8.1 INTRODUCTION

So far we considered the use of public and private source of irrigation separately. In the present chapter we discuss some of the economic implications of conjoint availability of public and private sources of irrigation. An attempt is made to point out the consequences of investment in privately owned tubewells in an area such as the Amritsar district which already has a high level of public investment in irrigation by canals.

First, we discuss the impact of this development of tubewells on the effectiveness of water use (E-factor to be defined below) for different categories of producers. This E-factor influences the total production economy of a household by determining the set of feasible production options open to it. It is pointed out that tubewell installation by large farmers generate external diseconomies resulting in a reduction of the E-factor for smaller cultivators and consequently to a deterioration in their relative economic position.

Secondly, the implications of investment in private tubewells for the overall efficiency of irrigation resources is discussed. It is argued that the development of private tubewells has led to a lower utilisation of public canals.
while, at the same time, the tubewells too are underutilised; thus resulting in an irrational allocation of resources from an overall social point of view.

8.2 EFFECTIVENESS OF WATER USE (E-FACTOR)

This is defined as the maximum attainable productivity for a given mode of irrigation where productivity may be measured in terms of any one or a combination of the indicators: physical yield per acre of major crops, level of cropping intensity, area devoted to high value crops or total value of output per acre. The E-factor would depend on both the irrigation factor as well as the use of complementary inputs. Below we discuss the possible influence of the holding size on the E-factor under public and private irrigation.

8.3 VARIATION OF E-FACTOR

8.3.1 Influence of Irrigation

We have already seen that the differential productivity of the various modes of irrigation arises from the differences in the following:

(a) Absolute amount of water available
(b) Leakages or wastage of water, i.e., water paid for but not secured
(c) Control over the amount and timing of irrigation.

(a) The first factor of total quantum of available water influences productivity by influencing feasible conditions
for growing high value crops, enabling the use of new methods of production (e.g. those involving HYV), increasing the probability of realising higher yields per acre by facilitating a greater use of complementary inputs; etc. It has already been observed (see Chapter V) that the quantum of assured water supply to the users from canals has been distinctly lower than that available from tubewells. Accordingly therefore, the E-factor for canals would be expected to be lower than that in the case of tubewells.

Further, within canal irrigated areas the per acre water availability generally increases with the size of holding. This is due to the higher per acre losses for the small holders as well as their relative difficulty of access to extra quantum of canal water achievable through legal or illegal methods (see Chapter V). Therefore the E-factor under canal irrigation, broadly speaking, varies negatively with holding size.

Under tubewell irrigation, the variation of water availability is neutral with respect to the land size of the tubewell owners but availability is lower for those who share tubewells and lowest for those who purchase water from tubewells owned by others. We have already shown in Chapter VI that these latter modes of tubewell irrigation are confined to the smaller land owners. Therefore in this case too, the E-factor is likely to be higher in the case of larger holdings.
(b) The second factor of water wastage, the expense for which has already been incurred, affects the monetary cost of a given irrigation. This in turn, cuts into the total financial resources for production thus affecting adversely the use of other purchased complementary inputs and hence productivity. Higher wastage therefore, depresses the E-factor. We have already shown that, within canal irrigated areas, this wastage is higher for smaller cultivators. It follows therefore, that E-factor on this account, declines with holding size under canal irrigation. Under tubewell irrigation also this wastage is higher for small holders due to their unutilised potential (see Chapter V). Hence, similar variation of E with holding size.

Between canal and tubewell irrigation however, it is difficult to compare the impact on productivity of increased monetary cost of irrigation due to wastage. However, given the observation that, wherever feasible, producers prefer to install their own tubewells despite the higher per acre cost of such irrigation, points to their relative advantage. Therefore, we can safely infer that the fact of high monetary cost of irrigation due to wastage, does not lower the E-factor for tubewells more than for canals.

(c) Finally, the most crucial aspect of irrigation effecting productivity is the degree of control over its quantity
and timing\(^1\): In order to have a quantitative measure of the control aspect in the case of the various modes of irrigation, we can construct the following statistic defined as: the weighted sum of the water available for each irrigation as a proportion of that required, where the respective weights reflect the importance of each irrigation for crop productivity.\(^2\)

\[^1\text{This is particularly important for the cultivation of HYV, which are very sensitive to the timing of irrigation.}\]

\[^2\text{For simplicity, if we assume an equal amount of }\bar{q}\text{ of irrigation water is required at each of the } n \text{ irrigations (i.e. at time } t_1, t_2 \ldots t_n\text{) and } q_1, q_2 \ldots q_n \text{ are the quantities of water in fact available at these times, then we may define an index of effectiveness of water as below:}\]

\[
\frac{w_1q_1 + w_2q_2 \ldots + w_nq_n}{n\bar{q}}
\]

where \(w_1, w_2 \ldots w_n\) are the relative weights associated with each irrigation on the basis indicated below. We further assume that

(i) \(q_1, q_2 \ldots q_n \leq \bar{q}\), i.e. we assume that with regard to the quantum of irrigation water available, the problem is typically one of shortage from the required amount and not of excess.

(ii) The weights are normalised so as to make \(\sum w = 1\). The value of the index will then vary from 0 in the worst case of no water availability to 1 in the best case, when the requisite amount, \(\bar{q}\) is available for all the irrigations.

(iii) The weight of each irrigation is an index of its relative criticality for the particular crop and depends on weather conditions, rainfall etc. It is assumed that this criticality is only a function of the timing of irrigation.

However, in actuality, this criticality of irrigation has two dimensions: timing as well as a minimum quantum of water required at each irrigation without which the crop could not be produced. The weights in the index are therefore not independent of the level of \(q_1, q_2 \ldots q_n\). However here we consider \(w\) to be independently assigned depending upon the timing alone and hence the statistic is only a rough and approximate way of capturing the quality of irrigation, although the problem is far more complex.
We have already demonstrated in Chapter V the poor control over irrigation through canals both with regard to its time and quantity as compared to tubewell irrigation. The E-factor on this account is therefore, lower under canal irrigation relative to that under tubewell irrigation.

Further, we have also shown that within canal irrigated areas the control over irrigation improves with holding size. Correspondingly therefore, the E-factor will also show a similar correspondence with holding size.

Under tubewell irrigation the variation of control factor is neutral to holding size for the tubewell owners since the better control over irrigation in this case derives from the fact of private ownership. However, for those who share tubewells or purchase water from them, control is considerably reduced. These modes as noted earlier, are confined to the smaller land owners. Therefore in their case the E-factor is much lower due to this factor.

To sum up the discussion above, we may generally infer that, first, the E-factor due to irrigation is higher under tubewell irrigation compared to canal irrigation. Secondly, under each of these sources separately, the E-factor works more favourably for large holdings. However, for the tubewell owners, the influence of irrigation on the E-factor due to the advantage of higher control and greater quantum available is neutral with respect to holding size.
8.3.2 Influence of Complementary Inputs

As discussed in the preceding chapter, productivity depends also on the use of adequate amounts of complementary inputs. However, the access to these can be assumed to be a function of the resource position of the producers, as reflected by land owned (see Chapter VII). Therefore on account of complementary inputs, the E-factor under both canal and tubewell irrigation tends to move favourably with holding size.

The above discussion can be summarised as follows:

(1) the effectiveness of water use by both public and private source of irrigation is influenced by land size; (2) the effectiveness of water use is higher for the private source (i.e. tubewells) compared to the public one (i.e. canals) for equivalent water availability; (3a) for the private source, the effectiveness of water use increases with size due to corresponding improvement in the access to complementary inputs, while the advantage due to control and quantum of irrigation, remains neutral to the size of farm possessed by the owner of the tubewell. (3b) for the public source the above effectiveness increases with land size - both due to the larger holdings having better access to complimentary inputs, and better control and greater quantum of available irrigation. Figure 8.1 shows a graphic representation of (1), (2) and (3) above, where the curves mn and xy refer to the relationship of E with land size, for private and public
Fig. 8.1

EFFECTIVENESS OF WATER USE (E)

LAND SIZE
source respectively. Point (1) explains the upward slope
of the curves mn and xy; point (2) the fact of mn lying above
xy; and point (3a and b) the narrowing of difference between
xy and mn on higher land sizes i.e. ab < cd.

8.4 TUBEWELL INSTALLATION BY LARGE FARMERS

Given the fact that cd > ab i.e. the difference in
the effectiveness of water use (E) by public and private
sources is higher for the smaller land holders. The incen-
tive to go in for private investment should be correspondingly
greater for them, compared to large land owners. However,
due to their resource constraint, it is in fact the larger
land owners who typically initiate the process of private
investment in tubewells. This has the following consequences:

(1) On the one hand, by reducing the possibility of
selling the excess water by the smaller private owners it
creates a potential excess capacity problems, rendering the
installation of tubewells less economic. This can be repre-
sented by lowering of the E curve from mn to m'n. This reduces

3 In a situation where they can overcome the scale
problem of installing tubewells on their small holdings, by
selling water to the bigger land holders.

4 In terms of access to credit, public agencies, etc.

5 With a large number of producers owning tubewells,
the possibility of selling water is diminished and this
difficulty arises more for the smaller farmers.
the difference of $E$ between public and private sources, say from $cd$ to $c'd$, resulting in a reduced incentive for private investment.

(2) On the other hand, due to the installation of their private tubewell, the larger land owners would tend to abstract out of the co-operative utilisation of the public canals. However, as has been discussed earlier, the water distribution of canals is such as to require the integrated participation of all the shareholders of a particular outlet in order to ensure adequate functioning of the water delivery system as a whole. Therefore, abstraction by a few shareholders makes the canals dysfunctional leading to a forced underutilisation of the same by the other shareholders who may be relying on the use of public canals on economic grounds. Hence the lowering of the curve $xy$ to $x'y'$. This lowering, it may be noted, is neutral to holding size. Therefore, while (1) reflects a reduced attractiveness of the private tubewells for the small holders, (2) forces them precisely to a greater dependence on the same. Both these aspects derive from the large land owner's preference for their private tubewells and at the expense of public canals.

8.5 **CONSEQUENCES FOR SMALL FARMERS**

As a result of the progressive deterioration of the functioning of canals the small land owners are typically forced to the following options.
(1) **Installation of Electric Tubewells:** Those who can afford install their own electric tubewells which are under-utilised due to the smallness of their scale of production and have an $E$ curve lower than $m_n$, i.e. $m'n$.

(2) **Installation of Diesel Tubewells:** The next lower category in the land size (i.e. below those opting for (1) above) say $p''$ ($<p'$) opt for the installation of diesel tubewells, which while are less efficient and more expensive than the electric ones,\(^6\) for larger holdings, are for holdings below a certain size, cheaper than electric ones on account of the different method of charging for the fuel for the diesel and electricity (see Chapter V). The $E$ curve for diesel tubewells is therefore lower than that for electric ones (i.e. $m'n''$ lower than $m'n$).\(^7\)

(3) **Purchase of Water from Tubewells:** Finally, the smallest category (say $p'''$), who cannot even install the diesel tubewells are forced to depend on purchased water (from tubewells) specially in the event when the effectiveness of canal water for this category (i.e. $x''''p'''$) falls below the limit for practically feasible irrigated cultivation. The $E$ curve for this category ($m''''n'''$) is the lowest, as irrigation through

\(^6\)See Chapter V for a gradation of efficiencies of the different modes of irrigation.

\(^7\)The poor technical efficiency of diesel engines, as well as the greater operational problems associated with their use, relative to an electric tubewell, have already been noted earlier (see Chapter VI).
purchased water has the poorest efficiency and turns out to be the most expensive mode.

Therefore, under the altered circumstances as we move towards smaller holdings, the E curve for the available irrigation moves lower.

Looking at the process in a dynamic sense, we find that as the proportion of area under tubewell irrigation increases (due to increased investment in tubewells), it leads to increased disutility of canals, which reinforces the incentives for a further increase in tubewells leading to further disutility of canals and so on. Hence, the process once initiated, become self reinforcing.

8.6 CONCLUSION

Following from the dynamics of the situation outlined above we can conclude the following:

(1) The burden of the external diseconomies of private tubewell installation is borne by the smallest land owners.

(2) Public and private investment in irrigation in the same area tends to be competitive and not complementary.

Thus, we have the simultaneous existence of highly under-utilised public canals on the one hand and underutilised private tubewells on the other, along with a section of cultivators demanding water but without access to either source. That is, a tremendous overinvestment in irrigation assets accompanied by inadequate levels of utilisation of the potential created. Evidence for this has already been discussed in Chapter VI.
Irrigation is a public good with major externalities and investment in irrigation raises therefore important questions of overall rationality of resource allocation and of social control.