Some Aspects of Canal Irrigation in Punjab

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The extension of canal irrigation in Punjab has been accompanied by a steady rise in the subsoil water level. As a result, waterlogging has become a very serious problem, threatening the very foundation of the State's agriculture.

The damage to crops as a result of waterlogging is growing every year and in parts of Amritsar, Cardaspur and some other districts, plots of cultivable land often have to be totally abandoned.

The shift in emphasis from artesian to canal irrigation has been largely responsible for the rising subsoil water table. It has been estimated that of the water in a canal at the head 17 per cent is lost through absorption and evaporation in the main canal and its branches, 8 per cent in the distributaries and 20 per cent in the water courses. Of the water that ultimately reaches the field, 30 per cent is absorbed below the root zone of the crop.

Wastage of irrigation water in the fields is encouraged by the system of charging irrigation rates on the basis of land area instead of water actually used.

Six pilot schemes to combat water-logging are at present being tried out in different parts of the State to determine the efficacy of different techniques. What methods are ultimately adopted will depend on soil conditions and the cost that the community is prepared to bear, but drainage has become absolutely indispensible if irrigation, intended as a boon to agriculture, is not to become its bane.

IRRIGATION is the controlled application of water to arable lands to supply crop requirements not satisfied by rainfall. * The word 'controlled' needs to be stressed. It is vital, from the point of view of the optimum utilisation of water for plant growth, that not only must it be supplied in a regulated manner, but that part of it which percolates beyond the root zone must be drained away promptly. These are the two essential aspects of controlled or regulated irrigation.

Canal irrigation, it may be pointed out, differs from artesian irrigation in a very important respect: while the former brings additional water to and into the soil, the latter draws upon the subsoil water resources already available. The former method will thus cause subsoil water level in the area irrigated (and even in other areas) to rise, but the latter will not.

This does not mean that fields served by wells or tube wells do not need to be drained. The subsoil water level in such fields may rise in spite of the wells. The operation of certain factors, extraneous to this mode of irrigation, like floods, proximity of canals, and obstructions to natural surface run off, etc, may add more to the subsoil storage than the wells can draw out. Nevertheless, since artesian irrigation has the advantage of a built-in pumping out mechanism, the subsoil water level will not rise as fast as it would otherwise.

* Ivan E Houk, "Irrigation Engineering".

But drainage to which we shall revert later is only a part of the problem of control of irrigation referred to above. Land preparation is another. For, without adequate land preparation, water may collect in undrainable depressions here and there, and leave parts of the field dry. Apart from preventing even and easy distribution of water, an undulating land surface and irregular and fragmented fields cause longer and circuitous water courses to be dug, and to the operational wastage of water and, in general, detract from irrigation efficiency. Levelling, grading and rectangulation of the fields over entire areas must, therefore, precede the introduction of any irrigation, and particularly of canal irrigation, since a common source is to supply water to several fields and it must be able to command them all. Besides the considerable supplementary expendi. Lure on land preparation and consolidation of holdings, irrigation also assumes a sound knowledge on the part of the cultivators regarding the mode, frequency and depth of irrigation required by various crops, and about scientific farm management in general.

Canal irrigation, being subject to erratic rainfall conditions involves another risk. Increased yields from irrigation make a heavier draft on plant nutrients present in the soil which must be replenished by judicious inputs of chemical fertilizers. But the damage done to a crop when there is a failure of water supply is greater when chemical fertilizers have been used than when they have not been. If, therefore, the water supplied by an irrigation system varies considerably with good and bad years and cannot be firmly depended upon, the fluctuations in yields are likely to be greater, and this may, in extreme cases, even discourage the use of fertilizers." (K N Raj: "Some Economic Aspects of the Bhakra Nangal Project", p 94).

It is vital to keep these limitations and pre-requisites of canal irrigation in mind while considering the figures of irrigation potential in Punjab, both created and planned which are impressive indeed. While this State has hardly 5 per cent of the country's cultivated area, its share of the total area irrigated is 14 per cent. In the circumstances, one is likely to forget that efficient running of channels, provision of 'controlled' supplies to the fields and reduction of operational waste of water to the minimum are at least as important as the construction of canal systems.

Utilisation of River Waters

Under the Indus Waters Treaty, India, after a transition period of ten years, has been given exclusive rights over the three eastern rivers, Ravi, Beas and Sutlej. The annual run off in these rivers is subject to great variations, but a rough idea of the water likely to be available in the region can be had from the following figures 'based on the water-
power studies for the last quarter-century or so:

<table>
<thead>
<tr>
<th></th>
<th>Mininum</th>
<th>Maximum</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ravi (at Modhapur)</td>
<td>4.23</td>
<td>9.30</td>
<td>6.40</td>
</tr>
<tr>
<td>Beas (at Harike excl Sutlej)</td>
<td>6.55</td>
<td>20.21</td>
<td>12.80</td>
</tr>
<tr>
<td>Sutlej (at Bhakra)</td>
<td>NA</td>
<td>NA</td>
<td>12.81</td>
</tr>
<tr>
<td>Sutlej (at Rupar)</td>
<td>12.25</td>
<td>17.39</td>
<td>13.60</td>
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The annual supplies delivered by a river or any other channel are made up of varying flows throughout the year. The annual supplies delivered, considered as cubic feet of water delivered per second. This expression is usually, though wrongly, abbreviated as 'cusecs'. This, being a combination of volume and time, can sometimes be misleading. A better abbreviation would be cft per sec.

Further, if the average discharge in a river is known, it is possible to find out the annual supplies delivered. Conversely, if the storage available in a reservoir is given, it is possible to ascertain the canal flows that it will sustain. The formula is easy to derive.

24 Hours $\times 86,400$ seconds

One acre foot = 43,560 cubic feet

A channel flowing at one cubic ft per second for one day will thus cover an acre with 198 feet deep water (86,400/43,560). One acre foot of water can be obtained by a channel of half a ft per second flowing for one day.

In view of these variations, the Bhakra reservoir is expected to fill only in 12 out of 20 years. In addition to these annual variations, there are also considerable seasonal variations during the same year, and it is one of the functions of a storage dam to even out the latter. But this can be accomplished only to a limited extent. For the large and often unpredictable variations must remain beyond human control, given the present state of knowledge.

The entire winter and a part of the summer supplies of these rivers as well as of the Yamuna had already been commanded at the time of the Partition with the help of weir controlled and inundation canals. The free flow of the river9 was continually reduced by extensions of irrigation facilities and in January 1955 the Inter-State Conference allocated the still free waters in the following manner:

- Punjab (incl the erstwhile Pepsi) 7.20 MAF
- Rajasthan 8.00
- Jammu and Kashmir 0.65
- Total 15.85

Rajasthan will receive its share of the free Ravi and Beas waters (the Sutlej waters having been completely stanched at Rupar) through the Rajasthan Feeder (as the Rajasthan Canal is known in Punjab) emanating from Harike, below the confluence of Sutlej and Beas. To divert the free Ravi waters into Beas, the Madhopur-Beas Link with a capacity of 10,000 cft per sec has already been completed. But the Link will become really useful only if a storage dam is constructed to contain the Ravi floods. This is planned to be built at Thein, about 10 miles upstream of Madhopur. But the scheme has just been suggested and no regular surveys have yet been conducted.

Similarly, a part of the free Beas waters is planned to be diverted into the Bhakra reservoir via Beas-Sutlej Link starting from Pandoh, 13 miles upstream of Mandi. This is the Unit I of the new Beas Project, but will be taken up after the second unit has been completed at Pong. The Beas-Sutlej Link will supply 2.18 MAF to the Bhakra reservoir during a mean year, thus helping to cover the shortage referred to above. Further, if this water is allowed to come down to Harike, Punjab cannot possibly use its share of water. For, Harike Headworksd0 not command enough area in the State. But by diverting this water into the Bhakra reservoir, it will be possible to firm up its supplies. Rest of the free Beas water will be stored at Pong near Mukerian, and the construction of an earth and rock dam is being undertaken. This will have a live storage of 5.5 MAF.

All these schemes to interlink the three rivers and to construct diversion (Pandoh, Madhopur* and Harike) and storage (Thein, Pong and Bhakra) dams form part of the three-river Master Plan.

Expansion of Canal Irrigation

Canal irrigation in Punjab began with the construction of the Western Jamuna, the Upper Bari Doab and the Sirhind canal systems during the second half of the 19th century. But by the turn of the century emphasis was shifted to the newly colonised areas of West Punjab and the fertile, though arid, districts like Hissar were neglected. Thus after the Partition, out of a total of 31 weir controlled canals in the Indus Basin only 4 fell to the share of the East Punjab, taking less than

* The old Head works have been strengthened to divert water into the Madhopur-Beas Link.

The gross area of Punjab as at present constituted is 303 lakh acres of which 225 lakh acres are cultivable. Out of this the area cultivated is 185 lakh acres and current fallows, 11 lakh acres. The area under the physical command of various irrigation schemes ("cul. titrable commanded area" or CCA) in 1947 was 77 lakh acres, only 39.70 lakh acres receiving actual irrigation—about half of it through canals. Subsequently, however, irrigation has been extended mainly through canals and in 1958-59 out of a total of 73.6 lakh acres irrigated, canals served 50 lakh acres. The total canal CCA was 128 lakh acres. By the end of the Second Plan total irrigated area was twice the 1947 figure. On the completion of the major and minor schemes, new and continuing, the total area irrigated by the end of the Third Plan will rise to 96.8 lakh acres. This increase of 17.3 lakh acres over the Plan includes 7.8 lakh acres which will be added to the Bhakra system on its completion. Compared to the Third Plan target, the Second Plan target and performance were respectively 31.58 lakh and 18.76 lakh acres.

In the extension of canal irrigation in Punjab, the Bhakra system occupies an important place. The area served by the system, however, does not represent a net increase in area irrigated. For, in some cases, old systems have had to be cut off completely, as, for example the Grey Canals system (inundation canals emanating from various points on the left bank of the Sutlej from Phillaur to Fcnwepur). In other cases, branches of older canals have been taken over by the Bhakra system and irrigation intensity has been increased and water allowance raised. The load of the Sirsa Branch of the Western Jamuna Canal for instance, has been taken over by Bhakra.

Its ultimate potential of 30.3 lakh acres at the outlets (perennial, restricted perennial and non-perennial) for Punjab is expected to be reached in 1963-64. The total CCA is 49.42 lakh acres. Besides, 5.70 lakh acres in Rajasthan are to receive perennial irrigation (CCA...
9.20 lakh acres). Naturally, it would not be possible to fully utilize this potential immediately, in view of the extensive land preparation needed. But a time lag of only one year — the Bhakra potential the Third Plan expects, will be fully utilized in the fields by 1964-65 — seems an underestimate.

This apart, even while the Project Design was being prepared, it was realized that the Sutlej waters would not be sufficient for the area proposed to be served. And the Beas-Sutlej Link and the Sirhind Feeder were visualized to cover this gap. Dr Raj's criticism of this aspect of the project is that "irrigation facilities which have been promised appear to be in excess of what can be actually provided" (op cit., p 54). The gap is now intended to be met by the Beas-Sutlej Link. But how it will be able to irrigate 8 lakh acres more, after meeting the deficiency in respect of the area already committed to, is not clear.

Likewise, the Sirhind Feeder (so called because it serves a part of the area originally commanded by the Sutlej-Sirhind Canal) was initially designed so as to take away a part of the Sutlej load to enable proper functioning of the Bhakra and Sirhind systems. The Feeder is taken out of the Ferapur Feeder emanating from Harike and is entirely fed by Ravi-Beas waters, the Sutlej having been stanched at Rupar. There is, thus, a corresponding saving of Sutlej waters to the extent of 2.39 MAF, since in the absence of the Feeder, this water would have continued coming to the area now served by the new channel. Considering that such saving was needed to honour the original Bhakra commitment, the further planned expansion of the same, now that the Feeder has taken away a part of the Sutlej load (as the official argument runs), seems odd.

However, as the river waters get gradually commanded, further extensions of canal irrigation will become increasingly difficult. Remodelling and lining of the old systems will, of course add to the area served. Thus the addition to canal irrigation after the Third Plan is tentatively put at only 8 lakh acres. Attention may again shift to artesian irrigation, the relative neglect of which has contributed so much to the rise of the subsoil water level in the State.

**Threat of Waterlogging**

This brings us to what is probably the most serious problem that threatens the very foundation of agricultural prosperity in the State. The subsoil water table has risen dangerously over vast areas in many districts. Out of a total cultivated area of about 200 lakh acres (including current fallsows) 30 lakh acres are acutely afflicted, the water table being within 5 feet of the surface and another 30 lakh acres have a water table between 5 and 10 feet below the surface. At places even surface accumulations are present. This excludes waterlogging of non-agricultural land. The situation is becoming increasingly grave, and the area affected is much larger after the monsoons.

Damage to crops as a result of waterlogging is considerable, and not uncommon itself may have to be abandoned, as is being done in parts of Amritsar, Gurdaspur and other districts. It is not possible to properly prepare the waterlogged soil for cultivation. Also, wet soil being both cold and compact, healthy germination of the seeds is hindered. Further a compacted soil impedes root penetration and the root system cannot spread out. At the same time the air content of saturated soils is low and roots get suffocated. Oxygen is replaced by carbon dioxide and hydrogen sulphide generated by the putrefaction and decomposition of organic matter, causing toxicity. Finally, additions to the subsoil storage dilute the soluble nitrates present in the soil, so that plant roots cannot get enough nitrogen, so vital for growth. With the rise of the subsoil water level, the nitrates come up, making the soilthur-infested.

Apart from the seepage through unlined channels and the abandoning of artesian irrigation, there is always some inevitable seepage of water below the root zone in the fields irrigated. Even if it were possible to completely stop seepage of water while in transit to the fields, there would still be deep percolation in the fields. It is estimated that "out of the total quantity of water that enters canal at the head, 17 per cent is lost by way of absorption and evaporation in the main canal and branches, 8 per cent in the distributaries and 'minors' and 20 per cent in the water courses. Of the water that ultimately reaches the field, as much as 30 per cent is lost by way of absorption in the region below the root zone of the crops" (Dr Raj: op cit., p 92).

Such wastage in the fields is encouraged by the method of charging irrigation rates from the cultivators. In Punjab, as in the rest of the country, water is sold on the basis of flat acreage and not on the basis of acre feet used. Different rates are charged for different crops over individual canal systems. The Sirhind Feeder rate for cotton, for example, is Rs 7.50 per acre per crop; for wheat, Rs 5.65; and for sugar cane, Rs 13.75. In the circumstances, everyone is in a hurry to get the maximum water possible, especially when future supplies are not certain. This usually results in over-irrigation. If water could be sold on the basis of acre-feet, different rates being charged for different crops, one could expect at least some reduction in the waste of water. But that would call for a very efficient running of the channels and installation of meters etc.

Some other factors that have contributed to waterlogging in the State include obstruction to the natural surface run off caused by railway tracks, roads, village paths and, sometimes, even canals, though these, being aligned to run along ridges to permit gravitational flow, do not usually cut across natural surface drainage. Besides, Punjab has been going through a cycle of unusually heavy rains in the period after 1947. Given a combination of all these factors, unaccompanied by any drainage worth the name, it would have been surprising, indeed, if the State had escaped waterlogging.

**Flood Control and Drainage Schemes**

A two-tier programme to prevent further additions to waterlogging and to drain away existing accumulations of water below and
above the surface is indicated. The Punjab Government have drawn up two schemes, known as 'master plans', to control floods and remove waterlogging. These will cost, respectively, Rs 28.44 crores and Rs 61 crores. Out of the latter sum, Rs 5.74 crores have been earmarked for reclaimingthur-infested lands. It is not intended here to go into the details of the two Plans. For, the programme, in any case, should be viewed as a whole. Obviously, measures to control Hoods automatically help control waterlogging and vice versa. Drier regions can withstand floods better, as they can absorb more water in an emergency than saturated areas. On the other hand, a measure which has flood control as one of its objectives, like the impounding of Sutlej waters upstream of Bhakra, also helps reduce waterlogging. For, the river becomes a natural drain which sucks away excess water available in the surrounding areas.

Examined in this light, the two schemes appear only to be the parts of a whole. The first phase of the flood control programme has been completed with the construction of 265-mile long embankments along the river banks and the excavation of 2,200-mile long Hood (as distinguished from seepage drains), intended to be a boon to agriculture. Water drained is not water wasted. For, it was never available for plant growth. Irrigation is good only if maximum effective intake of water is combined with speedy removal of excess water. A whole network of field drains, suitably spaced, falling into laterals which empty themselves into bigger drains, which will in turn fall into a river or some other natural outlet is needed. Only the broad principles may be indicated here:

When a drain is excavated up to a certain depth unwanted water in the surrounding area flows into it, thus improving the aeration in the soil, which is so vital for plant growth. The water table is lowered to the bottom of the drain. But drains are of different types, each having its own peculiar advantages and disadvantages and cost considerations. Further, size, design and spacing of drains must take into consideration the particular soil conditions available. Heavy soils with too much clay, for example, do not permit easy draining. This apart, while open ditches are easy to excavate, are relatively cheap and do not require much skilled labour, they obstruct the movement of farm implements and cattle, require constant care and get choked up with weeds and bushes. Underground tile drains or perforated pipelines embedded at suitable depth and intervals, on the other hand, are free from these disadvantages. Besides, much area that otherwise would have to be kept aside for open drains can thus be saved for cultivation. But the initial costs of this method are prohibitive. Besides, it is not suitable for soils with too much clay in them.

In the case of the open drains, land required forms about a fifth of the cost. About half of this land cost is expected to be met by the farmers themselves out of, the common pool land left out at the time of the consolidation of holdings operations. In addition, a good deal of slush and muck work involved can be done only by machinery. In some cases, it is not even possible to employ labour on any wide scale on account of the malarial conditions prevailing. Still, in other cases there is some scope for the employment of unskilled workers. And the Compulsory Service Act was enacted in 1960 to conscript adult males wherever needed, but the initial orders to this effect have been recently withdrawn. For the response to this measure was not encouraging. Paid labour is now employed.

Currently, six pilot anti-waterlogging schemes to try out the efficacy of various measures, are in progress in Hansi, Sangrur, Sunam, Zira, Fazilka and Amritsar and are scheduled to be completed before the 1962 monsoons. Of these, the Zira scheme will for example, cost Rs 53 lakhs and will benefit an area of 277,000 acres.

What precise method of drainage is finally adopted must depend on the specific soil conditions and the cost that the community is prepared to bear. But drainage as such is absolutely indispensable if irrigation, intended to be a boon to agriculture, is not to become its bane.