GOVERNMENT OF THE PUNJAB
Agriculture Department

TECHNICAL BRIEF
15

# INCREASING WATER PRODUCTIVITY

## (PRODUCING MORE CROP PER DROP)

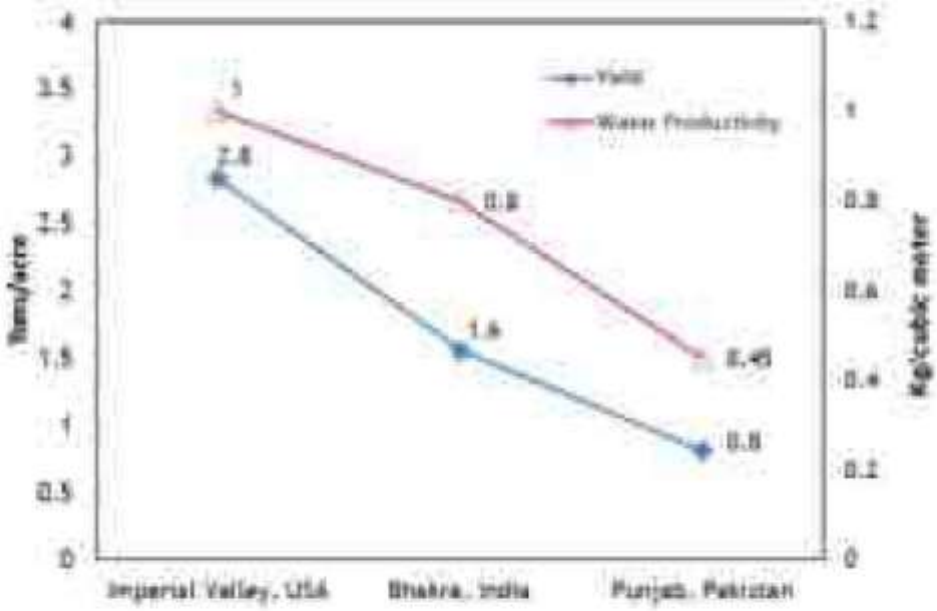
**Chaudhary Mohammad Ashraff**
Director General

**Hafiz Qaisar Yasin**
Assistant Director (Tech.)

**Directorate General Agriculture**
(Water Management) Punjab, Lahore

## 1. INTRODUCTION

Water Productivity (WP) has emerged as national growth determinant in agriculture dominated economies. The agrarian nature of Pakistan's economy relies fundamentally on water utilizing about 93 percent of available water supplies. About 80 percent of the cropped area is irrigated, and 90 percent of the agricultural output comes from irrigated lands. The sector is, however, faced with serious sustainability threats above all rapidly escalating water shortages. Inadequate water availability and its improper use remains the main obstacle to low productivity from otherwise highly productive agricultural lands. The overall irrigation efficiency is in the order of 50 percent, which is mainly due to wastage of huge volume of water during conveyance and application. Moreover, the productivity, both per unit land and per cubic meter of water, is much lower than international benchmarks and even poorer than neighboring areas having similar agro-climatic conditions. A comparison of wheat yields in Pakistan' Punjab, California (USA), and Indian Punjab show productivity ratios of about 3:6:10 per unit of land, and about 5:8:10 per unit of water, respectively.




Declining Wheat Yield per Unit of Land and Water
(Adopted from Water Economy Running Dry, the World Bank Publication, 2006)

## 2. DEFINITION AND CONCEPT

Irrigation efficiency or water use efficiency was initially used to describe the performance of irrigation systems. More recently, the term "WP" became known, which refers to magnitude of output/ benefit acquiring from input quantum of water applied on a unit base. In the domain of agriculture, it is expressed as the net consumptive use efficiency in terms of yield per unit depth of water consumed per unit area of cultivation. Its magnitude and meaning is, however, often changes with its scale of reference. Isolated scales of reference in agriculture can be crop, field, command basin, project, state and the country scale. The concept of WP in agricultural production is mainly focused on producing more food with same or less volume of water. The definition of WP is scale dependent. It is usually expressed as 'tonnes per acre per cubic meter of water' or 'kg yield per kg water consumed', or 'rupees per unit volume of water'.

$$WP = \frac{Y}{TWU}$$

Where,

WP = Water Productivity
Y = Yield
TWU=Total Water used

Stakeholders in agriculture have different perceptions about productivity of water. This is evident by different definitions of productivity in several ways according to purpose, scale, and domain of analysis (**Table-1**).

**Table-1: Definitions of WP According by Different Stakeholders**

| Stakeholder | Definition | Scale | Target |
|---|---|---|---|
| Irrigation Engineer | Yield/Diverted Water | Irrigation Scheme | Optimal allocation of water resources |
| Agronomist | Yield/Evapotranspiration | Field | Higher yield (tons/acre) |
| Farmer | Yield/Irrigation | Field | Maximize Income |
| Plant physiologist | Dry matter/Transpiration | Plant | Productive utilization of light and water resources |
| Policy maker | Rupee/Available Water | River Basin | Maximize Profits |

## 3. METHODS OF INCREASING CROP WATER PRODUCTIVITY

Food production is the perhaps the largest water consuming economic activity. An adequate human diet takes about 4,000 liters of water per day to produce, which is over 90 percent of the daily human water requirement. The escalating water scarcity resulting from population growth, inefficient water application, drudgery in irrigation operations, amid many limits the amount of water available for food production and threatens food security in many countries.



Increasing crop WP is a key response option in areas where water is scarce compared with land and other resources involved in production. It has been well established that there is a patent link between water, poverty reduction, and economic growth meaning thereby that for the rural poor more productive use of water can mean better nutrition for families, better income, and productive. Because WP can be quantified, it enables improvements to be charted encouraging faster progress.

In arid and semi-arid regions like Pakistan, water is often a key limiting input for crop production. In such situations, optimization of available water is the best option through adopting improved water management technologies and practices as well as improving use of other inputs. There is a substantial variation in crop yields and corresponding WP values obtained for different crops and also for the same crop grown in different locations. This gap is mainly due to differences in soil and water management practices. This indicates a great potential to improve the productivity of irrigated agriculture in Pakistan through adoption of modern irrigation technologies and practices. At field scale, interventions should aim at increasing water productivity by minimizing non-productive uses of water.

There has been modernization in every agricultural operation in Pakistan starting from tillage to threshing, except irrigation that is the most critical activity in crop production. The need for judicious and economical use of this scarce resource for enhancing its productivity at the farm level has become inevitable. The adoption of water conservation technologies, over the years, are contributing significantly towards enhancing water productivity and minimizing water losses as well as improving water availability at farm level. Besides these have resulted in several other tangible and intangible benefits including increased agricultural production, more employment opportunities in rural areas, higher incomes from the farming, better living standards of the farmers, and improved environment.

## 3.1 Watercourse Improvement

The watercourse improvement / renovation consists of complete demolishing of community channel and its rebuilding/re-aligning according to the engineering design to increase conveyance efficiency by reducing seepage, evaporation, and operational losses. A recently completed "Project Impact Evaluation Study (PIES) for the Project National Program for Improvement of Watercourses in Pakistan (NPIWC)" got conducted by the Planning Commission of Pakistan reveals that watercourse improvement is highly cost effective option for improving water productivity. The salient findings highlighted therein are summarized below.

| Sr. # | Impact | Extent (%) |
|---|---|---|
| 1 | Annual water saving (acre feet) | 123 |
| 2 | Improvement in crop yields | 2-15 |
| 3 | Increase in cropping intensity | 4 |
| 4 | Saving in irrigation time | 28 |
| 5 | Expansion in irrigated area | 21 |
| 6 | Reduction in labor for irrigation | 50 |
| 7 | Enhancement in farm incomes | 15 |
| 8 | Decrease in conveyance losses | 39 |
| 9 | Curtailment in saline area | 87 |

## 3.2 LASER Land Leveling

LASER land leveling is an ideal intervention for improving water application efficiency and enhancing crop yields viz-a-viz enhancing water productivity. An impact assessment study carried out by Planning and Evaluation Cell of Agriculture Department during 2008 reveals its following impacts.

- Saving in irrigation time from 25.1 to 32.1 percent
- Increase in irrigated area by 34.5 to 42.0 percent
- Improvement in crop yields from 10.7 to 12.9 percent
- Reduction in farm cultureable waste land by 2.10 percent
- Facilitation in better crop stand, uniform moisture availability and enhanced fertilizer use efficiency

## 3.3 High Efficiency Irrigation Systems

Surface flooding is the most widely used irrigation method in Pakistan due to its lower costs. This is, however, an inefficient practice with excessive water losses through runoff, deep percolation, and evaporation from farm channels as well as in the field. There has been many advancements in irrigation conveyance application systems that substantially increase the irrigation efficiency many fold. Some of the advanced irrigation systems are drip & sprinkler irrigation system, bed & furrow, gated pipe, syphon tubes etc.

The impact evaluation studies for drip irrigation undertaken by technical committees constituted by Agriculture Department for sugarcane, citrus, and potato show following impacts.

- Increase in water use efficiency by 40-50 percent
- Enhancement of yield from 34-105 percent
- Reduction in mortality rate to only 1-2 percent against 10-15 percent under surface flooding
- Adoption of high density orchard plantation for higher yields
- Uniform size and shape and better color fruit
- Easy, precise, efficient and uniform nutrient application

## 3.4 Irrigation Scheduling


Soil moisture is a critical and potentially highly variable component of the soil environment in crop production. The feel and appearance is the only method presently employed for guessing soil moisture content for irrigation purposes. There is a huge gap in amount of water being applied and actual irrigation requirements, which can be curtailed by modernizing application methods and scheduling the irrigation on scientific basis. There are, however, a numerous instruments and tools available for its correct measurement. The use of these devices can remove the guess work in irrigation management by providing an accurate assessment of the soil water status resulting in significant improvement of water productivity. There are numerous such devices used for moisture measurement such as weather stations, tensiometers, gypsum blocks, neutron probes, capacitance devices, soil moisture sensors, time domain reflectometry, time delay transmission, FullStop - wetting front detection, shovel / dig stick.

## 3.5 Capacity Building and Awareness Generation

The farmers in the Punjab normally follow traditional irrigation practices due to lack of access to modern techniques and technologies. The promotion of new irrigation techniques and their widespread dissemination amongst all stakeholders for enhancing water productivity may prove effective through a participatory approach combining traditional knowledge with scientific technology. It involves a complete paradigm shift from archaic traditional surface irrigation technologies and associated agricultural practices.






## 4. ON FARM WATER MANAGEMENT MODEL OF INCREASING WATER PRODUCTIVITY

The Punjab government has started the Punjab Irrigated-Agriculture Productivity Improvement Project (PIPIP) by integrating already tested and tried on farm water management interventions as one package. It envisages developing/upgrading tertiary conveyance system, promotion of high efficiency water conserving technologies like sprinkler/drip irrigation, LASER land leveling, capacity building of all stakeholders, and undertaking action research for acquisition, indigenization, and pilot testing of modern water management interventions to suit the local conditions. The combined effect of these advancements would lead to maximize productivity of available water by minimizing water losses at various levels in order to ensure its adequacy, equity, and reliability at the farm level. ***The project development objective (PDO) is to improve water productivity i.e. "producing more crop per drop" leading to greater agricultural output per unit of water used***, which will be achieved through increasing physical delivery efficiency, adoption of efficient irrigation practices, crop diversification, and effective application of inputs.

# WATER MANAGEMENT ACTIVITIES

LASER Land Leveling

Watercourse Improvement

Sprinkler Irrigation

Drip Irrigation

Bed & Furrow Technology

Solar Water Pump

Hydro Flume Irrigation

Flexible Pipe Irrigation


**Directorate General Agriculture**

(Water Management) Punjab

21-Davis Road, Lahore, Ph: 042-99200703, 99200713 Fax: 042-99200702

Web: www.ofwm.org.pk - E.mail: pipipwm@gmail.com