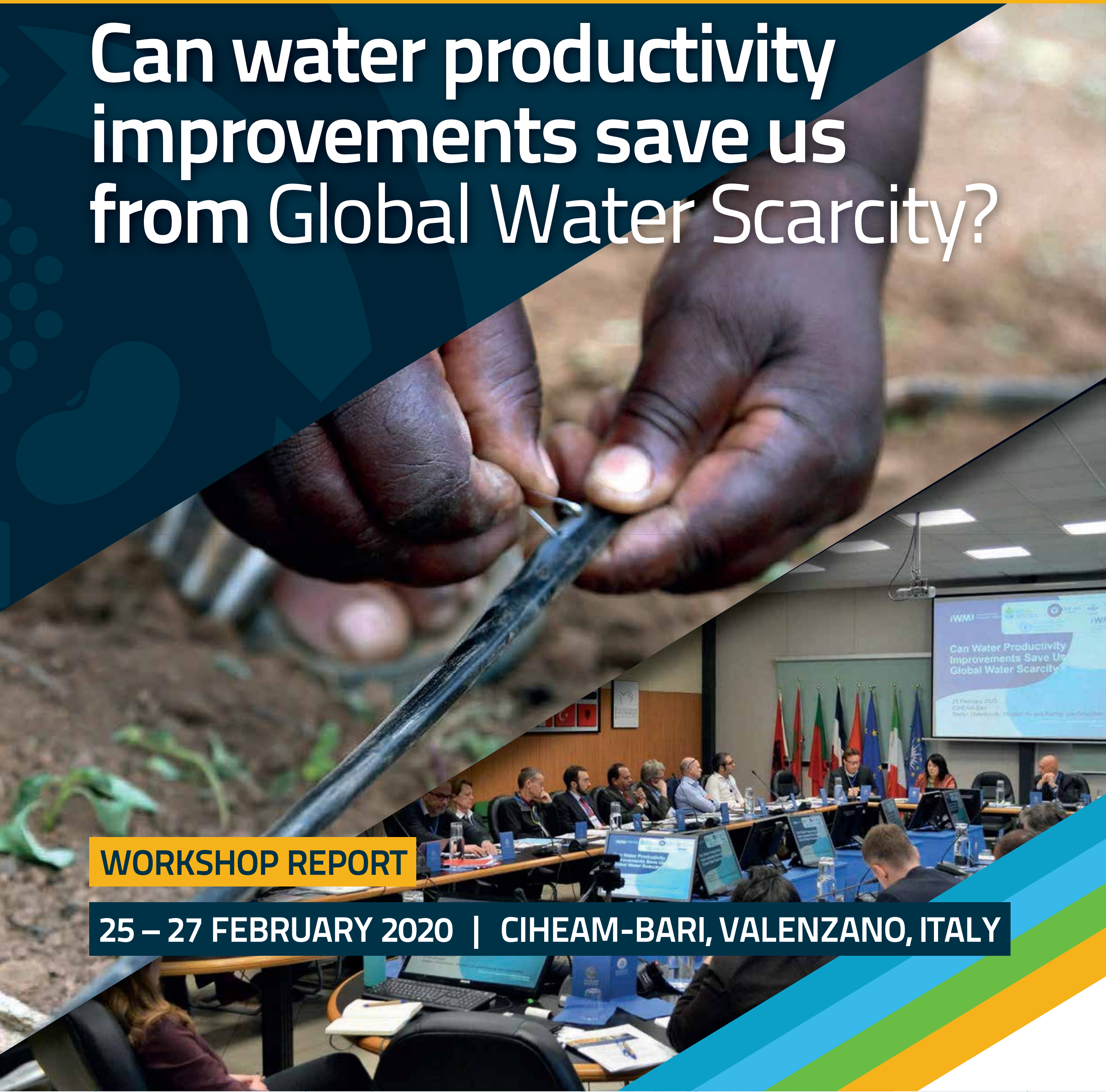
Food and Agriculture Organization of the United Nations

International Water Management Institute

WASAG | The Global Framework on Water Scarcity in Agriculture

WASAG WORKING GROUP ON
SUSTAINABLE AGRICULTURAL WATER USE

Can water productivity improvements save us from Global Water Scarcity?



WORKSHOP REPORT

25 – 27 FEBRUARY 2020 | CIHEAM-BARI, VALENZANO, ITALY

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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Introduction

The Global Framework on Water Scarcity in Agriculture (WASAG), launched in 2016, is designed to bring together institutions across the globe and sectors to tackle the challenge of using water better in agriculture to ensure food security for all. WASAG, coordinated by the Food and Agriculture Organization of the United Nations (FAO), has established thematic working groups led by its partners to further its initiative. Among these working groups is the Working Group on Sustainable Agricultural Water Use. This working group aims to increase awareness and action by agriculture and related ministries for more sustainable agricultural water use to address water scarcity for enhanced food security and nutrition, as well as for achieving all other Sustainable Development Goals.

The WASAG Working Group on Agricultural Water Use (led by the International Water Management Institute, IWMI) organized a workshop co-hosted by the Mediterranean Agronomic Institute of Bari (CIHEAM) and the CGIAR Research Program on Water, Land and Ecosystems (WLE). The workshop took place at the CIHEAM-Bari campus in Valenzano, Italy on 25-26 February 2020 with an optional field site visit on 27 February 2020 (see Annex 3.1 for the workshop agenda).

The workshop, *"Can Water Productivity Improvements Save Us from Global Water Scarcity?"*, brought together over 30 experts from governments, international organizations, development finance institutions, academia and practice (see Annex 3.2 for the list of participants). The main objectives of the workshop were (1) to share knowledge about successful examples of improving water productivity in the field and its implications on water scarcity, and (2) to discuss what is necessary to create an enabling environment and policy changes to scale these interventions as a basis for effective policy recommendations.

More specifically, the **following questions** were addressed:

- What are ***common objectives and indicators*** for enhancing water productivity? Are some objectives competing?
- What can be ***learned from successful examples*** of improving water productivity at the farm, basin, national and regional scales?
- What are the ***main obstacles*** to raising water productivity?
- What are key ***investment priorities*** to increase water productivity? How do they differ for small-holders and medium/larger irrigation schemes?
- What would be ***key elements of a future research agenda*** to address identified needs and create enabling environments and pathways for change?
- How can we close the ***gap between research and policymaking***?

The outcomes of the workshop will provide the basis for a *White Paper* on enhancing water productivity to address water scarcity. The *White Paper* will include key concepts and terms related to water productivity, criteria and indicators for sustainable agricultural water use, and examples from the field. Related policy recommendations will be included as appropriate. The *White Paper* will also support policy and decision makers in their efforts to achieve SDG Target 6.4 (increase water use efficiency) and to track progress.

Furthermore, the outcomes of this workshop were used to construct a key messages document that will feed into a session at the G20 meeting titled “Fostering Sustainable and Resilient Water Management Globally” in Saudi Arabia in mid-March 2020.

1. Summary of workshop sessions

1.1 OPENING AND WELCOME

The workshop began with opening and welcome remarks by Maurizio Raeli, Director of CIHEAM-Bari and Sasha Koo-Oshima, Deputy Director of Land and Water Division at the FAO. Stefan Uhlenbrook, IWMI, gave a presentation to introduce the objectives of the workshop, highlighting the importance of thinking about water productivity in a wider food systems context and considering different scales and users. The link to the Agenda 2030 for Sustainable Development and particularly to SDG 6.4 was also introduced. One objective of the workshop was to develop main messages for the G20 meeting in mid-March. Participants then introduced themselves and gave a brief explanation of their motivation to participate in the workshop.

1.2 KEYNOTE SESSION 1: SETTING THE SCENE

The purpose of this session was to set the scene for the workshop. Nicola Lamaddalena (CIHEAM-Bari) moderated the session. The keynote presentation by Winston Yu provided an overview of the background paper (see Annex 3.3). The presentation highlighted the different objectives, perspectives and terminology related to water productivity, listed common water productivity interventions, and provided examples of implemented water productivity interventions. Yu highlighted the need for water accounting and stated that technology is often implemented with the assumption it will be used; however, there is a social dimension that must be considered. Carlos Dionisio Pérez-Blanco's presentation summarized his empirical review of over 240 case studies of implemented water conservation technologies. He emphasized multiple objectives require multiple instruments (Tinbergen Principle), the importance of external policies and that trade-offs cannot be ignored. Pérez-Blanco explained the study found water was conserved when farmers abandoned introducing water conservation technologies or when water conservation technologies were implemented alongside with water conservation policies. A discussion with the whole group followed the presentations.

One participant commented that external policy drives choices and thus policy incentives cannot be ignored. Some participants cautioned making broad statements about the unsuccessfulness of water conservation technologies and emphasized that the positive implications of water conservation technologies cannot be forgotten. Participants agreed that water productivity is not a silver bullet. The group briefly discussed what level of water quality deems a return flow as non-recoverable. A participant noted technical solutions are quickly the focus rather than understanding the ecosystem of the community, and that the take up of technologies is still quite low as farmers do not want to adopt because of perceived financial and yield risks.

1.3 PANEL DISCUSSION 1: PRODUCTIVITY VERSUS EFFICIENCY – WHY IS TERMINOLOGY SO CHALLENGING? EXPERIENCES FROM PRAXIS

The panel topic for this session was the challenges with water productivity and efficiency terminology. Sasha Koo-Oshima (FAO) moderated the panel. Panelists included Pieter Waalewijn (World Bank), Julienne Roux (Global Water Partnership), and Ditlinde von Davidson (KfW). Each panelist discussed their experiences and thoughts on the session topic, and then the discussion opened to the larger group.

Panelists discussed actions that can be implemented at the basin scale to help encourage sustainable agricultural water use (e.g. water management, permits, incentives, regulations) and the need to consider a broader framework (i.e. how does agricultural water use interact with other water use and sectors?). Panelists emphasized investments can only work if farmers are supported, highlighting the important of extension service and technical assistance packages. The best technology will not work unless they are

working with the farmers. A member of the panel stated that while 'crop per drop' does have its limitations, everyone understands it. It was noted that while food self-sufficiency is often the primary concern of ministries, global and local perspectives also need to be considered; for example, global markets allow crops grown in one area to be sold in another area so they then do not have to be grown. Rainfed agriculture and the need to improve efficiencies in rainfed crops was mentioned. Participants noted that complexity increases through scales, and there is more 'use per drop' to consider rather than just more 'crop per drop' (i.e. fuel, fodder, fiber, etc.). Regarding indicators, it was stressed that it is important to have indicators that speak to actors to support policy processes.

1.4 KEYNOTE SESSION 2: CHALLENGES WITH 'WATER SAVINGS'

The purpose of this session was to provide examples of implemented water productivity interventions. Graham Jewitt (IHE Delft) moderated the session. The keynote presentation by Nicola Lamaddalen (CIHEAM) provided numerous examples of water productivity interventions from the Mediterranean Region. Lamaddalen's presentation highlighted the need to better manage water demand and the importance of timing (for example, a switch from daytime to nighttime irrigation can increase irrigation efficiency by up to 25 percent). Lamaddalen emphasized that capacity development is key. Stefanie Kaegi (HELVETAS) presented on HELVETAS' WAPRO program. She provided an overview of the lessons learned from 10 WAPRO program countries and outlined the "Push-Pull-Policy" approach. Discussion followed the presentations. Some participants emphasized the important role of government in these examples, while the private sector should not be forgotten.

1.5 BREAKOUT DISCUSSION 1: OBSTACLES TO RAISING WATER PRODUCTIVITY AND KEY INVESTMENT PRIORITIES

The purpose of this session was to discuss the following questions: 1) what are the main obstacles to raising water productivity? and 2) what are key investment priorities to increase water productivity? How do they differ for small-holders and medium/large irrigation schemes? Julie van der Bliek (IWMI) moderated the session. Participants divided into three groups to discuss and then all participants reconvened to share ideas. Below are the groups' discussion points.

GROUP 1 [FACILITATOR: RANU SINAH]

Main obstacles to raising water productivity:

- entry point; how to reconcile scales (plot, basin, global, livestock, crop, aquaculture, rainfed, surface); at which scale do we intervene; how to reconcile different definitions;

- water productivity is not the core term to focus on:
  - must consider economics and value chain;
  - it is the last element in the wider "master plan".
- farmers:
  - do not know what is meant by "water productivity";
  - need a market;
  - are self-sufficient.
- government (national) commitment requires:
  - regulation and enforcement.
- land-holding size;
- energy;
- input use (seeds, pest, fertilizer).

Key investment priorities to increase water productivity:

- speak about "system":
  - who are the key players;
  - what are the drivers;
  - which scale?
- IWRM: what are the incentives triggered:
  - wastewater
  - water balance (supply and demand)
  - unconventional water
  - water productivity.
- work with donors and investment banks;
- capacity farm-scale:
  - knowledge of consequences.
- what does "net zero" mean for the agriculture sector:
  - system balance:
    neutral
    technology
    legal
    interstate disputes
    urban-rural water
    reduce agri-water demand.?

GROUP 2 [FACILITATOR: RUHIZA JEAN BOROTO]

Main obstacles to raising water productivity:

- technical:
  - access to technologies;
  - understanding the concept of water productivity and water use efficiency;
  - access to other inputs (i.e. seed varieties, fertilizers, capacity);
  - competition between "use" of "technologies";
  - water accounting at basin and other levels; understanding the resource;

  - low efficiency for large scale schemes.
- institutional/governance/political:
  - definition of roles in adopting/promoting technology;
  - "de-risking change" / "behavior change";
  - lack of institutional / governance support;
  - definition of rules and reputation for better water management;
  - institutional accountability.
- financial/economical:
  - affordability;
  - lack of financing mechanism;
  - lack of access to markets.

Key investment priorities to increase water productivity:

- small scale;
  - modernizing existing schemes with appropriate technical approaches;
  - set up management of water approaches (energy);
  - pumping and drip irrigation for irrigation efficiency;
  - water innovations (context specific) combined with capacity development;
  - early warning system;
  - water management is important but also so are other inputs (seeds, seed varieties, fertilizers, crop diversification, high value crops);
  - extension service; and
  - minimize waste (pest management, post-harvest loss);
- medium/large scale;
  - modernize existing schemes, infrastructure and institution (i.e. asset management);
  - regular monitoring and feedback to management:
    field
    soil moisture;
  - management has capacity to react;
  - proper irrigation scheduling and delivery scheduling;
  - early warning systems;
  - extension services.

GROUP 3 [FACILITATOR: JULIENNE ROUX]

Main obstacles to raising water productivity:

- change takes time but farmers need immediate annual income;
- insufficient knowledge and common understanding of the issues and awards (including common definition of productivity);
- water productivity is not a goal for many actors (focus is rather on income, labor);
- water productivity determined by farm systems and food systems much bigger than water;
- limited incentives to act (water often "free");

- social, cultural and political issues;
- need contextual approaches; and
- difficulties to implement solutions:
  - investing in higher value crops can be risky;
  - you need reliable water supply;
  - limited resources to invest at farm level; and
  - supply chains for technologies are not in place.

Key investment priorities to increase water productivity:

- modernization of old irrigation schemes:
  - infrastructure
  - governance
  - market access
  - enabling environment.
- institutional capacity building including:
  - for operation and maintenance;
  - for legislation.
- careful with water markets;
- knowledge:
  - monitoring and evaluation;
  - need assessments and diagnostics to help decide where to invest;
  - need to understand the systems;
  - knowing the resource base, understanding hydrological cycle and forecasting.
- awareness raising;
- education and extension;
- access to credits and inputs;
- risk mitigation strategies are not the same versus whole systems;
- land consolidation but having in mind tradeoffs land tenure rights;
- effecting change on agricultural value chains;
- building political leadership; and
- focus on critical, most vulnerable areas.

1.6 KEYNOTE SESSION 3: LESSONS LEARNED FROM CASE STUDIES

The purpose of this session was to highlight lessons learned from experience. Dawit Mekonnen (IFPRI) moderated the session. The keynote presentation by Jippe Hoogeveen (FAO) was on water productivity for coping with water scarcity. Hoogeveen's presentation provided an overview of supply and demand side options to coping with water scarcity, the FAO portal to monitor Water Productivity through Open access Remotely sensed derived data (WaPOR), and FAO's 6 principles for action. The keynote presentation by Mesfin Mekonnen (Robert B. Daugherty Water for Food Global Institute) discussed trends in the water productivity of livestock products in the United States. Mekonnen's presentation was based on the findings of the 2019 Nebraska Water Productivity Report.

Discussion followed the presentations. It was noted that with projected increasing meat consumption, livestock water productivity will be increasingly more important. Participants discussed the importance in people understanding where their water comes from and resolving information asymmetries. Cost effectiveness of water productivity increases was discussed. The importance of access was emphasized; one cannot improve water productivity unless there is access to water. The distinction between “infrastructural” water scarcity and “institutional” water scarcity was noted.

1.7 DAY 1 - REFLECTIONS AND WRAP UP

Mark Smith (IWMI) provided a summary of the day’s discussions. Key discussion points included:

- critical action needed to accelerate agriculture;
- food system needs to work within planetary boundaries;
- water productivity is not a silver bullet;
- how do we address competition for water;
- under what circumstances do we see real water savings;
- the dichotomy between water conservation technologies and crop per drop versus basin management;
- how do we talk about water productivity;
- what technologies, data, institutions and governance do we need;
- how do we shape choices (incentives);
- climate change.

1.8 DAY 1 - RECAP AND SHORT DISCUSSION

Stefan Uhlenbrook (IWMI) opened the second day of the workshop with a brief recap of the prior day, and invited participants to share important 'aha moments’ from the previous day’s discussions. Ruhiza Jean Boroto (FAO) gave an overview presentation on the Global Framework on Water Scarcity in Agriculture (WASAG).

1.9 PANEL DISCUSSION 2: POLICY MAKING AND APPROACHES

The purpose of this session was to discuss policy making and approaches for water productivity. Julie van der Bliek (IWMI) moderated the panel. Panelists included Aart van der Horst (Ministry of Foreign Affairs, Netherlands), Eric S. Adu-Dankwa (Ministry of Food and Agriculture, Ghana), Halil Emre Kişlioglu (Ministry of Agriculture and Forestry, Turkey), Paolo Sertoli (AICS, Italy), and Raffaella Zucaro (Council for Agricultural Research and Agricultural Economy Analysis, Italy).

Panelists discussed the importance of understanding and bringing awareness to water availability, including the need for baseline data and monitoring. It was noted water productivity improvements cannot be made if users do not have access to water. A member of the panel mentioned the usefulness of vulnerability mapping to determine priority areas and the benefits to implementing early warning systems for drought preparedness. Panelists emphasized the importance maintaining trust with farmers and

being cognizant of farmers' behaviors and objectives. One panelist discussed the role of circular economy in investment programs (e.g. reuse of water) and the importance of considering the water-energy-food-environment nexus when planning investments to increase water use efficiency. Panelists and participants discussed the concept of setting clear water productivity targets, as such has been done by the Netherlands for foreign investments, and whether and how much this acts as a driver for policymakers.

1.10 KEYNOTE SESSION 4: INNOVATIVE AND DISRUPTIVE TECHNOLOGY

The purpose of this session was to highlight innovate and disruptive technology related to water productivity (such as the use of Earth observation combined with modelling, new sensors, ICT, etc.). SK Chaudhari (ICAR) moderated the session. The keynote presentation by Lisa-Maria Rebelo (IWMI) was on the use of Earth observation data. Rebelo's presentation covered the conceptual framework of IWMI's water accounting approach, how WaPOR is used to target investments and identify possible solutions to improve water productivity, and an example of a water accounting study and water productivity assessment used to inform investments in Lao PDR. The keynote presentation by Thomas Anken (Agroscope) discussed aspects of smart agriculture. Anken's presentation provided an overview of various technologies, such as soil moisture probes, meteorological stations and sensors, dendrometers and thermal cameras for drones. Anken described three cases that used smart agriculture practices and technologies to grow cocoa trees, apples and potatoes.

1.11 PANEL DISCUSSION 3: WHAT DO WE NOT KNOW? ELEMENTS OF A FUTURE RESEARCH AGENDA

The purpose of this session was to discuss what should be included in future research agendas for water productivity. Mark Smith (IWMI) moderated the panel. Panelists included SK Chaudhari (ICAR), Stefan Strohmeier (ICARDA), Dawit Mekonnen (IFPRI), Petra Schmitter (IWMI), and Graham Jewitt (IHE Delft).

The panelist discussed tools, data, methodology and technologies. The panel emphasized the importance of measurement, monitoring and evaluation. The panelists discussed the challenges of defining metrics for the multiple objectives and sub-themes of water productivity (livestock, economic, physical, etc.). The panel discussed behaviors at different scales and actors. Some panel members discussed how climate change and other future disruptors to the agriculture sector (such as artificial food and meat, vertical farming, urbanization, power, transportation) will change value chains, and how this will change and possibly improve water productivity.

Participants discussed the potential benefits of studying where water productivity interventions have been implemented and learning from them; we need to turn to what we already know. Panelists and participants noted the importance in gender inclusion and targeting youth in agriculture. Some participants brought attention to the gap between political economy and water productivity and questioned how researchers

can work more closely with policy and best communicate. The group discussed the advantages and disadvantages of declaring broad targets to engage political will, such as achieving a certain percentage increase in water productivity in a set timeframe. It was asked how we can make research most effective and impactful, and some participants suggested more transdisciplinary research, working in a co-design mode, being agile and learning from mistakes.

1.12 BREAKOUT DISCUSSION 2: KEY MESSAGES TO DELIVER TO G20

The purpose of this session was to discuss what key messages should be delivered to G20 in mid-March. Winston Yu (IWMI) moderated the session. Participants divided into three groups. Each group was asked to develop four to five key messages they think should be delivered to the G20 in mid-March. The groups discussed and then all participants reconvened to share. The messages were synthesized to produce the key messages document for the G20. Below are the groups' messages.

GROUP 1 [FACILITATOR: RACHEL VON GNECHTEN]

Background statement(s):

- There is need for real water savings in water scarce regions.
- There are benefits that can come from savings.
- There is urgency to this (i.e. climate change).

Key messages:

1. Governments need to commit to XX[1] percent increase in water productivity by XXXX[1] year.
2. Governments need to measure and monitor (i.e. water accounting) while considering climate change.
3. Water productivity interventions need to be thought of in a system context (whether that be basin, food system, nexus, etc.).
4. Multiple objectives require multiple instruments, necessitating management tradeoffs and evaluation of inclusivity.
5. Need investment in water scarcity, such as capacity building, infrastructure, etc.

GROUP 2 [FACILITATOR: RANU SINAH]

Background statement(s):

- Sustainable basin management is indispensable for climate resilient growth.

Key messages:

1. Know your national water accounts (current supply and demand).
2. Identify sustainable limits for current and future use at basin-scale (consider what shocks are likely to hit your system soon):
    a. apply WUE in agriculture;
    b. deploy:
        i. technologies
        ii. cutting-edge research

[1] Governments should define the percentage and timeline based on local needs and capabilities.

iii. behavior change

iv. capacity building (farmers, engineers, policy makers).

3. Create multi-agency policy, coordination and coherence (environment, water, agriculture, health, finance, MEA).
4. Develop and implement master plans (consider water quality and water quantity).
5. Monitor and iterate above steps. This is a consecutive process but should be done iteratively. Need to loop feedback back into each step.

GROUP 3 [FACILITATOR: PETRA SCHMITTER]

Background statement:

- water scarcity / crisis
- climate change
- agriculture uses 70 percent of all withdrawals
- agriculture is part of the solution.

Key messages:

1. Recognize boundaries / caps at basin scale for all sectors and define allocation for agriculture sector.
2. Setting targets on maximizing benefits generated from available water for agriculture.
3. Understanding transparency in communicating boundaries and progress along targets (accountability), which requires monitoring, evaluating and learning (iterative).
4. To ensure sustainability in changing climate, agriculture has a crucial role to play in de-risking (risk management) (absorb shocks, deliver service to other sectors, sectoral investments).

1.13 DAY 2 - WORKSHOP WRAP UP, NEXT STEPS, ACTION ITEMS AND CLOSURE

Stefan Uhlenbrook (IWMI) briefly summarized main points of the workshop, explained the next steps (i.e. drafting the key messages document for the G20 and the White Paper in the next months), and thanked participants for their contributions.

1.14 DAY 3 - FIELD SITE VISIT

An optional field site visit was held on 27 February 2020. Participants visited a farmers' cooperative, the Sinistra Ofanto irrigation scheme, and saw a demonstration of the computerized AcquaCard device used for monitoring and optimization of water use on the fields.

Annexes

A.1 AGENDA

Monday, 24 February 2020

7:00 PM	'Apericena' (ice-breaking buffet dinner) at CIHEAM-Bari Campus Restaurant

Tuesday, 25 February 2020

9:00-9:30 AM	Opening and welcome remarks by Maurizio Raeli, Director of CIHEAM-Bari, Italy Welcome remarks by Sasha Koo-Oshima, FAO, Rome Introductions, tour de table, presentation of the agenda Objectives of the workshop by Stefan Uhlenbrook and Winston Yu, IWMI
9:30-10:30 AM	Setting the scene through two keynote presentations (25 min each) followed by Q&A (10 min): ▪ Challenges, issues and approaches to deal with water scarcity by Winston Yu, Stefan Uhlenbrook, Rachel von Gnechten, IWMI; ▪ Lessons from a review of over 240 case studies by Carlos Dionisio Pérez-Blanco, University of Salamanca, Spain. Moderated by Nicola Lamaddalena, Deputy Director of CIHEAM-Bari, Italy
10:30-11:00 AM	*Health Break* *Group Picture*
11:00 AM-12:00 PM	Panel discussion (45 min) followed by Q&A (15 min): Productivity versus efficiency – Why is terminology so challenging? Experiences from praxis: ▪ Pieter Waalewijn, World Bank, USA; ▪ Julienne Roux, Global Water Partnership (GWP), Sweden; ▪ Ditlinde von Davidson, KfW, Germany. Moderated by Sasha Koo-Oshima, FAO, Rome
12:00-1:15 PM	Keynote presentations to introduce case studies to illustrate challenges with 'water savings' (25 min each incl. short discussion) followed by Q&A (25 min): ▪ Experiences from the Mediterranean Region by Nicola Lamaddalen, CIHEAM, Italy; ▪ Lessons learned from in ten countries (WAPRO program) by Stefanie Kaegi, HELVETAS, Switzerland. Moderated by Graham Jewitt, IHE Delft, Netherlands
1:15-2:45 PM	*Lunch*
2:45-3:45 PM	Breakout discussion (45 min) and reporting back to plenary by rapporteur (15 min) addressing the following questions: ▪ what are the main obstacles to raising water productivity; ▪ what are key investment priorities to increase water productivity; ▪ how do they differ for small-holders and medium/large irrigation schemes? The three breakout groups will be facilitated by: ▪ Ranu Sinah, University of Oxford, UK; ▪ Ruhiza Jean Boroto, FAO, Rome; ▪ Julienne Roux, Global Water Partnership (GWP), Sweden. One researcher from CIHEAM per breakout group will support the facilitators. Moderated by Julie van der Bliek, IWMI, Italy

3:45-4:00 PM	*Health Break*
4:00-5:15 PM	Keynote presentations to introduce lessons learned from case studies (25 min each incl. short discussion) followed by Q&A (25 min): ▪ Water productivity for coping with water scarcity by Jippe Hoogeveen, FAO, Rome; ▪ Trends in the water productivity of livestock products in the US by Mesfin Mekonnen, Robert B. Daugherty Water for Food Global Institute, University of Nebraska, USA. Moderated by Dawit Mekonnen, IFPRI, Ethiopia
5:15-5:45 PM	Reflections on the day and wrap up Moderated by Mark Smith, IWMI
6:00 PM	Travel to the old town of Bari, short walk through the historic city followed by a workshop dinner.

Wednesday, 26 February 2020

9:00-9:30 AM	Recap of Day One, short discussion Moderated by Stefan Uhlenbrook, IWMI
9:30-10:30 AM	Panel synthesis discussion: What do these case studies suggest in terms of policy making and approaches? ▪ Aart van der Horst, Ministry of Foreign Affairs, Netherlands; ▪ Eric S. Adu-Dankwa, Ministry of Food and Agriculture, Ghana; ▪ Halil Emre Kışlıoglu, Ministry of Agriculture and Forestry, Turkey; ▪ Paolo Sertoli, AICS, Italy; ▪ Raffaella Zucaro, Council for Agricultural Research and Agricultural Economy Analysis, Italy. Moderated by Julie van der Bliek, IWMI
10:30-11:00 AM	*Health Break*
11:00 AM-12:15 PM	Keynote presentations on innovative, disruptive technology (use of Earth observation combined with modelling, new sensors, ICT etc.; 25 min each incl. short discussion) followed by Q&A (25 min): ▪ Use of Earth observation data by Lisa-Maria Rebelo, IWMI, Sri Lanka; ▪ Smart agriculture by Thomas Anken, Agroscope, Switzerland. Moderated by SK Chaudhari, Indian Council for Agricultural Research, India
12:15-1:45 PM	*Lunch*
1:45-2:45 PM	Panel synthesis discussion: What do we not know? Elements of a future research agenda. ▪ SK Chaudhari, Indian Council for Agricultural Research, India; ▪ Stefan Strohmeier, ICARDA, Egypt; ▪ Dawit Mekonnen, IFPRI, Ethiopia; ▪ Petra Schmitter, IWMI, Myanmar; ▪ Graham Jewitt, IHE Delft, Netherlands. Moderated by Mark Smith, IWMI, Sri Lanka
2:45 PM-3:00 PM	*Health Break*

3:00-4:00 PM	Breakout discussion (45 min) and reporting back to plenary by rapporteur (15 min) addressing the following questions: ▪ Key messages to deliver to G20 in mid-March, and key elements to cover in the White Paper on Water Productivity. The three breakout groups will be facilitated by: ▪ Rachel von Gnechten, IWMI, USA; ▪ Ranu Sinah, University of Oxford, UK; ▪ Petra Schmitter, IWMI, Myanmar. One researcher from CIHEAM per breakout group will support the facilitators. Moderated by Winston Yu, IWMI, USA
4:00-4:30 PM	Wrap up, next steps, action items and closure Moderated by Stefan Uhlenbrook, IWMI, Italy

Thursday, 27 February 2020
Technical visit to an irrigation consortia in Southern Italy (Consortia of Capitanata)

9:00 AM	Depart CIHEAM-Bari
9:00-10:30 AM	Travel to field site
10:30-2:00 PM	▪ Visit to the Sinistra Ofanto Irrigation scheme: water distribution systems and the storage reservoir; ▪ Visit of irrigation fields equipped with sprinkler and drip irrigation systems, and discussion with farmers and extension service; ▪ Metering including good practice examples; ▪ Presentation of a computerized AcquaCard device for monitoring and optimization of water use on the fields; ▪ Operation and maintenance problems. Lecturers: Nicola Lamaddalena, CIHEAM – Bari and Luigi Nardella, Capitanata Consortia
2:00-3:30 PM	*Lunch at a restaurant in Capitanata*
3:30-4:30 PM	Visit a farmers' cooperative
4:30 PM	Depart field site
4:30-6:00 PM	Travel to CIHEAM-Bari
6:00 PM	Arrive back at CIHEAM-Bari

A.2 LIST OF PARTICIPANTS

	Name	Organization
1.	Paolo Sertoli	AICS, Italy
2.	Thomas Anken	Agroscope, Switzerland
3.	Nicola Lamaddalen	CIHEAM, Italy
4.	Raffaella Zucaro	Council for Agricultural Research and Agricultural Economy Analysis, Italy
5.	Jippe Hoogeveen	FAO, Rome
6.	Rosaida Dolce	FAO, Rome
7.	Ruhiza Jean Boroto	FAO, Rome
8.	Sasha Koo-Oshima	FAO, Rome
9.	Julienne Roux	Global Water Partnership (GWP), Sweden
10.	Stefanie Kaegi	HELVETAS, Switzerland
11.	Stefan Strohmeier	ICARDA, Egypt
12.	Marco Arcieri	ICID, Italy
13.	Dawit Mekonnen	IFPRI, Ethiopia
14.	Graham Jewitt	IHE Delft, Netherlands
15.	SK Chaudhari	Indian Council for Agricultural Research, India
16.	Julie van der Bliek	IWMI, Italy
17.	Stefan Uhlenbrook	IWMI, Italy
18.	Petra Schmitter	IWMI, Myanmar
19.	Lisa Maria Rebelo	IWMI, Sri Lanka
20.	Mark Smith	IWMI, Sri Lanka
21.	Rachel von Gnechten	IWMI, USA
22.	Winston Yu	IWMI, USA
23.	Ditlinde von Davidson	KfW, Germany
24.	Halil Emre Kışlıoglu	Ministry of Agriculture and Forestry, Turkey
25.	Eric S. Adu-Dankwa	Ministry of Food and Agriculture, Ghana
26.	Aart van der Horst	Ministry of Foreign Affairs, Netherlands
27.	Mesfin Mekonnen	Robert B. Daugherty Water for Food Global Institute, University of Nebraska, USA
28.	Laura Sommer	Switzerland
29.	Ranu Sinha	University of Oxford, UK
30.	Carlos Dionisio Pérez-Blanco	University of Salamanca, Spain
31.	Pieter Waalewijn	World Bank, USA

A.3 BACKGROUND PAPER

Can Water Productivity Improvements Save Us from Global Water Scarcity?

A background paper[2]

[DRAFT, 7 February 2020]

INTRODUCTION

Numerous factors are contributing to increased global water scarcity (e.g. climate change, population growth, increasing urbanization, expanding industrial demands, changing diets). This raises concerns whether there will be enough water for all users and uses and particularly for food production as irrigated agriculture is the major water user, responsible for about 70 percent of global withdrawals (Giordano, 2007; Perry *et al.*, 2017). In response, a wide variety of water productivity interventions (both technical and policy instruments) have been used in the sector. Water productivity is here defined as the "ratio of the net benefits from crop, forestry, fishery, livestock and mixed agricultural systems to the amount of water used to produce those benefits. In its broadest sense, it reflects the objectives of producing more food, income, livelihood and ecological benefits at less social and environmental cost per unit of water consumed" (Molden *et al.*, 2010).

Water productivity interventions can have multiple objectives apart from reducing water scarcity. These interventions can, *inter alia*, increase agricultural production to meet increasing food demands, raise farm-level income, alleviate poverty and inequality in the agriculture sector, contribute to economic growth, reduce agricultural water use, aid water reallocation from agriculture to other sectors, and ensure enough water is available for environmental demands (Molden *et al.*, 2010; Giordano *et al.*, 2017). The objectives of any water productivity intervention must be clearly defined to assess effectiveness and success.

Stakeholders' objectives and reasons for implementing a water productivity intervention may vary, having different interests and scale perspectives.

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Agronomists, driven by crop scientific improvements, often focus on individual plant productivity enhancements. Farmers, needing to support livelihoods, focus at the farm-scale (Perry *et al.*, 2017). Public water resources managers, ideally driven by sustainability concerns, focus at the basin, national, or regional scales (Perry *et al.*, 2017). Reducing water scarcity may not always be the major driver behind water productivity interventions for every stakeholder. As such, behaviors and actions at different scales and the outcomes of technologies and practices are not generalizable.

To complicate matters, there are often inconsistencies, ambiguity and misconceptions with water productivity terminology. Definitions have been developed by various academic fields each with different perspectives. For example, an engineer perceives water "loss" when it flows beyond its designated system boundary, whereas an environmentalist sees this as not a "loss", but instead a "source" to an aquifer or wetland or for evaporation (Perry *et al.*, 2017). The terminology utilized can also often be ambiguous. For example, "water use" is commonly said; however, understanding the distinction between water "use" and water "consumption" is essential to the management of the resource. Water productivity terms can also be misleading. For example, a common misperception is that water productivity interventions result in water "savings". Determining water "savings" is much more complex as it requires not only understanding the objective of the stakeholder, but also the broader hydrological and water accounting context (i.e. see irrigation paradox by Grafton *et al.*, 2018).

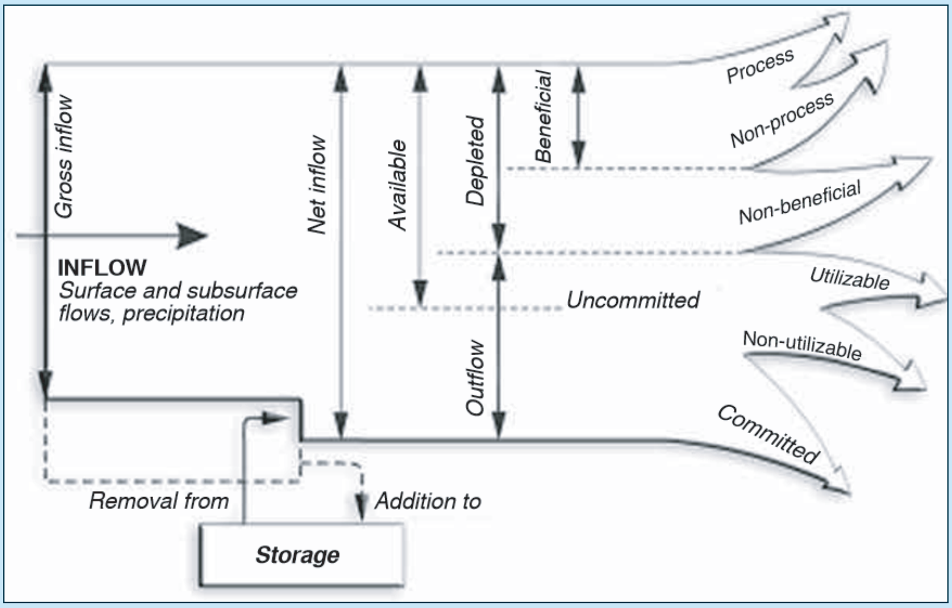
The aim of this paper is to review established water productivity terminology, outline commonly used water productivity interventions, and review the experience with water productivity interventions in the field to help answer if and how far these interventions can save us from global water scarcity. Finally, we summarize some lessons learned and provide preliminary policy recommendations.

KEY TERMINOLOGY

The inconsistencies, ambiguity and misconceptions around water productivity terminology can cause confusion and miscommunication among different academic fields and sectors. Water productivity terminology and associated terms are defined in Boxes 1, 2 and 3. Box 1 gives standard water accounting terminology. Box 2 defines terminology needed to better understand various productivity and efficiency terms. Box 3 defines water productivity and efficiency terms.

Box 1. Established water accounting terminology

Figure 1: Water accounting framework



Source: Giordano et al., 2017

- **Inflow into** the domain of interest is classified as gross inflow (i.e. the amount of water flowing into a sub-basin from precipitation and surface and subsurface sources) and net inflow (i.e. gross inflow plus any changes in storage).
- **Available water** is the net inflow less the amount of water set aside for committed outflows (such as for downstream water rights, environmental water requirements and non-utilizable outflows), and includes depleted water (i.e. water withdrawn that is unavailable for further use) and uncommitted utilizable outflows.
- **Depleted water** includes:
  - **Beneficial depletion**, such as (i) **process depletion** (i.e. for an intended process; for example, in agriculture, the water transpired by crops plus the amount incorporated into plant tissues); and (ii) **non-process depletion** (i.e. for a process other than the one for which the diversion was intended; for example, the water transpired by trees along an irrigation canal); and
  - **Non-beneficial depletion** (such as water flows to sinks).
- **Outflow** from the domain comprises:
  - **Uncommitted outflows**, both **utilizable** and **non-utilizable** (i.e. water that is not depleted and in excess of requirements or storage or operational capacity); and
  - **Committed outflows** for other purposes downstream (e.g. downstream water rights, minimum streamflows, offshore fisheries).

Source: Giordano et al., 2017.

Box 2. Water use distinctions referred to in efficiency and productivity terminology

Water withdrawal: This measure refers to the amount of water removed (or diverted) from a surface water or groundwater source.

Water application: Water applied (or delivered) differs from water withdrawn by the amount of water lost in transit from the point of withdrawal to the point of use. This delivery (or conveyance) loss usually stems from leakages (for example, from unlined earthen canals).

Water consumption: This measure (also called consumptive use, crop evapotranspiration, or depletion) refers to the amount of water that is actually depleted by the crops, i.e. transferred to the atmosphere through evaporation from plant and soil surfaces and through transpiration by plants, incorporated into plant products, or otherwise removed from the immediate water environment.

Source: Giordano et al., 2017.

Box 3. Productivity and efficiency terminology

Water productivity: The term refers to the ratio of the net benefits from crop, forestry, fishery, livestock and mixed agricultural systems to the amount of water used to produce those benefits. In its broadest sense, it reflects the objectives of producing more food, income, livelihood and ecological benefits at less social and environmental cost per unit of water consumed. The selection of the numerator and denominator depends on the scale and focus of the analysis.

- **Physical water productivity** [kg/m^3]: Ratio of agricultural output to the amount of water consumed – 'more crop per drop'.
- **Economic water productivity** [USD/m^3]: Value derived per unit of water used and this has also been used to relate water use in agriculture to nutrition, jobs, welfare and the environment.
- **Other types of water productivity:** Numerator or denominator term reflects water source (rainfed versus irrigated), i.e. total available water productivity, total consumed water productivity, applied irrigation water productivity and consumed irrigation water productivity; see Mekonnen *et al.*, 2019.

Irrigation efficiency: The term reflects the percentage of water efficiently used in irrigation. Ratio of water consumed relative to the volume of irrigation water applied.

- **Classical irrigation efficiency:** The term refers to the ratio of water consumed by crops relative to water applied or, in some instances, relative to water withdrawn from a source. The numerator sometimes takes into account effective precipitation, by deducting it from the water consumed. To assess losses in the conveyance and application of irrigation water, the terms conveyance efficiency (ratio of water received at the farm gate relative to the water withdrawn from the water source) and application efficiency (ratio of water stored in the root zone and ultimately consumed by crops relative to the water delivered to the farm gate), respectively, are used.

Sources:Israelsen, 1932, 1950; Keller and Keller, 1995; Burt et al., 1997; Cai et al., 2006; Jensen, 2007.

- **Water-use efficiency:** The term refers to the ratio of plant biomass (or yield) relative to the water consumed (or, in some instances, transpired). In the field of agronomy and plant physiology, it is typically expressed in kilograms per cubic meter (kg/m^3).

  Sources: Viets, 1962; Molden, 1997; Renault and Wallender, 2000; Howell, 2001; Hsiao et al., 2007; Perry et al., 2009.

- **Effective irrigation efficiency:** The term is defined as the ratio of water consumed, minus effective precipitation, relative to the effective use of water. Effective use of water is the difference between water inflow to an irrigation system and water outflow (with both flows discounted for the leaching requirements to hold soil salinity at an acceptable level). The term was developed to address some of the limitations of classical irrigation efficiency by taking into account the quantity of water delivered from, and returned to, a water supply system (as well as the leaching requirements).

  Sources: Keller and Keller, 1995; Keller et al., 1996; Cai et al., 2006; Jensen, 2007.

Source: Molden et al., 2010; Giordano et al., 2017; Mekonnen et al., 2019.

TERMINOLOGY MISCONCEPTIONS AND UNINTENDED CONSEQUENCES

Water productivity interventions and modernized irrigation technologies are branded for their water "saving" capabilities and improved irrigation "efficiencies." Though, interpreting these terms at face value can result in unintended consequences. The terms water "savings" and irrigation "efficiency" (IE) cannot be equated to similar terms used in reference to other resources. The term "efficiency" carries the "implication that the increase in efficiency actually saves some of the resource" (Perry, 2011). Unlike other resources, such fuel or power, water is never "lost" (Perry, 2011). Many case studies (see Table 2) reveal that water "savings" at the farmer-scale may not translate to water "savings" at the larger basin scale. In fact, "advanced irrigation technologies that increase IE may even increase on-farm water consumption, groundwater extractions, and water consumption per hectare" (Perry *et al.*, 2017; Pfeiffer and Lin, 2014) (Grafton *et al.*, 2018). This lack of water "savings" could be because, at the farm-scale, farmers switch to more water-intensive crops, expand production, or see "a strong marginal yield response from additional water" with the same crop (Grafton *et al.*, 2018); water becomes more valuable to the farmer and demand for it increases. This is known as the irrigation efficiency paradox. However, one could argue that water "savings" still occur. For instance, food produced at a farmer's increased irrigated scheme (enlarged through higher field irrigation efficiency) does not need to be produced elsewhere and, thus, water can be saved in a different basin.

COMMON WATER PRODUCTIVITY INTERVENTIONS

Table 1 lists common water productivity interventions. Water productivity interventions have different objectives, and not all directly address water scarcity.

Table 1
Common water productivity interventions

Type of Practice	Interventions
Breeding and biotechnology practices	▪ crop breeding for fast leaf expansion ▪ crop breeding for vigorous early growth for fast ground cover ▪ crop breeding for increased resistance to pests and diseases ▪ crop breeding for reduced susceptibility to drought
Precision application practices	▪ deficit Irrigation ▪ drip irrigation ▪ level basins ▪ pressured systems ▪ sprinkler irrigation ▪ supplemental irrigation ▪ surge irrigation
Production practices	▪ increasing yield ▪ lowering the costs of inputs ▪ changing from low to high value crops
Soil practices	▪ mulching ▪ plowing ▪ soil fertility maintenance ▪ soil-water conservation through zero or minimum tillage
Water delivery practices	▪ canal lining ▪ pipes ▪ shorter furrows
Water management practices	▪ alternating wet and dry irrigation ▪ small-scale affordable management practices for water storage, delivery and application ▪ water harvesting ▪ pricing ▪ water use restrictions ▪ reallocation from low to high value uses

Source: Perry et al., 2017, Molden et al., 2010, Molden et al., 2007.

SELECTED CASE STUDIES

Table 2
Case studies overview

Location	Main water productivity intervention	Summary and lesson learned	Source
Punjab province, Pakistan	Resource Conservation Technologies (such as zero tilled wheat and laser leveling)	*Intention:* Reduce water use. *Outcome:* At the field scale, water application was reduced, but over water use was not reduced. Overall, there was increased water demand and groundwater depletion because (1) water could no longer percolate to the groundwater table for reuse, and (2) medium and large-scale farmers expanded cropped areas.	Ahmad *et al.*, 2007
Rajasthan state, India	Drip irrigation	*Intention:* Conserve groundwater and increase resilience to climate change. *Outcome:* Instead of conserving groundwater, farmers intensified production. There were no regulations on groundwater use.	Birkenholtz, 2017
North China Plain, China	Pipeline conveyance systems, sprinkler irrigation, mulching	*Intention:* Reduce groundwater pumping *Outcome:* Groundwater pumping rates declined but so did the water table because of the now limited recharge to the shallow groundwater aquifer.	Kendy *et al.*, 2003
Morocco	Drip irrigation	*Intention:* Conserve groundwater, raise productivity, increase rural incomes. *Outcome:* Increased crop density, switched to more water intensive crops, expanded agricultural area resulting in higher water consumption.	Molle and Tanouti, 2017

Kansas, United States	Dropped-nozzle center pivot system	*Intention:* Reduce groundwater use *Outcome:* Shifted crop patterns and increased groundwater extraction.	Pfeiffer and Lin, 2014
Limarí Basin, Chile	High-ef ciency drip irrigation	*Intention:* 'Promote the development of high irrigation ef ciency and irrigation supply reliability" *Outcome:* Reduction of the basin's ability to withstand sustained drought due to the extension in irrigated land, especially the extension of permanent crops	Scott *et al.*, 2014
Imperial Valley, California	Irrigation efficiency improvements (such as sprinkler irrigation, automated monitoring and control systems), canal lining	*Intention:* Transfer 'saved" water to urban uses *Outcome:* Significant ecosystem impacts (i.e. increased salinity of the Salton Sea)	Scott *et al.*, 2014
Guadiana Basin, Spain	Low-volume irrigation techniques (pressurized irrigation systems, center pivots), improvement of storage facilities, lining and piping of old canals	*Intention:* 'To save water to alleviate the consequences of cyclical droughts and to free water resources for river flows and the natural habitats they provide in order to achieve the environmental objectives of the European Water Framework Directive" *Outcome:* 'Water savings obtained from increasing technical irrigation ef ciency have been re-used to expand the irrigated area, increase yields and evapotranspiration of existing crops, as well as to support a higher value and more diversi ed agricultural production, increasing overall consumptive use"	Scott *et al.*, 2014

Hai Basin, China	Mulching, zero tillage, deficit irrigation, revised cropping patterns, improved cultivars	*Intention:* Restore sustainable water consumption. *Outcome:* Projected results for winter wheat, maize and cotton indicate mulching would reduce over consumption at the basin scale.	Yan *et al.*, 2015

OBSERVATIONS AND COMMON IDEAS THROUGHOUT THE LITERATURE

Table 3
Water productivity interests at different scales

	Crop, plant, or animal	Field or pond	Farm or agricultural enterprise	Irrigation system	Basin and landscape
Processes	Energy conversion, nutrient uptake and use, photosynthesis, and the like	Soil, water, nutrient management	Balancing risks and rewards, managing farm inputs including water	Distribution of water to users, operation and maintenance, fees, drainage	Allocation across uses, regulation of pollution
Interests	Agricultural producers, breeders, plant and animal physiologists	Agricultural producers, soil, crop, fish, livestock scientists	Agricultural producers, agriculturalists, agriculture economists	Irrigation, engineers, social scientists, water managers	Economists, hydrologists, social scientists, engineers, water managers
Production terms (numerator)	Kilograms of produce	Kilograms of produce	Kilograms, $	Kilograms, $, value, ecosystem services	$, value, ecosystem services
Water terms (denominator)	Transpiration	Transpiration, evaporation, water application	Evapotranspiration, irrigation supply	Irrigation deliveries, depletion, available water	Deliveries, flows, depletion

Note: The $ sign represents marketable financial values, while the word *value* includes other intrinsic values such as the value of livelihood support, ecological benefits, and cultural significance.
Source: Molden et al., 2007.

The following points summarize observations and common ideas of the reviewed literature.

- Water productivity interventions have multiple objectives and different motivations for adoption. “Improving water productivity is not a goal in and of itself” (Giordano *et al.*, 2017). Is the water productivity intervention intended to increase agricultural production, reduce agricultural water use, increase farm-level income and/or alleviate poverty and inequity? Governments and policymakers must identify what they are trying to

achieve through water productivity interventions, while also recognizing its objective may not align with other stakeholders. Different stakeholders, such as agricultural producers, irrigation districts and water resource managers, each have their own aims for introducing certain water productivity interventions.

- The impact of a water productivity intervention needs to be evaluated at the crop, field, farmer and basin scales (Table 3) as well as regional scale. From the public resource management perspective, the basin implications need to be considered. This is where understanding the broader hydrological picture is crucial. Water accounting tools can provide quantitative estimates of the resources currently available in a basin and give insight into the impact of a water productivity intervention across scales. This can help policymakers better foresee risks, tradeoffs and/or unintended consequences. Water accounting makes "transparent 'who gets what and where'" (Grafton *et al.*, 2018). Water accounting can help understand where "saved" water really goes.
- The multidisciplinary and cross-sectoral nature of water productivity requires accepted, unambiguous terminology. Governments and policymakers must be clear in the terminology they use and understand the (mis)conceptions of commonly used terms, such as water "savings."
- To help make water productivity interventions successful, enabling conditions for farmers need to be created; farmers, donors and policy makers need to be made aware of potential unintended consequences; and interventions need to be implemented in a logical order. Perry *et al.* (2017) believe water accounting and water allocation limits must be done prior to promoting hi-tech irrigation.
- "There are rather few examples of carefully documented impacts of hi-tech irrigation, while there are many examples of projects and programmes that assume that water will be saved and productivity increased. Such studies as do exist, are either inconclusive or, more often, show that water consumption actually increased (as science would predict) when irrigation systems were upgraded, and that productivity per unit of water consumed was more or less constant" (Perry *et al.*, 2017).

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