# BETTER IRRIGATION



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**THE COMMUNITY PROJECTS ADMINISTRATION**

**(Planning Commission)**

GOVERNMENT OF INDIA

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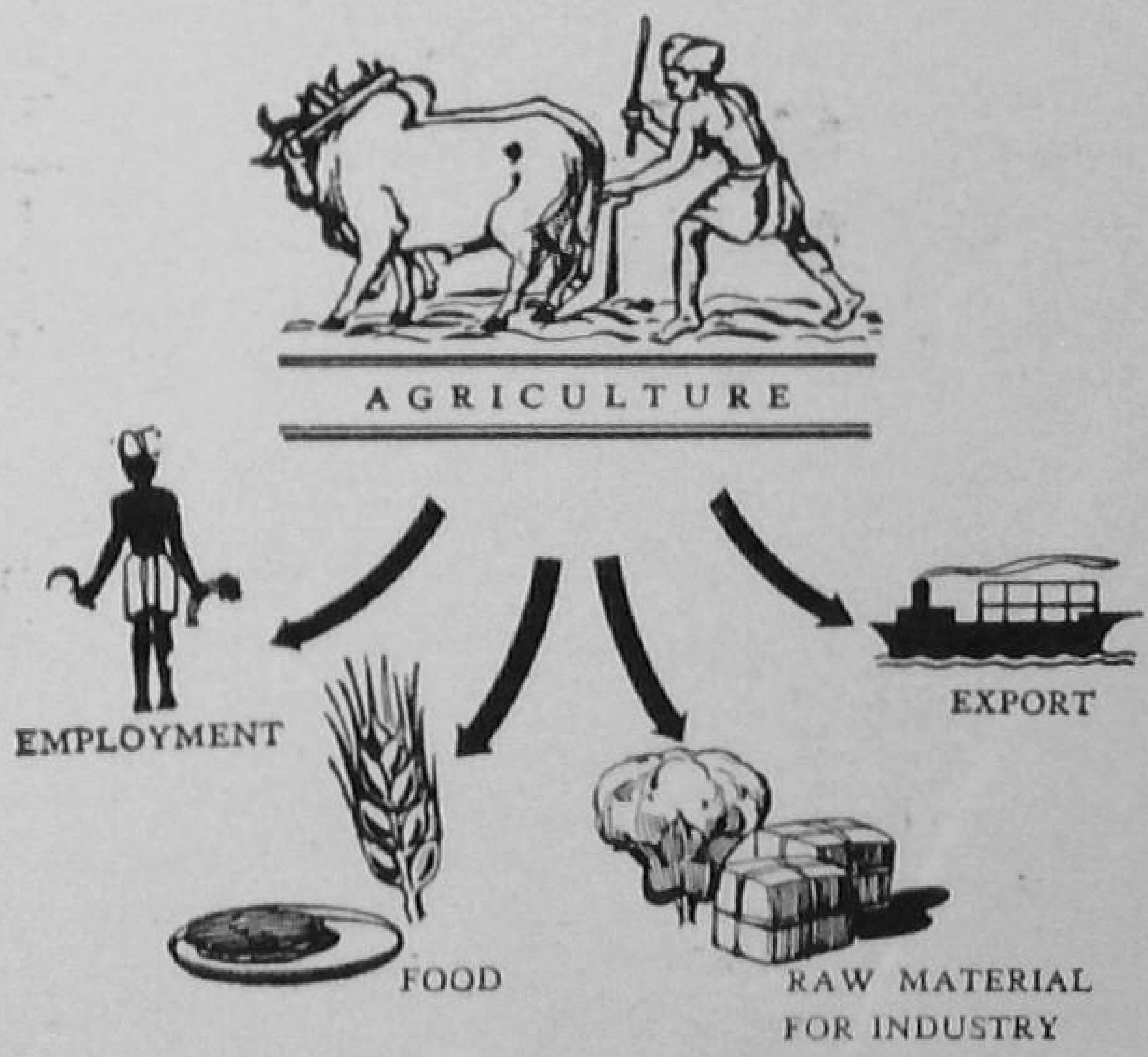
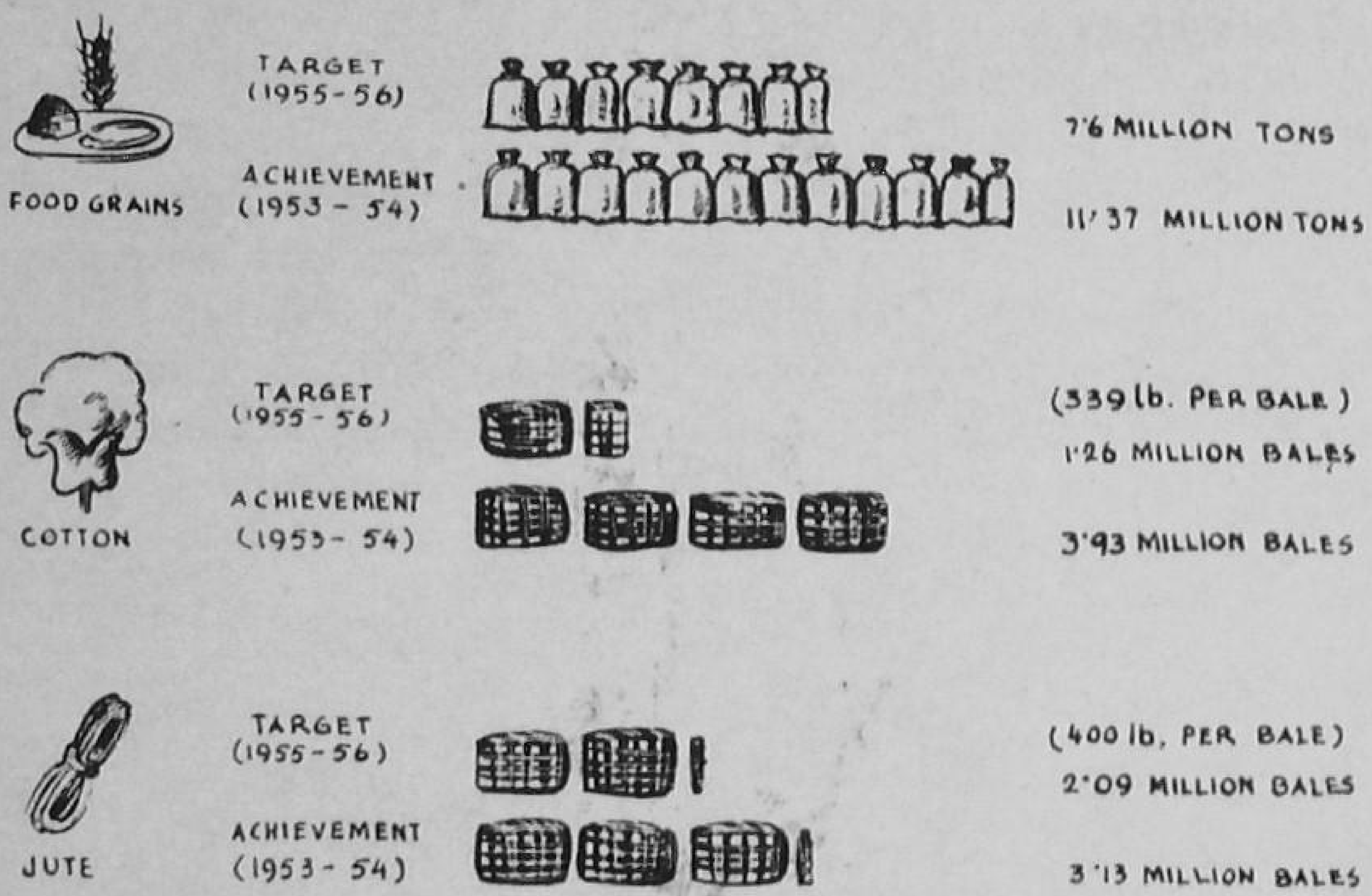
## 1. INTRODUCTION

The Five Year Plan, as we know, is largely concerned with the development of agriculture. This is but natural. Ours is primarily an agricultural country. Land is our most valuable asset. It gives us food. It supplies raw materials for our industries. It also provides work for the majority of our people. In fact, it is the main source of our country's wealth. We produce cotton, jute, lac, tobacco and oilseeds. We sell them to foreign countries and, in return, receive large sums of money. Our happiness thus depends on the prosperity of agriculture.



And yet, for some time, we have not been growing enough food for our people. Nor have we been producing sufficient cotton and jute for our mills. This has been our main problem. We have had to import foodgrains from abroad. But this could not solve our difficulty. The foodgrains became more and more expensive. We have had to spend about Rs. 750 crore in importing them.

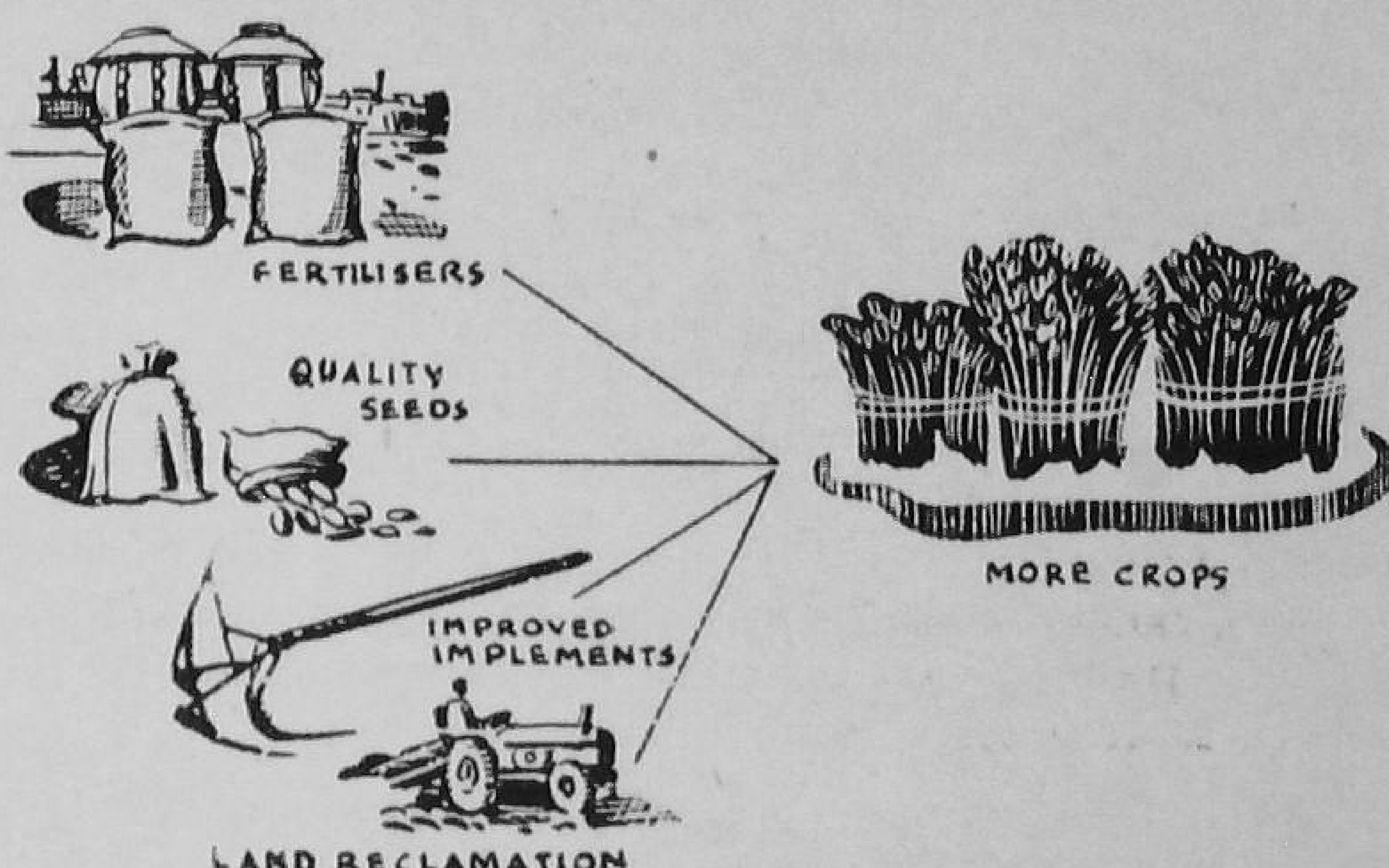
What exactly is the extent of the shortage? Our experts had calculated, when the first Five Year Plan was drawn




up, that our requirements of foodgrains fell short by about 3 million tons. Considering the rate of increase of population, this deficit would have risen to 6.7 million tons by 1956. We are also short of commercial crops like cotton and jute. The Plan, therefore, aims at raising the production of foodgrains by 7.6 million tons, of cotton by 1.26 million bales and of jute by 2.09 million bales. Fortunately, we have exceeded these targets during the first three years of the Plan. Thus, in 1953-54, we produced 11.37 million tons of foodgrains, 3.93 million bales of cotton and 3.13 million bales of jute.

The import of foodgrains, too, was reduced from 4.7 million tons in 1951 to 2 million tons in 1953, thereby making a saving of Rs. 130 crore. Meanwhile, the prices of cereals and pulses have shown a marked decrease. After a period of more than ten years, food controls have disappeared.

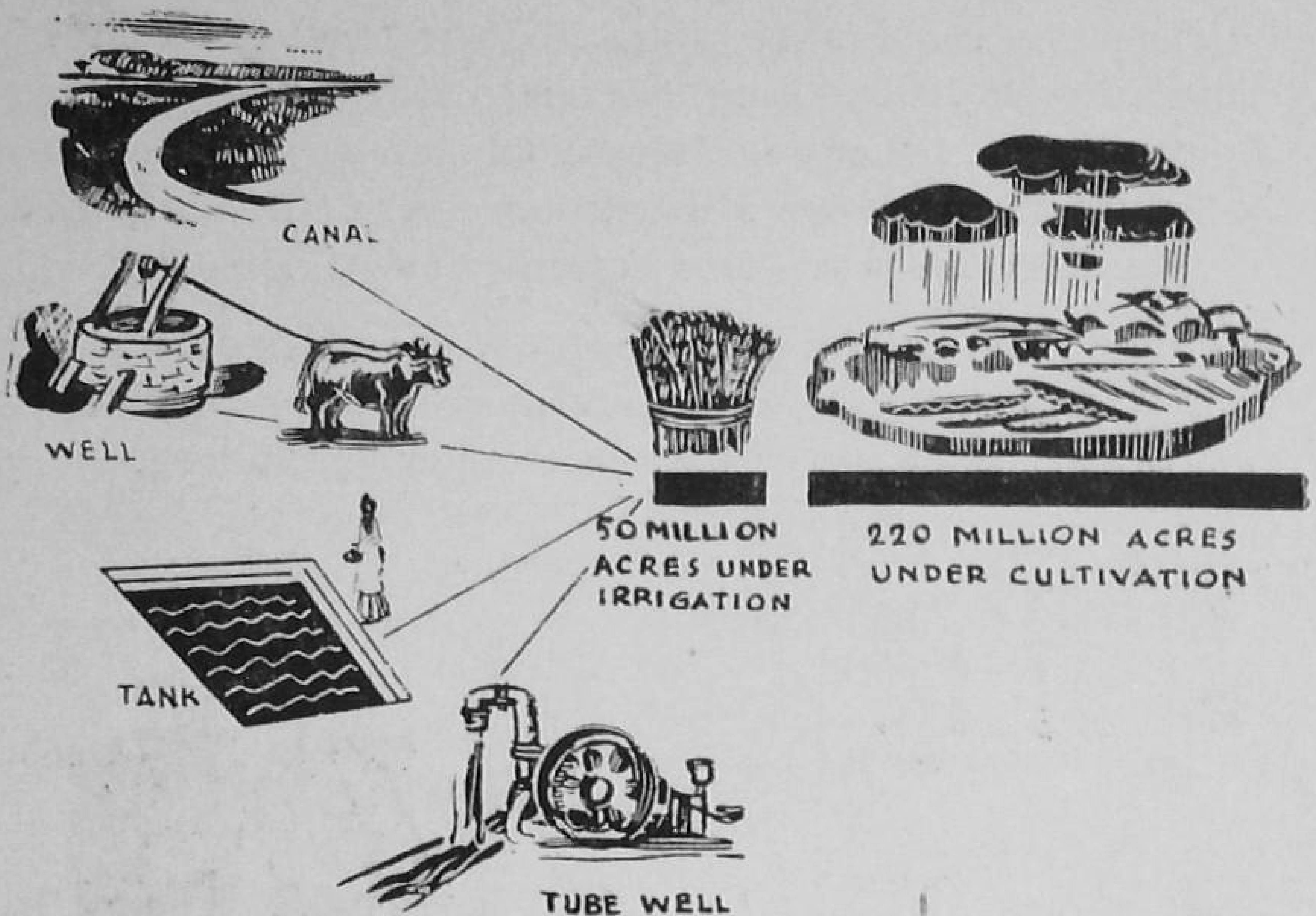
How was all this achieved? Well, we have adopted several means. We have brought more land under cultivation. We are using better seeds, better ploughs, more manure




and fertilizers. Large areas, which were covered with weeds, have been cleared, and we are growing crops on the reclaimed land.

Nothing, however, will grow without water. At present, large parts of our country are without enough water. Only about 50 million acres are served by canals, wells, tanks and tube-wells. This is just a fifth of the total area under cultivation. The remaining four-fifths are at the mercy of the monsoon which often fails. Hence, sometimes we have too little, sometimes too much of rain. Droughts and floods follow. The crops are ruined.

What are we to do, then? Obviously, we must no longer




depend exclusively on the monsoon. We are, therefore, building more canals, wells, tanks and tube-wells. Under the Five Year Plan, we expect to provide water for 19.7 million more acres of land than in 1950.

## 2. IRRIGATION WORKS

There are two types of irrigation works. The major ones are canals, dams and reservoirs. The minor works include wells, tanks, pumps, tube-wells and channels.

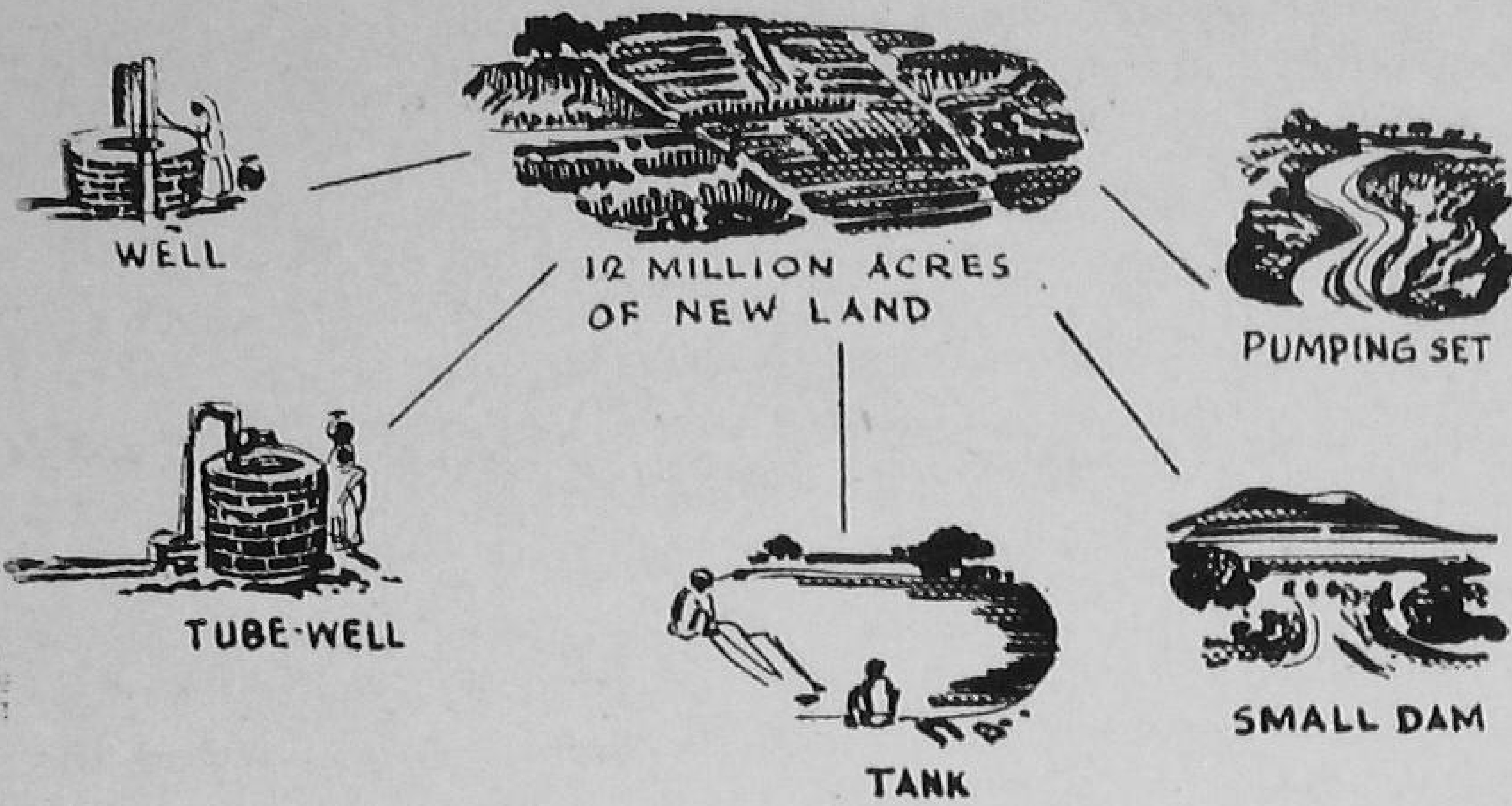
Irrigation from wells and tanks is not new to India. It has been practised in our country for thousands of years. Wells, canals and dams are mentioned in the *Vedas*. The large number of tanks found in Deccan have been in existence for centuries. The Cauvery delta canals, for instance, date back to the second century A.D. Sudarshan Lake in Kathiawar was dug during the times of Chandragupta and Asoka. Bhojpur Lake in Bhopal belongs to the eleventh, while the Jumna canals were built about the fourteenth century A.D.

The first major irrigation works undertaken by the British was the Ganga canal in Uttar Pradesh. Then followed the Upper Bari Doab canal in the Punjab and the Godavari and Krishna delta systems in Madras. A number of other large irrigation works were started early in the present century. Among these were the Sirhind and the Lower Chenab canals in the Punjab; the Ken, the Betwa and the Sarda canal systems in Uttar Pradesh; and the Periyar dam and the Stanley reservoir in the south. The Ekru reservoir and the Bhandara and the Bhatagar dams in Bombay State are other important works. Some very fine irrigation reservoirs were also constructed in Jaipur and Ajmer-Merwara.

But these works are inadequate for the irrigation of a vast country like ours. They meet the requirements of only a small percentage of the cultivated land. That is why, we are building, under the Five Year Plan, a number of mighty dams across certain rivers. The water thus stored will be used to irrigate the fields. These are the major irrigation works.

The Plan also provides for a large number of minor irrigation schemes. Old wells and tanks are thus being repaired and new ones dug. Tube-wells are being sunk to lift water by electric pumps. Pumps, too, are being installed to draw water from rivers and lakes. In addition, there are the small dams and channels which are being built at a cost of Rs. 77 crore These will bring water to 12 million acres of new land.

One may ask: why is so much emphasis laid on minor irrigation works? In the development of irrigation, the minor irrigation works are just as important as the major




ones. In fact, they are more advantageous in many ways. They can be executed in a relatively shorter period. They yield quicker results. There is also no need to obtain equipment from abroad.

Major irrigation works are needed for the control of floods, generation of power and irrigation. These, however, are costly and require specialised technical skill. Naturally, the Government have to provide both the funds and skill. The minor irrigation works, on the other hand, depend largely on the co-operation of the villagers and on local material for their construction. They are truly a people's programme.

## 3. REQUIREMENTS OF WATER

We know the importance of moisture in the soil for the growth of crops. Deep ploughing helps a great deal in retaining the moisture. The result is that less water is needed. Farm yard manure also saves water.

It is a common belief among our cultivators that the more the quantity of water used, the better for the crops. But this is not wholly correct. More and more water will now be available for irrigation as new wells, channels and tanks are dug and small dams are built. We must, therefore, know how much water a particular crop needs so that the available supply of water is put to the maximum use.

The amount of water required for crops depends upon several factors, such as climate, soil, drainage, subsoil water, manure, crop rotation, the area of land, the quality of water, the method of delivery and the system of irrigation.

Let us examine how much water is required for a few important crops like rice, wheat, sugarcane and cotton.

### RICE

The rice plant requires periodical watering at three stages. The first is the seedling stage covering about 10 days. The second is the pre-ploughing stage lasting about 25 days. Finally, the plant must be watered when the ground is being ploughed, i.e., for 5 to 7 days.

Generally, rice is planted in extremely wet conditions. But this is unnecessary for normal growth and yield of crop. The practice of ploughing the fields for nearly three weeks after transplantation has been found helpful for the growth of the plant. The standing water increases the height of the plant by producing conditions of temperature suitable for young seedlings to grow. The fields should, however, be cleared of water afterwards, otherwise tilling suffers.

### WHEAT

The amount of water required for wheat depends on rainfall during September-October and December-January. If it is adequate and well distributed, there is no need for extra irrigation. But, as we know, such conditions are rare. Generally, sixty thousand gallons of water per acre, applied twice, give the best yield. It is true that more water gives increased yield. But this is not in proportion to the extra water supplied.

### SUGARCANE

It has been observed that about eighty thousand gallons of water per acre give the best results in the case of sugarcane. Our cultivators generally fill the field to the maximum at each irrigation, which is a wasteful practice.

The quantity of water required for sugarcane, however, differs from region to region. In South India, the normal irrigation consists of seven waterings. The sugarcane crops in Uttar Pradesh need to be irrigated frequently. The minimum requirement of water in Bombay State is 95 acre inches. The amount of water required for the plant is also not the same for all the stages. It is highest at the vegetative and flowering stages and the lowest when the plant becomes mature.

### COTTON

The season for sowing cotton is between April and mid-June. The crop is lifted by the end of December. To turn to irrigation, the normal varieties of cotton should be watered three to four weeks after sowing. Any delay would affect the yield. No water should be used for these varieties after the middle of December. It would, however, be necessary to water those varieties that mature late.

## 4. THE RAIN WATER

The rain water is an important source of irrigation. We can collect this water in tanks for crops when the rains fail. Such a tank should have a bund for storing water, a gate for letting out water, and a weir for disposing of the surplus water.

### THE CATCHMENT AREA

The area which feeds a tank is known as the catchment area. The whole of the rain water, however, does not flow into the reservoir. A part of it escapes underground, some is absorbed by plants and trees or evaporates. The remaining water appears as a stream and fills the tank. This is the real yield, i.e., the total amount of water in accumulation in the tank.

This quantity depends upon several factors. One is the intensity of rainfall. The amount collecting in the tank would naturally be more when the rainfall is heavy than when it is small. Most of the water would disappear underground where the catchment area is porous or sandy. This would leave little water for the tank. More water would flow into the tank if the catchment is sloping than where it is flat and bunded.

### THE TANK BASIN

A tank with a flat basin will have a much bigger storage capacity than the one with a sloping basin. The irrigating capacity of the tank will, however, depend on the catchment area. It is no use digging a big tank if the catchment area is not large.

### THE WASTE WEIR

When the tank is full, the waste weir lets out the surplus water through a channel into the main *nala*. It should be built on rocky soil or hard ground to prevent scouring. Small weirs would ordinarily do for small tanks.

### EARTHEN DAMS

It should be remembered that the long and low dams are often cheaper and safer than the shorter and higher ones. Moreover, the soil for the foundation of an earthen dam should be compact. It should not yield when wet. Nor should it settle or slip under the weight of the dam.

It is important to drain off the ground at the rear of a high earthen dam downstream. Care should be taken to see that the subsoil at the base of the embankment is not sodden, lest the damp ground give way under the weight of the dam. It is, therefore, a good plan to slope off the ground just below the outer toe of the catchment for about 30 feet.

A small drain should also be cut at the foot of the slope to carry away the water. Another drain parallel to the embankment should also be constructed downstream. This will help to drain thoroughly the subsoil at the base of the dam.

The maximum percolation through the embankment generally takes place along the base of the dam. It is, therefore, necessary to intercept any flow that may take place there. We should also drain off the water, but avoid injury to the dam.

## FIELD EMBANKMENT

Sometimes, the rain water is collected inside large field *bundhies*. Such field embankments are a very common sight in the northern districts of Jabalpur and Sagar in Madhya Pradesh. Many such embankments are also found in the Kotah and Bundi districts of Rajasthan. Regular escape-weirs are built on both sides of the embankments to let out surplus flood water. A flat basin is considered best for these embankments.

The water collected in this fashion is not generally used for irrigation, but is just drained out after the rains when the winter crops are sown. The land under water thus becomes so saturated with moisture that it does not require any irrigation. Such fields are often known to give a bumper crop of wheat.

### GRAVITY DAMS

Masonry or concrete dams are not really necessary for minor irrigation tanks. The earthen dams can safely be built to a height of 90 to 100 feet. It is only where the site has a natural gorge that a gravity dam is found useful. It is easy to construct a gravity dam as stones are available in plenty in the hilly tracts. A masonry dam has some advantages, for it is possible to discharge the flood water directly over the lower bank to the main dam. Moreover, silting can be reduced considerably by providing under sluices in the lower reaches. A masonry dam should, however, have a sound foundation.

## 5. THE STREAM WATER

Another important source of irrigation is stream or river. The weir or regulator should be built across the stream to enable water to flow into the fields. This should have one or more openings at one end or in the centre, and these should be fitted with wooden or iron shutters to prevent the river bed silting upstream. As the canal taking off from the weir will carry only a fixed quantity of water, a sluice control should be provided at its head so that it does not get choked by water during the rains. Finally, earthen embankments should be built to protect it from submersion during floods.

### THE FLOW IN A STREAM

It is generally believed, but mistakably, that the flow of water in a stream depends upon its catchment area. The truth is that the flow of water in a stream depends largely on the geological formation of the tract through which it happens to pass. If the subsoil is porous, the flow ceases immediately after the rains, even if the catchment area is large. On the other hand, the stream would continue to have adequate flow of water long after the rains if the underlying strata are impervious or if the supply from a groundwater source is continuous. If the stream is fed by some mountain stream or melting snows, it would also have sufficient amount of water.

## LOCATION

As for location, a lower diversion weir can easily be built where the bed of the stream and the adjoining land slope down steeply. We come across such sites in hilly areas and at the foothills. The *kuhls* in the northern hills or the *dongas* in Assam take off from perennial streams which come down steeply. But if the land is not as steep, we could head up the water up to the bank level of the *nala*. The diversion work in such cases should be like a regulator or a low weir with collapsable shutters.

## DESIGN OF WEIRS

While designing a weir, one must guard against the horizontal thrust of water which tries to overturn the weir. Then again, the weir should have a floor of sufficient length to make it possible for the water to travel far through the subsoil. Moreover, as the subsoil flow is under pressure and tries to lift the floor, it should be strong enough to bear the uplift pressure so that it does not blow up or be fractured. Furthermore, the action of the falling water generally scours the river bed downstream. It is, therefore, necessary to build protective works to absorb the shock and prevent its erosive action.

### FLOOD IRRIGATION

It is a common practice to divert the flood water into bunded fields. The huge quantities of silt which are thus brought in manure the fields. Also, by keeping the bunded fields flooded, it is possible to raise winter crops without irrigation.

## 6. GROUNDWATER

We have seen that a part of the rain water filters through the surface of the earth. This forms groundwater and is another important source of irrigation. Wells and tube-wells come under this category. The subsoil also receives water through surface percolation from rivers, lakes, canals, irrigated fields and floods.

The tank or canal water, however, flows into the fields, but groundwater has to be lifted by manual or mechanical methods. Although this means more expense, it is the common practice throughout the country.

### FLOW OF GROUNDWATER

The simplest method of tapping subsoil water is through the open percolation well. We know that when water is pumped from a well, its level goes down and then becomes stationery. The extent to which it falls depends upon the rate of pumping. One should, however, be careful not to draw water beyond the maximum permanent yield, otherwise the well will go dry. The discharge should also not exceed a certain maximum, for the sand particles may start moving and the well collapse. The amount of water drawn from a percolation well should not, therefore, be more than its safe yield.

## SITING OF PERCOLATION WELLS

For any major scheme of sinking of the wells, one must know the quantity of water pumped in a given time as well as the minimum level of the water. If the water level becomes stationery against a certain rate of pumping, it means that the groundwater supply is adequate. By increasing the rate of pumping, we could roughly calculate the available supply.

We should also know the level to which the water rises after pumping is stopped. If the water does not rise to its original level, it means that pumping has been overdone. But if it returns to the original position between the pumping periods, it shows the safe yield. It could also be known from the time it takes to return to the original level after the water has been pumped for some time. The safe yield determines the number of wells to be installed in an area.

The broad open valleys in hilly regions are more suitable sites for wells than the narrow ones with a rapid fall. As the land is steep and sloping, most of the water escapes and does not have time to go underground. Moreover, the high velocity of surface water washes away large portions of the soil and reduces the depth of waterbearing formation. The sinking of wells in valleys with easy slopes and at junctions will also be successful.

## WELL SINKING

Before a well is sunk, we should dig a round pit slightly bigger than the proposed diameter of the well. The digging should be continued to within a foot or two of the subsoil water or soft soil like sand whichever is met with earlier. The well curb made of wooden planks or boiler plates should then be fixed in a horizontal position.

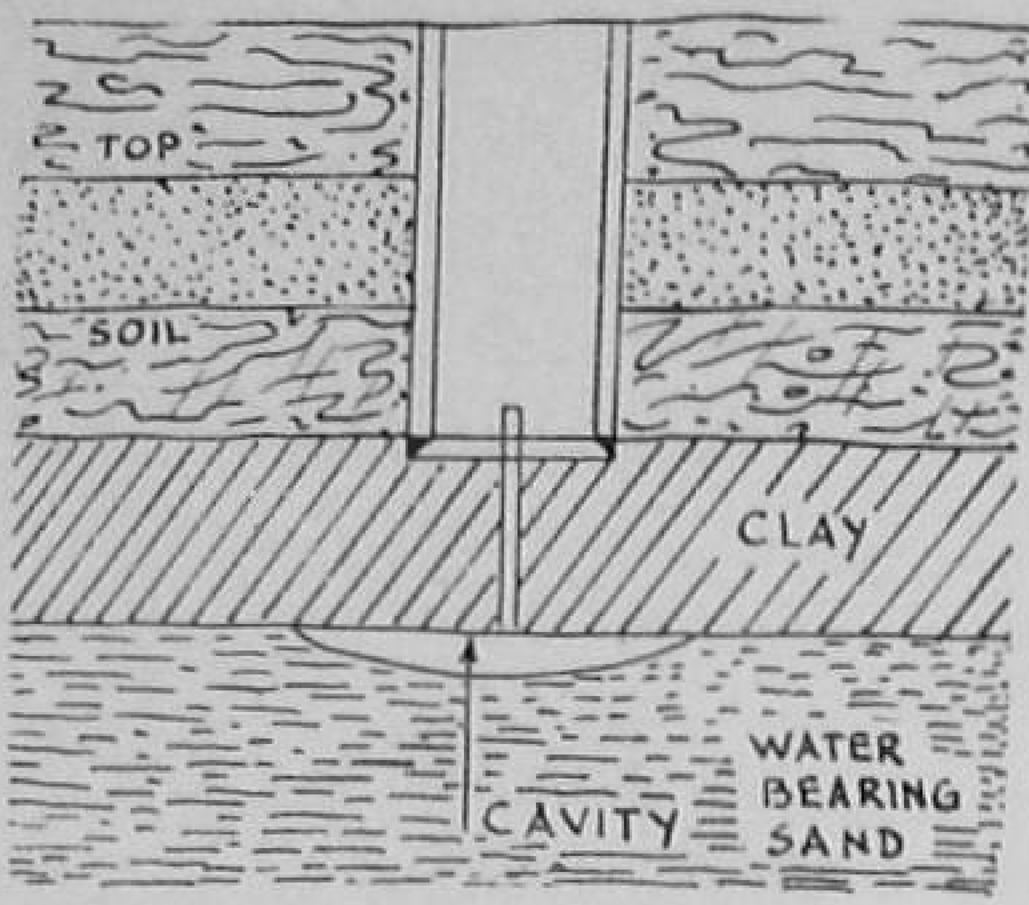
Sometimes, the well does not sink even after the earth under the curb has been completely cleared off. When this occurs, the well and the curb remain suspended, as they are held together by the strength of the mortar. The danger, however, is that the curb may become detached from the well. This could be prevented by fixing vertically 5 to 6 tie-rods, about 8 ft. to 10 ft. long, to the curb and the well steaning. The tie-rods should have screwed ends and iron plate washers with nuts, each plate joining the two adjacent tie-rods. When the nuts are tightened, the entire masonry at the bottom of the well and the curb are held together. As the curbs have often to support considerable pressure in deep and bigger wells, they should be made of reinforced cement, concrete or thick steel plates.

After fixing the curb in position, the masonry ring should be constructed and constantly watered till it sets. Afterwards, the earth and sand should be scooped out. The ring will thus gradually sink by its own weight. This process should be repeated by constructing another layer of masonry. The more the weight, the easier for the well to sink.

The above method will not, however, be found suitable if the subsoil is hard. Here the well should be excavated right up to the proposed depth. The subsoil water which rushes into the well should be pumped out and the steaning of the well started right from the bottom. The use of a well curb is unnecessary. The steaning of the well should be carried out step by step to avoid deep vertical cutting and consequent danger to workmen. Starting with the widest diameter at the top, we should finish off each step of the masonry ring before beginning to excavate the well.

## CAVITY WELLS

It often happens that in the alluvial plains a thick layer of sand or other porous material is found below a layer of clay. Although the two porous strata are separated by clay, they are connected at their upper edges and form a continuous medium. The water passing through the upper layer finds its way into the lower porous strata where it is




held up between the intervening layers. Hence, there may be a third or even a fourth layer. The water contained in the lower strata of the sand will obviously be under pressure and would rise if we drill a hole through the intervening clay. The water thus held up is known as the "confined water," from which cavity wells draw their supplies.

As pumping proceeds, the confined water starts flowing into the well. When the rate of pumping is increased, the sand is blown out into the well through the pipe and this should be cleared off. As pumping continues, more and more sand is pumped out and a cavity is formed just below the clay which, when firm and strong, serves as a roof. A much larger area thus becomes exposed to the bottom end of the pipe. When no more sand comes out, the cavity is large enough for the well to be in use. The pipe should be sunk to such a depth that its lower end is flush with the bottom of the clay. The average depth of the cavity is about three inches. It is essential for a cavity well to have a strong and dependable roof.

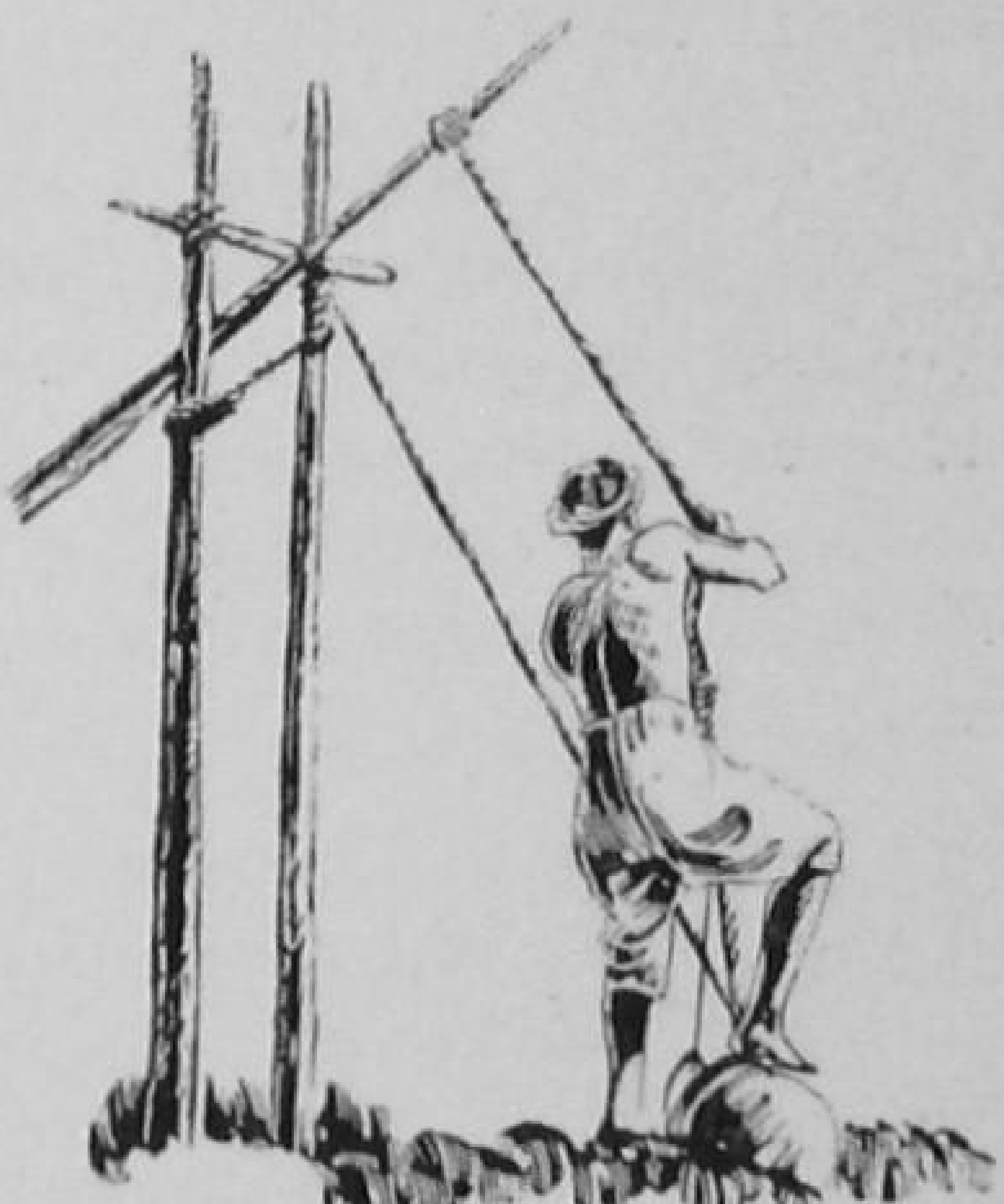
### INCREASING WATER SUPPLY

Where the supply from a well is inadequate, it should be deepened to increase the supply. The diameter of the well may also be made bigger to give more water. In the alluvial plains, the boring will increase the supply of water in the well, while in the rocky areas the hard rock at the bottom should be excavated. The well may be widened to obtain greater storage.

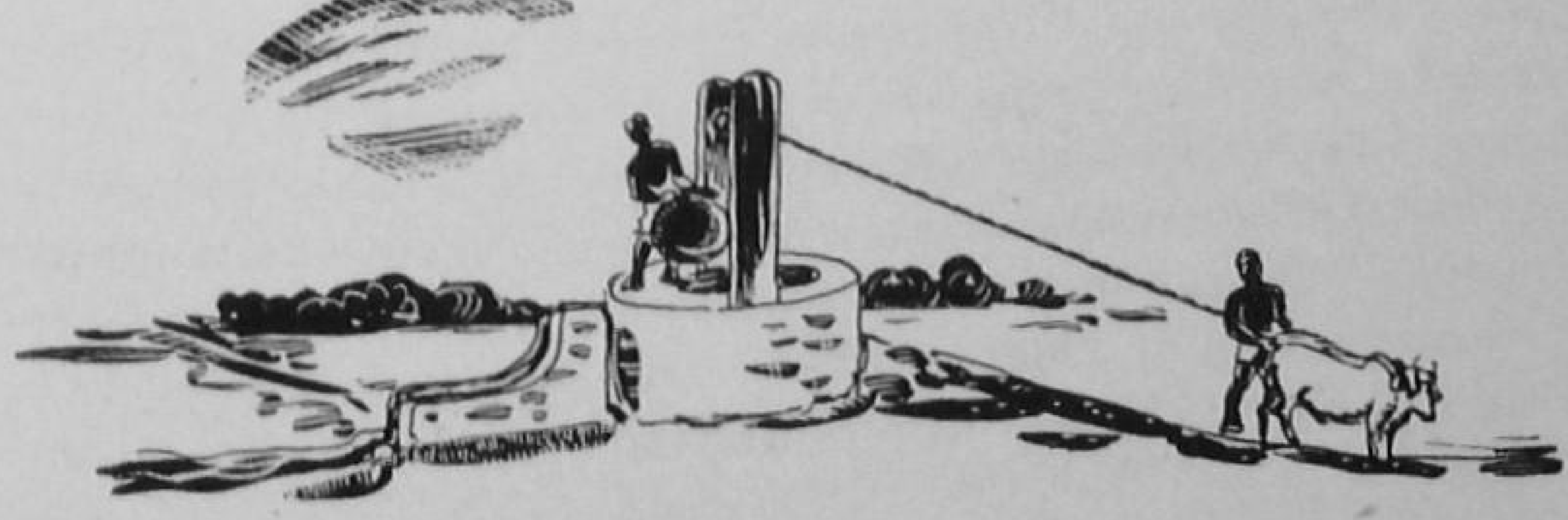
In such parts where the rainfall is scanty and the surface water easily escapes, the best way to increase the supply of groundwater is to check its free and quick flow. This can be done by building suitable embankments or subsurface dams across the drainage. A road causeway also prevents the quick flow of surface water and charges the subsoil with plenty of groundwater.

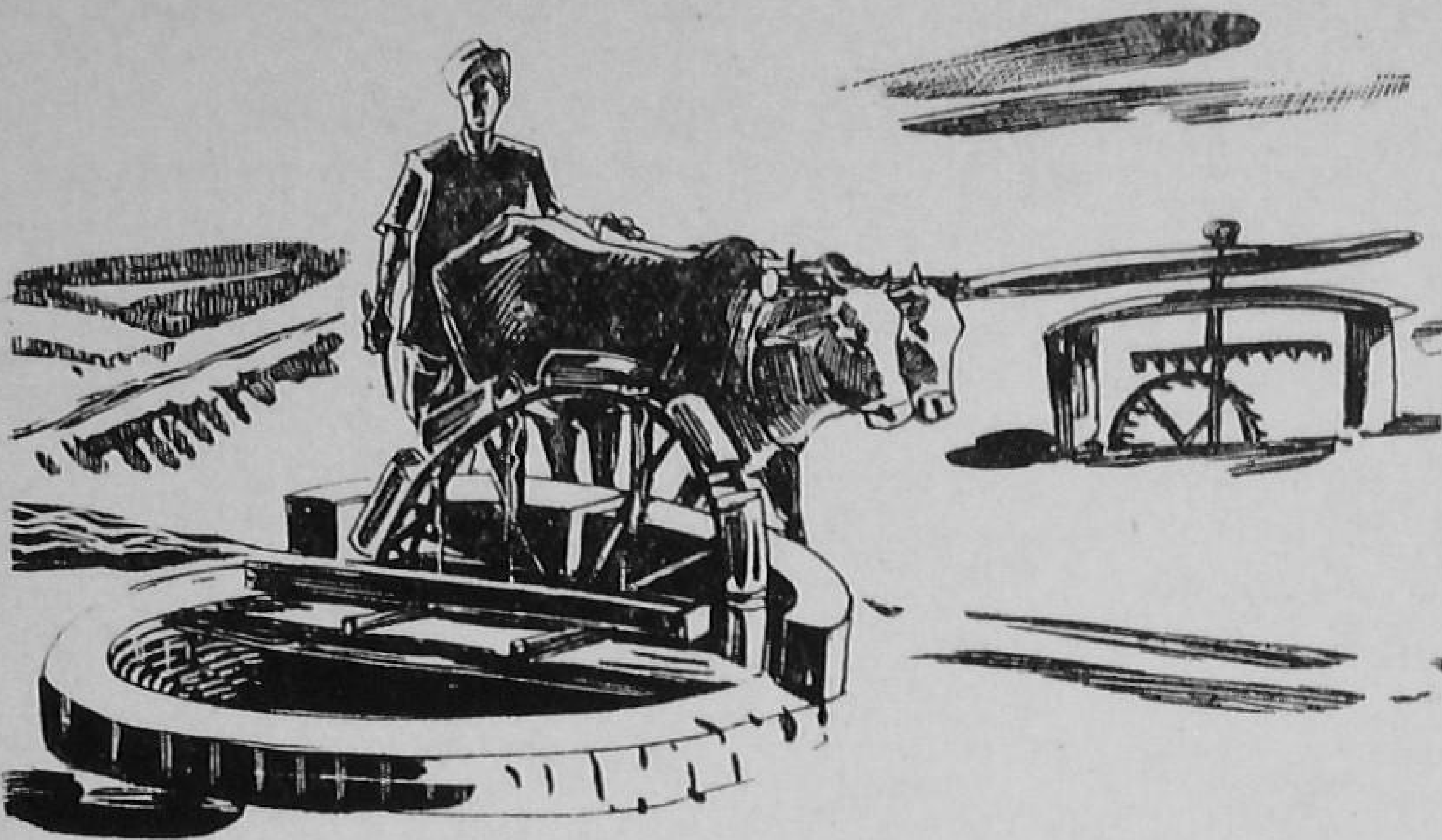
### PRACTICE OF LIFTING WATER

The raising of the water for irrigation has been practised for many centuries in our country. The *dauri*, the



*don* and the *dhenki* system are still very common in northern India. In the *dauri* system, two men lift water





to a height of 3 to 4 ft. by means of a swinging basket. Approximately 12 gallons of water are lifted per minute by this method. The *dhenki* system uses the principle of a lever with a suspended fulcurum and a counter weight. About 5 to 8 gallons of water are lifted per minute in this way. The *don* is an improvement on the *dauri* system, but it uses the principle of *dhenki*.

The Persian wheel and the mote are other common methods. A bullock or a pair of bullocks draws water from the well in a big leather bucket or mote, hence the mote system. The Persian wheel is able to lift about 1,500 to 2,000 gallons of water per hour.

### MODERN PUMPING METHODS

The pumps and tube-wells are now commonly used for irrigation. The pumps are of various types and are driven by an electric motor or other prime mover. Like the cavity wells, the tube-wells draw their supplies from the confined water. We can instal a tube-well wherever we have water-bearing strata of great depths. The flow in a tube-well is radial and the water enters through perforations in the pipe.

## 7. ECONOMICS OF IRRIGATION WORKS

The economics of irrigation works may be examined either from the point of additional yield of foodgrains or from that of the net revenue.

The extra yield from irrigation for food crops is approximately 5 maunds per acre. The cost varies from Rs. 60 to Rs. 80. But the increase is several times more where the rainfall is low and uncertain. Even the most expensive method of irrigation, however, would not cost more than Rs. 30 per acre. This would mean a saving of nearly Rs. 40 per acre for the cultivator.

Any type of irrigation is thus found to be economical in terms of the cash value of the extra yield of crops. None the less, it would be a mistake to conclude that irrigation works are necessarily paying. The net revenue or income realized in the shape of water rate depends not only upon the extra yield of foodgrains, but upon what the cultivator can or is willing to pay.

### FLOW IRRIGATION

*Tank Irrigation*

The digging of major tanks ordinarily costs between Rs. 200 to Rs. 400 per acre of the area irrigated. The minor tanks cost somewhat more. The working expenses of an irrigation tank would range from Rs. 10 to Rs. 15 per acre. According to the present rates, the schemes for the construction of tanks will not generally be self-financing, unless a betterment fee is levied on the area. This will bring down the capital cost. In the drier parts of Rajasthan and Ajmer, the loss of water from percolation and seepage is considerable and consequently the cost per acre is much higher.

*Canal Irrigation*

Canal irrigation costs about Rs. 50 to Rs. 75 per acre and the maintenance and working charges are anything between Rs. 3 to Rs. 5 per acre. It would be possible to levy water rates equal to or in excess of this amount. The schemes would thus be not only self-financing but remunerative.

*Flood Irrigation*

Where the flood water is diverted into the fields to keep them under water for the duration of the rains, the cost will come to 4 annas to 8 annas per acre or less. The people would willingly pay for the working expenses and the scheme is self-financing.

## LIFT IRRIGATION

*Lifting Water by Mote or Charas*

The cost of digging a well is about Rs. 2,000 in the alluvial plains. The leather bucket and the rope are the only movable articles used. Generally speaking, a pair of bullocks and two men can work the mote. The lift is 20 to 30 ft. and the discharging capacity varies from 1,000 to 1,500 gallons per hour according to the lift. Thus a third or a fourth of an acre is irrigated per day. The working cost of the mote would come to Rs. 48 per acre.

Our cultivators generally believe that irrigation by the mote is cheaper. They do not include either the cost of labour or the bullocks in the irrigation charges. Thus when pump irrigation is suggested to them, their first reaction is that they are not in a position to bear its recurring and maintenance costs. The cultivators are naturally concerned about their bullocks and their family. What will happen to them, they ask, when they are replaced by pumps and pump drivers? They have, however, begun to realize that by sparing the bullocks they give them a longer life. Also, that the members of the families can be more profitably engaged in intensive cultivation.

### RAHAT OR PERSIAN WHEEL

This is a much better method of lifting water than the mote, even though animals are employed in both. Here human labour and animal power can raise between 2,500 to 3,000 gallons of water per hour for a lift of 20 ft. to 30 ft. A Persian wheel costs between Rs. 600 to Rs. 800. Besides other expenses amounting to Rs. 200, the cost of digging a well and installing a Persian wheel would be about Rs. 3,500. The area irrigated per day is half an acre or more, depending on the depth from which the water is lifted. The irrigation charges vary from Rs. 22 to Rs. 25 per acre.

### PUMPS

The use of pumps has become common in this country. This method makes irrgiation more efficient and less costly, as the energy is derived from coal, gasoline, crude oil or electricity.

### TUBE-WELLS

Irrigation by tube-wells has been practised most extensively in Uttar Pradesh and has, of late, been introduced in the Punjab also. Each tube-well unit of 1.5 cusec with a diesel engine pumping set costs Rs. 39,000.

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