IRRIGATION EFFICIENCY
WATER USE EFFICIENCY (WUE) & INDICES

An efficient irrigation system implies effective transfer of water from the source to the filed with minimum possible loss. The objective of the efficiency concept is to identify the nature of water loss and to decide the type of improvements in the system. Evaluation of performance in terms of efficiency is prerequisite for proper use of irrigation water.

1. Irrigation Efficiency

It is defined as the ratio of water output to the water input, i.e., the ratio or percentage of the irrigation water consumed by the crop of an irrigated farm, field or project to the water delivered from the source.

$$Ei = \frac{Wc}{Wr} \times 100$$

where,

Ei = irrigation efficiency (%)

Wc = irrigation water consumed by crop during its growth period in an irrigation project.

Wr = water delivered from canals during the growth period of crops.

In most irrigation projects, the irrigation efficiency ranges between 12 to 34 %.

2. Water Conveyance Efficiency

It is a measure of efficiency of water conveyance system from canal network to watercourses and field channels. It is the ratio of water delivered infields at the outlet head to that diverted into the canal system from the river or reservoir. Water losses occur in conveyance from the point of diversion till it reaches the farmer's fields which can be evaluated by water conveyance efficiency, as under:

$$Ec = \frac{Wt}{Wf} 100$$

where, Ec = water conveyance efficiency, per cent

Wf= water delivered to the farm by conveyance system (at field supply channel)

Wt = water introduced into the conveyance system from the point of diversion

Water conveyance efficiency is generally low; about 21% losses occur in earthen watercourses only.

Water Application Efficiency

It is a measure of efficiency of water application in the field. It is the ratio of volume of water that is stored in the root zone of crops and ultimately consumed by transpiration or evaporation or both to the volume of water actually delivered at the field. Alternatively, it may be defined as the percentage of water applied that can be accounted for as increase in soil moisture in soils as occupied by the principal rooting system of the crop. It is also termed as farm efficiency as it takes into account water lost in application at the farm. We have

$$Ea = \frac{Ws}{Wf} 100$$

where,

Ea = water application efficiency, per cent

Ws = irrigation water stored in the root zone of farm soil

Wf = irrigation water delivered to the farm (at field supply channel)

In general, water application efficiency decreases as the amount of water during each irrigation increases. Water losses due to inefficient application of water in the field vary from 28 to 50 %.

Common sources of loss of irrigation water during application are represented thus:

Rf = surface runoff from the farm

Df = deep percolation below the farm root zone soil

Neglecting evaporation losses during application, we have

$$Wf = Ws + Df + Rf$$

$$Ec = Wf - \frac{(Df + Rf)}{Wf} \times 100$$

3. Water Use Efficiency

Having conveyed water to the point of use and having applied it, the next efficiency concept of concern is the efficiency of water use. It is expressed in kg/ha cm. The proportion of water delivered and beneficially used on the project can be calculated using the following formula

$$Eu = \frac{Wu}{Wd} 100$$

where,

Eu = water use efficiency, per cent

Wu = water beneficially used

Wd = water delivered

Water use efficiency is also defined as (i) **crop water use efficiency and (ii) field water efficiency.**

(a) Crop Water Use Efficiency: It is the ratio of yield of crop (Y) to the amount of water depleted by crop in evapotranspiration (ET).

$$CWUE = \frac{Y}{ET}$$

where,

CWUE= Crop water use efficiency

Y = Crop yield

ET = Evapotranspiration

CWUE is otherwise called consumptive water use efficiency. It is the ratio of crop yield (Y) to the sum of the amount of water taken up and used for crop growth (G), evaporated directly from the soil surface (E) and transpired through foliage (T) or consumptive use (Cu)

$$\textbf{CWUE} = \frac{\textbf{Y}}{\textbf{G + E + T}}$$

where,

(G + E + T) = Cu

In other words ET is Cu since water used for crop growth is negligible.

$$\text{CWUE} = \frac{\text{Y}}{\text{CU}}$$

It is expressed in kg/ha/mm or kg/ha/cm.

(b) Field Water Use Efficiency:

It is the ratio of yield of crop (Y) to the total amount of water used in the field.

$$\text{FWUE} = \frac{\text{Y}}{\text{WR}}$$

where,

FWUE = field water use efficiency

WR = water requirement

This is the ratio of crop yield to the amount of water used in the field (WR) including growth (G), direct evaporation from the soil surface (E), transpiration (T) and deep percolation loss (D).

Y

$$FWUE = \frac{\text{---------}}{G + E + T + D}$$

$G + E + T + D = WR$

It is expressed in kg/ha/mm (or) kg/ha/cm

Deep percolation is important for rice crop. For other crops seepage is important.

Of the two indices defined, the crop water use efficiency is more of research value whereas the field water use efficiency has grater practical importance for planners and farmers.

4. Water Storage Efficiency:

It is defined as the ratio of the water stored in the root depth by irrigation to the water needed in the root depth to bring it to the field capacity. Also termed as water storage factor.

$$Es = \frac{Ws}{Ww} 100$$

where,

Es = water storage efficiency, per cent

Ws = water stored in the root zone during the irrigation

Ww = water needed in the root zone prior to irrigation, i.e., field capacity available moisture.

5. Water Distribution Efficiency

Expression for distribution efficiency to evaluate the extent to which the water is uniformly distributed is as follows:

$$Ed = \frac{(1-d)}{D} 100$$

$$= \frac{(1 - \text{Average deviation})}{\text{Average depth applied}} 100$$

where,

Ed = water distribution efficiency, per cent

d = average numerical deviation in depth of water stored from average depth stored during irrigation

D = average depth of water stored along the run during irrigation

A water distribution efficiency of 80% means that 10% of water was applied in excess and consequently 10% was deficient in comparison to the average depth of application.

6. Consumptive Use Efficiency

It is defined as the ratio of consumptive water use by the crop of irrigated farm or project and the irrigation water stored in the root zone of the soil on the farm or the project area. After irrigation water is stored in the soil, it may not be available for use by the crop because water may evaporate from the ground surface or continuously move downward beyond the root zone as it may happen in wide furrow spacing. The loss of water by deep penetration and by surface evaporation following irrigation is evaluated from the following expression:

$$Ecu = \frac{Wcu}{Wd} 100$$

where,

Ecu = consumptive use efficiency, per cent

Wcu = normal consumptive use of water

Wd = net amount of water depleted from root zone soil

Consumptive use efficiency is useful in explaining the difference in crop response from different methods of irrigation.

Exercise

1. Work out the irrigation efficiency from the following data.

Water conveyance and delivery loss	=	40%
Deep percolation and surface runoff in farms	=	30%
Water stored in soil lost by evaporation	=	20%

2. A borewell fitted with 7.5 HP motor discharges water at the rate of 12 lit/sec. Water received at the main field. Channel was measured as 8.5 lit/sec. Workout the conveyance efficiency.
3. Work out the water use efficiency for the following crops using the data given in the table.

Crop	Yield (kg/ha)	ET (mm)	WR (mm)
Rice	6,200	500	1,200
Groundnut	800	320	500
Sugarcane	110,000	1,260	2,050