whole flood on to land. This would happen every time the stream is in floods. The result is a thorough drenching and soaking of a large area. When the stream is at low water, the 'dongs' divert just the available flow. In a soil already flooded earlier and saturated with moisture the small flow in the 'dong' is often able to irrigate large areas. Although the system is quite uncontrolled, the net effect is utilisation of a much larger quantity of stream water than would be the case in a normal flow irrigation scheme. In the latter case, only the minimum flow is harnessed while the flood flow is allowed to escape into the main stream. The 'Bandharas' of Bombay, irrigation by flooding in Madhya Pradesh, series bunding of valley in Travancore—all these aim at utilisation of water much in excess of the minimum flow. Even in wet areas like Manipur there is fight for flood water between different villages necessitating interference by local authorities.

The method of conserving moisture in soil by flooding as outlined in the preceding paragraph would appear to suggest a possible use of the flood water escaping from irrigation storage reservoirs. In Central India regions, including Orissa, it is a common practice to design a storage tank for 1/3rd to ½ of the average yield from the catchment. The balance of water escapes over the wasteware into the valley. In some cases where topography of land may so permit, this spill water could, to some extent, be canalised to flow over cultivated land intermetently. This would enable the tank to irrigate larger areas from unit storage. In villages, waste weir irrigation from minor tanks is often practised, although it is not always appreciated. Just as the cultivator wonders why in newly constructed Government tanks, we allow so much water to go waste over the escape weir, we also at times, lost in our technique, fail to appreciate his methods when he leads the escape water to cultivated land.

It would appear that water application from minor irrigation sources is at two extremes. From the very small sources owned singly or jointly like wells and tube wells, water is applied to the crops in rationed quantities and much better duties are obtained than in the case of canal irrigation. The other extreme is wholesale flooding and diverting large quantities of water on to land in an uncontrolled manner. The State-owned irrigation works, on the other hand, occupy a middle position in which water application, though neither rationed nor let loose, is just controlled. If a system could combine all the three practices, rationing, controlling and flooding in one, it may be possible to achieve much better water use for the same unit cost.

Of late, a good deal of thinking has been done on the merits of contour bunding vs. direct irrigation as a measure of water conservation. During the famine years of 1950-51, a large number of irrigation storage tanks were constructed in the famine-stricken districts of Rayalseema in the Andhra State. These works cost Rs. 1000 to Rs. 1200 per acre of land brought under irrigation while the appreciated land value consequent on the construction of these works did not exceed Rs. 200/- per acre. Here, it has been correctly opined that a better method of water utilization would have been to conserve moisture in the water-shed itself by large scale contour bunding rather than collecting the run-off from a big area in a storage tank and utilizing the water therefrom for wet cultivation in a smaller area lower down.

4. **Minor Irrigation—A Method to Accelerate Water Utilization :** One of the difficulties experienced in irrigation works is the time lag between water conservation and water utilization. In the case of river valley projects, this holds good even in a greater measure. Always the problem is how to get the maximum out of a cusec of water in the shortest possible time. The minor irrigation works in the Community Projects and N.E.S. would perhaps provide a possible solution. With the help of the Extension staff in the Community Projects, agriculture and other rural development activities could be intensified on an integrated basis in small blocks of land located in the command of a minor irrigation source. These blocks could develop into nuclei of intensive irrigation activity and are sure to accelerate water utilization.

CHAPTER X

FUTURE TRENDS

The first phase of the Community Development Programme is soon to come to an end. To what extent this has improved the living standards of the common man as judged purely from the physical achievements would convey a very meagre idea of its performance. The impact this programme has made on the minds of the people, how the symbolic works in Community Projects have influenced them and how the people have responded—these tell us its real story. Minor irrigation is one facet of this integrated programme. It has made people water conscious. It has evoked an awareness for better and fuller use of water. It has, above all, prepared the people to receive the large quantities of water being collected and conserved in the medium and major irrigation projects.

In the second and succeeding Five Year Plans, increasing emphasis is being given to the employment aspect of the development programmes. Unless increased production could be synchronised with increased purchasing power, our rural economy would continue to be unstable. The cultivator today is still deeply attached to his well, to his wooden Rahat and to his bullocks, even though alternative methods of lifting water, more efficient and much cheaper are available. The reason for this is not far to seek. In the former case, the cultivator gets the precious water by a productive use of his man-power, his bullock power etc. at no cash expenditure to himself. The latter costs him money and unless man-power released by the introduction of improved practices could be absorbed into gainful employment, he cannot collect cash to pay for the cost of water. The minor tanks, the bundhis, the wells, the bullock-operated Rahat—all these provide gainful employment and are in consonance with rural economy. The ever-growing emphasis on minor irrigation in all our land and water programmes should thus be understandable.

Till lately, we have been adopting strict standards of productivity tests for irrigation works. We have been maintaining that the schemes must be commercially attractive from their revenue return alone. Fortunately, in the recent past, these standards have undergone a good deal of change and much healthier trends are noticeable. Why is it that in Assam, the cultivator spends Rs.1 to Rs.1/8/- per acre on irrigation from 'dong' and 'bund', and why the Rajasthan cultivator spends Rs. 8,000/- on his well for irrigation of 3 acres of land or the Madras cultivator spends Rs. 200/- per acre per year on irrigation of paddy by lift ? A study of the minor irrigation practices gives us an insight into these problems. The receptivity to irrigation water, the water consciousness and the ability of the cultivator to invest on irrigation water—all these are determined from climatic conditions, the physical features and above all, the economic system. If we become alive to these factors, our insistence on rigid productivity tests would greatly diminish. Yardsticks are good and when applied region-wise may even be desirable but when insistence on these yard-sticks becomes an obsession, bigger interests of the country are likely to be lost sight of.

Questions are often asked, "Why should we think in terms of minor works which offer only short-lived and uncertain protection ? Why not have bigger and long-term plans ? Why should we not just concentrate on big river valley projects because eventually these would replace the minor irrigation system ?" We are on the threshhold of the Atomic age. If the logic is carried forward, should we not be afraid of the fact that the tremendous energies released from the splitting atom may put all our big water and power projects out of commission. Obviously, this cannot be the guiding factor. We have to have all kinds of schemes—the short-term, the medium term and the very long-term. One scheme cannot replace the other. Each would only serve to reinforce the plan as a whole.

When the full development of a valley has taken place, we may visualise a perfect irrigation system as consisting of a big canal bringing water to the field in a controlled manner, temporary dams across the drainages causing flooding of the land and saturating it with moisture and finally small irrigation sources issuing water in rationed quantities-combination of all the three aiming at optimum water utilization.

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GOVERNMENT OF INDIA PHOTO-LITHO PRESS, NEW DELHI