ONLINE
CONFERENCE
IWRA 2021

ONE WATER, ONE HEALTH

WATER, FOOD AND PUBLIC HEALTH IN A CHANGING WORLD

JUNE 7TH-9TH, 2021

FINAL REPORT

BY THE INTERNATIONAL WATER RESOURCES ASSOCIATION (IWRA)

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IWRA 2021

ACKNOWLEDGEMENTS

The International Water Resources Association (IWRA) would like to thank FAO and UNESCO for their invaluable contribution to conduct this event in 2021. We also extend our highest appreciation to the invaluable contribution of rapporteurs (Denzel Keith Urieta; Francisca Olavarría; Ines Gasmi; Sandra Ricart; Syeda Saleha Fatim Ali; Karishma Asoodani; Marta Zaragoza Navarro; Daniel Koto Dagnon; Nupur Jain; Tami Koroye; Destiny Osayi Ogedegbe; and Collins Ogonnaya Arikor) as well as to the partners who made this Conference a success: the American University of Beirut (AUB), the China Water Resources Association (CWRA) and Texas A&M University.

This Report has been produced by the IWRA Executive Office (Ignacio Deregibus, Callum Clench, and Rut G. Sobrino), was copy-edited by Audrey Crosby, and was designed by Nathalie Lyon-Caen.

EXECUTIVE OFFICE

51 rue Salvador Allende
92027 Nanterre Cedex - France
office@iwra.org
www.iwra.org
www.iwraonlineconference.org

Food and Agriculture Organization of the United Nations

IWRA

United Nations Educational, Scientific and Cultural Organization

Intergovernmental Hydrological Programme

AUB

CWRA

MESSAGE FROM IWRA PRESIDENT, GABRIEL ECKSTEIN

I am delighted to present this report on the results of the International Water Resources Association's most recent Online Conference held from 7-9 June 2021 under the title "***One Water, One Health: Water, Food and Public Health in a Changing World***." This event was quite impressive and brought together an interdisciplinary group of experts from around the world. It addressed many of IWRA's core areas, including water use in agriculture and farming, manufacturing and trade, as well as the interlinkages between freshwater resources and public health challenges.

This year, our online conference welcomed **1400 registered** participants from over **110 countries**. The event involved **over 100 speakers** and panellists, as well as included **16 sessions** addressing topics such as water and agriculture, water quality in food production, the science-policy nexus in water resource management, the use of big data in the administration of freshwater resources, and much more. Experiences from countries like India, Iran, and Ethiopia, among others, enriched the debates and provided an added value to the presentations.

We are all very conscious that these achievements would not have been possible without the invaluable support of our sponsors and partners, who included the **UN's Food and Agriculture Organisation** (FAO), **the UNESCO Intergovernmental Hydrological Programme** (IHP), **the American University of Beirut** (AUB), **the China Water Resources Association** (CWRA) and **Texas A&M University**. Working with such diverse and high-level range of organizations, ranging from UN agencies to academic institutions, is a testament to the respect that IWRA has achieved within the international community. We are proud and honoured to be engaged with such esteemed partners and to have the opportunity to contribute to the SDG framework and Agenda 2030, and to overcoming the world's water challenges. We are extremely grateful for their support and for their contributions to this important knowledge-sharing event, and we look forward to continuing our collaborative relationship with them in the near future.

As IWRA's 50th Anniversary approaches, milestones like this conference are an inspiration to us all as we work to continue collaborating and cooperating to save the planet. Let us continue working together and make our contribution relevant! Discussions around the 2022 Online Conference will begin soon!

INTRODUCTION FROM THE CO-CHAIRS OF THE INTERNATIONAL SCIENTIFIC COMMITTEE (ISC)

During the preparations for the recent IWRA Online Conference 2021 on 'One Water, One Health: Water, Food, and Public Health in a Changing World', the word 'System' came into our discussions in a recurrent manner. Water is a catalyst for human security lifeline from food, hygiene, and human and ecosystem health; therefore, the current water challenges are complex and can only be addressed at this systematic level.

Current water management practices are based on **water allocations** made to various sectors of the economy. Agriculture sectors have the highest proportion of this allocation. As a result, this practice has created **competition** among various water stakeholders.

We face multiple challenges such as (i) projected diminishing fresh surface and subsurface water available to food production due to climate (10-30% precipitation in subtropical region), (ii) land use changes (urbanization and population growth and demographic shifts and projected 50% increase in food production) and (iii) malnutrition at rise in many parts of the world (40 % global water gap is projected).

With these challenges ahead, we need a **new business model** that governs a water-food-health relationship. The **new model** should be based on **values** of water, land, energy, and human and ecosystem health. We also should work to **reduce interdependencies** and increased resilience between water and food.

To do so requires **multiple interlinkages and talents** from science, engineering, social sciences, policies, behaviour changes, and technologies. It requires transformation of how we **produce and consume**, keeping **circularity** in mind, and it calls for **alternative** safe and cost-efficient **water sources** including, green and wastewater.



Sasha Koo-Oshima, Deputy Director & Head of Water, Food and Agriculture Organization (FAO) of the United Nations.
Yuanyuan Li, IWRA Vice-President; Professor, General Institute of Water Resources and Hydropower Planning and Design at the Ministry of Water Resources of China.
Rabi Mohtar, Dean of the Faculty of Agricultural and Life Sciences American University of Beirut; Professor of Environmental Resources Engineering Texas A&M University; Chair of the IWRA Awards Committee.

With the goal of advancing on these fronts, the IWRA Online Conference 2021 tried to address the following key questions:

1. How to produce more for less?
2. How do you create synergy among these sectors?
3. How do you promote circularity in these systems?
4. How do we transform the Food system to integrate nutritional value of food, values of water input and air, soil, water pollution into the food production business model?
5. How do we increase the resilience of the food system to future pandemics?
6. What platforms are missing to foster multi-disciplinarity in the Water-Food-Health system?

This Report intends to summarize the debates and conclusions held around these questions and the underlined challenges.

ONLINE CONFERENCE IWRA 2021

IWRA's 2021 Online Conference on "*One Water, One Health: Water, Food, and Public Health in a Changing World*" was conducted in collaboration with the UN's Food and Agriculture Organisation (FAO) and UNESCO Intergovernmental Hydrological Programme (IHP) between June 7th and June 9th, 2021. The event addressed **five different sub-theme challenges** and aimed to promote the sharing and exchange of latest scientific and policy knowledge on the links between Water, Food, and Public health for the sustainable governance, use, and management of these resources globally.

With the support of FAO, all registered attendees, coming from all geographic regions, including low-income countries, were granted **free access** to the conference.

The contribution of UNESCO focused on themes, debates, and results, addressing the question: "*How can science better inform public policy, governance and capacity building for water, food and health?*" (Theme 5). This theme also helped to further on the implementation of UNESCO's Phase Eight of the Intergovernmental Hydrological Programme (2014-2021).

> LINK TO THE RECORDINGS
iwraonlineconference.org/recordings-2021

1400 REGISTERED PARTICIPANTS

OVER 110 COUNTRIES FROM AFRICA, ASIA, EUROPE AND THE AMERICAS

MORE THAN **100 SPEAKERS** AND MODERATORS

16 SESSIONS HELD OVER 2 AND HALF DAYS:

11 REGULAR SESSIONS INCLUDING:
2 PLENARY SESSIONS
2 FAO SPECIAL SESSIONS
1 HIGH-LEVEL PANEL

A HIGHLY DIVERSE LIST OF SPONSORS AND SUPPORTERS, INCLUDING:

UN'S FOOD AND AGRICULTURE ORGANISATION (FAO)

UNESCO INTERGOVERNMENTAL HYDROLOGICAL PROGRAMME (IHP)

AMERICAN UNIVERSITY OF BEIRUT (AUB)

CHINA WATER RESOURCES ASSOCIATION (CWRA)

TEXAS A&M UNIVERSITY

INTERNATIONAL SCIENTIFIC COMMITTEE

Name	Affiliation	Country
Sasha Koo-Oshima Co-Chair	Deputy Director and Head of Water, Food, and Agriculture Organization of the United Nations	USA / Italy
Yuanyuan Li Co-Chair	Professor, General Institute of Water Resources and Hydro-power Planning and Design at the Ministry of Water Re-sources of China	People's Republic of China
Rabi Mohtar Co-Chair	Dean of the Faculty of Agricultural and Life Sciences Ameri-can University of Beirut; Professor of Environmental Re-sources Engineering Texas A&M University	Lebanon / USA
Alice Aureli	Chief of the Groundwater Systems and Settlements Section, UNESCO's Intergovernmental Hydrological Programme and Programme Coordinator, ISARM	Italy / France
Tala Awada	Associate Dean in the Agricultural Research Division Professor of Plant Ecophysiology in the School of Natural Resources, University of Nebraska-Lincoln	Lebanon
Barry Boubacar	Chair of GWP-WA Technical Committee	Senegal
Henning Bjornlund	Research Professor, Water Policy and Management, Univer-sity of South Australia and Chair, Science, Technology and Publication IWRA Committee.	Australia
Bassel Daher	Texas A&M	USA / Lebanon
Xiaokai Li	WBG	China
Iman Nuwayhid	Professor of Public Health and Occupational and Envi-ronmental Health at the Faculty of Health Sciences at the American University of Beirut	Lebanon
Pedi Obani	Assistant Professor in the School of Law, University of Bradford	Nigeria
Rabindra Osti	Asian Development Bank (ADB)	India
Mark Smith	Director General of the International Water Management Institute (IWMI)	Sri Lanka
Jennifer Sara	Global Director, Water Global Practice, World Bank	USA
Raya Stephan	International Water Consultant	France / Palestine
David Tickner	Chief Freshwater Adviser at WWF - UK	UK
Lesha Witmer	Steering Committee (advocacy lead) of Women for Water Partnership	The Netherlands
Lili Yu	Professor Level Senior Engineer, GIWP, Ministry of Water Resources (MWR), China	People's Republic of China

THE ROAD TO THE IWRA ONLINE CONFERENCE

In 2019, the International Water Resources Association (IWRA) decided to hold its first ever fully online conference on water. The intention was to facilitate the international sharing and the presentation of the latest research to people who are often unable to travel to international conferences due to the cost, travel restrictions, or other ethical or personal reasons. Following this decision, the first IWRA Online Conference was scheduled for 2020. What IWRA could not have expected was that the Covid-19 pandemic would impose travel restrictions and the cancellation of most live events in 2020. Despite these dramatic circumstances, however, the first IWRA Online Conference was well placed to meet and attracted an even wider audience than we could have hoped for. The model proved to be so successful that it was decided to make it an annual fixture in the IWRA calendar.

The theme of IWRA's 2021 Online Conference was "One Water, One Health: Water, Food, and Public Health in a Changing World". In it, new partners came together to leverage knowledge, namely the UN Food and Agricultural Organization (FAO) and UNESCO-IHP; the American University of Beirut (AUB); the China Water Resources Association (CWRA); and Texas A&M.

As the global debate focused on the interlinkages between public health and the COVID-19 pandemic, and the impact on farming, production, and shipping, the Online Conference aimed at emphasizing the fragility of water resources, as a critical factor in agriculture, food processing, nutrition, and broader human health issues. The Online Conference was designed to respond to these nexuses which are especially critical under the current circumstances of the global pandemic, accelerated climate change, population growth, and increasing urbanization.

On behalf of the IWRA Executive Board and Office we would like to thank our partners, attendees, and participants but also the IWRA Board members for the dedicated efforts. Together with these, our sincere appreciation goes to the International Scientific Committee (ISC) co-chairs, the ISC theme leaders and members, rapporteurs, moderators, panelists, poster authors, and Zoom's Customer Support Team. The efforts and support from IWRA Membership and External and Public Relations Committees should be also recognized in these lines.

> LINK TO THE RECORDINGS
iwraonlineconference.org/recordings-2021

THEMATIC FRAMEWORK AND TOPICS ADDRESSED

IWRA's 2nd Online Conference was held from June 7th to June 9th, 2021 on the theme, "*One Water, One Health: Water, Food, and Public Health in a Changing World.*" This theme aligns with the preparations of the "Road to Dakar" for the 9th World Water Forum to be held in Senegal in March 2022.

With the COVID-19 pandemic, the whole world has put renewed focus on public health. COVID-19 has disrupted farming, production, and shipping, as well as highlighted the fragilities of the interconnected systems we depend upon. Water is a critical factor in both agriculture and food processing, as well as in nutrition and broader human health issues. This complex nexus of sectors is often treated in silos, from both science and policy perspectives. The main goal of the IWRA 2021 Online Conference was to examine the inter-linkages between water, food, and public health which are now more critical than ever as the world changes in response to the stressors of pandemics, climate change, population growth, and urbanization.

Five sub-themes were identified by the ISC to explore the connections between water, food, and public health. These sub-themes were drafted in the form of questions to be addressed by conference presenters and were all connected to different Sustainable Development Goals. These sub-themes are summarised below:

THEME 1 - HOW CAN WE BETTER MANAGE WATER FOR FOOD AND PUBLIC HEALTH IN A CHANGING WORLD?

Water resources are critical to produce food. Additionally, access to safe and clean water is important for public health as it is essential for drinking and for personal hygiene. Under the current momentum where we face crises of multiple nature, the availability of water resources is under threat. This is due to drought periods and less rain as a result of climate change. Parallel to these, are the enhanced intensity and frequency of extreme events which have a strong impact on water quality, access, and food production. These phenomena have also had an impact on human security as populations tend to migrate upon water scarcity and related challenges. Theme 1 addressed these global changes with the concern of overcoming their impacts on water, food, and health, either by prediction or other management solutions. Panellists gave due consideration to the new realities of urbanization, conflict and political crises, groundwater, and ecosystems.

Issues to be discussed:

1.1 How do we identify and overcome climate change and other challenges on water, food, and health?

1.2 How is groundwater for food and public health affected by global changes?

1.3 How do we predict and measure the impact of water-related extreme weather events on food and public health?

1.4 How do we factor in urbanisation and demographic changes into integrated water food and public health management?

1.5 What are the impacts and possible water solutions for food and health in regions suffering conflict and political crises?

1.6 How do we find synergies and reconcile trade-offs between water for food and health and other services provided by surface and groundwater ecosystems?

THEME 2 – HOW CAN MANAGING WATER IN AGRICULTURE CONTRIBUTE TO FOOD SECURITY AND PUBLIC HEALTH?

The synergies between food security and public health are complex, and agricultural water management plays a critical role at the interface between them. Addressing these elements in isolation will not achieve the desired outcomes for food, health, or water management. This subtheme will focus on the complexities at work at the interface of agricultural water management, food security, and public health.

Key questions related to trade-offs include:

i) Should farmers give priority in water management to raising productivity or to increase their ability to buy nutritious food through higher profitability to secure access to nutritious foods?

ii) Should policy focus be on increasing yield or increasing beneficial output from farming, by enhancing access to markets or reducing post-harvest losses due to poor storage?

iii) How can data and knowledge on soil moisture and nutrient dynamics be applied to reducing water use and fertilizer losses, and therefore trade-offs in farm water management with the quantity and quality of water to meet needs for drinking water and hygiene in rural communities?

iv) What are innovations that strengthen the integration of irrigation, inland fisheries, aquaculture, and livestock production for more profitable outcomes and improved diets and health?

v) How can the resilience of food security and public health be strengthened in rural communities through the management of water infrastructure and ecosystem services?

vi) How can farmers integrate water management into the wider food system to strengthen rural economies, improve drinking water services, integrate more nutritious crops for better health outcomes, and create small-business opportunities and jobs?

Issues to be discussed:

2.1 How can we increase yields and reduce post-harvest losses to secure access to nutritious food?

2.2 What can farmers do to increase productivity/ profitability to secure their access to nutritious food – interdependencies with resilience, ecosystems, and infrastructure?

2.3 How can better understanding of soil moisture and nutrient dynamics reduce water use and fertilizer losses?

2.4 How can farmers integrate into a wider food system as part of rural economies: value adding, job creation, and better diets?

2.5 How can integrating dryland, irrigation, inland fisheries, aquaculture, and livestock production provide more profitable outcomes, and improve diets and health?

THEME 3 - WHAT OPPORTUNITIES LIE IN THE IMPROVED COOPERATION BETWEEN WATER, FOOD, AND PUBLIC HEALTH SECTORS?

Water, food, and public health systems are complex and tightly interconnected. Water is essential for food production; agricultural practices have direct impacts on water demand and water quality. Ensuring access to sufficient clean water and safe, affordable, and nutritious food have direct impacts on public health. Addressing the challenges that face these interconnected and complex systems will require the development of a suite of interdisciplinary technical, policy, and behavioural levers which might result in different trade-offs for each of the sectors. Better understanding of these trade-offs and quantifying them through the development of the necessary analytics and assessment tools contributes to an informed evidence-based dialogue between the cross-sectoral stakeholders. Our readiness for rapid and coordinated responses will depend on our success in creating an environment of cross-sectoral cooperation while innovating at the interface of multi-disciplinary research expertise. Multiple barriers for cross-sectoral cooperation currently exist; these include differences in planning horizons and language, lack of coordinating platforms and financing mechanisms, differences in governance models–among others. This session will focus on highlighting key opportunities for overcoming these barriers and implementing innovative levers for improved evidence-based decision-making and cooperation between the three sectors. We welcome contributions from low-income and middle-income countries and from countries experiencing conflicts and other humanitarian crises.

Issues to be discussed:

3.1 What are lessons learned from implementing solutions that improve public health outcomes through enhancing access to nutritious food and safe drinking water and sanitation?

3.2 What technological, social, and institutional barriers exist to ensuring access to nutritious food and safe drinking water and sanitation, and what are examples of innovative ways to address these?

3.3 What public health policy responses are required to address non-point source pollution from agricultural production?

3.4 What role can public health play in catalysing a transition toward circular food and water value chains?

3.5 What are examples of opportunities for improving the resilience of societies facing compound shocks (pandemics, climate change, migration) through the lens of interconnected water, food, and public health systems?

THEME 4 - WHAT ARE THE SYNERGIES OR TRADE-OFFS BETWEEN ECOSYSTEM HEALTH AND HUMAN HEALTH?

Conventionally, management of water bodies and resources have often focused on the use of built infrastructure to maximise a narrow range of benefits to society, such as water supply for agricultural, urban or industrial use, generation of hydropower, or flood risk reduction. While this approach has brought successes, it has also contributed to widespread deterioration in the health of freshwater ecosystems and a global collapse of freshwater biodiversity. These adverse impacts have, in turn, had consequences for people who rely on ecosystem services such as freshwater fisheries, sediment replenishment to low-lying delta regions, or cultural values of water bodies.

As calls grow stronger for action to address the global climate and nature crises, this sub-theme will focus on how decision-makers can find greater synergy–or at least a more balanced approach to managing trade-offs–between ecosystem health and human development objectives. In particular, the sub-theme will address three questions:

i) How do we identify and capitalise on synergies between maintaining or restoring freshwater ecosystem health and providing water, food, and health benefits for people?

ii) What role do markets and regulation play in capitalising on synergies and reconciling trade-offs between water for ecosystems, food, and public health?

iii) How can we protect and restore aquatic ecosystems urgently and at scale for both biodiversity and human welfare?

Issues to be discussed:

4.1 How do we identify and capitalise on synergies between maintaining or restoring freshwater ecosystem health and providing water, food, and health benefits for people?

4.2 What role do markets and regulation play in capitalising on synergies, and reconciling trade-offs, between water for ecosystems, food and public health?

4.3 How can we protect and restore aquatic ecosystems urgently and at scale for both biodiversity and human welfare?

THEME 5 - HOW CAN SCIENCE BETTER INFORM PUBLIC POLICY, GOVERNANCE AND CAPACITY BUILDING FOR WATER, FOOD, AND HEALTH?

Our academic system has two basic features: it focusses research on "niche" topics and "talks" to fellow academics in the same discipline. Which of course is important and useful. However, we always talk about getting out of the water box and then, we turn around and address our fellow experts. But how do we then go from research to applied science to make it useful for policymakers? How do we make research multi-disciplinary and multi-topic? How do we go from single purpose to MUS (multiple use)? Look at nexus-issues (water-food-nutrition-health)? How do we ensure multiple voices heard, incorporate citizens science? What would be the biggest challenges for the educational system to get the knowledge to the ground? But also, who teaches the teacher? How do we make people aware of what is out there in terms of rights and obligations, laws and regulations, as well as assist people in actually using that information? This subtheme will look into these issues, addressing the questions below.

Issues to be discussed:

5.1 How can we innovate capacity building and education for managing water for food and health?

5.2 What new, direct legal mechanisms are emerging that can promote more integrated water resource management, as well as overcome regulatory barriers to integrate the management of water for food and health?

5.3 What indirect legal approaches are there to water governance, including trade and investment law, which affect access to and allocation of water resources?

5.4 How can we ensure allocation, nutrition, tenure rights, and more are available and accessible to vulnerable individuals and groups, as well as indigenous communities in developed and developing countries.

5.5 How can we look at water and food in more inclusive ways, including access, nutritional value, economic and productive uses, health, and overall footprint.

5.6 How can we better integrate WASH and irrigation from financing to implementation through multiple use systems?

> LINK TO THE RECORDINGS

iwraonlineconference.org/recordings-2021

SESSION SUMMARIES

There were a total of 16 sessions over three days in the following programme:

Day 1 Monday, June 7th, 2021	Day 2 Tuesday, June 8th, 2021	Day 3 Wednesday, June 9th, 2021
13:15-14:45 **Opening Ceremony**	**08:00-09:30** **Abstract Session 3** "*How can science better inform public policy, governance, and capacity building for water, food and health?*" (Part 1)	**08:00-09:30** **Abstract Session 8** "*How can we better manage water for food and public health in a changing world?*" (Part 3)
15:00-16:30 **FAO Special Session 1** "*Bugs and superbugs: water quality, food safety, and preventing environmental antimicrobial resistance (AMR).*"	**09:45-11:15** **Abstract Session 4** "*How can managing water in agriculture contribute to food security and public health?*" (Part 2)	**09:45-11:15** **Abstract Session 9** "*What opportunities lie in the improved cooperation between water, food, and public health sectors?*" (Part 2)
16:45-18:15 **Abstract Session 1** "*How can we better manage water for food and public health in a changing world?*" (Part 1)	**11:30-13:00** **Abstract Session 5** "*How can we better manage water for food and public health in a changing world?*" (Part 2)	**11:30-13:00** **Abstract Session 10** "*What are the synergies or trade-offs between ecosystem health and human health?*" (Part 2)
18:30-20:00 **Abstract Session 2** "*How can managing water in agriculture contribute to food security and public health?*" (Part 1)	**15:00-16:30** **High Level Panel** "*Water, Food and Public Health in a Changing World*"	**15:00-16:30** **FAO Special Session 2** "*Applying water tenure approaches to achieve the SDGs*"
	16:45-18:15 **Abstract Session 6** "*What opportunities lie in the improved cooperation between water, food, and public health sectors?*" (Part 1)	**16:45-18:15** **Abstract Session 11** "*How can science better inform public policy, governance, and capacity building for water, food and health?*" (Part 2)
	18:30-19:45 **Abstract Session 7** "*What are the synergies or trade-offs between ecosystem health and human health?*" (Part 1)	**18:30-20:00** **Closing Ceremony**

OPENING CEREMONY

Moderator

Renée Martin-Nagle, IWRA Treasurer; CEO, A Ripple Effect, Special Counsel, Eckert Seamans; and Visiting Scholar at the Environmental Law Institute

Co-Moderator

Mary Trudeau, Project Officer, IWRA

Welcome messages

Gabriel Eckstein, IWRA President; Professor of Law, Texas A&M University; and Director, Law School's Program, Natural Resources Systems

Daniel Gustafson, Former Deputy Director General, Special Advisor to the Director General FAO

Setting the Scene by the Co-Chairs of the Online Conference International Scientific Committee

Sasha Koo-Oshima, Deputy Director and Head of Water, Food, and Agriculture Organization (FAO), United Nations

Yuanyuan Li, Vice-President, IWRA
Professor General, Institute of Water Resources and Hydropower Planning and Design, Ministry of Water Resources, China

Rabi Mohtar, Dean, Faculty of Agricultural and Life Sciences, American University of Beirut and Professor of Environmental Resources Engineering, Texas A&M

Keynote Speaker

James (Jim) W. Jones, Distinguished Professor Emeritus, University of Florida

"*Understanding and Guiding Complex Systems to Achieve Multiple Societal Goals*"

Opening Remarks

Aziza Akhmouch, Head of Division – Cities, Urban Policies and Sustainable Development OECD

Loïc Fauchon, President, World Water Council

Key messages

- **Water is interconnected with everything, and especially with food and public health; however, there is a 40% water gap that needs to be filled.**
- **Our goal is to secure water resources everywhere for everyone.**
- **This conference looks at related to the interconnectedness of water, food, and health systems, as framed by the SDGs and under the influence of global changes, such as climate change, population growth, and urbanisation.**
- **We need scientists, academics, policy makers, and business sectors to come together in coordinating their efforts.**
- **Societal goals imply the need for use of systems approach, considering complex systems concepts.**
- **Convergent systems approaches are needed to adequately understand and guide them to achieve multiple goals.**

Session Summary

The purpose of this session was to launch the online conference and introduce the topic and sub-themes of the online conference. It included welcoming messages from the President of IWRA and the Former Deputy Director General, Special Advisor to the Director General of the FAO. The more detailed background was provided by the co-chairs of the International Scientific Committee (ISC) to the conference on the areas of water, food, and public health. The support of the American University of Beirut (AUB), the China Water Resources Association (CWRA), and Texas A&M University was also acknowledged.

This Online Congress was held in the year of IWRA's 50th Anniversary and marks a historic moment for IWRA. It demonstrates how much things have changed since the Association was inaugurated half a century ago where the main way of sharing knowledge was at face-to-face events or through paper journals. Now, we are able to leverage the internet and online platforms to reach more people than ever before.

It was discussed that there is the need for a transdisciplinary approach to better manage the complex systems that are interrelated through water resources. The concept of 'One Health' also has taken on more meaning in the context of COVID-19. This can help us move to more sustainable pathways. Water cuts across all the SDGs.

The FAO strategy was also described. One-fifth of the world population live in areas of water scarcity. Reducing food waste also reduces water waste. Food waste is up to 50% in some developed countries. Water related diseases exacerbate issues of nutrient and nutrition deficiency in other regions. To address these issues, water, land, agriculture, and food production policies need to be aligned to increase water security. In addition, wastewater also needs to be integrated into these policies. Circular economies must be part of the solution.

FAO SPECIAL SESSION 1
BUGS AND SUPERBUGS: WATER QUALITY, FOOD SAFETY, AND PREVENTING ENVIRONMENTAL ANTIMICROBIAL RESISTANCE (AMR)

Moderator
Omar Elhassan, Environmental AMR and Water Management Expert, Land and Water Division, Food and Agriculture Organization of the United Nations (FAO)

Co-Moderator
Mary Trudeau, Project Officer, IWRA

Introduction & welcome remarks:
Sasha Koo-Oshima, Deputy Director and Head of Water Food, FAO

Keynote Speaker
Steve Musser, Deputy Director, U.S. Food and Drug Administration (USFDA)
"*The environmental surveillance of agricultural water using WGS and its impact on food safety*"
Jaap Wagenaar, Professor, Utrecht University; Director, WHO-Collaborating Center for Campylobacter and Antimicrobial Resistance from a One Health Perspective; Director, OIE-Reference Laboratory for Campylobacteriosis
"*Experiences and lessons learned from food safety and AMR monitoring and surveillance projects in Indonesia*"
Kang Zhou, Food Safety and Quality Officer, FAO – Joint FAO/WHO Expert Meetings on Microbiological Risk Assessment (JEMRA)
"*Microbiological Hazards and Safety and Quality of Water Used in Food Production*"

Panel Discussion on "*Food safety and AMR and experiences and lessons learned*"

Panellists
Eric Stevens, – Moderator - International Policy Analyst, Office of the Center Director, Center for Food Safety and Applied Nutrition, USFDA
Carmen Bullon, Legal Officer, Legal Division, FAO
Sarah Cahill, Codex Alimentarius, Senior Food Standards Officer, FAO
Kate Medlicott, Team Lead, Sanitation and Wastewater, World Health Organization (WHO)
Pernille Nilsson, SEQAFRICA Project Manager, Technical University of Denmark

Closing remarks
Eric Stevens, International Policy Analyst, Office of the Center Director, Center for Food Safety and Applied Nutrition, USFDA

Key messages
- **The use of next-generation sequencing (NGS) approaches in agricultural water, combined with genomics, is being proven to be important catalysts for better water resources quality standards tracking.**
- **The next steps for genomics-based water surveillance should be to ensure open access by optimizing methods, evaluating technologies, and promoting collaboration among administration, academics, and the agricultural sector.**
- **The solution shall be legal, managerial, scientific, and inclusive-driven to ensure sustainability, coordination, knowledge and data exchange, as well as civil society involvement.**
- **'One Health Agenda' and the Tricycle Program will provide a holistic view of common problems that should be adopted by anyone wishing to solve them.**
- **Quality, cross-country, and easily accessible data collection should be key.**

Session Summary

Agricultural water is undoubtedly an essential element for ensuring human, animal, and environmental health. Water is central through the entire alimentary chain; it is present in all food chain stages and all consumer products. Thus, water quality (potable or clean water) should always be considered in managing a healthy food international trade. So far, innovative pilot programs advocating for the use of next-generation sequencing (NGS) approaches in agricultural water, combined with genomics, are being proven to be important catalysts for better water source tracking and the development of preventive controls (instead of post-problem adaptive measures). This to ensure environmental surveillance and food safety. Despite past costs having been a deterrent for the use of genome sequencing, its effective use can be key for experts from across the globe to better understand, compare, and analyse, collaboratively, water, public health, food safety, and environmental linkages (only if complete and open access to Whole Genome Sequencing, WGS, data is ensured).

The next steps for genomics-based water surveillance should be to ensure its open access nature, among others, by:

1) optimizing and standardizing methods for sampling pathogens (parasites, bacteria, viruses) in surface water to allow for cross-country comparisons;
2) evaluating new NGS approaches and metagenomics technologies, providing a publicly accessible platform for sharing data (free and developing data but also software data); and
3) working toward the implementation of a model, efficiently enabling government officials, academic organizations, and the agriculture community to work collaboratively on agricultural water by building the necessary collaborations on pathogen monitoring in surface water.

To work towards this objective, several symposiums, forums, and meetings have been programmed to take place in the upcoming months. Similarly, collaborators to support FAO's efforts in this direction are looked for.

To address the issue of limited water in the current economic environment aiming to boost agricultural production, the solution shall be legal, managerial, scientific, and inclusive-driven:

- Legal resources should be used as a tool to help ensure sustainability, enabling every implicated actor to know their respective roles, rights, and responsibilities when it comes to water use and protection1.
- Institutional coordination of water management (monitoring, implementing, and evaluating) should be reached, and mandates should be clarified to allow the practical implementation of scientific ideas in the field, acting as an 'add-on' to the adoption of high normative standards.
- The importance of science (mainly in terms of new technologies and new sources of data and information) as a tool to help changemakers understand where problems are coming from and how to better address them should be clearly recognized.
- To create the much-needed behavioural change key for changing the done, getting data to the people, and showing them the role, they have in the observed results should be key.
- Civil society should be included in the negotiating table, with the voice and rights of minorities being given special attention.

Indeed, a holistic view of common problems should be adopted by anyone wishing to solve them; 'one health agenda' should be adopted, taking special care in understanding how it impacts programmatic agendas. The Tricycle Program project developed in collaboration with the World Health Organization (WHO) at Utrecht University, in the Netherlands, on the creation of a model for integrated surveillance on Antimicrobial resistance (AMR), offering basic surveillance on E.Coli impact on the human, the food chain and the environment, is one of the many examples showing the importance of the adoption of a 'one-health perspective' where the different sectors involved (mainly public health, agriculture and the environment, but not only) are considered.

Moreover, homogenized and widely made available data collection is crucial for the efficient development of preventive analysis and solutions. In the running of an international 'one-health agenda', quality, cross-country, and easily accessible data collection should be key. The first results obtained in the Tricycle Program clearly show this, as result comparisons made available due to a homogenized data collection among countries shed light on clear differences in upstream and downstream antimicrobial resistance concentrations.

ABSTRACT SESSION 1
"HOW CAN WE BETTER MANAGE WATER FOR FOOD AND PUBLIC HEALTH IN A CHANGING WORLD?" (PART 1)

Moderator
Raya Marina Stephan, International Water Consultant, Deputy Editor-in-Chief Water International & Executive Board, IWRA

Co-Moderator
Asma Bachikh, Executive Board, IWRA & Consultant, World Bank Group

Keynote Speaker
Josiane Nikiema, Research Group Leader – Circular Economy and Water Pollution, IWMI
"*How can we better manage water for food and public health in a changing world?*"

Panellists
Kenneth Strzepek, Professor, Massachusetts Institute of Technology
"*Presentation on Climate Change Implications to Food Security in High Food Importing Countries: Food Import Vulnerability in the Gulf Cooperation Council and Some Global Insights*"
Shehla Chowdhury, Research Associate, Environmental Law Institute
"*Conflict-Sensitive Programming for Water Management: Lessons from the Global Environment Facility*"
Gretchen Miller, Associate Professor Civil & Environmental Engineering, Texas A&M University
"*Quantifying Embedded Water in Agricultural Goods for Sustainable Groundwater Use in Mexico*"
Jingbo Liu, Professor, Texas A&M University-Kingsville and Texas A&M Energy Institute
"*Use of Natural Products as Green Reducing Agents to Produce Effective Nano-Disinfectants for Wastewater Remediation*"
Karen G. Villholth, Principal Researcher, IWMI, International Water Management Institute – Southern Africa Office
"*One Water – One Health – One Earth: The Triple-O concept for a sustainable Anthropocene*"

Key messages
- **There are multi-dimensional links between poverty, education, environment, public health, and food security. There exists interdependencies, trade-offs, synergies, and interactions between these sectors to fully understand the behaviour of the system. Integrated assessment is of paramount importance.**
- **Inclusion of a water component within food security analysis and assessment is essential, especially in Asian and African countries with lower data availability and a higher percentage of drylands, causing food security challenges.**
- **Science and policy interlinking to develop robust ground water policies in different states of India are missing.**
- **Stakeholder inclusion from designing and planning the transfer of workflow in water infrastructures is crucial for both short-term and long-term sustainability.**
- **There is a correlation between human health risks and pesticides usage in agriculture and groundwater.**

Session Summary

A water-secure world needs cross-cutting teams and research, governance and equality approaches, and economic incentives to address changes and disruptions. Circular economy is the best way in which the water-food-public health nexus can be managed more accurately to address sustainability and water security.

Most of the efforts have been focused on wastewater resources to guarantee water availability and reduce the dependency of freshwater and groundwater resources. The question is how to develop sustainable solutions to wastewater management, which technologies and processes for consumption and use, and through which models can water scarcity be addressed in an integrative way?

Consequently, some actions have been focused on urban/peri-urban areas in which water reuse can increase water availability for agricultural and industry water demands. For example, by increasing the incentives to farmers to ensure safely irrigation practices, hygienic handling practices, or safe food washing and preparation; by subsidizing tertiary treatment water reuse to farmers to enhance water quality standards (increasing the use of nano-disinfectants); or by nutrients recovering from wastewater to support aquaculture and irrigation in areas in which surface and groundwater resources are limited or polluted. However, the benefits of using wastewater must achieve to revert some relevant challenges, such as cost recovery, social behaviour, technical constraints, or policy and capacities. Among those, cost recovery is one of the main issues to discuss because its meaning differs in north and south regions, so models adapted to each context must be developed and applied to ensure farmers and other actors are confident with wastewater use. Likewise, issues such as gender, diversity, and inclusion, combined with cross-sectoral linkages (public-private sector, civil society, and research) could improve the acceptance of wastewater use, especially considering that about 65% of the global cropping irrigation areas are located in catchments highly dependent of wastewater access and availability.

Climate change will increase pressure on water availability in crops production. Likewise, and according to the Global Trade Analysis Project (GTAP), global change will lead to major increase in food trade by 2050. Current food security pictures show how 75-80% of food is imported. The “Import Vulnerability Index” aims to analyse what happens in those countries from which food is imported from countries with high water scarcity risk, such as most of the Golf Cooperation Countries (GCC), which are among the more food-insecure per the Global Food Security Index when considering the availability, quality, and safety of food supply.

The Global Environment Facility (GEF) was formed in 1992, and supports more than 5,000 projects in 170 countries. The GEF works in six focal areas, among which international water projects is the largest funding mechanism for multi-country collaboration. The majority of these projects are developed in conflict-affected or fragile environments where the solution is to promote transboundary cooperation in shared marine and freshwater ecosystems. In these contexts, social conflicts, economic drivers, and political and weakness governance are key factors to achieve better and more secure water management. Consequently, Risk Management Strategies are developed as proactive actions to deepen historical tensions, identify mutual interests, and be present and open to adaptation. In addition, projects in fragile and conflict-affected regions should be approached differently than non-conflict-affected regions.

A key issue when addressing water-food nexus is the fraction of surface and groundwater used for agriculture and where the crops are located. The ratio between surface and groundwater is used to explain risks for food. This asks for quantification of water embedded in agricultural food production by distinguishing between green water (site-specific precipitation that does not run off but more or less temporarily contributes to soil water storage and is eventually consumed by ecosystems through evapotranspiration) and blue water (surface and groundwater that is stored in rivers, lakes, aquifers, and dams, and can be extracted for water demands).

Finally, the triple-O concept (one water, one earth, one health) considers that interactions are crucial to reduce water intensive food products, even when they are not healthy at nutritional level. To achieve this, studies on food consumption patterns in developed and developing countries are needed to clarify this issue, especially for addressing SDG2 (Zero hunger) and SDG3 (Ensure healthy lives and promote well-being for all ages).

ABSTRACT SESSION 2
"HOW CAN MANAGING WATER IN AGRICULTURE CONTRIBUTE TO FOOD SECURITY AND PUBLIC HEALTH?"
(PART 1)

Moderator
Tala Awada, Associate Dean, Agricultural Research Division; Professor, Plant Ecophysiology, University of Nebraska-Lincoln

Co-Moderator
Mark Smith, Director General, International Water Management Institute (IWMI)

Keynote Speaker
Andre F Van Rooyen, Acting Country Representative – Ethiopia; Innovation systems for the Drylands International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Panellists
Fernando Riaza, Universidad Politéncia de Madrid
"*Water as an explanatory factor for food security in drylands: development of a composite index*"
Gayathri Naik, Ph.D. Candidate, SOAS University of London
"*Water Energy Food Nexus and Energy in Irrigation in India: Externalities and its impacts on Food Security, Water Security and Public Health*"
Riccardo Torri, EG-Team (Engineering Geology Consultancies)
"*Hydrological assessment approach for the elaboration of the hydro-agricultural infrastructure project aimed at the development of mangrove rice cultivation in Guinea Bissau*"
Tebogo Keletso, KGM Consulting
"*Achieving Sustainable Food Security through Water Accounting within the Agricultural Sector in Botswana*"
Imane Berni, Cluster of Competency "Health and Environment", Moulay Ismail University, Meknes, Morocco
"*Health risk assessment based on pesticide monitoring in Saïss plain (Morocco) groundwater*"

Key messages
- **Circular economy is one important way to address better water for food and public health management by creating synergies between actors.**
- **The benefits of using wastewater must achieve to revert some relevant challenges, such as cost recovery, social behaviour, technical constraints, or policy and capacities.**
- **Social conflicts, economic drivers, and political and weakness governance are key factors to achieve better and secured water management.**
- **Quantification of water embedded in agricultural food production by distinguishing between green and blue water is needed to reduce food risk, especially when considering the dominance of local or global food products and food trade dynamics.**
- **The triple-O concept (one water, one earth, one health) considers that interactions are crucial to reduce water intensive food products even when they are not healthy at nutritional level.**

Session Summary

Through different scientific and research perspectives, it is established that there exists a positive correlation between food security, water, public health, and education. Several projects are carried out in different regions that do not pre-assess the local, socio-economic, and ecological conditions, agricultural practices, and inter-dependent policies in water, energy, and food. Furthermore, it is well researched that the negative aspects of the agriculture sector include an impact on water and health conditions.

Systemic changes and transformations are possible and brought by soil moisture, nutrient monitoring tools, and innovations transferred to the local farmers. Multi-functionality of water can be leveraged to increase water and nutrient productivity, and therefore, income, causing less conflicts and improved education.

There exist gaps in data availability and food security assessments especially in Asian and African countries. In most cases, food security indicators do not always include water as an essential component, despite evident positive correlation. Indicators like total renewable water resources per capita reflect the physical dimensions of water accessibility, availability, and effects like malnutrition. Political instability and lack of consistent data collection also amplifies the challenge which is true for many African countries. Additionally, lack of robust data availability from regions also leads to disincentives like predictive modelling due to climate change, etc.

Existing national policies on groundwater does not translate to regional ground water regulatory policies. This is evident through the study of the states which have highest ground water consumption but do not have regional regulatory policies on ground water management (Punjab, Rajasthan, etc). These missing gaps have negative impacts on employment and economic conditions, leading to food insecurity and high poverty conditions among farmers.

It is well recognised that hydro-agricultural infrastructure in most cases deals only with the geological and technical side of it. However, stakeholders, socio-economic conditions, local hydro-geo-physical conditions, regional financial capacities, and long-term sustainability of these infrastructures are not considered. Such ignorance causes project failure, instability, unacceptance, and ownership by the stakeholders, and hence, not reaching desired benefits.

Lastly, connecting public health risks with the agricultural process of applying pesticides, its interference with water cycles, and dependent ground water quality risks, was also discussed. An example from Morocco of regular pesticide and environmental monitoring resulted in confirmed interference with human and ecosystem health. The conclusions from Morocco are also applicable in other countries where risks assessment is either not done or is not conducted in an integrated manner.

ABSTRACT SESSION 3
"HOW CAN SCIENCE BETTER INFORM PUBLIC POLICY, GOVERNANCE, AND CAPACITY BUILDING FOR WATER, FOOD, AND HEALTH?" (PART 1)

Moderator
Alice Aureli, Chief of the Groundwater Systems and Settlements Section, UNESCO's International Hydrological Programme & Programme Coordinator, ISARM

Co-Moderator
Pedi Obani, Assistant Professor, School of Law, University of Bradford

Panellists
Stanley Nzama, Water Ecosystems Management, Department of Water and Sanitation, Pretoria
"*Science-policy nexus: using resource directed measures as policy implementation strategies to promote integrated water resource management, South Africa*"
Daina Mudimbu, Department of Chemistry and Earth Sciences, University of Zimbabwe
"*Capacity building in multi-disciplinary scientific methods for improved understanding of the impact of conservation agriculture on groundwater resources in Africa*"
Disha Gupta, Delhi School of Economics
"*Free Power, Irrigation and Groundwater Depletion: Impact of the Farm Electricity Policy of Punjab, India*"
Sergey Myagkov, Hydrometeorological Research Institute
"*Method for assessing the health risk of the rural population from the hydrochemical regime of surface waters*"
Imad Antoine Ibrahim, College of Law – Qatar University
"*Legal Implications of the Use of Big Data in the Transboundary Water Context*"
Florence Tanui, University of Nairobi, Kenya
"*Comprehensive Groundwater Research: Evidence to Policy Perspectives in ASALs*"

Key messages
- **Emerging new technologies develop Big Data for extensive usage among countries sharing transboundary aquifers, and this is necessary for groundwater management.**
- **Continuous monitoring programs from local to national levels can map potential sources for spatial distributions of groundwater pollutants.**
- **Alternative pricing policy for farm electricity can promote efficient use of resources and prevent further overexploitation of groundwater.**
- **Conservation Agriculture (CA) is a tool that improves the resilience of crops to certain conditions, such as drought, by consistently quantifying groundwater recharge through field monitoring and modelling in every change in surface activities.**
- **Science-policy interface must be practical and reflective, and it must manifest an approach where scientific results are translated into readily usable formats.**

Session Summary

n our progressive world, the acquisition of data from scientific research has proven to be a vital resource that supports decision-making processes for policymakers and stakeholders. The agreement between ground-based and satellite-measuring instruments works to enhance the data outputs for different practical applications, such as forecast modelling and real-time monitoring of fluxes. For instance, in the context of groundwater quality, evaluating the deterioration of water quality index through seasonal changes can lead to regulations in irrigation and watershed conservation. Moreover, continuous monitoring programs from local agencies can produce GIS maps of spatial distributions of groundwater pollutants. Also, constant observations of parametric resources (sourced from scientific research) have been proven to be essential and heavily utilizable for water management at different spatial scales. Big Data acquisition has most importantly shown the importance of groundwater resources as these resources can be utilised for water, food, and healthy capacity building, including the promotion of science-based data for policy implementation.

Advancement of newer and cheaper technology promulgates anthropogenic activities that have impacts on natural resources– particularly groundwater. The scenario in Punjab, India, portrays a classic example where for irrigation purposes, farmers are operating low-cost electric pumps for groundwater abstraction. However, there has been the occurrence of overexploitation of water resources as a direct negative impact of technological usage. This overexploitation is not unconnected to the loose policy on power consumption subsidization. Conservation Agriculture (CA) considers the overexploitation as counterproductive to the training being developed in the Sub-Saharan African regions and encourages the monitoring of all kinds of separation from conventional agricultural practices to quantify their impact on groundwater levels. Incentivizing farmers is also a viable option. A more sustainable approach targets groundwater recharge, such as CA. It is a tool that follows the principles of minimum soil disturbance and focuses on the available water to improve the resilience of crops to certain conditions such as drought.

Water in a certain catchment area moves and interacts at different sections, thus, surface water and groundwater qualities are usually related. Moreover, activities that happen on the upstream have implications on the downstream area and its population. A case study in Tashkent region, Uzbekistan, demonstrated that the risk of morbidity is higher for populations inhabiting the upper and lower reaches of the river catchment. The primary reason for this is associated to poor quality of surface water and groundwater, which are used to irrigate food production and for drinking. Similar observations can be seen in Lodwar, Kenya, wherein their groundwater resources are vulnerable to all upstream activities. Risk of groundwater contamination from natural factors and anthropogenic pollution is heightened during wet seasons due to flushing, eventually leading to various degrees of aquifer mineralization.

Emerging new technologies allow the development of Big Data and its extensive use. Capturing, storing, managing, and analysing can provide extremely valuable and up-to-date information for water management– particularly of those countries sharing transboundary basins. However, conflicts could potentially ensue due to socioeconomic disparities if legal frameworks and treaties that would satisfy individual country's interests will not be established. Thus, it is necessary that flexibility exists within legal frameworks, granting the involved states a provision to amend or withdraw in the treaties.

Capacity building is one way of bringing knowledge to the ground. Training big groups of multi-disciplinary backgrounds and levels results in cross-pollination of ideas and generation of innovative solutions. These activities strengthen and build equitable partnerships within the involved people. Scientists from different sectors formulate new questions for the integration of informed policies. Future collaborations with international network can improve governance and policy on water management. Conclusively, science and policymaking are not mutually exclusive. Integration of these facets should favour scientists and policymakers by encouraging engagements of both parties. This will result in a science-policy interface that is practical, reflective, and considers the nexus approach where scientific results are translated into readily usable formats.

ABSTRACT SESSION 4
"HOW CAN MANAGING WATER IN AGRICULTURE CONTRIBUTE TO FOOD SECURITY AND PUBLIC HEALTH?" (PART 2)

Moderator
Mark Smith, Director General, International Water Management Institute (IWMI)

Co-Moderator
Henning Bjornlund, Research Professor, Water Policy and Management, University of South Australia & Chair, Science, Technology and Publication Committee, IWRA

Panellists
Kunal Sharma, Consultant Civil Nabcons, Guwahati, Assam
"Sustainable spring watershed management system in the Indo- Himalayan Region: Village community challenges and its planning approaches"
Shivaraju Harikaranahalli Puttaiah, Department of Water and Health, JSS Academy of Higher Education and Research
"Water Management at Agricultural Catchment – Sustainable & Technological Approaches for Pollution"
Partik Kumar, Revitalising Rainfed Agriculture Network
"Rejuvenating resilience in the agrarian livelihood of Western Indian Himalayan region – A water perspective"
Kakoli Ghosh, Chief Technical Advisor, SRAD – Programme, FAO
"Integrating sustainable agriculture management and increasing farmers income in Saudi Arabia"
Siroos Jafari, Soil Sciences Department, Agriculture Sciences and Natural Resources, University of Khuzestan
"Adaptation Strategies and Barriers to Water Scarcity: A Qualitative Analysis in Southern Iran"
Chloe Van Biljon, International Food Policy Research Institute (IFPRI)
"The WASH-small-scale irrigation linkage: Insights from rural Ethiopia"
Enrique Fernández-Escalante, Tragsa Group- IAH-MAR Commission
"Industrial and environmental Managed Aquifer Recharge-related water security cases contributing to food safety and public health"

Key messages
- **When evaluating possible solutions for sustainable spring watershed management, various structural measures (spring chambers, dugout, rooftop pit, contour trench, afforestation, etc.), and nonstructured measures (awareness programs, working groups and activities, maintenance, etc) have to be taken for proper planning and management.**
- **An integrated approach including modelling tools can be used for agriculture management at the catchment level to cater to the water-energy-food-environment nexus.**
- **Techniques like protective irrigation can be selected and driven by a comprehensive characterization of various hydro-climatic parameters, agriculture features, and community involvement for natural resource management.**
- **Through sustainable development initiatives, crops, livestock, fisheries, and natural resources management have to be addressed to empower the rural farmers.**
- **Public engagement will foster ownership and contribute to the long-term viability of the initiatives, including capacity building, value addition, research and outreach, and digitalization, etc.**
- **WASH is closely impacted by irrigation water supply and has a profound impact on health. Irrigators (either by ground or surface water) are seen to have better WASH practices than non- irrigators.**
- **Apart from warming and climatic conditions, factors like anthropogenic activities and state policy also contribute to water resource management and must be taken into consideration.**
- **Managing the aquifer's capacity (industrial and environmental) is crucial as it contributes to the food security, health, and well-being of the dependents.**

Session Summary

The world is running out of clean water to feed and nourish a growing population, ensure sustainable development, and maintain the health of our people and planet. There is not enough water as it is currently managed to sustain the world's population and end hunger and malnutrition. Therefore, better water management is crucial to global food and nutrition security, as well as to public health. In this session, tools for managing water security, food security, and public health are discussed, with a focus on managing, monitoring, and understanding agricultural water.

As the land use/land cover procedures and the climate changes, the movement of water (surface & ground) is also affected. It also increases the risks of extreme events even at the catchment scale. In such hydrological zones, various spatial differences in vegetation, topography, soil properties, geology, land use/land cover, and meteorological conditions are observed and can be well-understood even on small scales. This contributes to the contamination of water and pollution. Sustainable technological and non-technological practices have been discussed in the session.

The HKH region hosts a large, rapidly growing population that depends on agriculture and the world's largest irrigation scheme. Due to unsustainable development, the region encounters various issues. The accessibility is difficult, hindering updated ground measurements of geological, meteorological, glaciological, and hydrological processes taking place due to the remoteness. These processes are not still clear and need to be well understood in the Himalayan region, as indicated in two case studies. An integrated approach, including modelling tools, can be used for agriculture management at the catchment level to cater to the water-energy-food-environment nexus. Likewise, the Spring watershed management in the region has also been addressed in the session, as well as possible structural and non-structural measures for sustainable development and management.

The Food and Agriculture Organization is working in the Saudi Arabian rural community to empower them and promote their work. FAO (The Food and Agriculture Organisation) has a vision of sustainable development initiatives for crops, livestock, fisheries, and natural resource management. The initiatives and ongoing projects including capacity building, value addition, research and outreach, and digitalization, etc. have been well communicated in the session.

Although irrigation is key to increasing food production and farm income, as well as improving resilience against weather variability, this is an indicator of WASH practices in different regions including Ethiopia as discussed in the session that affects water security, hygiene, and sanitation through other pathways. It is indicated that WASH is closely impacted by irrigation water supply and has a profound impact on health and irrigation (either by ground or surface water) are seen to have better WASH practices than non-irrigators.

Intensive groundwater pumping for irrigation and domestic purposes have depleted aquifers in many regions, leading to water security cases and contributing to food safety and public health due to declining water tables. Integrated Water Resource Management through reuse and aquifer recharge promotes long- term sustainable solutions to water supply, food security, and public health issues in Los Arenales, Spain (industrial and environmental managed) as addressed in the session.

Agriculture is undoubtedly one of the most important sources of livelihood. Therefore, it is significant to manage the water and natural resources through sustainable agriculture practices as it is important for food security, good health, and well-being of the dependent communities

ABSTRACT SESSION 5
"HOW CAN WE BETTER MANAGE WATER FOR FOOD AND PUBLIC HEALTH IN A CHANGING WORLD?" (PART 2)

Moderator
Raya M. Stephan, International Water Consultant, Deputy Editor-in-Chief Water International & Executive Board, IWRA

Co-Moderator
Asma Bachikh, Executive Board, IWRA & Consultant, World Bank Group

Panellists
Kene Dick, Department of Water & Sanitation
"*Sustainable Development: A Strategic Approach for Sustainable Business Practices in Francistown Region in Botswana*"
Andrew Limantol, Lecturer, University of Environment and Sustainable Development
"*Access to Handwashing with Soap Facility in Binduri District: A Post-sensitization Investigation of Drivers*"
Nilsu Gevrekcioglu, Dokuz Eylul University, Graduate School of Natural and Applied Sciences, Department of Environmental Engineering
"*Receiving Water Quality Models for Estimation of Total Maximum Daily Pollutant Loads: Case Study of the Küçük Menderes River Basin*"
Hodo Abdilahi, Water & hydrological engineering
"*How Can We Better Manage Water for Food and Public Health in a Changing World: Case of Somaliland*"
Srishti Gaur, Ph.D. Student, Indian Institute of Technology, Kharagpur
"*Projecting LULC growth and associated impacts on hydrological process through scenario-based modelling – A road ahead for sustainable future*"
Partik Kumar, RRA Network
"*Sustaining Groundwater resources for stabilising agrarian livelihood: A case study of South-western Haryana*"
Deepika Slathia, University of Jammu
"*GIS based fluoride contamination mapping of groundwater and its exposure risks to the hilly populace of the Chenab River Basin in Jammu*"

Key messages
- **Sustainable Development principles should be highly adopted, and industry viewpoint must be considered in analysing the challenges with improved leadership and governance.**
- **Handwashing and basic hygiene are gender constraints; there is need for efficient awareness and widespread sensitization for the alert, younger population, especially the females.**
- **Water quality modelling should be widely considered to set aside concentrations in the receiving river and to control discharges.**
- **Government and political participants must include water safety conservation at global policy level and must ensure that science and technology are deployed in areas with poor conserving methods.**

Session Summary

Water is a critical factor in agriculture and food processing. Examining the inter-linkages between water, food, and public health is important due to the rapid industrialization and technological advancements. The necessity of striking a triangular balance amongst the three concepts–water, food, and public health–becomes crucial more than ever due to changing scenarios and the after effects of the pandemic.

However, food is severely threatened by the existential crisis of ground water contamination, and this consequently impacts public health. More than 200 million people worldwide drink groundwater with fluoride concentrations. Different case studies conducted across India suggest the fluorosis problem has reached alarming proportions, affecting at least 19 states in the Northern and Southern parts of India. A case study conducted in the Doda district in UT–one of the 230 districts which is declared as an endemic for dental and skeletal fluorosis–found that a probable solution could be the use of alternative surface water resources, such as spring water and the difluorination of supply water in the contaminated areas.

Proper hand hygiene is the single most important tool, especially living in a pandemic that requires constant hand washing to avoid the transmission of germs. Despite the extensive research done in this respect, non-availability of water and less awareness on hand hygiene with soap is a rising concern for public health diseases and a distorted food chain. As per Global Handwashing Partnership 2020, only 19% of the world's population practice hand washing and hygiene. Considerable research has examined the status and the determinants of hand washing facilities in healthcare settings and schools, but its status at home and in the community, especially in developing countries, remains unclear. A case study analysis performed in Binduri District of Upper region of Ghana, with study population of 6,188 households, reveals that females are the drivers in maintaining hand washing hygiene with soap while more awareness is needed for the younger populations.

Agriculture requires 70% fresh water to be utilised to produce food. Thus, with the increasing population, the need and demand for food and water is also increasing. The World Bank lists agricultural food production and water management as global issues. If current trends continue, water scarcity is inevitable in many parts of the world. In a case study done across Somaliland to better understand the inter dependency of water, food, and public health, it was found that only 53% of the population in Somaliland had access to a water supply. Furthermore, limited regulation of private water suppliers often leads to expensive prices, forcing families to fetch water from far and unsafe open wells. A predictable solution to this should focus on effectively adapting SDG 2030, globally, by countries with political support. Sustainable goals which are interrelated in nature will help to maintain a genuine public health system without depleting or wasting resources.

Thankfully, a different approach was taken to study how water stands as a key binding factor in both food and human health. A case study analysing sustainable ground water resources for stabilizing Agrarian Livelihood lists three frame solutions which can help in solving the ground water crisis.

Engineering interventions demand side interventions like reducing unproductive irrigation, recharge from domestic waste water, sensitization towards water resources, and promotion to fewer intensive crops, for help in achieving stability.

HIGH LEVEL PANEL
WATER FOOD AND PUBLIC HEALTH IN A CHANGING WORLD

Moderator
Rabi Mohtar, Dean, Faculty of Agricultural and Life Sciences, American University of Beirut & Professor, Environmental Resources, Engineering, Texas A&M

Co-Moderator
Sasha Koo-Oshima, Deputy Director & Head of Water, FAO

Panellists
Gerda Verburg, Coordinator of the Scaling Up Nutrition (SUN) Movement and Assistant Secretary-General
Steve Musser, Deputy Center Director for Scientific Operations, Center for Food Safety and Applied Nutrition U.S. Food and Drug Administration
Akiça Bahri, Former Ministry of Agriculture, Tunisia
Tom Panella, Director – Environment, Natural Resources, Agriculture – East Asia Department / Chair – Water Sector Committee, Asian Development Bank (ADB)
Tom Williams, Director, Water World Business Council For Sustainable Development (WBCSD)
John C. Tracy, Director of Texas Water Institute and Interim Head of the Biological and Agricultural Engineering Department, Texas A&M University

Key messages
- **There is a strong need to investigate the efficient use of developing resources as well as technology, policy, and human factors.**
- **The creation of synergy around water, food, and health sectors which are characterized by a critical interlinkage is a necessity to protecting human well-being.**
- **Looking into governance issues and developing governance platforms is needed to foster multidisciplinary actions in the water, food, and health system.**
- **Having no access to technology makes access to water more difficult, time-consuming, and more expensive.**
- **The role of the global water community towards achieving sustainable water food and health is crucial to engaging other sectors (ministries, research, etc).**
- **Educating people on how to use technology and how to talk about data is more critical than the data itself.**
- **Humans are always a part of the technology, the security, and the sustainability improvement.**
- **To better access data, a standardized approach to collecting, using the data, and making it public must be implemented.**

Session Summary

With the covid-19 situation, there are big changes taking place. Hence, there is a need to rethink ways of dealing with water, food, humans, ecosystems, and health. Furthermore, biodiversity and nature contribution to people are fundamental to support food production and to provide clean water and therefore to ensure good health. The challenge is to achieve a good health with maintaining a food and water security without adversely impacting biodiversity, water quality, and ecosystems in the context of climate change. There is a strong need to adapt and trust from the way that potential trade-off is identified, managed, and understood at local and national levels. Several integrated approaches in water, agriculture and nutrition, human ecosystems, and health need to be used properly to address these challenges at the global and the local scale.

Understanding trade-offs is needed to develop appropriate responses, develop integrated research across SDGs, and to develop politically relevant tools for helping policy makers respond to future crises. As a matter of fact, SDGs are always linked, and therefore policy coherence is a target of SDG and under the responsibility of national governments and relevant ministries.

In general, solutions that conserve biodiversity and promote human well-being are difficult to realize, which emphasizes the necessity of bringing together different actors from government, private sectors, and civil societies to achieve a shared understanding of each actor behaviour. Moreover, though there is a necessity to have access to strong business models to manage these complex relationships. These are not always successful due to several issues. Normally, conventional business models are structured around shareholder primacy with their main goal being to deliver profit to shareholders. This represents the backbone of capitalism, which is not the best fit for achieving a sustainable future. Hence, there is a need to switch to the stakeholder's capitalism where business models are orientated towards the interests of all stakeholders, customer communities, and suppliers. Good accountability is always the best solution, mainly the nature accountability and impacts from sources, which encourage corporates to be aware of protecting ecosystems and water resources by being involved in natural capital accounting. However, nowadays investors are becoming very sharp at understanding climate-related risks.

The current emerging technologies related to ecosystem services have a very important role in facilitating the transformation to a more sustainable rooted food and health system. Nevertheless, the continuous cyber-attacks and failures of the IT and energy systems negatively affecting the food production and thus, water consumption. The focus on communication and information technology investments will lead to better improvements of water security and water sustainability. As a direct fact, it is important to invest on infrastructure improvement, understand the correlations between all these infrastructures, and have a better social training to allow a better understanding of the different security risks.

There are always multiple dimensions of human rights. Access, availability, and affordability of water services while recognizing the price to pay for water related services (water treatment, water distribution, etc.) is a challenge. However, the main challenge that many public and private entities have is calculating drinking water tariffs to enable them to have government subsidies, which led to the necessity to change the current mindset around human rights.

ABSTRACT SESSION 6
"WHAT OPPORTUNITIES LIE IN THE IMPROVED COOPERATION BETWEEN WATER, FOOD, AND PUBLIC HEALTH SECTORS?" (PART 1)

Moderator
Bassel Daher, Research Scientist, Texas A&M Energy Institute

Co-Moderator
Jennifer Sara, Global Director, Water Global Practice, World Bank Group

Keynote Speaker
Christine Moe, Professor, Eugene J. Gangarosa Chair in Safe Water and Sanitation, Rollins School of Public Health, Emroy University

Panellists
Virender Sharma, Professor, Texas A&M University, School of Public Health
"*Agricultural Practices by Enhanced Water Quality through Iron-Based (Ferrate) Technology: Improved Population Health*"
Yilin Zhuang, University of Florida
"*Enhancing Well Water Safety through University and Health Department Partnership*"
Isaiah Akoteyon, Department of Geography and Planning, Lagos State University
"*Challenges of persons with physical disabilities in accessing WaSH: Implications for sustainable universal health coverage. A case study from Lagos metropolis, Nigeria*"
Neil Grigg, Professor, Colorado State University
"*Breaking organizational stovepipes: Connecting water, sanitation, food, and public health*"

Key messages
- **In breaking barriers and resolving organizational stovepipes, involvement of inter-agencies in making joint programs is necessary to build and achieve collective action without interference.**
- **Partnerships between universities and health departments increases awareness among residents. Engagement from the community enhances capacity-building for water safety, ensuring well water quality are maintained.**
- **Inadequate sanitation leads to multiple faecal exposure pathways. Food being at the core of the F-diagram makes them a universally dominant exposure pathway to diseases. Widespread use of contaminated wastewater for irrigation in urban agriculture contaminates raw produce; hence, ingestion poses an increased health risk.**
- **The application of Ferrate technology can improve water quality for agricultural practices, segregate urea from pharmaceuticals to produce fertilizers, and drastically reduce time of water treatment.**
- **WASH facilities should be made accessible for people with disabilities. Developing policy, guidelines, and infrastructure design will enhance access to WASH facilities for improved health and living conditions for people with disabilities.**

Session Summary

The inauguration of the circular economy allows for a systemic approach to economic development, minimizing wastes and continual reusing of resources. It supports the water-food-public health nexus by overseeing that finite resources are properly managed and well-allocated. In optimizing this approach, water management is the focal point that tethers and enables all other sectors. However, an uncertainty on the adequacy of the current technologies, knowledge, and frameworks exist. This session focuses on recent studies developing the water-food-public health nexus, and the efforts in enhancing the coordination among respective organizations.

One of the pre-existing problems globally that inhibits the progression of one water and one health is the disconnection of projects among regulators, agencies, NGOs, etc. which result in organizational stovepipes. Essentially, stovepipes refer to the propensity of each sector to secure individual incentives instead of collective benefits, or the lack of interdependence within bureaucracies controlled by a political agenda. It can be argued that many scientific solutions and terrific frameworks exist, but they do not reach the ground level for implementation. To break the barriers caused by stovepipes, involvement of inter-agencies in making joint programs is necessary. Soon enough, collective action will be built and achieved; then progress will be evident.

A case study in Florida demonstrated how university and health department partnership can breakdown stovepipes that hurt residents and well owners. If the partnership did not intervene, awareness on the locality's well water quality would not spread, and people would be uninformed about what they consume for drinking. Prior to this project, more than half of the population did not have any information about their well system and has never tested the water quality. Moreover, tap water has been consumed without treatment, increasing health risk among the residents. This highlights how important community engagement is in capacity-building for water safety and protecting the health of the people.

Other problems brought upon by organizational stovepipes are visible in cities, particularly in urban agriculture. Globally, open defecation still exists, which is an indication for poor and inadequate sanitation. This leads to multiple faecal exposure pathways – for example, direct water consumption or usage of untreated wastewater for irrigation. The discontinuity between sanitation and water for irrigation contaminates raw produce; hence, increasing health risk through ingestion. Food, being at the core of the F-diagram, makes it a universally dominant exposure pathway to disease. This challenge can be mitigated through the integration of responses from water, sanitation, and health sectors– primarily focusing on the management of faecal contamination. It is also important to build water knowledge for different groups such as farmers and consumers.

On the other note, the applicability and efficacy of Ferrate technology is currently under scrutiny for general market use. This technology enhances water quality by segregating urea from pharmaceuticals and removing any unwanted organics and metals. Without the hazardous nutrients from wastewater, the treated water is suitable for reuse in agricultural practices. Furthermore, the extracted urea contains nitrogen and phosphorous which is beneficial in producing fertilizers. On top of these functionalities, it also drastically reduces the average time for water treatment. Such type of innovation should always be explored, while targeting multi-use objectives.

Lastly, the breaking down of stovepipes must not only accommodate the general population, but it should also reach the under-represented domains (e.g., people with disabilities (PWDs)). After all, equity in access to WASH facilities is vital to achieving sustainability. Therefore, policy, guidelines, and infrastructure designs must enhance the accessibility of PWDs to WASH facilities for improved health living conditions. Moreover, what is the purpose of integrating water, food, and public health if not all groups will benefit? It will only revert to organizational stovepipes.

ABSTRACT SESSION 7
"WHAT ARE THE SYNERGIES OR TRADE-OFFS BETWEEN ECOSYSTEM HEALTH AND HUMAN HEALTH?" (PART 1)

Moderator
Rabi Mohtar, Dean, Faculty of Agricultural and Life Sciences, American University of Beirut & Professor of Environmental Resources Engineering, Texas A&M

Co-Moderator
Mary Trudeau, Project Officer, IWRA

Keynote Speaker
Christine Moe, Professor, Eugene J. Gangarosa Chair in Safe Water and Sanitation, Rollins School of Public Health, Emroy University

Panellists
Vedendranand Chummun, Open University of Mauritius
"*Influences of Pesticide Residue on attaining Food Security in Mauritius*"
Robin Craig, University of Southern California Gould School of Law
"*Can shellfish and kelp aquaculture take advantage of water quality and carbon trading to reduce coastal pollution? A legal case study from California, USA*"
Sandra Yanni, Faculty of Agricultural and Food Sciences, American University of Beirut
"*A Nexus trade-offs analysis of water, energy, food, nutrition and feedback to the environment in Lebanon*"
Isabel Santos, Centre de Recherches Rhumatologiques et Thermales d'Aix-les-Bains
"*Thoughts: Genomics and Sulfur Water Bath through skin of emotional Rheumatoid Arthritis Patients*"

Key messages
- **The usage of excessive pesticides negatively affects not only the ecosystem, but also human health. This should consequently be discouraged. Moderation should be enthroned in cases of necessity.**
- **Shellfish and Kelp Aquaculture greatly benefit the environment through carbon sequestration and pollution reduction, while also serving as a useful economic tool.**
- **The water-food-energy (WEF) nexus is central to sustainable development. It is therefore imperative that well-suited mechanisms are deployed towards ensuring water, food security, sustainable agriculture, and energy production.**
- **There is a link between the natural environment and individuals' health, particularly evidenced by the intersection between hydro-mineral resources and the treatment of emotional rheumatoid arthritis patients. The presence of this linkage increases the need for environmental sustainability.**

Session Summary

What are some of the synergies or trade-offs between ecosystem health and human health? First, the use of pesticides by farmers has been found to be one of the major factors that affects the attainment of food security. A study on the cultivation practices amongst farmers in Mauritius has shown that some farmers apply pesticides above the appropriate dosage, which births the absorption of pesticide residue in crops. Given that crops with excessive pesticides cannot be consumed, it becomes clear that excessive pesticide application has a negative impact on human health. This danger, particularly in the light of how necessary pesticides are for agrarian purposes, should inspire investigations and continuous monitoring of pesticide residue on edible crops, and tighter regulations for food crops. These should be done alongside increased sensitization campaigns regarding dangers of pesticide usage. Additionally, Artificial Intelligence (AI) should be used to detect pesticides at early stages of crop production, and most importantly, organic farming should be highly encouraged. These measures will benefit not just human health but the health of the ecosystem, as well.

Traversing western ecosystem challenges, Shellfish and Kelp Aquaculture has proven to be viable means for the reduction and check of Green House Gas emissions and Coastal Pollution in the U.S., particularly, in California. Research indicates that shellfish and seaweed aquaculture play a significant role in removing nutrient pollution from water, carbon sequestration, and improving water quality. Being such a valuable tool, aquaculture can potentially be maximized for the benefit of both kelp and shellfish aquaculture facilities, as well as the environment. Companies who own such facilities can harness pollutant trading programs, earn and sell emission reduction offset credits, and promote their expansion while simultaneously benefitting the ecosystem through habitat and riparian improvement and flood retention.

On another note, the water-food-energy (WEF) nexus is central to sustainable development. Demand for all three is increasing, driven by a rising global population, rapid urbanization, and economic growth. Undisputedly, agriculture is one of the largest consumers of freshwater resources and an immense amount of energy is expended on food production and supply. The inseparable link between these critical domains requires a suitable integrated approach to ensuring water and food security, sustainable agriculture, and energy production. In Lebanon's case, it has been demonstrated that investing in locally produced needs of pulses (broad beans, lentils, chickpeas, and peas) results in increased nutritional value in the locally produced basket and reduced reliance on foreign markets. In addition, with proper resource allocation, the focus on these locally produced foods work not only to reduce the pressure on fresh water and the contamination of surface and groundwater, but also to reduce GHG emissions, ultimately impacting public health positively. Needless to say, however, there is a need for improved technologies, better policies and incentives, increased public awareness, as well as a change in behaviour of producers and consumers if these benefits are to be realized.

Lastly, naturally available resources such as natural mineralized water can be used to treat human diseases. This is made possible by the properties of the skin. Virtually all cell types that reside and pass through it can exhibit immune functionality. It allows transmission of messages to the whole body of patients suffering from rheumatoid arthritis, for example. Groundwater is a true imprint of the thermal water. Sulfide is naturally dissolved in geothermal waters of many springs. Because of its richness in endogenous and exogenous hydrogen sulfide, which has many therapeutic functions, we can consider sulfurous water as a medicine for the treatment of illnesses in body with active principles that define its unique hydro-geochemical form. Thus, hydro-mineral resources have significant economic value to the spa industry, promoting the quality of life for the population through proper prescription. Essentially, preserving and promoting natural wealth, such as thermal waters, can help to restore human well-being.

ABSTRACT SESSION 8
"HOW CAN WE BETTER MANAGE WATER FOR FOOD AND PUBLIC HEALTH IN A CHANGING WORLD?" (PART 3)

Moderator
Rabindra Osti, Asian Development Bank (ADB)

Co-Moderator
Gary Jones, Executive Board, IWRA

Panellists
Matthew McCartney, Research Group Leader, International Water Management Institute – Colombo
"*Transformation of rural landscapes for sustainable and nutritious food systems in Myanmar*"
Maria Paula Mendes, Ph.D. in Earth Resources, Researcher, CERIS, Civil Engineering Research and Innovation for Sustainability, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, Lisbon
"*Digital Water Management for Improving Resilience of Agriculture, Food and Health as a Response to Global Risks*"
Krzysztof Janik, Assistant Professor, University of Silesia in Katowice, Faculty of Earth Sciences
"*Suitability mapping as an effective tool for identifying potential locations for Managed Aquifer Recharge. A case study: Dunajec catchment, Poland*"
Enrique Fernández-Escalante, IAH-MAR Commission – Tragsa Group
"*The Co-MAR concept and how the groundwater user associations are improving integrated water resources management schemes, governance and water security. Demo-sites from Castilla y León*"
Maher Salman, Senior Land and Water Officer, FAO
"*How can multiple water use services help mitigate the impacts of COVID-19? SMART Irrigation SMART WaSH in support of food security and health*"
Hella Schwarzmüller, Head of Groundwater Department, Kompetenzzentrum Wasser Berlin gGmbH
"*Digital-water city: Leading urban water management to its digital future*"

Key messages
- **As correlation between agricultural sector and water footprint exists, future projects should aim to achieve food production for healthier diets using less water and emitting less Green House Gases (GHG).**
- **The multi-faceted impacts of COVID-19 go beyond the health sector and displays how vital access to clean water is for public health. MUS technologies allow integration of irrigation and WASH facilities and indirectly aid food security and promote public health.**
- **Applications of Managed Aquifer Recharge (MAR) can alleviate stress on water resources by restoring the water balance of groundwater systems. Engagement from communities enhances IWRM schemes, governance, and water security. PPP improves the pre-existing water management mechanisms and benefits all users' collective interests.**
- **Digital Water Management is a probable alternative way of improving resilience to agriculture, food, and health by utilizing advanced technology such as IoT. It is also a feasible proposition for urban water management. Digital solutions allow dynamic network and data sharing as well as enable prompt decision-making based on real-time data.**

Session Summary

Global changes place natural resources under extreme stress and necessitate societies to adapt to the negative impacts. As the population increases, the demands to provide for everyone increases. Water is interlinked with food and public health. Without sufficient water resources and efficient management, society will be in peril of survival due to food insecurity and lack of sanitation.

The paradigm of food production requires litres of water for subsistence–for instance, crop and livestock production results in a huge contribution to our water footprint. For instance, Myanmar is an agricultural country that is capable of exporting crops. However, a high level of malnutrition exists within the population. This simply shows that abundant production does not translate into having adequate food and nutrition security. Furthermore, there are no dietary guidelines in the country and people overconsume starchy products for compensation. Within the agricultural sector, rice production dominates the use of water, followed by livestock. As a result, they comprise the largest shares in water footprint, and the biggest sources of GHG emissions as well. A correlation between agriculture and water footprint exists, therefore, future projects should aim to achieve food production for healthier diets using less water and emitting less GHG.

The current pandemic situation displays how vital access to clean water is for public health. The number of impoverished people increased more than ever and this underscores that without access to clean water, public health is in jeopardy. To minimize and prepare for possible outbreaks, water facilities must be installed. However, implementing multi-use system (MUS) technologies would be a better approach that could be beneficial for irrigation as well. Since no one-size solution fits in terms of technology, integration of irrigation, and WASH could indirectly aid food security and promote public health.

In many countries, groundwater is the primary source for water usage. However, climate change and population growth strongly affect this vital resource through decreased recharge and overexploitation, respectively. A promising way of dealing with these challenges is through MAR. It enhances water storage in suitable regions for use during dry periods. Therefore, suitability mapping is deemed an effective tool in identifying potential locations for MAR; further studies are encouraged. Applications of MAR can alleviate stress on water resources by restoring the water balance of groundwater systems and modelling them to withstand future negative impacts. Once MAR is installed in viable areas, engagement from communities enhances IWRM schemes, governance, and water security. By having users intervene in decision-making, exploitation can be avoided and users can contribute to soft non-structural management measures. The introduction of people public-private partnerships (PPPP) improves the pre-existing water management mechanisms and results in a win-win scenario and because all users' benefit from the collective interests. MAR near arable areas can provide sustainable water for irrigation and consequently, be utilized for food production.

As the world gradually shifts toward integrating digitalization, a potential alternative way of improving resilience to agriculture, food, and health is the introduction of Digital Water Management. It is viewed from an internet of things (IoT) perspective wherein various necessary information about a farm is stored. As such, it utilizes plant-based sensors and other monitoring components of an IoT, and consequently allows smart water to be used for irrigation. Digitalized farms would be a part of a dynamic network and share data with many stakeholders. An interdependence among farmers will be established and beneficial in large-scale because water flow can be traced from water consumption, soil moisture, etc. Moreover, diverse settings can be implemented conforming to the farmers' needs accordingly.

Digital Water Management is also a feasible proposition in cities, leading urban water management to a digital future. The value of digital solutions relies on public involvement and a focus on public health. These aim to contribute to real-world and future water problems in urban water management through interoperability of real-time monitoring systems, water infrastructures, and sewer conditions. Through valid data inputs, real-time control of wastewater treatment facilities is probable to assess the water quality that is suitable for reuse. Overall, a low cost and easy-to-handle technology enables prompt decision-making based on real-time data.

ABSTRACT SESSION 9
"WHAT OPPORTUNITIES LIE IN THE IMPROVED COOPERATION BETWEEN WATER, FOOD, AND PUBLIC HEALTH SECTORS?" (PART 2)

Moderator
Iman Nuwayhid, Professor, Faculty of Health Sciences, American University of Beirut

Co-Moderator
Mirella Aoun, Assistant Research Professor at the Faculty of Agricultural and Food Sciences at the American University of Beirut

Panellists
Attaullah Shah, Professor, University of Haripur Pakistan
"*Impacts of Climate Change on the Production of Major Crops and Health Security in Gilgit Baltistan Pakistan: Water-Food and Health Nexus*"
Etim Eteng, Department of Geography and Environmental Sciences, University of Calabar
"*Socio-Economic Status and access to Sanitary Facilities among Inhabitants of UGEP Community, cross River State Nigeria*"
S. K. Gunatilake, Sabaragamuwa University of Sri Lanka
"*Analysis of spatial variability of groundwater quality in different climatic zones of Sri Lanka*"
Jagdeesh Kumar, Department of Hydrology, Indian Institute of Technology Roorkee, Roorkee
"*Exploring removal of heavy metal ions from wastewater stream employing electrocoagulation and nanofiltration processes*"
Greg Leslie, Professor, School of Chemical Engineering & Director, UNSW Global Water Institute
"*Food and Water for Life: co-creation and evaluation of sustainable community-led innovations to strengthen food and water security*"
Lazaro Paruason, Civil Society- Field Worker and Researcher
"*Critical review on the technological, social and institutional Barriers towards ensuring Sustainable access to safe Water as a pivot for Resilience in Societies living in the Refugees Settlement*"
Joshua Ntajal, Department of Geography, University of Bonn
"*Linking land use dynamics, urban transformation and the complexity of surface water pollution: identifying risks and developing integrated solutions to water-borne disease in Accra, Ghana*"

Key messages
- **Cultivation and cropping in the right strategies and in terms of climate can work to achieve a triangular-balanced mechanism between food, health, and water.**
- **There is a need for government and private health agencies to increase their existing efforts towards policy making and awareness on sanitary process across regions and communities.**
- **Urgent interventions of governments across Nations are needed to uplift standard of living of the poor and to equip sanitation and hygiene facilities with advised water resources.**
- **Equip industries with technological innovations and processes like Nanofiltration and electrocoagulation to remove metal ions and toxic substances from water.**
- **There are positive examples of drought-resilient community gardens and cultivation of traditional medicine plants.**

Session Summary

Sustainable water management is integral to the future of food and sustainability. Agriculture is highly dependent on water and increasingly subject to water risks. Examining the inter-linkages between water, food, and public health is significant due to rapid industrialization and technological advancement. The necessity of striking a triangular balance mechanism amongst the three is an opportunity that can be fetched through the right strategies.

Water security at global and regional level has been threatened due to increase in population, urbanization, and climate changes. Climate change induced modification in the glacial mass will lead to water shortage in the Himalaya region. This water shortage will further lead to food and nutrition insecurity. Analyses of crop rotation prospects in the Himalaya region due to climate change say that the food basket of valleys around the Himalayas is depleting in terms of yields and productivity. Besides this, irregular changes in rainfall patterns may have impacts on water availability and subsequent crop production. To preserve water, certain crops that are prone to high usage of water must be avoided in valleys, and a climate responsive agricultural approach is required to preserve the postures.

Governments across hills and valleys must explore water and agricultural policies respective to climate conditions to promote cultivation with less degradation.

Another research with a different approach was adopted to study water imbalance in UGEP community. The main occupation and livelihood of UGEP community is dependent on Subsistence agriculture, Artisans, Commercial concerns, Business and trade opportunities. Sanitary conditions in UGEP community are in a devastating state with solid waste, usually dumped in river channels leading to blocked drainage. As per research finds that the low socio-economic level of most inhabitants have denied a majority of households the needed empowerment to invest and access water resources. With not enough water and a low income, the sanitary conditions across UGEP community have led to various health diseases. A government policy intervening to help UGEP community will not change their lives, but it will lead them toward proper standards of living with food and good health.

Industries are one of the major users of water, and optimal water use is critical for sustainable water management. Wastewater generated in metal processing causes a severe pollution problem and impacts the food chain, in turn impacting public health. Though there are conventional chemical treatment programmes, they have limitations in terms of cost and maintenance. Research with an objective of removing metals from a multi mixed solution through nanofiltration and electro-coagulation process shows the above two processes to be successful mediums in removing heavy metal ions from Wastewater stream.

While water is an integral part of food, its contamination can have adverse effects on human health. A study done to analyse water borne diseases in parts of Accra, Ghana discusses how 48 interdependent factors related to water, food, and human health are impacted due to contamination. Certain long-term solutions like investments into the healthcare sector, funding, WASH, wastewater treatments, and Sensitization can help in decreasing water borne diseases like diarrhoea, cholera, and typhoid. There should be a certain management of solid waste at household levels and multi-stakeholder collaboration to protect urban water systems with appropriate land use safe disposal.

ABSTRACT SESSION 10
"WHAT ARE THE SYNERGIES OR TRADE-OFFS BETWEEN ECOSYSTEM HEALTH AND HUMAN HEALTH?" (PART 2)

Moderator
Dave Tickner, Chief Freshwater Adviser, WWF-UK

Co-Moderator
Lesha Witmer, Steering Committee (advocacy lead), Women for Water Partnership

Panellists
Diosa Marie Aguirre, PSSE-BatStateU Student Chapter Member
"Removal Efficiency of Banana Pseudo Stem as Activated Carbon for Pre-Treated Laundry Wastewater Treatment"
Charles Essery, Sustainable Water Solutions
"Sustainable Water Cycle Management – balancing conflicting demands for water services"
Yan Yang, General Institute of Water Resources and Hydropower Planning and Design (GIWP), Ministry of Water Resources, China
"Strategy of Groundwater Exploitation and Utilization based on Groundwater Functions in China"
Ding Wang, General Institute of Water Resources and Hydropower Planning and Design (GIWP), Ministry of Water Resources, China
"Exploration of a good water management system for both human development and ecosystem sustainability"
Charles Essery, Sustainable Water Solutions
"The role of water recycling, environmental services, pollution licensing and effluent credits in delivering net zero discharge objectives for future communities"

Key messages
- **The principles of water management are mainly reducing human impact while increasing water resource carrying capacity and maximizing their capacity to support human activities.**
- **Well-drafted and well-implemented regulations can be key to balancing water demands and water supply.**
- **The politicization of sustainable water management initiatives can prevent achieving the end goal of providing people with clean water and sanitation services.**
- **The role of water technology innovation is expected to be more exacerbating by increasing water use efficiency.**

Session Summary

Synergies and trade-offs between ecosystem health and human health have always existed. The principles of water management are clear: reducing human impact while increasing water resources carrying capacity (maximizing their capacity to support human activities) to create a well-balanced water use where all–water, nature, and humans–are protected and where both humans and the environment can prosper. This is done by mainly pursuing the objectives of ensuring acceptable water abstraction quantities, only producing a degradable amount of pollutants and nutrients, and guaranteeing a sustainable timing of flow regimes, as well as well-managed water and riparian space for ecosystems.

However, while developing sustainable water management is easy, the challenges posed by regulation and unaccountability-induced impediments are considerable barriers to implementing such models. Indeed, well-drafted and well-implemented regulations can be key to balancing water demand and water supply. Yet, human and political dimensions of action on water exist and do not always go in the sense of reducing and controlling the water demand of humans or increasing water availability and water supply scarcity. Amongst others, the politicization of sustainable water management initiatives can prevent achieving the end goal of providing everyone with clean water and services that are basic to their most basic human needs (such as being given access to drinkable water and the opportunity of waste disposal). Thus, impending social and environmental benefits could stem from developing sustainable water management or any other similar activities.

Over complexifying, the approach to sustainable water management can also unconsciously thwart concrete results. Scientifically produced knowledge on water use, management, and resources should be easily accessible and understandable by all so that affected communities can use it. By the end of the day, it is the people that we find in communities who are the customers of water resources. Community engagement is thus crucial. This shows that the best ways and channels of scientific communication about sustainable water management are still to be found.

Today, the thinking about resources is changing. Now, the challenge is to implement that thinking effectively. For this purpose, the role of water technology innovation is expected to be more exacerbating in the following years; it is having the potential to significantly increase the efficiency of water (in other words, to increase the amount of water available to the public and reducing the consumption of water in everyone's daily life). Soil and water conservation measures (SWCM) and management should also be considered, as well as efforts such as the method of land-surface zoning according to groundwater's functions for groundwater protection put forward.
A good example is the study led by the General Institute of Hydropower and Water Resources Planning and Design of the Chinese Ministry of Water Resources (GIWP) that prototypes a strategy of groundwater exploitation and utilization based on groundwater functions in China. Similarly, newly developed methods using natural ingredients should be easily accessible to generate solutions for commonly observed problems, such as the pilot project being currently developed in the Philippines on the removal efficiency of the banana pseudo stem as activated carbon for pre-treated Laundry Wastewater Treatment. This worked to analyse the positive effects of the use of banana waste utilization in wastewater treatment, especially for removing surfactant, among others, and this deserves special attention.

Shortly, water-related problems will be exacerbated as urbanization processes go on. Water shortages and degradation of water quality in some new Chinese cities could be cited as an example.

To conclude, to really improve sustainable water management, all developed tools, even if valuable on their own, should be used together to see concrete, impactful results.

FAO SPECIAL SESSION 2
APPLYING WATER TENURE APPROACHES TO ACHIEVE THE SDGS

Moderator
Benjamin Kiersch, Coordinator, Project "Knowing water better: towards fairer and more sustainable access to natural resources – KnoWat", Land and Water Division, FAO

Co-Moderator
Sofia Ramirez Fionda, Publishing and Communication Specialist, Land and Water Division, FAO

Welcome remarks
Sasha Koo-Oshima,Deputy Director & Head of Water, FAO

Keynote speakers
Stefano Burchi, President, International Association of Water Law
"*Applying the water tenure concept for improved water security: SDG 6*"
Rojina Manandhar, Programme Officer, Adaptation Division, UNFCCC
"*SDG 13 Water tenure and climate change*"
Jessica Troell, Director, International Water and Africa Programs, Environmental Law Institute
"*SDG 5 Water tenure and gender equity*"
Jean Maurice Durand, Senior Land Tenure Officer, FAO
"*SDG 15 Life on Land – Land and Water tenure linkages*"
Rebecca Metzner, Chief, Policy, Economics and Institutions Branch, Fisheries & Aquaculture Department, FAO
"*SDG 14 Live below Water – A fisheries and ecosystem perspective*"

"Applying water tenure to achieve the SDGs: Perspectives from the audience"
Facilitated discussion among panel and audience

Key messages
- **There is no food production without water resources.**
- **Building a stronger knowledge of water governance and exploring its linkages to the achievement of the diverse sustainable development goals, such as climate change resilience, gender equity, and sustainable life on land will be key for achieving more equitable and secure access to water.**
- **A better understanding of water governance and water tenure is a necessity for achieving major transformations, especially that we are progressing towards sustainable and inclusive land and water management use.**
- **Water is a vital resource. Everyone, including smallholder farmers, must be able to access and use it without excluding others to sustain their livelihoods and to ensure that no one is left behind.**
- **The national adaptation plans make very specific adaptation actions on water.**
- **Women constitute about 43% of the world's agricultural labour force, but they are much less likely than men to have control over their water resources.**
- **The fact that water laws are generally Gender-Blind means that in practice, they often reinforce existing gender inequities and discriminatory cultural norms.**
- **Strengthening women water tenure includes the bundle of rights that are most essential to women rights to water.**

Session Summary

Water tenure is very particular to water governance. Considering global changes and challenges accentuated by the current pandemic situation, this is important because the pressure over natural resources is more intensified. Hence, this pressure calls for a responsible governance of natural resources to promote an economic development that provides a decent livelihood for all communities and programs that ensure food security. Water scarcity and land degradation could result in food insecurity.

The interdependencies between water, land, and food are visible through the intensification of demand for these resources due to the continuous growth of population and the changing of consumption patterns. These challenges cannot be effectively confronted without appropriate and good governance arrangements that address these complex interdependencies and trade-offs across natural resources and across economic sectors. A responsible governance of water resources relies on various mechanisms and processes that can articulate the interests of citizens while also mediating the differences between communities and ensuring their rights and duties with respect to water rights in a way that is both transparent and equitable. These are the principal foundations of governance. The concept of water tenure will help to elucidate these issues and identify, recognize, and ultimately protect all legitimate water rights to eradicate hunger and to ensure that no one is left behind.

Freshwater resources were identified as a priority area by enhancing water infrastructures through water resource planning, strategies, and systems. Thus, the aim is to achieve a good efficiency in irrigation and integrated water resource management which also includes protection and restoration of water-related ecosystems forests, wetlands, and rivers as well as supply diversification, for example. The interlinkages of these priorities are intimately contained within the SDGs. These are topics around water tenure which is, for example, on indigenous water management practices and traditional knowledge irrigation systems which are considered as the best adaptation plans.

Women around the world have important water management responsibilities, unique water needs, and differentiated priorities for water use and management, globally. Women and girls carry the main burden of unpaid household work, including water collection. Women also play critical roles in food production and water management for both household and productive uses. Hence, satisfying the water and sanitation needs of women is an important aspect of achieving positive reproductive health outcomes and increasing educational opportunities for girls. This will also help to realize the SDG 5 targets. Men continue to dominate water governance and decision-making at all levels. This continued failure to represent women's water needs, knowledge, and skills in decision-making inhibits the establishment of truly equitable and sustainable water policies and practices. There is a critical need to clearly recognize and protect women's water rights at both the national and regional level. The fact that water laws are generally Gender-Blind means that in practice, they often reinforce existing gender inequities and discriminatory cultural norms.

The water sector has a dynamic and complex environment. It is an ecosystem and, at the same time, provides ecosystem functions and services. It maintains fire diversity and works to ensure a better environment. It is also important to address the different groups such as indigenous women, farmers, fishermen, and others, which all of them can benefit from enhanced access to water and ensure food security, leading to a healthy well-being.

ABSTRACT SESSION 11
"HOW CAN SCIENCE BETTER INFORM PUBLIC POLICY, GOVERNANCE AND CAPACITY BUILDING FOR WATER, FOOD AND HEALTH?" (PART 2)

Moderator
Lesha Witmer, Steering Committee (advocacy lead), Women for Water Partnership

Co-Moderator
Pedi Obani, Assistant Professor, School of Law, University of Bradford

Keynote speakers
John Etgen, CEO, WET Project

Panellist
Thouraya Souissi, Institution of Agricultural Research and Higher Education – IRESA
"*Competency-Based Curriculum design to enhance the employability of Agricultural Engineers in Water Sector in Tunisia*"
Habila Alfred Zingchang, National Water Resources Institute, Mando Road Kaduna
"*Groundwater Potentials Assessment of Langtang Area, Plateau State North Central*"
Thijs de Lange, Wageningen University and Research
"*Nutrient-rich diets increase food security, only if proper water quality is guaranteed*"
Peter S. K. Knappett, Department of Geology & Geophysics, Texas A&M University
"*Accounting for the Human Impacts of Over-Exploiting Aquifers with Deteriorating Water Quality in Semi-arid Regions*"

Key messages
- **Education on many levels would change the future of water.**
- **Competency-based curriculum (CBC) development is necessary to overcome the skill gap and better prepare future engineers to address agriculture and water's challenges.**
- **Hydraulic characteristics and properties (from groundwater potential maps, sampling kits, records, etc.) are useful tools for groundwater prospecting in complex geological rural contexts.**
- **In areas with poor water quality, the promotion of nutrient-rich diets with perishable food can deteriorate food safety due to water pollution.**
- **The recovery of over-exploited aquifers will take centuries even in the most optimistic scenario. Thus, it is important to act now.**

Session Summary

Due to the current situation of growing world population and water usage, it is necessary to educate people on the correct use of water resources. Water education is extremely important because it's a health issue. Improving quality of life for people implies a change in the way we learn. It is important to take all the data we collect from different studies worldwide and make it available for people in ways that are easy to understand. This creates learning opportunities for everybody. In this context, it is also important to educate young children on the right way to use water resources. Because the young children of today would be the world leaders of tomorrow (ages from 4 – 11 are critical). The way in which children can learn is through their educators. Professors worldwide have a huge impact on their student's day by day. It is also important that big corporations act on their water usage and how they educate their employees.

Tunisian system of research and higher education in agriculture was founded in 1990. Today, one of the biggest concerns when it comes to investigation and education in the agricultural field is the low employability for agricultural engineers, especially the ones that are just graduated.

The formulation of competencies in Tunisia presently is based on four main things: policy reports, surveys, workshops, and benchmarking. In the context of water sector, three domains of professional development are needed to be developed:

1. Water resources and development
2. Water, sanitation, and hygiene
3. Irrigation

Water management and climate change are two big challenges for Tunisia's agriculture policy. Degradation of water quality, mismanagement of water resources, and scarcity of renewable water resource are others.

Hydraulic characteristics and properties (from groundwater potential maps, sampling kits, and records) are useful tools for groundwater prospecting in complex geological rural contexts. These tools are especially needed to address public health concerns due to fluoride concentration which is doubling the WHO upper limit.

In areas with poor water quality, the promotion of nutrient-rich diets with perishable food can deteriorate food safety. Water pollution directly from food systems indirectly induce other contaminations. Contamination of fruits and vegetables along the food system creates cross- contamination if water is not refreshed sufficiently. Therefore, lack of access to safe tap water indirectly affects food security.

The impact of over-exploiting an Aquifer can be divided into four main areas:

1. Falling water tables
2. Deteriorating water quality
3. Human development
4. Wealth

Falling water tables would lead to problems in regions that are exclusively dependent on groundwater. This is important because the impact and the recognition of these problems usually have very long-time lags that hide the true externalities of big agriculture production. When it comes to low quality water, the cost of mitigating his problem is large. But there is a high economic return if there is a good investment in mitigating. The recovery of this over-exploited aquifers will take centuries, even in the most optimistic of scenarios. Lack of systematic accounting for present and future impacts will delay the full recognition of trade-offs and inequalities from over-exploiting aquifers.

Overall, it can be concluded that education and research are needed to identify the problems that the world is facing right now with the use of water resources. Correct use of these resources is extremely important, due to lack of consumable water worldwide. Also, it is very important to bring research close to people, in particular people from poor and vulnerable countries to create a larger impact on future generations. Food quality and usage are both public health issue; therefore, it is urgent to endorse them and take action now.

CLOSING CEREMONY

This session is dedicated to the memory of Marlos De Souza, who passed away in November 2021

Moderator

Renée Martin-Nagle, IWRA Treasurer; CEO, A Ripple Effect pllc; Special Counsel at Eckert Seamans; Visiting Scholar at the Environmental Law Institute

Co-Moderator

Mary Trudeau, Project Officer, IWRA

Summary Remarks

Tanja Miškova, Ambassador of Water Diplomacy and Circular Economy, Ministry of Foreign Affairs, Slovenia
Abou Amani, Director, Division of Water Sciences, UNESCO & Secretary, Intergovernmental Hydrological Programme (IHP)

Keynote speakers

Edeltraud Guenther, Director, UNU-FLORES

Thematic Summaries

Bassel Daher, Research Scientist, Texas A&M Energy Institute
Pedi Obani, Assistant Professor, School of Law, University of Bradford
Mark Smith, Director General, International Water Management Institute (IWMI)
Raya Marina Stephan, International Water Consultant, Deputy Editor-in-Chief Water International & Executive Board, IWRA
Dave Tickner, Chief Freshwater Adviser, WWF-UK

Closing Remarks

Marlos De Souza, Secretary – Water Platform, Food and Agriculture Organization of the United Nations
Rabi Mohtar, Dean Faculty, Agricultural and Life Sciences, American University of Beirut & Professor, Environmental Resources, Engineering Texas A&M
Gabriel Eckstein, IWRA President; Professor of Law, Texas A&M University, & Director, Law School's Program, Natural Resources Systems

Highlights

- **Water, food, and agriculture are bound together as a system; hence, agricultural management provides a set of system levers for better understanding.**
- **Agricultural practices are directly related to health, considering the food supply chain.**
- **The complex inter-linkages between water, food, and public health can be fully understood through accessible science and data.**
- **Groundwater plays a key role in global water supply, resulting in more emphasis on their associated challenges.**
- **The all-important nexus between water, food, and public health is best demonstrated in the pharmaceutical, textile, and farming industries, respectively.**
- **Different stakeholders bear the costs of neglecting the nexus between water, food, and public health, resulting in intended and unintended consequences and effects.**
- **Climate change has the potential to impact major exporting nations of the world, thereby increasing world market prices and risk of hunger in low-income nations.**

Session Summary

The availability of water is a humanitarian issue. Hence, there should be a contextualised and transformative approach to the study of water, food, and public health and their interlinkages. Also, human development and capacity building in the study of water should be given the utmost importance. Water should be at the top of every global and environmental discussion. It is equally important to support inter-disciplinary data sharing, innovation, human development, and capacity development in order to improve global water regulations.

There is an opportunity for cross-fertilization in the issues of water, food, and public health. The inter-linkages extend to the environment and ecosystems. The complexity of the inter-linkages cannot be fully addressed without the aid of relevant and accessible scientific knowledge. One pressing issue, which is yet to be fully addressed, is the pumping of groundwater. Intensive groundwater pumping for irrigation and domestic purposes has depleted aquifers in many regions, leading to water security cases and contributing to food safety and public health issues. This is due to declining water tables. As groundwater plays a significant role in global water supply, water resources control can aid vulnerable countries in addressing the issue of groundwater management.

The cost of neglecting the nexus between water, food, and public health results in intended and un-intended effects. The un-intended effects include damages (costs) as sanctions by the courts, other legal sanctions, licences, insurance, as well as opportunity costs. The costs are borne by different stakeholder, most notably, the public and private sectors.

Community engagement is key to understanding the complex relationship between water, food, and public health. This can be done by creating partnerships between governmental and non-governmental organisations (NGOs). The public can then support the public policies enacted by government. New technology also has a role to play.

Finally, the potential for science to better inform public policy, governance, and capacity building for water, food, and public health is best understood through a three-dimensional framework: science as driver; science and inclusivity; and science and public policy. It is very important to play close attention to the issue of inclusivity in promoting better water policies.

MAIN FINDINGS

Throughout the 16 sessions conducted within the IWRA Online Conference 2021, it has become evident that water is a humanitarian issue, with wider implications in themes such as food, agriculture, and public health, just to name a few. These three areas, explored throughout the three days of the Conference, present clear inter-linkages to the protection of environment and ecosystems. In consequence, water resource management is deeply rooted in the survival of all livelihoods.

The level of specificity addressed in the sessions aimed at covering these complexities as well as worked to highlight the role that water plays at the core of environment-related actions.

Coming together to advance those themes, with the support of FAO, UNESCO, AUB, CWRA and the Texas A&M University, this conference has worked to advance the interlinkages between academic research and the work in the field. Only by enhancing cooperation modalities can we advance the nexus between water, food production, and public health, especially in changing and challenging times such as the ones we are currently living in.

A clear finding resulted from the debates conducted at the Online Conference, which is that the health of the ecosystems reflects the health of the entire humanity. Under those premises, governance and capacity building lie at the core of all efforts, and this explains the selection of this theme as one of the five areas addressed.

We hope that the lessons learned from the IWRA Online Conference 2021 will lead us to continue leveraging the debates and contributing to advancing these topics. We hope that the 2022 Online Conference will be even more productive.

THEME I: HOW CAN WE BETTER MANAGE WATER FOR FOOD AND PUBLIC HEALTH IN A CHANGING WORLD?

Water is intrinsically linked with food and public health. Without sufficient water resources and effective management, food insecurity and lack of hygiene and sanitation threaten human health and wellbeing. Managing water as the binding element for food and public health is crucial to achieving the Sustainable Development Goals (SDGs), adapting to global changes, and preparing for future pandemics. It is increasingly more important to manage water for food and public health as it is to adapt to climate change, recover from COVID-19, and to increase resilience to future uncertainties. Policy makers and water managers have a wide variety of established strategies at their hands to address challenges within the water-food-public health nexus, along with innovative new approaches for managing water in a changing world. Selecting a portfolio of appropriate actions for managing water for food and public health requires consideration of local conditions, community support, and technical and human capacity.

Key Policy Messages:

- **Climate change and the impacts of COVID-19 highlight the increased importance of examining the inter-linkages between water, food, and public health.**
- **Strategies to address challenges within the water-food-public health nexus include Managed Aquifer Recharge (MAR), Circular Economy approaches, and the strategic application of data and information.**
- **The long-term sustainability of policies and programs requires location-specific strategies, with community participation, considering the critical role of women and girls.**

THEME II: HOW CAN MANAGING WATER IN AGRICULTURE CONTRIBUTE TO FOOD SECURITY AND PUBLIC HEALTH?

Water management in agriculture is becoming increasingly complex with climate change and other stressors, such as land use change and population growth. Sound water management is crucial to global food and nutrition security, for public health, and for poverty reduction. Pilot projects, use of lessons learned, and flexibility for adaptive management, with local farmers at the centre of all interventions, lead to on-going measures to prioritize human welfare and ecosystem functionality.

Key Policy Messages:

- **Agricultural water management, always complex and multi-dimensional, is becoming more so.**
- **New challenges require both teams of transdisciplinary experts and local knowledge.**
- **Policy design and shared governance should target barriers and provide incentives to adopt best practices.**
- **To improve water-food-energy management, engage and empower farmers.**

THEME III: WHAT OPPORTUNITIES LIE IN THE IMPROVED COOPERATION BETWEEN WATER, FOOD, AND PUBLIC HEALTH SECTORS?

The water, food, and public health sectors are interrelated in multiple and complex ways. Water is essential to agricultural production, and it is also the foundation for public health, hygiene, and sanitation services. Similarly, food is a key determinant of health; yet food production and sanitation services can have direct impacts on water quality, water availability for other uses, and ecosystem health. Environmental components–such as air, water, land, and ecosystems–provide essential services to humans while also creating potential pathways for exposure to pathogens under conditions of poor hygiene, inadequate infrastructure, inundation, scarcity, a lack of standards and codes, and incomplete public education. Water management is a focal point that tethers and enables all other sectors. Water, food, and public health share many common goals, but there has been a lack of coordinated cross-sectoral initiatives. Education, outreach, communications materials, websites, and inter- agency partnerships to maximize available resources are all part of a comprehensive approach to protect water supplies, food sources, and public health.

Key Policy Messages:

- **Formal and informal institutional relationships need to be developed and fostered across the water, food, and public health sectors to break barriers and to develop collective actions.**
- **Resources are needed to support partnerships and to engage communities in solutions to cross-sectoral challenges.**
- **Technologies, tools, and data are important to inform public policy and to reduce risk.**
- **Alternative crops and monitoring trends in food production is needed in regions experiencing climate-related shifts in water availability.**

THEME IV: WHAT ARE THE SYNERGIES AND TRADE-OFFS BETWEEN ECOSYSTEM HEALTH AND HUMAN HEALTH?

The carrying capacity of water resources is the maximum level of sustainable socioeconomic activity that can be supported by available water resources, while also protecting ecosystems. This idea is straight-forward conceptually, but very complex in practice. To protect ecosystems, human water resource use must consider water quality, quantity, timing of flows, and the natural spaces that convey and store water resources, such as river corridors, riparian zones, and aquifers. For aquatic ecosystems to function, human demand-supply relationships need to be managed on an on-going basis, for example to release pulse flows at critical times of the year and to maintain minimum flows required to sustain aquatic biota.

More work is needed to effectively communicate scientific information to the general public. Also, more focus is

needed on making difficult decisions regarding trade-offs which will benefit the environment but also have potential economic or social cost benefits over the short-term, or on a local scale. Sound decisions to protect the environment ultimately also benefit society and the economy. There is an urgent need to protect and restore aquatic ecosystems. The rationale for making difficult decisions to protect ecosystems needs to be developed by governments and all stakeholders, and they must be supported by communications and capacity development activities.

Key Policy Messages:

- **Capacity development is needed to implement comprehensive water management processes, such as triple-bottom line and life-cycle cost analyses.**
- **Economic instruments, such as pollution trading and carbon credits, can stimulate improved agriculture and aquaculture practices that benefit human and ecosystem health.**
- **Well-drafted and well-implemented regulations can be a key to regulate human water demand and water supply to accommodate aquatic ecosystem needs.**
- **There is an urgent need to protect and restore, as well as to make difficult decisions that may have negative social or economic trade-offs.**

THEME V: HOW CAN SCIENCE BETTER INFORM PUBLIC POLICY, GOVERNANCE AND CAPACITY BUILDING FOR WATER, FOOD, AND HEALTH?

Scientific research and knowledge are crucial inputs for policymaking, providing not only deeper understanding about ecological processes but also systematic guidance in how monitoring is undertaken and used by policymakers.

The way forward should be built around the three T's: transparency in data and policy processes; transition in individual and collective thinking and habits; and translation of complex scientific issues into information which is understandable by the public. These steps are essential as ecological threats worsen and technology continues to develop and deepen its influence.

Key Policy Messages:

- **Emerging technologies are changing how groundwater policy decisions are made by expanding monitoring and communications.**
- **The science-policy interface is facilitated by these technologies but also remains a primarily political dynamic, underscoring the importance of communication and public understanding.**
- **The public should be better educated on groundwater management and related matters to enable more equitable facilitation of science-based policies.**

CONCLUSIONS

The high participation levels registered under the IWRA Online Conference 2021–comprising 1,400 attendees from over 100 countries–speak about the interest around water resources management alone, but also about the global scope of this theme.

A second lesson learned is the impact that cross-cutting analysis and multi-stakeholder engagement followed throughout the three-day event–including UN agencies, civil society entities and research and academic institutions–bring to this type of events. They guarantee that all areas of research and levels of expertise are included.

Knowledge-sharing and bringing together different areas of expertise, ranging from water governance, capacity building and public information around water management has been at the core of the work of IWRA in the last 50 years. However, it is especially in our Online Conference where we realise that these approaches constitute the best way to advance.

In addition to these, a key concern when organizing the Conference was to incorporate the latest trends and movements around water management. For that purpose, technology and innovation occupied a remarkable part of the sessions. The impact of water management on communities but also how urbanization needs to be included when proposing solutions was also part of the discussions.

With the inclusion of these many complexities, the IWRA Online Conference tried to underline the need to have all relevant stakeholders aligned, from governments to multilaterals but also to private sector recipients and even media.

We will strive to continue engaging new stakeholders but also tackling current themes around water management in future conferences.

> LINK TO THE RECORDINGS

iwraonlineconference.org/recordings-2021

RECOMMENDATIONS FOR FUTURE ACTION

The complexities around the interlinkages between water, food and health, that were explored throughout the IWRA Online Conference 2021 have helped us to reflect on a series of recommendations that we would like to keep in mind for enhancing our future action and for advancing toward the Agenda 2030 and the eventual SDGs:

1) For many years, the presence of water resources management has been absent from global debates around food, health, and other key challenges, such as climate change. At present, and under an unprecedented crisis, we started to see how water has been included in these discussions that should lead to policy development. The inclusion of water resources management in wider debates around climate change and environmental protection should continue to be enhanced as it lies at the core of the current crises that the world faces.

2) The multidisciplinary approach emphasised across the IWRA Online Conference 2021 that allowed to bring experts from different backgrounds and levels guarantees that all angles, interests, and expertise of diverse nature around water resources management are tackled.

3) The online context provides a unique opportunity to convene experts from diverse territories and to respect the geographical balance of this type of forums. Only by protecting this added value, can the discussions, debates, and proposed solutions achieve their full potential and can we respond to real challenges.

4) The dissemination of knowledge generated by this type of events is as important as its preparation and implementation. IWRA has widely focused on this aspect with the intention of continuing engaging diverse stakeholders in future debates, as well as leveraging the debate around water resources management. This Report and other outreach actions, especially those conducted in the online environment, are shaped to cover that vision.

ANNEX I
ABSTRACTS

Gevrekçioğlu, N., Elçi, A., Dilaver, M., Ayaz S., Receiving water quality models for estimation of total maximum daily pollutant loads: case study of the Küçük Menderes river basin (Turkey) (Theme 1)

Ghosh, K., Integrated pathways for sustainable agriculture and rural development for smallholders in Saudi Arabia (Theme 2)

Grigg, N., Breaking organizational stovepipes connecting water, sanitation, food and public health (Theme 3)

Guenther, E., The costs of neglecting the nexus of water, food and health (Closing ceremony)

Gunatilake, S.k., Analysis of spatial variability of groundwater quality in different climatic zones of Sri Lanka (Theme 3)

Gupta, D., Free power, irrigation and groundwater depletion: impact of the farm electricity policy of Punjab, India (Theme 5)

Höllermann, B., Näschen, K., Tibanyendela, N., Kwesiga, J., Evers, M., Environmental perception and agricultural decision-making: understanding the hetereogeneity of farmers' agricultural practices in a changing and uncertain environment - Case study from Kilombero Valley, Tanzania (Theme 1)

Ibrahim, I., Legal implications of the use of big data in the transboundary water context (Theme 5)

Ijioma, U., Herd, R., How safe are drinking water sources in developing urban settings? A case study of Aba, Nigeria (Theme 1)

Jones, J., Understanding and guiding complex systems to achieve multiple societal goals (Opening Ceremony)

Kaur, L., Godara, P., Suthar, K., Impact of Mining Activities on the Socio-Economic Status and Water Quality of Kolayat Mining Area, Bikaner (Rajasthan) (Theme 1)

Knappett, P., Woodward, R., Farias, P., Hoogesteger, J., Hernandez, H., Datta, S., Miller, G., Mendoza, I., Carrillo, G., Li, Y., Loza, I., Terrell, D. Accounting for the human impacts of over-exploting aquifers with deteriorating water quality in semi-arid regions (Theme 5)

Kumar, J., Joshi, H., Exploring removal of heavy metal ions from wastewater stream employing electrocoagulation and nanofiltration processes (Theme 3)

Kumar, P., Rangi, M., Rohtak Mr, Singh K., Rejuvenating resilience in the agrarian livelihood of Western Indian Himalayan region - A water perspective (Theme 2)

Kumar, P., Rangi, M., Singh, K,, Sustaining groundwater resources for stabilising agrarian livelihood: a case study of South-Western Haryana (Theme 1)

Li, Y., Yu, L., Yang, Y., Sun, F., Strategy of groundwater exploitation and utilization based on groundwater functions in China (Theme 4)

Linderhof, V., De Lange, T., Reinhard, S., Nutrient-rich diets increase food security, only if proper water quality is guaranteed (Theme 5)

Manoba Limantol, A., Amoah, A., Access to handwashing with soap facility in Binduri district: a post-sensitization investigation of drivers (Theme 1)

McCartney, M., Mendes, M.P., Janik, K., Fernández-Escalante, E., Salman, M., Schwarzmüller, H., How can we better manage water for food (Theme 1)

Mendes, M.P., Likar, D., Digital water management for improving resilience of agriculture, food and health as a response to global risks (Theme 1)

Metzner, R. Fish food lives and livelihoods (FAO Special Session)

Miseckaite, O., Impact of climate change on the hydrological changes of subsurface drainage (Theme 3)

Miškova, T., Amani, A., Guenther, E., Eckstein, G., Koo-Oshima, S., Mohtar, R., Thematic speakers: Stephan, R., Introduction to Closing Ceremony

Moe, C., How studies of water, sanitation and health lead us to food (Theme 3)

Mudimbu, D., Banda, K., Brauns, B., Lapworth, D., MacDonald, A., Namaona, W., Owen, R., Sinda, M., Capacity building in multi-disciplinary scientific methods for improved understanding of the impact of conservation agriculture on groundwater resources in Africa (Theme 5)

Mudimbu, D., Meck, M., Davies, T., Tagwireyi, D., Mudimbu, D., Geogenic contaminants in water and vegetables and the aetiology of non-communicable diseases in mineralised areas: the case of Kadoma, Zimbabwe (Theme 3)

Mudimbu, Myagkov, S., Ibrahim, I., Tanui, F., How can science better inform public policy, governance and capacity building for water, food and health? (Theme 5)

Musser, Steven M., The environmental surveillance of agricultural water using WGS and its impact on food safety (FAO Special Session)

Myagkov, S., Zadoroznaya O., Method for assessing the health risk of the rural population from the hydrochemical regime of surface waters (Theme 5)

Naik, G., Shenoi, P., Water, energy, food nexus and energy subsidies in irrigation in India: externalities and its impacts on food security, water security and public health (Theme 2)

Ntajal, J., Falkenberg, T., Kistemann, T., Evers., M., Land use dynamics, urban transformation and the complexity of surface water pollution identifying risks and developing integrated solutions to water-borne disease in Accra, Ghana (Theme 3)

Nzama, S.M., Kanyerere, T.O.B., Science-policy nexus: using resource directed measures as policy implementation strategies to promote integrated water resource management, South Africa (Theme 5)

Pancevska, N., Pancevski, I., Kungulovski, D., The variation of microbiological quality of water from reserve Hasen, North Macedonia (Theme 1)

Puttaiah, S., Anilkumar KM, Water management at agricultural catchment - Sustainable and technology approaches for pollution control (Theme 2)

Rahmani, S., Rouzaneh, D., Razmavar, F., Jafari S., Adaptation strategies and barriers to water scarcity: a qualitative analysis in Southern Iran (Theme 2)

Riaza Fernández, F., Blanco Gutiérrez, I., Esteve Bengoechea, P., Millan Gómez, J., Water as an explanatory factor for food security in dryland countries (Theme 2)

Rooyen, A., Riaza Fernández, F., Naik, G., Torri, R., Keletso, T., Berni, I., How can managing water in agriculture contribute to food security and public health? (Theme 2)

S.M. Nzama, T.O.B. Kanyerere and H.W.T. Mapoma, Using groundwater quality index and concentration duration curves for classification and protection of groundwater resources to improve access to clean water and sanitation, South Africa (Theme 1)

Salman, M., Pek, E., Ahmad, W., How can multiple water use services help mitigate the impacts of Covid-19? Smart irrigation smart wash in support of Food Security and Health (Theme 1)

Samuel, A., Coupled Natural and Economic Systems: the role of efficient water resource management in economic recovery (Theme 3)

Santos, I., Forestier, R., Forestier F.B., Françon A., Muela A., Thoughts: genomics and sulfur water bath through skin of emotional, rheumatoid arthritis patients (Theme 4)

Schwarzmüller, H., Caradot, N., Sperlich, A., Greenhill, B., Bernardi, M., Housni, S., Dimoval, V., Rouault, P., Digital-water city leading urban water management to its digital future (Theme 1)

Shah, A., Eteng, E., Gunatilake, S.K., Kumar, J., Leslie, G., Paruason, L., Ntajal, J., What opportunites lie in the improved cooperation (Theme 3)

Shah, A., Nizami, S.M., Ali, K., Impacts of climate change on the production of major crops and health security in Gilgit Baltistan Pakistan: Water-food and health nexus (Theme 3)

Sharma, K., Laskar, N., Sustainable spring watershed management system in the indo-himalayan region: village community challenges and its planning approaches (Theme 2)

Sharma, K., Puttaia, S., Kumar, P., Ghosh, K., Jafari, S., Van Biljon, C., Fernández-Escalante, E., How can managing water in agriculture contribute to food security and public health? (Theme 2)

Sitek,S., Janik, K., Piechota, A., Mukawa, J., Suitability mapping as an effective tool for identifying potential locations for managed aquifer recharge: a case study: Dunajec catchment, Poland (Theme 1)

Slathia, D., Jamwal, K., GIS based fluoride contamination mapping of groundwater and its exposure risks to the hilly populace of the Chenab River Basin in Jammu Province, North India (Theme 1)

Soussi, T., Mahjoub O., Competency-based curriculum design to enhance the employability of agricultural engineers in water sector in Tunisia (Theme 5)

Tanui, F., Olago, D., Oluma, G., Kuria, Z., Dulo, S., Comprehensive groundwater research: evidence to policy perspectives in Asals (Theme 5)

Torri, R., Barbero, A., Manni, F., Benacchio, G., Cerise, S., Hydrological assessment approach for the elaboration of the hydro-agricultural infrastructure project aimed to the development of mangrove rice cultivation in Guinea Bissau (Theme 2)

V. Sharma, Agricultural practices by enhanced water quality through iron-based (ferrate) technology improved population health (Theme 3)

Van Biljon, C., Ringler, C., Bryan, E., Mekonnen, D., Does small-scale irrigation improve wash outcomes? Insights from rural Ethiopia (Theme 2)

Van Rooyen, A., Bjornlund, H., Pittock, J., Evidence from Africa and propositions for further work (Theme 2)

Verburg, G., Musser, S., Bahri, A., Panella, T., Williams, T., Tracy, J., One water, one health: water,food and public health in a changing world (High panel)

Wagenaar, J., WHO model for integrated surveillance on AMR. The ESBL EC tricycle protocol (FAO Special Session)

Webster, J., Corby, C., Spencer, W., McCausland, R., Bennett-Brook, K., Shanthosh, J., Rosewarne, E., Baldry, E., Leslie, G., Food and water for life: co-creation and evaluation of sustainable community-led innovations to strengthen food and water security (Theme 3)

Yamasaki, T., Janzen J., Mass retention in a floating treatment wetland with varying root lengths (Theme 4)
Yanni, S., Daher, B., Bachour, Koo-Oshima, S., Mohtar, R., A nexus trade-offs analysis of water, energy, food, nutrition and feedback to the environment in Lebanon (Theme 4)
Zhongnan Z., Wang, D., Exploration of a good water management system for both human development and ecosystem sustainability (Theme 4)
Zhou, K., Microbiological hazards and safety and quality of water used in food production (FAO Special Session)
Zhuang, Y., Enhancing well water safety through university and health department partnership (Theme 3)
Zingchang, H., Groundwater potentials assessment of Langtang area, Plateau State North Central (Theme 5)

ANNEX II
POSTERS

Abraham, M., Venugopal, K., Hydrological Modelling of Chain of Tanks to Augment Rural Water Supply for Increasing Agricultural Productivity, (Theme 2)

Aliyu A.Q., Abdulrahman, S.H., Wulet, A.A., Impacts and Possible Water Solutions for Food and Health in Regions Suffering Conflict and Political Crises: A Perspective of North-Eastern Nigeria, (Theme 1)

Bisht, M., Suitability of Groundwater for Irrigation Purposes in Mewat Region of Haryana, India, (Theme 1)

Höllermann, B., Näschen, K., Tibanyendela,N., Kwesiga, J., Evers, M., Environmental Perception and Agricultural Decision-Making: Understanding the Heterogeneity of Farmers' Agricultural Practices in a Changing and Uncertain Environment – Case Study from Kilombero Valley, Tanzania, (Theme 1)

Ijioma, U.D., Herd, R., How Safe Are Drinking Water Sources in Developing Urban Settings? A Case Study of Aba, Nigeria, (Theme 1)

Kaur, L., Godara, P., Suthar, K.G., Impact of Mining Activities on the Socio-Economic Status and Water Quality of Kolayat Mining Area, Bikaner (Rajasthan), (Theme 1)

Miseckaite, O., Impact of Climate Change on the Hydrological Changes of Subsurface Drainage, (Theme 2)

Mudimbu, D., Meck M.L., Davies, T., Tagwireyi, D., Mudimbu, D., Geogenic Contaminants in Water and Vegetables and the Aetiology of Non-Communicable Diseases in Mineralised Areas: The Case of Kadoma, Zimbabwe, (Theme 3)

Nzama, S.M., Kanyerere, T.O.B., Mapoma, H.W.T., Using Groundwater Quality Index and Concentration Duration Curves for Classification and Protection of Groundwater Resources to Improve Access to Clean Water and Sanitation, South Africa, (Theme 1)

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Samuel, A.J., Coupled Natural and Economic Systems; The Role of Efficient Water Resource Management in Economic Recovery, (Theme 3)

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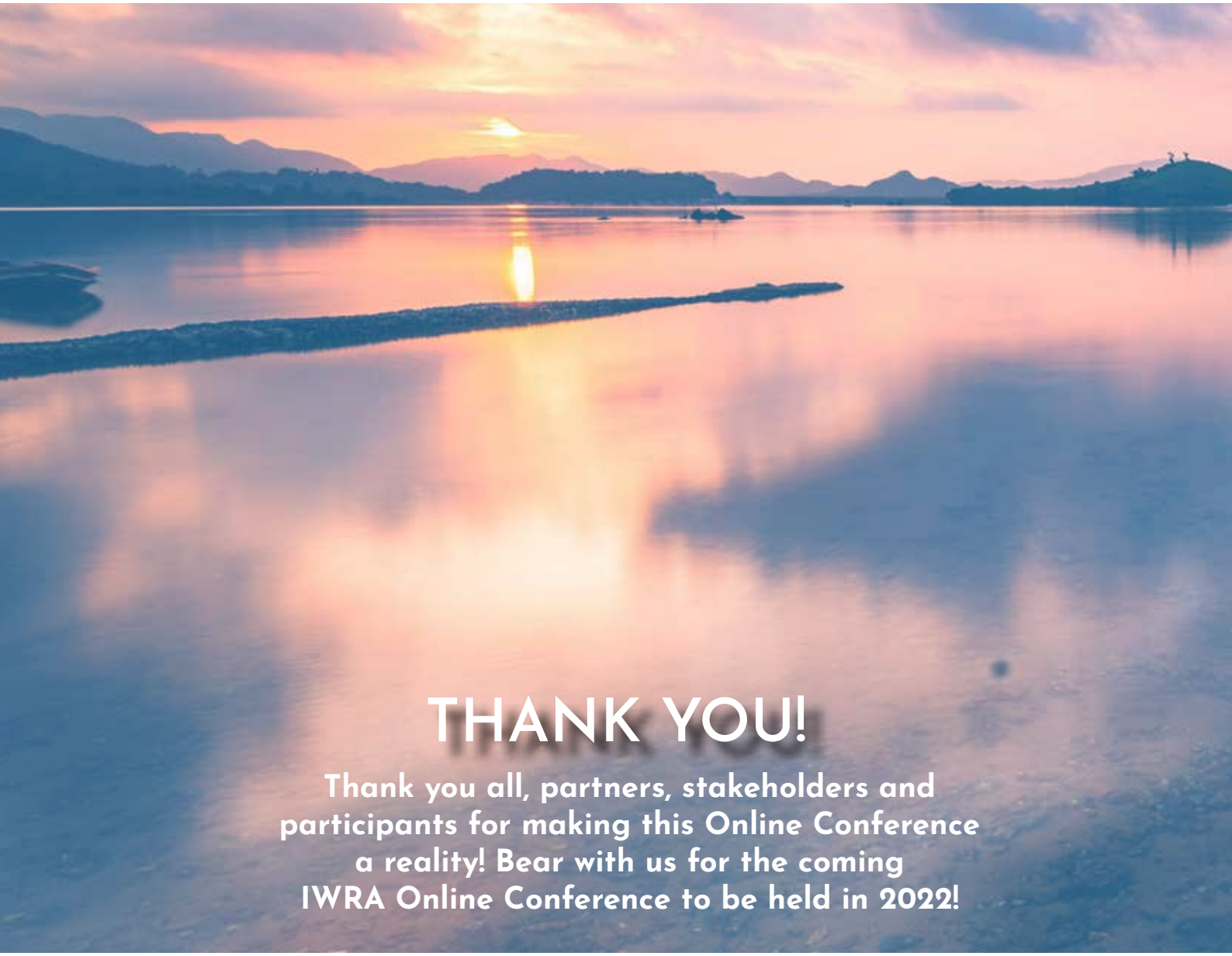

THANK YOU!

Thank you all, partners, stakeholders and participants for making this Online Conference a reality! Bear with us for the coming IWRA Online Conference to be held in 2022!

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