Increasing Agricultural Water Productivity: Promises and Perils

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Outline

1. Increasing Agricultural Water Productivity as Critical Intervention
2. Complexities of Tackling Agricultural Water Productivity
3. Limitations of Single-Factor Productivity Measures
4. Moving Beyond: Economic Concepts
5. Going Forward

Reference
1. Increasing Agricultural Water Productivity as Critical Intervention

It is widely believed that we are facing **two emerging and unprecedented crises** involving agricultural water management:

- global water crisis
- global agricultural crisis

In order to at least partially respond, it is increasingly recommended that efforts should **focus on improving agricultural water productivity**.
Increasing Agricultural Water Productivity - Promises

Given the large amounts of water involved, and the widely held belief that water use in agriculture is relatively inefficient, it is thought that even small improvements in agricultural water productivity could have large implications for local and global water budgets.

Such improvements would allow

- **higher** agricultural production with the **same** amount of water, or

- the **same** amount of agricultural production with **less** water, thus lead to **water savings** that could be reallocated to other higher-value uses.
Increasing Agricultural Water Productivity - An Important Policy Goal

Global Water Partnership (2000)
An important global water security target is the increase in water productivity for food production by 30% in 2015.

World Water Council (2000)
To avoid intensification of the water crisis, about half of the increased demand for agricultural water use in 2025 should be met by increases in water productivity.

Crop water productivity increases are called for with the aim of reducing pressure to develop new supply sources or increase water allocation to agriculture.

Food and Agriculture Organization of the United Nations (2012)
Demand management is an important option to cope with water scarcity, with increasing agricultural water productivity as the single most important avenue for managing water demand in agriculture.
Sustaining Water for All in a Changing Climate (WBG, 2010)
Water productivity in agriculture is an issue that has emerged as critical.

Agriculture Action Plan (WBG 2013)
Especially in regions where the scope for further expanding irrigated agriculture is limited, more efforts are needed to better use the available water, raising water productivity and its sustainable use.

Study on Climate-Smart Agriculture (WB, 2011)
In water stressed countries measures to enhance agricultural water productivity are often most helpful if combined with measures to support broader economic diversification.

Inclusive Green Growth (WB, 2012)
Sustainable management of water is becoming particularly urgent. The sustainable intensification of production systems is called for to increase productivity while maintaining and even enhancing the value of natural capital.

Turn Down the Heat: Climate Extremes, Regional Impacts (WB, 2013)
In South Asia there is a high potential for improvements in irrigation systems and water productivity, and more efficient agricultural water management in general.
A review of the irrigation and drainage portfolio (i.e. projects with 51% or more of their commitments allocated to the sector code for irrigation and drainage) active at the end of FY12 showed:

• Related PDO is in a sixth of the active portfolio (or 7 out of 41 projects).

• Projects differ widely with regard to their interpretation of “agricultural water productivity” as well as their interventions and the measurements of results.

• Indicators in the Results Framework are often variations of “more crop per drop”, baseline data are often missing, and little details are provided on how the monitoring would be carried out.
Increasing Agricultural Water Productivity – Common Problems

• Most reports and public communications are vague on the meaning of “agricultural water productivity”. If a definition is given or implied, it is usually along the lines of “more crop per drop”, emphasizing water as if it were the only agricultural input that mattered.

  For example:

  “…we need a Blue Revolution in agriculture that focuses on increasing productivity per unit of water, or ‘more crop per drop’”.

  (Kofi Annan in an address to a summit of the Group of 77 developing countries, 2000)

• There is little discussion about the instruments available for improving agricultural water productivity, and which interventions may be suitable and feasible in a particular situation.

• Little attention is paid to monitoring and measuring the results of the different interventions, and thus measurements showing positive results of interventions (such as water savings) continue to be rare.
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2. Complexities of Tackling Agricultural Water Productivity

Many of the complexities in the discussion about how to improve agricultural water productivity and efficiency are related to two key issues:

• the unique physical characteristics of water; and

• the multidisciplinary nature of the topic.
Complexities –
Unique Water Characteristics

Among the unique characteristics are:

- **Water is mobile.** Typically found in its liquid form, water tends to flow, evaporate and seep as it moves through the hydrologic cycle.
  - Exclusive property rights are relatively difficult/expensive to establish and enforce (“high-exclusion cost resource”).

- **Water is rarely completely consumed in the course of its “use”** (especially in agricultural production).
  - Downstream users are affected by the return flows of upstream users (“externalities”, implying that full costs are not incorporated in individual users’ decisions).

As a result, it is often difficult to derive insights from what is observed on the field (or farm/irrigation system level) to the overall effects at the basin level.
Different disciplines—such as irrigation engineering, agronomy, and economics—use the concepts (irrigation water) productivity and efficiency in different ways.

There is also little communication across disciplines.

• For example, irrigation engineers tend to focus on physical aspects, and often use “irrigation efficiency”—in its basic form defined as ratio of water consumed by crops to water applied (on-farm irrigation efficiency).

• The concept of “more crop per drop” (in its common and widespread use) partly relates to this.

A number of problems are associated with such single-factor productivity measures for water.
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The use of such measures is dominant in productivity-related studies in the irrigation literature.

Generally, *agricultural water productivity* is understood as agricultural output per unit volume of water, with

- **nominator** usually in physical terms (such as kg yield); and

- **denominator** in one of the measures of water:
  - water withdrawn
  - water applied
  - water depleted (consumed by evapotranspiration, and/or lost in a sink)

Some of the limitations are illustrated with hypothetical cases at the field (or farm/irrigation system level) and basin level.
(On-Farm) “Irrigation Efficiency” and “Crop per Drop”

#### 40% Irrigation Efficiency

Yield: 100 kg

<table>
<thead>
<tr>
<th>Water Measure (m³)</th>
<th>Crop per Drop (kg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Terms of Water Withdrawn</td>
<td>100 → 67</td>
</tr>
<tr>
<td>In Terms of Water Applied</td>
<td>90 → 60</td>
</tr>
<tr>
<td>In Terms of Water Consumed</td>
<td>36 → 36</td>
</tr>
</tbody>
</table>
(On-Farm) “Irrigation Efficiency” and “Crop per Drop” (cont.)

40% Irrigation Efficiency

Yield: 100 kg

60% Irrigation Efficiency, Water Spreading

Yield: 150 kg

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<td>90 → 90</td>
</tr>
<tr>
<td>In Terms of Water Consumed</td>
<td>36 → 54</td>
</tr>
</tbody>
</table>
(On-Farm) “Irrigation Efficiency” and “Crop per Drop” (cont.)

40% Irrigation Efficiency

Yield: 100 kg

60% Irrigation efficiency, No Water Spreading, Reduction of Non-Beneficial Consumptive Use (NB) by Two-Thirds

Yield: 100 kg

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Basin-Wide Effects
(On-Farm) Irrigation Efficiency Increase from 40% to 60%, Water Spreading

Source: Authors.
Insights from Illustrations

Need to revisit the use of “crop per drop” ratios as
- productivity measures, and
- in particular for addressing productivity issues at the basin-level.

Key shortcomings:

• Only one input (water) is considered.
• Productivity increases only stem from technological progress (possible efficiency gains are not considered).
• Prices are not accounted for.

Economic concepts on productivity and efficiency are better suited to address some of the shortcomings.
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4. Economic Concepts: Sources of Productivity Improvements

Single-Input Single-Output Case:

(i) Increase in technical efficiency
(ii) Economies of scale
(iii) Technological progress
(iv) Allocative efficiency

Source: Based on Coelli et al., 2005.
Water Productivity and Its Dimensions
(i) Technical and Allocative Efficiency

Source: Authors.
Water Productivity and Its Dimensions

(ii) Technical and Allocative Efficiency, Accounting for Return Flows

Source: Authors.
Water Productivity and Its Dimensions (iii) Including Technological Progress

Source: Authors.
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• Given the complexities involved in agricultural water management issues, resorting to single-factor productivity measures such as “crop per drop”—and supporting interventions to increase it—is unlikely to deliver on the perceived promises.

• Caution is especially warranted when assessing the extent to which irrigated agriculture is able to achieve real water savings that can be reallocated to other uses.

• To overcome these many limitations, a richer set of tools is needed that accounts for the complexities of both agricultural production (e.g. including other production factors beyond water, and the possibility for input and/or output substitution as well as prices and costs) and water use in agriculture (e.g. incorporating the pervasive physical externalities among water users).
5. Going Forward (cont.)

Going forward, it will be important to achieve progress on several fronts:

• More emphasis should go into economic studies that incorporate water productivity in its many dimensions, consider the return flow issue, and adopt a multi-input and multi-output framework.

• This will require that more data are gathered on the different measures of agricultural water use (even though the special characteristics of water make this a more difficult and costly endeavor compared to most other factors involved in agricultural production).

• Also the collaboration between the various concerned disciplines should be intensified to arrive at more comprehensive approaches.