2nd Summer School WEFECA 2023

Contents

About

Sustainability assessment of the water–energy–food–environment nexus for irrigated agriculture: Interdisciplinary approaches for Central Asia (WEFCA)

2nd International Summer School 2023

Aim: The summer school aims to strengthen professional capacities of participants to adopt a water–energy–food–environment (WEFE) nexus approach to meet multiple sustainable development goals and support inclusive development in Central Asia and beyond. The training will focus on sharing advanced methods for conducting sustainability assessment of the WEFE nexus, integrating the notions of ecosystem services, resource use efficiency, long-term soil quality maintenance, human health and economic viability using empirical examples from Central Asia (CA).

Target Participants: The summer school brings together talented early-career scientists (PhDs and Post-docs) conducting research on natural or social sciences in CA to stimulate intraregional research cooperation. Interested candidates from universities and research institutions in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, as well as in Germany are encouraged to apply. The maximum number of participants is 25. The course language is English.

Content and Format: The summer school starts with two days of classes that include introductory lectures on advanced empirical methods for analyzing sustainability dimensions of WEFE as well as extensive practical exercises. The summer school provides a panorama of interdisciplinary and transdisciplinary methods and experiences in social and natural sciences, relevant to the study of WEFE nexus. During the exercises, the students form a group (5–6 students per group) and get individual advice from their teachers. On the third day, a field trip to the case study region (preferably, Tashkent province) is planned, where local stakeholders present their practical problems and students learn from practical examples/observations. On the last two days, the students prepare and present the results of their group work by applying different methods that they have learned during the week. Throughout the week, the students have the chance to interact and get personal feedback on their projects from lecturers, all being renowned scientists.

Date and Location: The summer school is planned for five days during the period 21 – 25 August 2023 in Tashkent, Uzbekistan. It will be hosted by "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers National Research University" National Research University ("TIIAME" NRU).

Rationale: Agriculture remains an important sector in the economy of CA (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan). The sustainable use of agricultural land is therefore essential to economic growth, human well-being, social equity, and ecosystem services (Hamidov et al. 2016). However, salinization, erosion, and desertification cause severe land degradation which, in turn, endanger human health and ecosystem services. Elevated water tables, associated with decades of heavy irrigation, combined with insufficient drainage have led to secondary salinization of croplands and watercourses (Toderich et al. 2002; Varis 2014). Soil salinization now affects over 47% of the irrigated lands of CA and is a major threat that is leading to declining crop production and deteriorating environmental services (Bucknall et al. 2003; Kushiev et al. 2005). Moreover, population growth along with emerging climate change problems (e.g. increased temperatures) have resulted in rising water demand for both, energy and irrigated agriculture. The conflicting interests between water for energy (numerous power plants are newly built or planned in the area) and water for irrigation have been complicating water resource management there, including efforts to meet the increasing food demands of a rapidly growing population (Djumaboev 2015). For instance, in May 2017, the government of Uzbekistan issued a decree to construct 42 small hydroelectric power plants for energy purposes between 2017 and 2021. This may have implications for water availability for irrigation in terms of quantity, quality, reliability and timing of water delivery, which are decisive parameters for irrigated agriculture. These issues have resulted in a decline in the production of agricultural crops in the region. Meanwhile, construction of power plants for energy may have environmental impacts, as there is a recent discussion on increased carbon dioxide (CO_2) and methane (CH_4) emissions (Deemer et al. 2016). Because of the strong correlation between soil salinization and yield decline, consideration of soil quality maintenance in the water–energy–food concept can be taken as a means for assuring long-term food security and long-term maintenance of ecosystem services. Proper irrigation management at the technical level as well as proper water management at the WEFE governance level is key to bringing them into the decision process, and ex-ante impact assessment is a means of doing so (Helming et al. 2011).

Introduced by the United Nations in 2015, Sustainable Development Goals (SDGs) are globally applicable and will need to be implemented by all national governments in the coming years. Central Asian countries also agreed to fulfill the SDGs by 2030 to ensure the protection and sustainable use of its natural resources. In this vein, WEFE nexus study aims to support facilitating a number of SDG achievements. In particular, nexus-relevant SDGs include SDGs 2 (food security and sustainable agriculture), 6 (sustainable management of water), 7 (modern energy), 13 (climate action), and 15 (terrestrial ecosystems).

Educational Objectives: The main aim is to train early–career scientists on advanced research methods for studying agricultural land use systems under irrigation. The specific objective is to apply interdisciplinary approaches for advancing scientific knowledge in the areas of water, energy, and food in CA. It seeks to undertake sustainability assessment of the WEFE nexus, taking into consideration soil quality, ecosystem service maintenance and long-term food production (Fig. 1). Last but not least, it plans to provide its participants with a comprehensive look into theories and methods (e.g. Qualitative comparative analysis (QCA), systematic reviews (Web of Science and Scopus analysis, as well as Endnote), participatory impact assessment (PIA), driver–pressure–state–impact–response (DPSIR), and text analysis using Atlas.ti qualitative data analysis tool for addressing empirical problems.

The students will be engaged in discussions and group work on the key issues. The study field visit will be organized to the areas that are affected by salinization and the dilemma between water for energy use and water for agriculture. In addition, soil degradation and crop production under environmentally stressed areas will be monitored. A field trip will provide participants the opportunity to interact with local stakeholders to discuss their experience with WEFE challenges. This kind of interdisciplinary teaching approach usually does not appear in regular courses at universities in CA and is also not mainstreamed yet in German universities. Thus, students will be introduced to

Salinization of agricultural land in Central Asia.
https://www.jircas.go.jp/en/program/3rd/program_a/b7

research ideas that open cutting-edge research to address sustainability problems in their study area.

Participants will be expected to contribute to the course in the following way:

→ active participation in all phases of the course, this includes reading the relevant literature in advance of the course and discussions;
→ carrying out a group project that applies one of the methods discussed in the class to a self-selected case study;
→ participating in study field visits and collecting empirical data using different methods;
→ presenting and discussing the group assignments.

Figure 1 provides a schematic overview of the interpretation of the WEFE nexus for the proposed summer school, where water is utilized for energy purposes as well

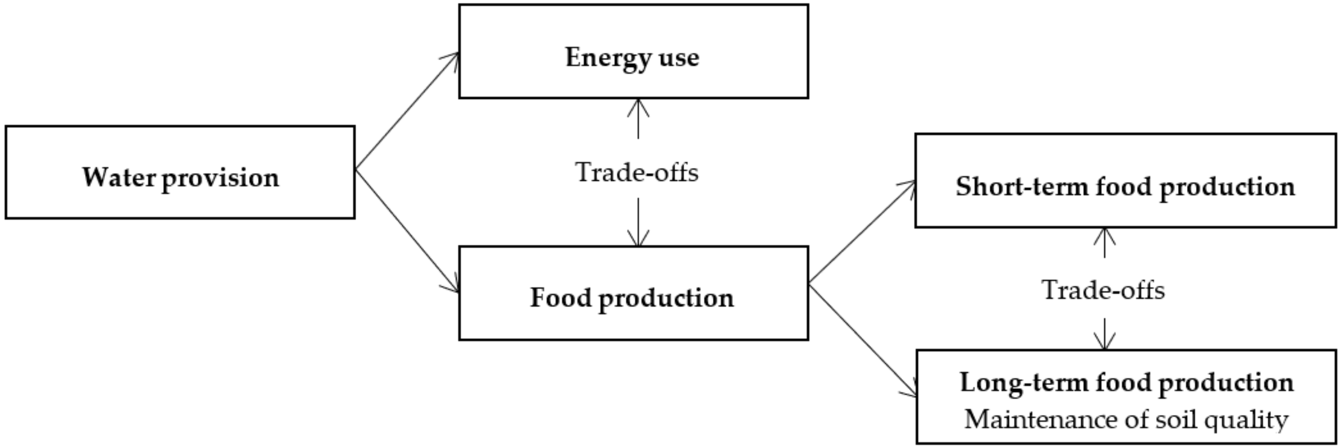

Figure 1. Schematic overview of the interpretation of the WEFE nexus for the proposed summer school

as for agricultural food production. There is a trade-off between these two sectors over water provision. In addition, food production can have short-term or long-term targets when taking into consideration maintenance of soil quality, and there is a trade-off between these targets with regard to irrigation and crop management. The sustainability perspective of the study focuses on decisions for long-term food production that take avoiding soil salinization into account.

Organizing Institutions: "TIIAME" NRU, hosting institution of the summer school, is well-known agricultural and water-related university in Uzbekistan. "TIIAME" NRU mostly educates specialists in agriculture with focus on water and land management, hydro-melioration, environmental conservation, soil salinity, and power dynamics engineering. "TIIAME" NRU has gained a broad international recognition in the aspect of research and academic exchange. It has participated in numerous international research projects, such as SusWEF (Sustainable Water-Saving Irrigation Technologies for Achieving Water, Energy and Food Security in the Context of Climate Change in Uzbekistan) and BioWat (Resources management in the salinized and drought stress-endangered irrigated areas of Central Asia for adapting to climate change), both funded by the German Federal Ministry of Education and Research. The vice rector for research – Prof. Takhirjan Sultanov – will be supporting the organizing team of this summer school at "TIIAME" NRU. He is an expert in the area of irrigation and drainage, soil science, hydraulic structures, and mechanical engineering.

Leibniz Centre for Agricultural Landscape Research (ZALF), Consortium of International Agricultural Research Centers (CGIAR) NEXUS Gains Initiative, International Water Management Institute (IWMI) CA Office, International Center for Agricultural Research in the Dry Areas (ICARDA) Office, International Food Policy Research Institute (IFPRI), Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT), organizing partners of this summer school, have long-term research experience on addressing issues related to water, energy, soil, and sustainable agriculture. In particular, ZALF is well-known for its interdisciplinary group of scientists who employ theoretical as well as advanced methodological tools in analyzing natural resource use.

Expected Results: After completing the course, participants will be able to:
→ understand and analyze empirical problems of the WEFE nexus in irrigated agriculture from scientific and practical perspectives;
→ apply theoretical and methodological tools to address research problems in relation to sustainable development;
→ work more effectively in collaboration with other disciplines for investigating trade-offs and interconnectedness of the three sectors water, energy, and food;
→ prepare a joint draft paper about the sustainability impact assessment of water–energy–food–environment nexus for irrigated agriculture in CA.

Selection of Participants: In order to get early-career scientists aware of the summer school, the call will be developed and circulated among the network of colleagues at agricultural faculties in Germany (e.g. Humboldt University of Berlin, University of Kassel, University of Göttingen, Osnabrück University, University of Bonn, Leibniz Institute of Agricultural Development in Transition Economies (IAMO), GFZ German Research Centre for Geosciences, University of Würzburg, University of Tübingen, and University of Eichstätt) as well as in Central Asia (e.g. "TIIAME" NRU, Samarkand Agricultural Institute, German-Kazakh University, Kazakh National Agrarian University, Kyrgyz National Agrarian University, Naryn State University, Tajik Agrarian University, Turkmen Agricultural University, and Khorezm Rural Advisory Support Service).

Application: Interested researchers should send their application documents in English language by e-mail (1 single pdf-file, max. 3 MB) to Dr. Shavkat Kenjabaev at S.Kenjabaev@cgiar.org. The participants are selected via group evaluation. The criteria considered are:

- → short statement about motivation for interdisciplinary agricultural research and expectations from attending the summer school (1 page max);
- → abstract of an own nexus-relevant research project (400 words);
- → background in scientific fields related to water, energy, environment and agricultural sciences;
- → interdisciplinary balance of the participants;
- → geographical balance of the participants;
- → gender balance;
- → proficiency in English language (IELTS 5.0 score or higher).

As a rule, PhD students should provide a letter from their organizations to prove their status. For Post-docs, the requirement is to have completed their PhD degree less than five years ago.

Application Deadline is June 20, 2023. Successful applicants will be offered fellowships covering travel, visa fees (if required), food and accommodation.

Lecturers: A list of preliminary participating lecturers and their profiles are provided below.

Prof. Katharina Helming is professor for sustainability assessment at the University for Sustainable Development (University of Applied Sciences) in Eberswalde, Germany. She is co-chair of the Research Area 3 "Landscape Research Systems" as well as the head of the Impact Assessment of Land Use Changes working group at ZALF. She has conducted sustainability impact assessment of agricultural land use in Central Asia, China and Europe. She uses scenarios and participatory methods to integrate knowledge systems for sustainable land use and soil management.

Prof. Abdulkhakim Salokhiddinov is Vice-Rector for International Affairs at "TIIAME" NRU in Uzbekistan. He also serves as Chairholder of the UNESCO Chair on Water Diplomacy, Water Resources Management and Environmental Protection at the "TIIAME" NRU. His areas of expertise are multipurpose water resource planning/management strategies/policies, hydrology of surface and groundwater resources, environmental protection, integrated basin management, and regional sustainable development.

Prof. Yarash Pulatov is professor and the head of the Department of Innovative Technologies of the Institute of Water Problems, Hydro Energy and Ecology of the Academy of Sciences of Tajikistan. His main research interests are sustainable water and energy management, irrigation and water law, and water, energy, food and ecosystem nexus. He is a member of the Regional Council of the Global Water Partnership in Central Asia and Caucasus, a member of Tajikistan society of soil scientists, and the chairman of the National Water Partnership in Tajikistan.

Dr. Ahmad Hamidov is post-doc researcher at ZALF and coordinator of SusWEF project. He is a lecturer at Humboldt University of Berlin for Master students on Advanced Empirical Methodology for Social-Ecological Systems Analysis course. He has vast experience in conducting research related to natural resource management (e.g. water, land, and pasture) in CA. His research work involves understanding the interconnectedness and the trade-offs of the three sectors water, energy, and food in small-scale river basins in Uzbekistan.

Dr. Mohsin Hafeez is Country Representative for Pakistan and Regional Representative for Central Asia at IWMI. He has expertise in climate change, hydrology and hydrological modelling (field, irrigation, basin and continental), integrated water resources management, remote sensing, water accounting and productivity assessment, water-energy-food nexus and water policy. He is an Adjunct Professor (Water Resources) with two Chinese universities.

Mr. Kakhramon Djumaboev is a water management researcher at IWMI CA Office. He has more than 20 years of experience in conducting research related to natural resource management (e.g. water, land, and energy) in CA and beyond. His research interests include sustainability of land and water resources management, assessment of institutions and governance structures in shared river basins, water-energy-food nexus, community-based natural resource management, irrigation governance, institutions, climate change and adaptation.

Dr. Bunyod Holmatov is a Researcher in Data Analysis and Innovation in Water Management at IWMI's Sri Lanka office. He has a broad research background related to the water-energy-food nexus, water and climate change, and transboundary water cooperation. Dr. Holmatov holds a professional master of environmental management degree from the Yale School of the Environment where he focused on environmental management and policy before pursuing a PhD at the University of Twente, where he modelled tradeoffs and synergies (nexus) between water, land, and emissions across different renewable energy systems.

Dr. Shavkat M. Kenjabaev is a National Researcher at IWMI CA Office. He has about 20 years of experience in land reclamation and irrigation water management. Throughout his career, he has studied the specifics of the soil and groundwater regime under drip and surface irrigation practices, assessed capacity needs of institutions responsible for training provision in water sector, analyzed natural regularities of faults in irrigation and collector drainage network, and has a unique blend of research and practical experience.

Dr. Santosh Nepal is water resources and climate change researcher at IWMI, Nepal. He has more than 16 years of professional experience in hydrological assessment, climate change and water resources management at different scales in river basins.

Dr. Shilp Verma is a Senior Researcher on water–energy–food policies at IWMI, India. He has expertise in water resources management, water–energy–food nexus, groundwater governance, rural livelihoods, water economics, and policies and institutions.

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Agenda

2nd International Summer School 2023

Sustainability Assessment of the Water–Energy–Food-Environment Nexus for Irrigated Agriculture: Interdisciplinary Approaches for Central Asia (WEFECA)

(Devoted to K. Djumaboev, Project leader and Regional Researcher IWMI-CA)

Date: 21 – 25 August 2023

Venue: "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University ("TIIAME" NRU)

Program:

Time	Topic	Lecturer
	21 August 2023	
08:30 – 09:00	Registration	All participants
09:00-09:30	Welcome remarks: **Moderator:** Mr. Rustam Ibragimov	Prof. Abdulkhakim Salokhiddinov Mr. Oyture Anarbekov
9:30-10:00	Navigating WEF Nexus complexity using environmental footprint assessments	Dr. Bunyod Holmatov
10:00-10:30	WEF nexus – concepts and cases	Dr. Ahmad Hamidov
10:30-11:00	*Tea and coffee break*	all
11:00-11:30	Land use and water management in Central Asia	Prof. Abdulkhakim Salokhiddinov
11:30-12:00	Women's role in addressing climate change and food security	Prof. Dilfuza Egamberdieva
12:00-13:00	Introduction to the working groups: objectives, methods, time schedule, expected outcomes, and expectations from the summer school	Dr. Ahmad Hamidov
13:00-14:00	*Lunch at "TIIAME" NRU cafeteria*	all
14:00-15:30	Elevator Pitch I: each student presents a research project. 1-2 slides, 5 min max.	all
15:30-16:00	*Tea and coffee break*	all
16:00-16:30	Elevator Pitch II: each student presents a research project. 1-2 slides, 5 min max.	all
16:30-18:00	Forming working groups, planning, and developing future scenarios for solutions for the specific problem cases and look at the impacts of the different scenarios.	all
18:00-20:00	City tour in Tashkent (optional)	all
	22 August 2023	
9:30-10:00	**Official opening and welcome, introduction round, and setting the scene: water- energy- food-environment (WEFE) and sustainable development.** **Moderator:** Mr. Oyture Anarbekov – IWMI Central Asia office, Country manager	Prof. Bakhadir Mirzaev - "TIIAME" NRU rector Dr. Mohsin Hafeez - IWMI Dr. Olimjon Tuychiev - Director of Innovative Development Agency Prof. Katharina Helming - ZALF Dr. Akmal Akramkhanov - ICARDA Dr. Otabek Shavkatov - Youth Association
10:00-10:45	**Participatory sustainability assessment**	Keynote speaker Prof. Katharina Helming
10:45-11:15	"The NEXUS GAINS Initiative"	Dr. Mohsin Hafeez
11:15-11:45	Coffee break/Group photo	all
11:45-12:15	Water-Energy-Food Nexus in Action: Comparing Notes from around the World	Dr. Shilp Verma
12:15-12:45	Systematic review of WEF nexus research for the case of irrigated agriculture	Dr. Ahmad Hamidov
12:45-14:00	*Lunch at "TIIAME" NRU cafeteria*	all
14:00-15:30	Install student working groups; develop research design (problem statement and formulate research objective)	all
15:30-16:00	*Tea and coffee break*	all
16:00-18:00	Group work: Detail design of data collection method (questionnaire, survey, experiments)	all
18:00-20:00	*Welcome dinner for all participants*	all
	23 August 2023	
8:30-9:30	**Field trip to Tashkent province (NRU-TIIAME),** Grand capital – Tashgres **Focal point:** Dr. Sobir Qodirov and Dr. Kamol Khamraev	
9:30-11:00	Tashgres tour	
11:00-11:30	*Tea and coffee break*	
11:30-13:00	Visit agricultural fields: Orchard farms with water-saving irrigation technology practices	
13:00-14:00	*Lunch*	
14:00-16:00	Toshmorya tour	
16:00-17:00	*Travel back to Tashkent*	

	24 August 2023	
9:00-9:45	Strengthening WEFE Nexus Approach for Managing Trade-offs and Synergies of Irrigation Management in Transforming Agri-Food Systems **Moderator:** Dr. Akmal Akramkhanov	Keynote speaker Dr. Mohsin Hafeez
9:45-10:15	Harvesting the Sun for Sustainable Development in Central Asia, and Beyond	Dr. Shilp Verma
10:15-10:45	*Tea and coffee break*	all
10:45-12:45	*WEFE-NEXUS River Basin Game*	Dr. Bunyod Holmatov
12:45-13:45	*Lunch at "TIIAME" NRU cafeteria*	all
13:45-15:30	Group work: Transcribe interviews and data analysis	all
15:30-16:00	*Tea and coffee break*	all
16:00-17:30	Group work: Final consultation with senior lecturers and preparation of group presentation	all
17:30-18:00	Gender capacity development and supporting women leaders	Dr. Marlène Elias
	25 August 2023	
9:00-9:45	**WEF and environmental nexus: An example from the lift irrigated areas of Central Asia** **Moderator:** Dr. Bunyod Holmatov	Keynote speaker (Dr. Zafar Gafurov)
9:45-10:15	WEF and ecosystems nexus in Syrdarya river basin	Prof. Yarash Pulatov
10:15-10:45	F2R CWANA nexus studies	Mr. Oyture Anarbekov
10:45-11:00	*Tea and coffee break*	all
11:00-13:00	Group work: preparation of group presentation	all
13:00-14:00	*Lunch at "TIIAME" NRU cafeteria*	all
14:00-15:30	Group presentation (15 min presentation + 15 discussion)	all
15:30-16:00	*Tea and coffee break*	all
16:00-17:30	Group presentation (15 min presentation + 15 discussion)	all
17:30-18:00	Closing ceremony: Final remarks and award certificate of participation	Prof. Tohirjon Sultanov - "TIIAME" NRU vice rector, Prof. Katharina Helming

Day 1

International Water Management Institute

CGIAR

Navigating WEF Nexus complexity using environmental footprint assessments

Bunyod Holmatov, PhD

Researcher – Data Analysis and Innovation in Water Management

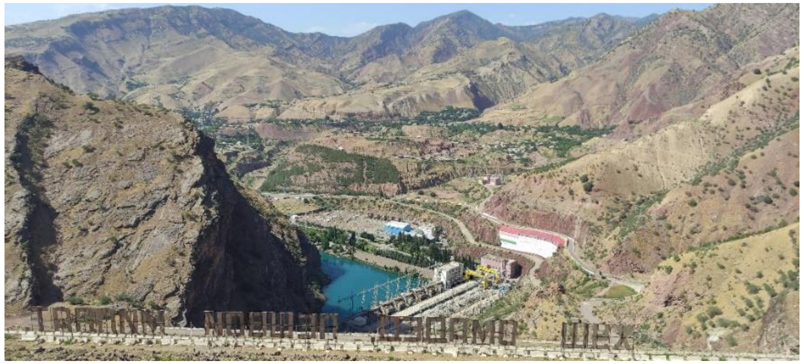
21 – August, 2023

Tashkent, Uzbekistan

Innovative water solutions for sustainable development

Food·Climate·Growth

Introduction



About IWMI

- IWMI is a research-for-development organization
- IWMI is a Research Center of CGIAR, a global research partnership for a food-secure future
- IWMI's vision is "a water-secure world"

Learn more @:
www.iwmi.cgiar.org

IWMI International Water Management Institute

WEF Nexus Complexity

- Different systems: water, energy, food
- Different disciplines: biophysical sciences, ecology, economy, political sciences, social sciences

2. Systems thinking

If it is so important, then what exactly *is* systems thinking? The term has been defined and redefined in many different ways since its coining by Barry Richmond in 1987. What makes systems thinking so difficult to define? Why is it constantly redefined? What is everyone missing? Perhaps, rooted in our own field, lies the answer to defining the elusive concept of systems thinking in a way that will allow it to be measured. To this end, proposed is a surprisingly straightforward step in defining systems thinking – the application of systems thinking *to itself*.

According to the Merriam-Webster dictionary, a system is defined as a regularly interacting or interdependent group of items forming a unified whole (Merriam-Webster's online dictionary, n.d.). A basic principle of a system is that it is something more than a collection of its parts[5] (Meadows, 2008). Following this line of reasoning, it immediately becomes apparent that systems thinking can be viewed *as a system*. Systems thinking is, literally, a *system of thinking about systems*. As discussed later in this paper, this highlights the problems with the definitions available in the literature. These definitions tend to analyze systems thinking through a reductionist approach – generally considered a non-systems-thinking approach. Reductionist models are unable to fully depict, or to allow us to deeply understand, new complex and dynamic scenarios[2] (Dominici, 2012).

As with most systems, systems thinking consists of three kinds of things: elements (in this case, characteristics), interconnections (the way these characteristics relate to and/or feed back into each other), and a function or purpose[5] (Meadows 2008). Notably, the least obvious part of the system, its function or purpose, is often the most crucial determinant of the system's behavior[5] (Meadows, 2008). Though not all systems have an obvious goal or objective, systems thinking does. In order to convey its definition, especially to those unfamiliar with the concept, it is critically important to communicate this goal.

Therefore, a requirement for a complete systems thinking definition should be that it defines the latter as a goal.

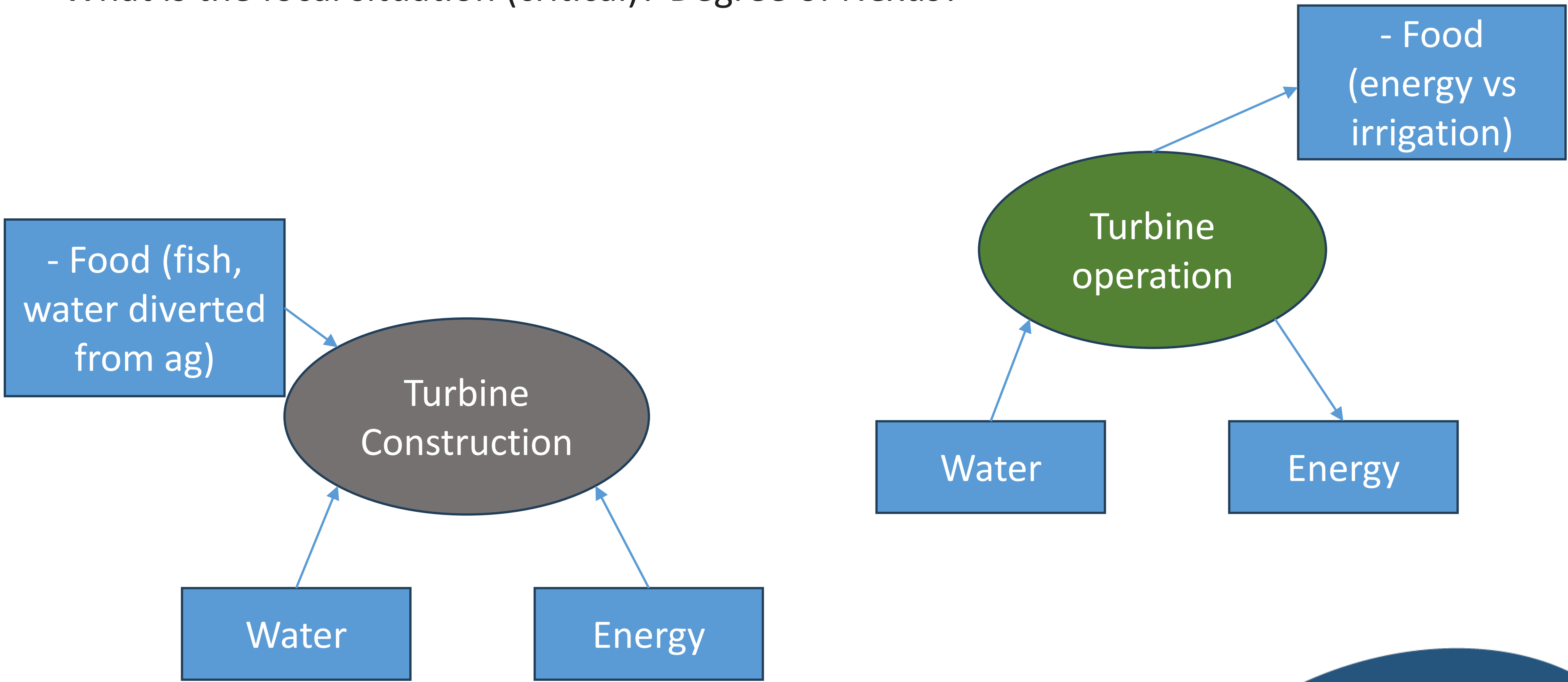
Source: Arnold & Wade, 2015

International Water Management Institute

WEF Nexus Complexity Cont'd

Important: entry point & system boundary

What is the focal situation (critical)? Degree of Nexus?



WEF Nexus Complexity Cont'd

Holmatov et al. (in submission)

Comprehensive review:

Collected ~1000 peer reviewed, highly cited papers + reports

Most papers focus on large scales (e.g., global, national), use review or modelling, very few have on-the-ground outcomes

WEF Nexus Complexity Cont'd

Relation to other frameworks:

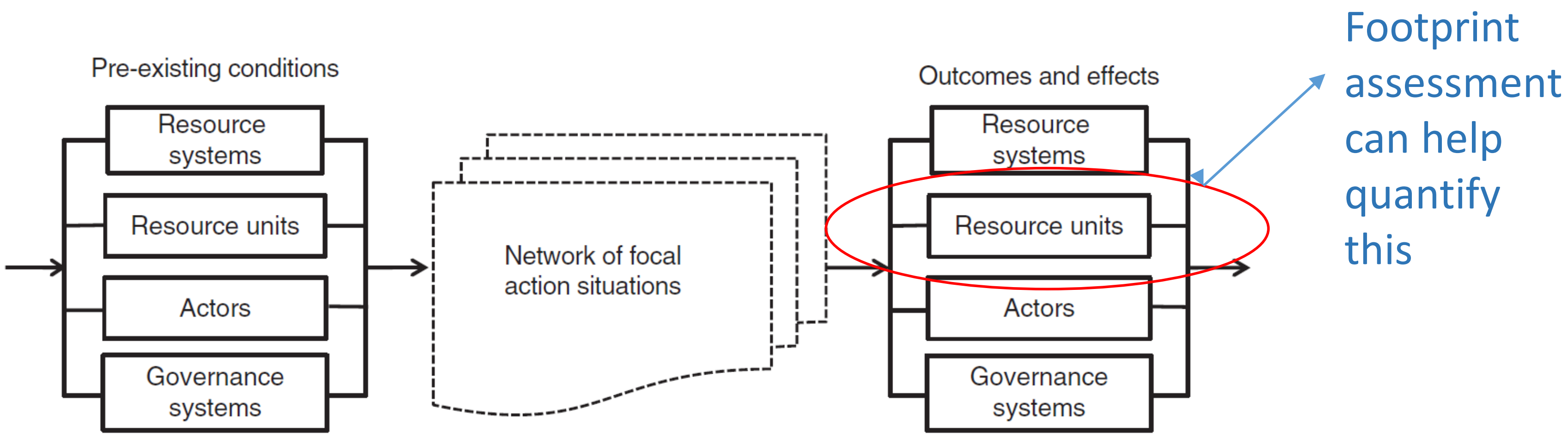


Figure 4: Generic representation of combined IAD-SES framework.

Source: Cole et al. 2019

Defining footprints

In essence a footprint is a method to quantify and compare human pressure on the environment (using a supply chain thinking);

They (footprints) help to understand environmental changes and impacts resulting from our pressure;

Source: https://ams-iac.com/what-is-carbon-footprint-in-business

	C. Gaseous Fossil Fuels									
Aardgas 3)	Natural Gas (dry) 3)	Nm3 ae	31.65	31.65	31.65	CS	56.5 3)	56.6 3)	56.6 3)	CS
Compressed natural gas (CNG) 3)	Compressed natural gas (CNG) 3)	Nm3 ae	31.65	31.65	31.65	CS	56.5 3)	56.6 3)	56.6 3)	CS
Liquified natural gas (LNG) 3)	Liquified natural gas (LNG) 3)	Nm3 ae	31.65	31.65	31.65	CS	56.5 3)	56.6 3)	56.6 3)	CS
Koolmonoxide	Carbon Monoxide	Nm3	12.6	12.6	12.6	CS	155.2	155.2	155.2	CS
Methaan	Methane	Nm3	35.9	35.9	35.9	CS	54.9	54.9	54.9	CS
Waterstof	Hydrogen	Nm3	10.8	10.8	10.8	CS	0	0	0	CS
	Biomass 4)									
Biomassa vast	Solid Biomass	kg	15.1	15.1	15.1	CS	109.6	109.6	109.6	IPCC
Houtskool	Charcoal	kg	30.0	30.0	30.0	CS	112.0	112.0	112.0	IPCC
Biobenzine	Biogasoline	kg	27.0	27.0	27.0	CS	72.0	72.0	72.0	CS
Biodiesel	Biodiesels	kg	37.0	37.0	37.0	CS	74.3	74.3	74.3	CS
Overige vloeibare biobrandstoffen	Other liquid biofuels	kg	36.0	36.0	36.0	CS	79.6	79.6	79.6	IPCC
Biomassa gasvormig	Gas Biomass	Nm3	21.8	21.8	21.8	CS	90.8	90.8	90.8	CS
RWZI biogas	Wastewater biogas	Nm3	23.3	23.3	23.3	CS	84.2	84.2	84.2	CS
Stortgas	Landfill gas	Nm3	19.5	19.5	19.5	CS	100.7	100.7	100.7	CS
Industrieel fermentatiegas	Industrial organic waste gas	Nm3	23.3	23.3	23.3	CS	84.2	84.2	84.2	CS
	D Other fuels									
Afval 2)	Waste 2)	Kg	9.9	9.9 2)	9.9 2)	CS	105.3	105.3 2)	105.3 2)	CS

Zijlema, P. J. (2018). *The Netherlands: list of fuels and standard CO_2 emission factors version of January 2018*. Netherlands Enterprise Agency. https://english.rvo.nl/sites/default/files/2017/04/The_Netherlands_list_of_fuels_version_January_2017_final.pdf

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Defining footprints (cont'd)

There are many different footprints

Integrating multiple environmental footprints ("footprint family") can provide better idea about our pressure stemming from a certain activity

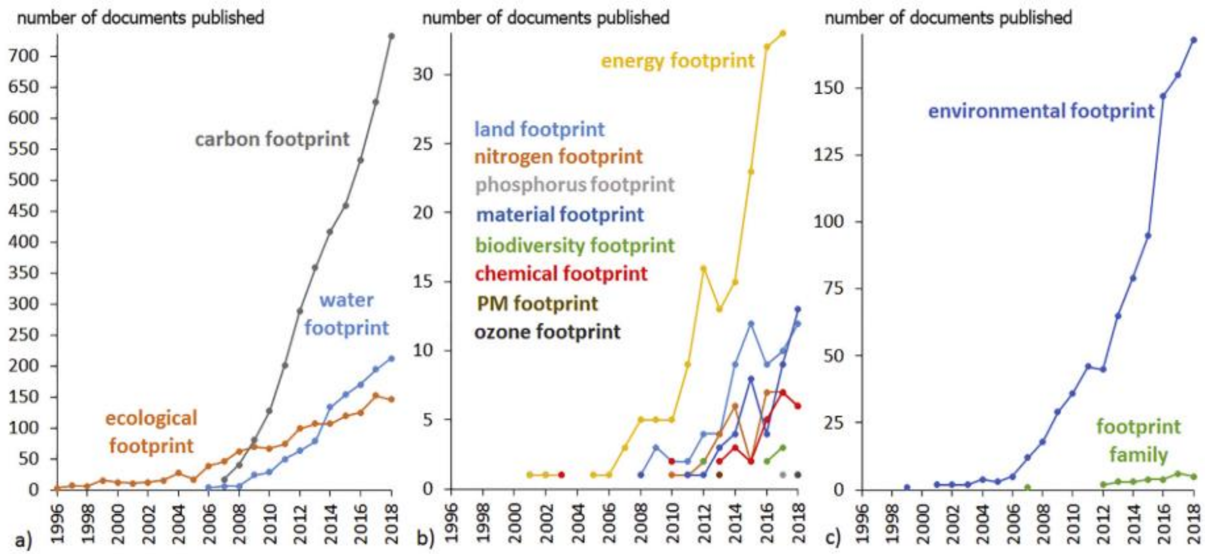

Fig. 1. Number of documents published (Y-axis) on environmental footprints from 1996 to 2018 (X-axis) in Science Citation Index Expanded (SCI-EXPANDED) or Social Sciences Citation Index (SSCI). Footprints are depicted in different panels due to the different magnitude of the number of documents: (a) the three most published footprints; (b) other footprints with less publications and (c) umbrella terms "environmental footprint" and "footprint family". Publications using terms close to "footprint", such as "embedded resource" or "virtual resource", are omitted.

Vanham, D., Leip, A., Galli, A., Kastner, T., Bruckner, M., Uwizeye, A., van Dijk, K., Ercin, E., Dalin, C., Brandão, M., Bastianoni, S., Fang, K., Leach, A., Chapagain, A., Van der Velde, M., Sala, S., Pant, R., Mancini, L., Monforti-Ferrario, F., . . . Hoekstra, A. Y. (2019). Environmental footprint family to address local to planetary sustainability and deliver on the SDGs. *Science of The Total Environment*, *693*, 133642. https://doi.org/https://doi.org/10.1016/j.scitotenv.2019.133642

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Using footprints assessments to navigate WEF Nexus Complexity

Define a system and its boundary

Quantify water-energy-food units for a product / activity

Example 1: Irrigation and Drainage

Research Article

Assessing Water Use, Energy Use And Carbon Emissions In Lift-Irrigated Areas: A Case Study From Karshi Steppe In Uzbekistan†

Kakhramon Djumaboev, Tulkun Yuldashev, Bunyod Holmatov, Zafar Gafurov

First published: 03 February 2019 | https://doi.org/10.1002/ird.2321 | Citations: 6

† Évaluation de l'utilisation de l'eau, de l'énergie et des émissions de carbone dans les zones irriguées par élévation d'eau: étude de cas de la steppe Karshi en Ouzbékistan.

Read the full text > PDF TOOLS SHARE

Abstract

EN FR

The advantages of a nexus approach in addressing complex environmental challenges are becoming increasingly clear. In Central Asia, however, the nexus between water–

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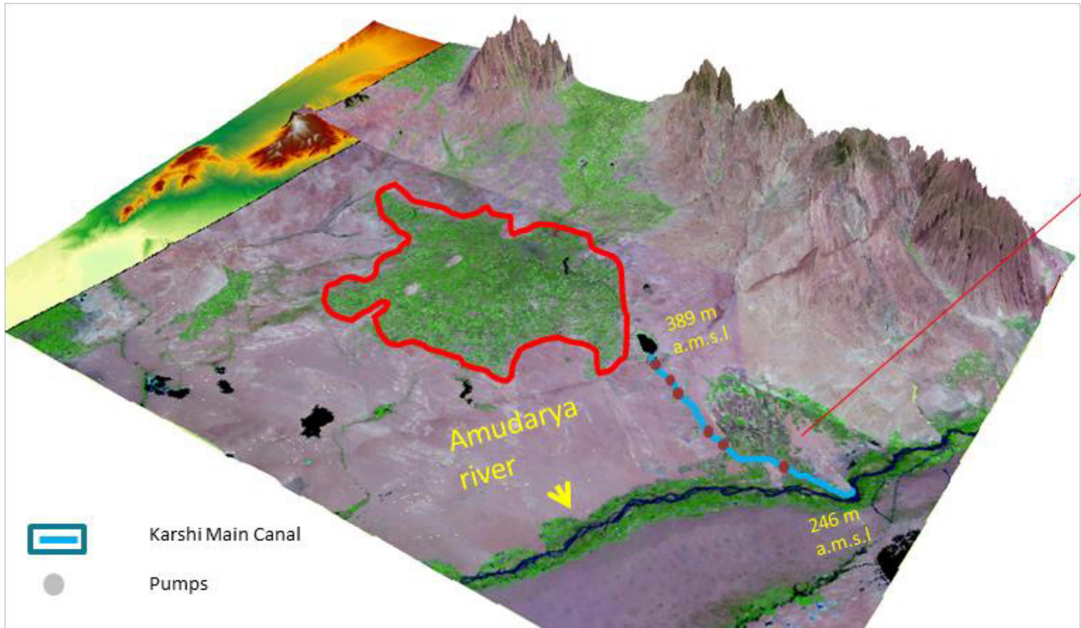
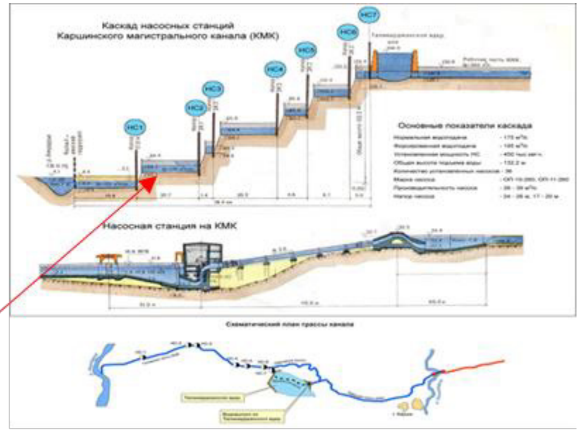
Using footprints assessments to navigate WEF Nexus Complexity



- Pumping distance is about 80 km
- Pumping altitude is about 153 m
- Irrigated area is about 335,000 ha



Karshi Steppe:
@175 m3/sec
7 pump stations

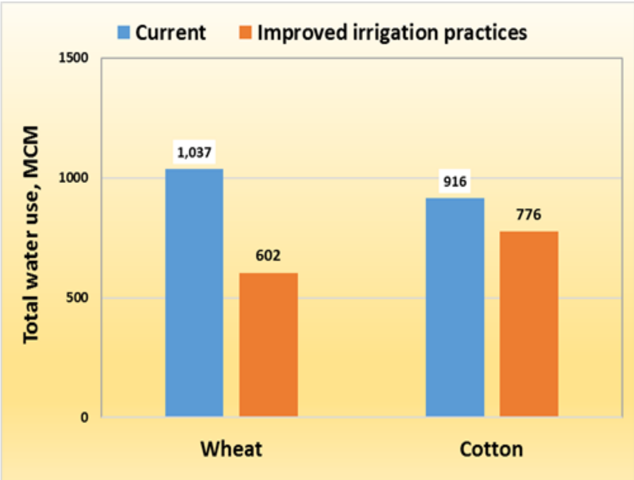
Using footprints assessments to navigate WEF Nexus Complexity

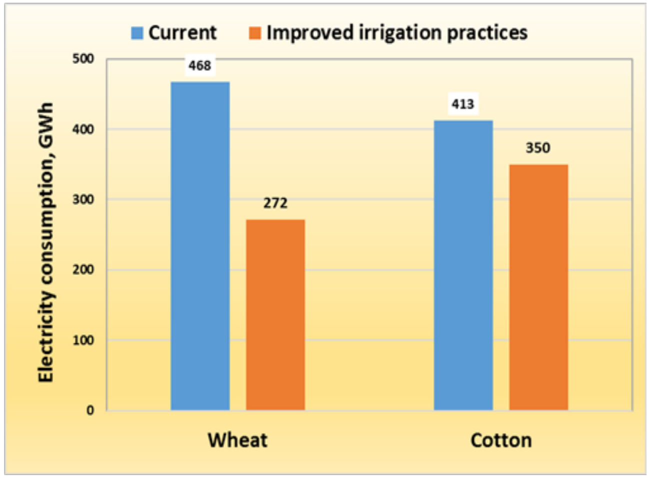
- The aim is to assess water and energy use intensity in lift-irrigated agricultural area in Uzbekistan.
- **Methods**:
- Major crops grown in the area were first identified
- crop water requirements were calculated for baseline & improved irrigation scenario (using CROPWAT)
- Energy requirements & the CO_2-equivalent emissions were calculated considering water volume; lifting height; pumping plant efficiency; & distribution and transmission losses

Using footprints assessments to navigate WEF Nexus Complexity

Crop	Total pumped area, ha	Irrigation application, mm		Total water use, MCM		Total water saving, MCM	Electricity consumption, GWh		Total energy saving, GWh	GHG emissions, Kton		CO_2 reduction, Kton of GHGs
		Current	Improved irrigation practices	Current	Improved irrigation practices		Current	Improved irrigation practices		Current	Improved irrigation practices	
Wheat	102600	1011	587	1037	602	**435**	468	272	**196**	219	127	**92**
Cotton	119681	765	648	916	776	**140**	413	350	**63**	194	164	**30**
Total	222281	N/A	N/A	1953	1378	**575**	880	621	**259**	413	291	**122**

Reduction %	
Water	CO_2
42%	42%
15%	15%





Using footprints assessments to navigate WEF Nexus Complexity

Example 2:

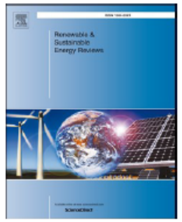
Renewable and Sustainable Energy Reviews 111 (2019) 224–235

ELSEVIER

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser



Land, water and carbon footprints of circular bioenergy production systems

B. Holmatov[a,*], A.Y. Hoekstra[a,b], M.S. Krol[a]

[a] Twente Water Centre, Faculty of Engineering Technology, University of Twente, Horst Complex Z223, P.O Box 217, 7500, AE Enschede, Netherlands

[b] Institute of Water Policy, Lee Kuan Yew School of Public Policy, National University of Singapore, 469C Bukit Timah Road, 259772, Singapore

A R T I C L E I N F O

Keywords:
Bioenergy
Biofuel
Energy scenario
Carbon footprint
Land footprint
Sustainable development
Water footprint

A B S T R A C T

Renewable energy sources can help combat climate change but knowing the land, water and carbon implications of different renewable energy production mixes becomes a key. This paper systematically applies land, water and carbon footprint accounting methods to calculate resource appropriation and CO_2eq GHG emissions of two energy scenarios. The '100% scenario' is meant as a thinking exercise and assumes a complete transition towards bioenergy, mostly as bioelectricity and some first-generation biofuel. The 'SDS-bio scenario' is inspired by IEA's sustainable development scenario and assumes a 9.8% share of bioenergy in the final mix, with a high share of first-generation biofuel. Energy inputs into production are calculated by differentiating inputs into fuel versus electricity and exclude fossil fuels used for non-energy purposes. Results suggest that both scenarios can lead to

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Using footprints assessments to navigate WEF Nexus Complexity

What is the scale of water and land resources necessary to meet the global energy demand if we use bioenergy?

Two scenarios: 9.8% of global energy demand VS 100% of global energy demand

Table 1
Shares of biofuel, heat and bioelectricity in the two scenarios.

	Electricity	Fuel	Heat	Total
	100% scenario			
Exajoules	316.1	47.1	11.4	374.6
% composition	84.4	12.6	3.1	100
	SDS-bio scenario			
Exajoules	6.1	16.0	15.9	38.0
% composition	1.6	4.1	4.1	9.8

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Using footprints assessments to navigate WEF Nexus Complexity

Table 6
Energy outputs in GJ ha^{-1} specified per crop.

Crop	Accounting	Electricity[b]	CHP[b]		Bioethanol[c]	Biodiesel[c]
			Electricity	Heat		
Sugar beet	Gross	147.2	75.3	215.7	157.3	–
	Net[a]	126.2	69.9	200.1	139.6	–
Sugarcane	Gross	261.2	133.6	382.7	157.3	–
	Net	239.8	128.1	366.8	142.0	–
Maize	Gross	90.5	46.3	132.6	56.1	–
	Net	80.7	43.8	125.4	29.1	–
Soybean	Gross	27.8	14.2	40.7	–	15.8
	Net	23.9	13.2	37.8	–	6.5
Rapeseed	Gross	19.3	9.9	28.3	–	23.8
	Net	13.3	8.3	23.8	–	13.3

[a] Net is gross minus bioelectricity and biofuel inputs per hectare.
[b] Feedstock is the total biomass.
[c] Feedstock is the economic yield fraction.

Changing to a 100% scenario is not possible because the land footprint will exceed global arable land while the water footprint will exceed global water footprint of humanity (~9K km3/y). Even meeting the 9.8% of global demand will require at least 11.4% of global arable land and 17.6% of global water use.

Using footprints assessments to navigate WEF Nexus Complexity

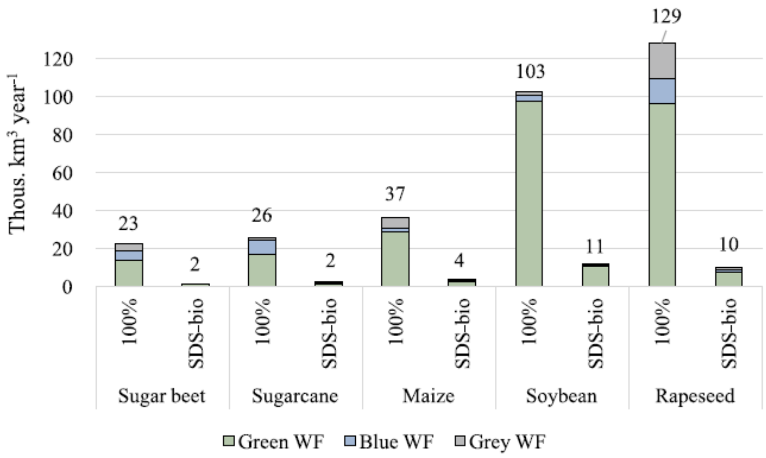

Fig. 4. WF of two global bioenergy production scenarios based on different feedstock and specified by WF component (green, blue, grey). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

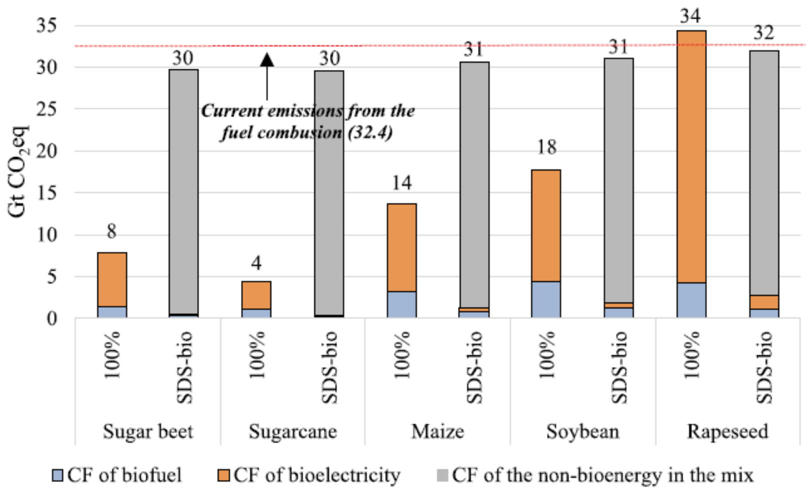

Fig. 6. CF of two global bioenergy production scenarios based on different feedstock and specified by energy type.

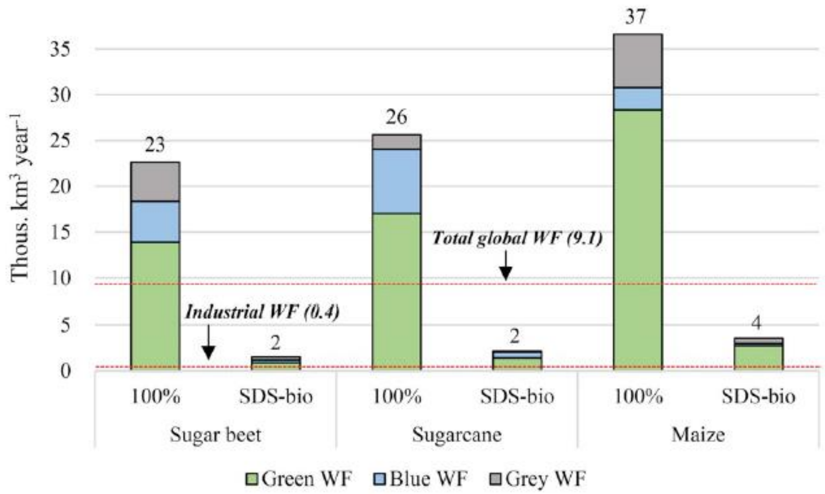

Fig. 5. WF of two global bioenergy production scenarios based on three most water efficient feedstock and specified by WF component (green, blue, grey). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

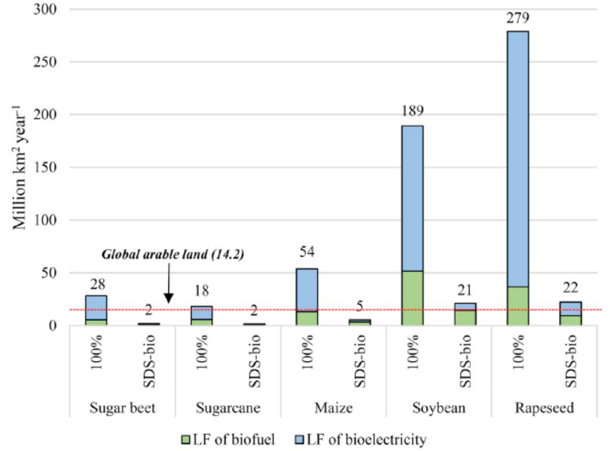

Fig. 3. LFs of the two global bioenergy production scenarios based on different feedstock specified by type of energy (biofuel or bioelectricity).

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References

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2. Vanham, D., Leip, A., Galli, A., Kastner, T., Bruckner, M., Uwizeye, A., van Dijk, K., Ercin, E., Dalin, C., Brandão, M., Bastianoni, S., Fang, K., Leach, A., Chapagain, A., Van der Velde, M., Sala, S., Pant, R., Mancini, L., Monforti-Ferrario, F., . . . Hoekstra, A. Y. (2019). Environmental footprint family to address local to planetary sustainability and deliver on the SDGs. *Science of The Total Environment*, *693*, 133642. https://doi.org/https://doi.org/10.1016/j.scitotenv.2019.133642

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4. Cole, D., Epstein, G., & McGinnis, M. (2019). The utility of combining the IAD and SES frameworks. *International Journal of the Commons, 13*(1).

5. Djumaboev, K., Yuldashev, T., Holmatov, B., & Gafurov, Z. (2019). Assessing Water Use, Energy Use And Carbon Emissions In Lift- Irrigated Areas: A Case Study From Karshi Steppe In Uzbekistan. *Irrigation and Drainage, 68*(3), 409-419. https://onlinelibrary.wiley.com/doi/abs/10.1002/ird.2321

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Questions?

Thank You!

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b.holmatov@cgiar.org

Innovative water solutions for sustainable development

Food · Climate · Growth

CGIAR

Women's role in addressing climate change and food security

Dr. Dilfuza Egamberdieva

Institute of Fundamental and Applied Research,
National Research University “TIIAME”

Outline

- Food security and climate change
- Gender equality for a sustainable tomorrow
- What are women's challenges?
- What can we do to get girls into Science?

The five megatrends pose difficulties that must be addressed if the globe is to continue to be a safe haven for people and other animals

← Contents

Solutions

- **Solution for air pollution**

Renewable energy, reforestation by reducing agricultural emissions

- **Solution for deforestation**

Conserve what's left of natural forests, replant damaged regions with native tree species

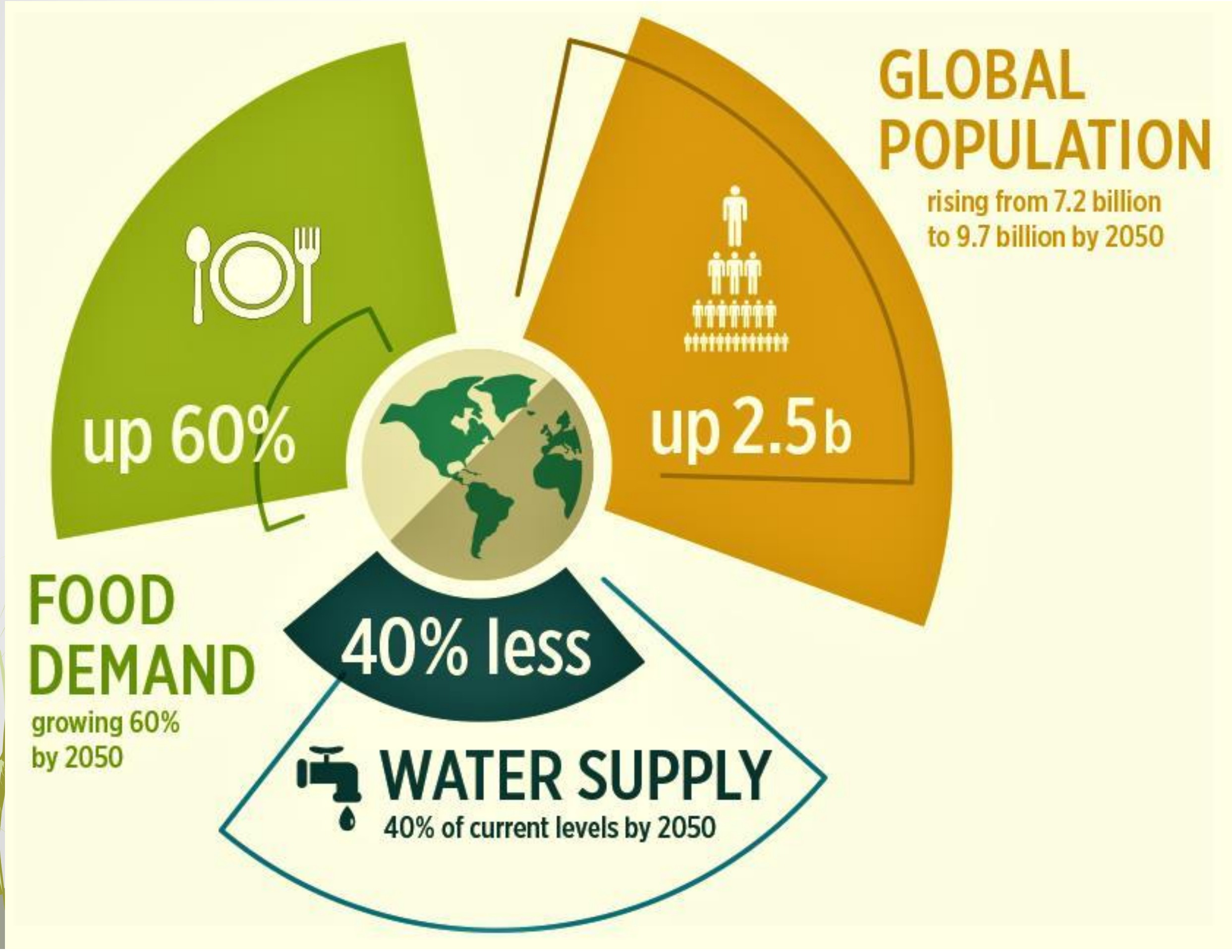
- **Solution for species extinction**

Protecting and restoring habitats, preventing poaching and animal trading

- **Soil Degradation**

No-till agriculture, crop rotation, organic fertilizers

By the year 2050, the world population will be close to 10 billion, and global food production will need to increase by about 50%



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Why Gender and Diversity Issues Are Important in Agriculture

Source: http://news.nationalgeographic.com/news/2014/03/140308-international-female-farmers/

- Female farmers are 8% of the world's population; male farmers are 11%.
- Women make up 20% of the agricultural labor force in Latin America and nearly 50% in East Asia and sub-Saharan Africa.
- Closing the gender gap, and therefore increasing agricultural yields, could reduce the number of undernourished people by 130 million, or 15%

- Women farmers produce more than 50% food grown worldwide
- Women make up 50-70% agricultural labour force.
- “Gender gap” results in:
  - Less food grown
  - Less income generated
  - Higher levels of poverty and food insecurity
- It is estimated that 12% to 17% hungry people in the world could be fed if women had equal opportunities.

Gender-sensitive responses to climate change change

Mitigation and adaptation efforts should systematically and effectively address gender-specific impacts of climate change in the areas:

- food security
- agriculture and fisheries
- biodiversity
- water
- health
- human rights
- peace and security

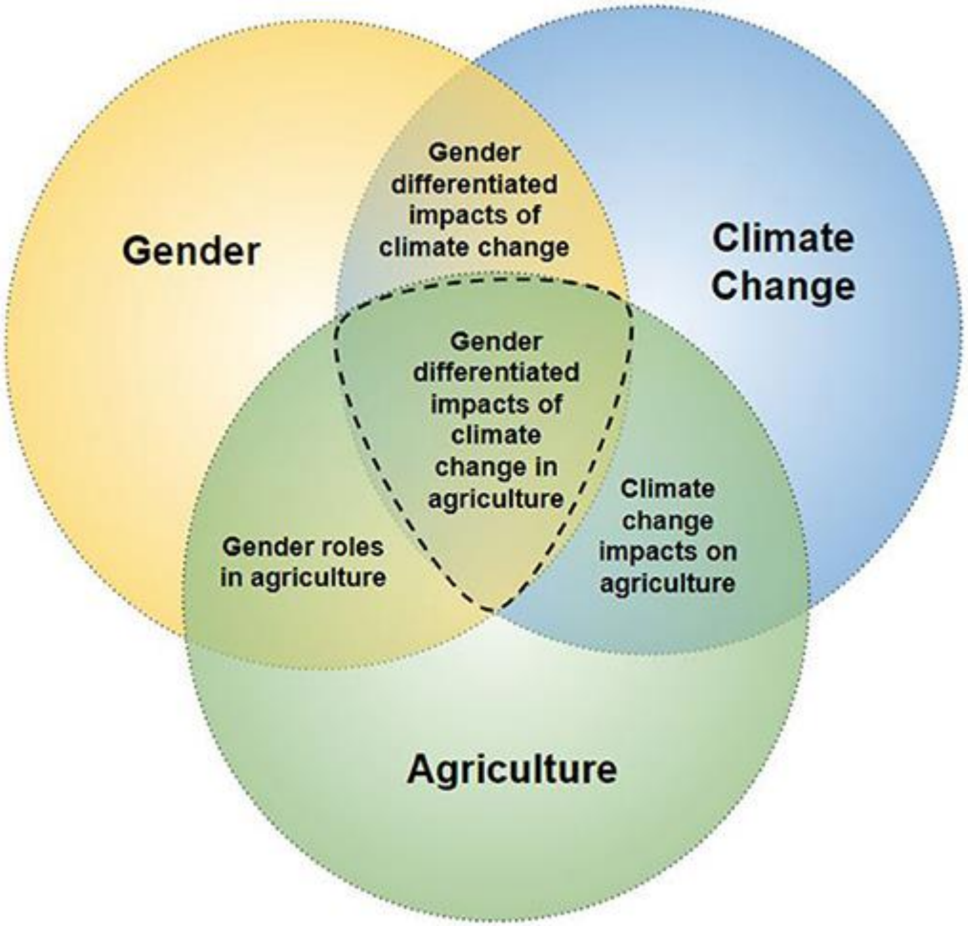
Technological developments related to climate change

- It should take into account women's specific priorities, needs and roles, and make full use of their knowledge and expertise, including indigenous knowledge and traditional practices.

- Women's involvement in the development of new technologies can ensure that they are user-friendly, affordable, effective and sustainable.

- Women should also have equal access to training, credit and skills-development programmes to ensure their full participation in climate change initiatives

Conceptual diagram to define the gender-agriculture-climate change nexus.



INDICATORS

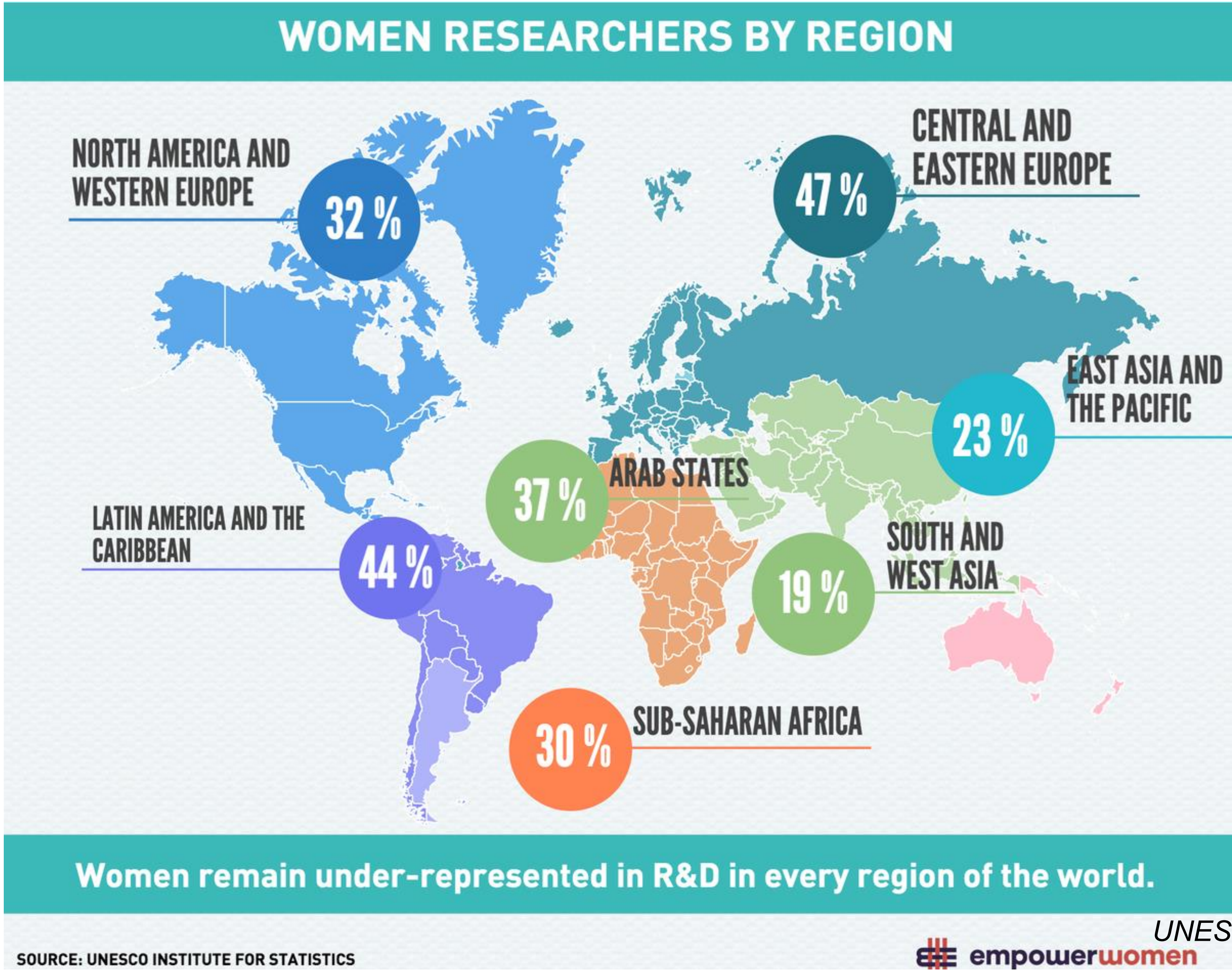
- Recognition of climate change impact on agriculture
- Policy provision for climate change adaptation in agriculture
- Recognition of gender differentiated roles in agriculture:
- Policy provision for gender in agriculture
- Recognition of gender differentiated impacts of climate change in agriculture

Paudyal et al. 2019. Front. Sustain. Food Syst.

Environmental and agricultural challenges are solved with sound science and engineering approaches

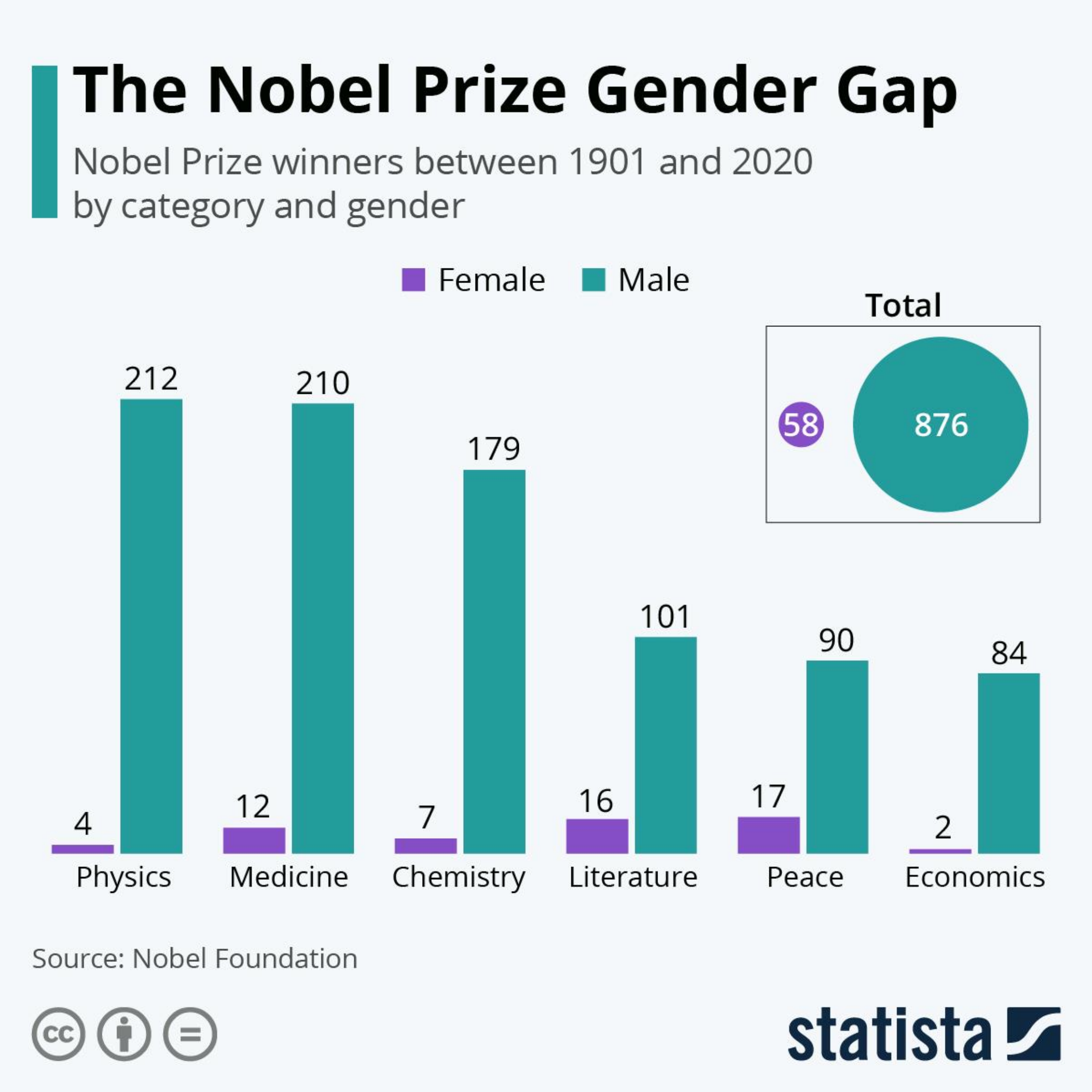
Why women need to be at the heart of climate action?

For climate action to be impactful, inclusive and meaningful, we must address the systemic barriers that prevent women from entering careers in science and technology.

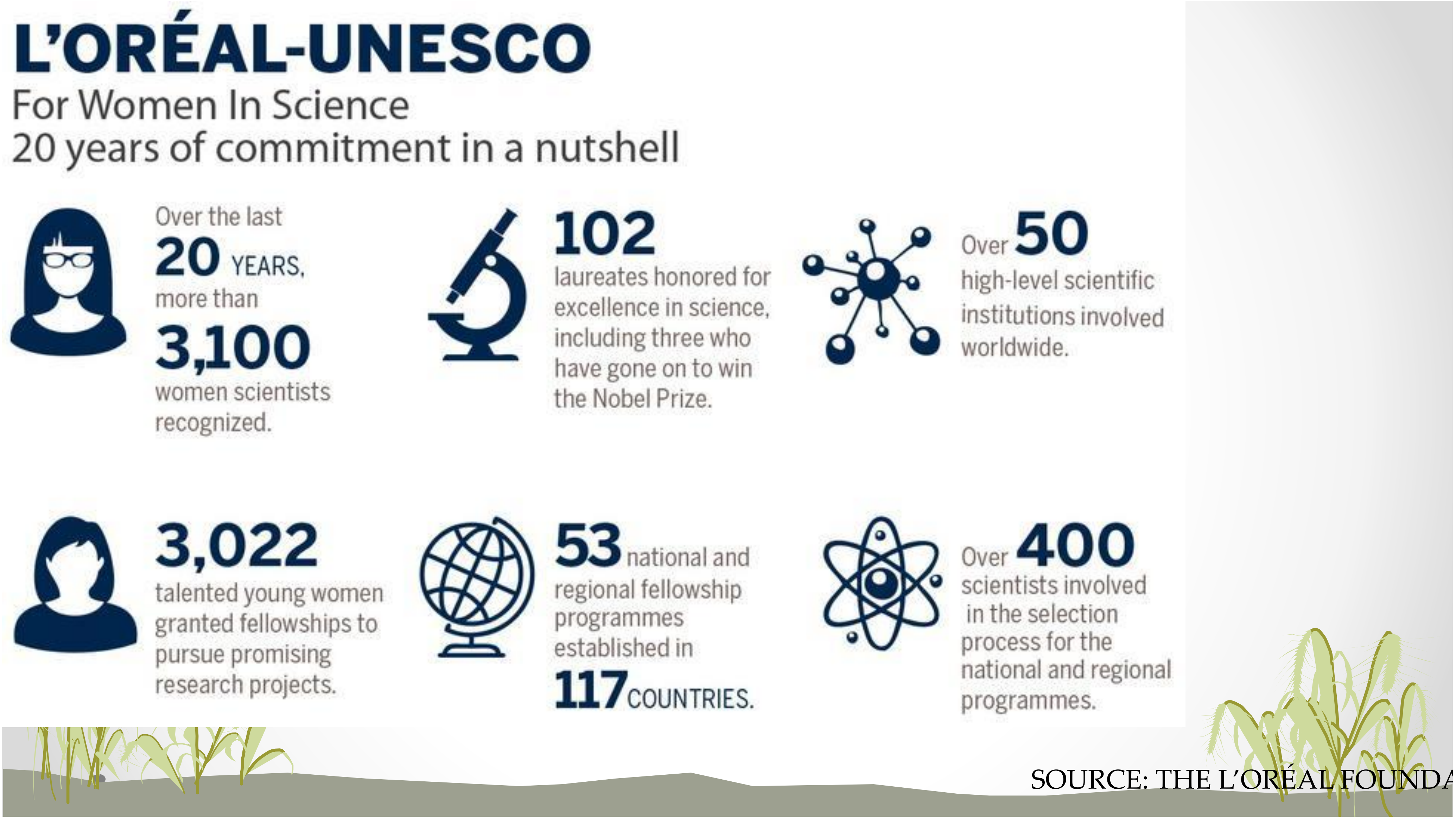


The regional averages for the share of female researchers

UNESCO Institute for Statistics, June 2019.



Between 2001 and 2020, 28 women have received the honor, compared with only eleven between 1981 and 2000 and only seven between 1961 and 1980.



SOURCE: THE L'ORÉAL FOUNDA

What are the possible female role in todays society?

- Mother: family issues, time with her children
- Wife/partner: time with companion
- Homemaker/housewife: needs of the household
- A balanced individual with some free time: friends, hobbies, social life, outings

Why Are There Still So Few Women in Science?

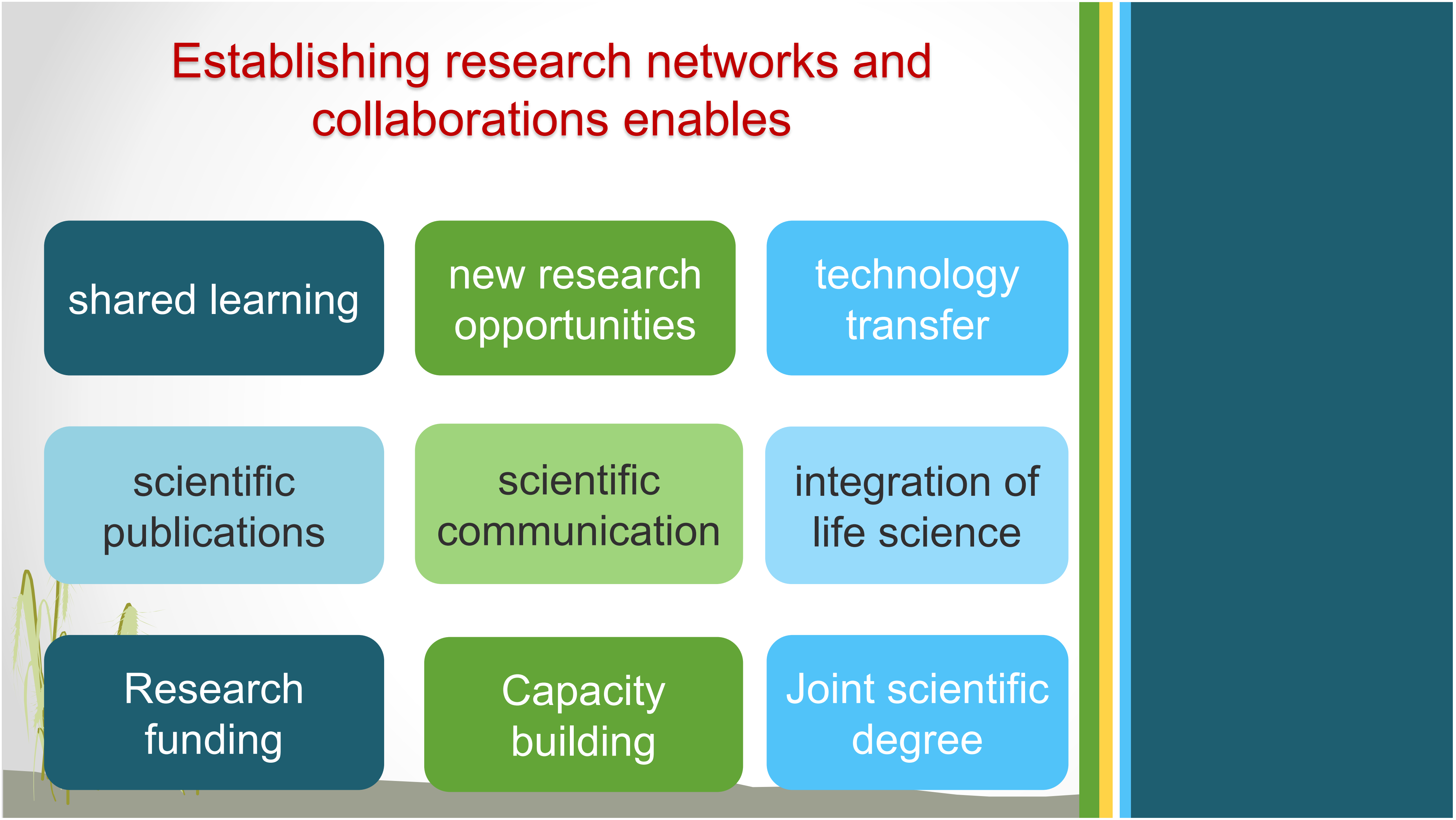
Socio-cultural norms: beliefs, culture-attitudes, aspirations, self assessment;
Teachers' and parents' poor support
Lack of role models, mentors.
Lack of motivation, self esteem and encouragement
Career break for family issues
Fewer network for support and counselling
Reproductive health challenges; poverty, violence, harassment
Women and girls are denied full and equal opportunities for education

Strategic plan for increasing the numbers of women in science and engineering

Education Infrastructure: identifying educational programs that have been effective in facilitating the recruitment and retention of women in S&E careers

Career Patterns: developing a program of studies to facilitate the positive employment opportunities related to diversification in the workplace

Stimulating Research: grant-research programs, hiring junior and senior science majors to staff assistant positions, fellowship, associateship appointments


Establishing research networks and collaborations enables
shared learning
new research opportunities
technology transfer
scientific publications
scientific communication
integration of life science
Research funding
Capacity building
Joint scientific degree

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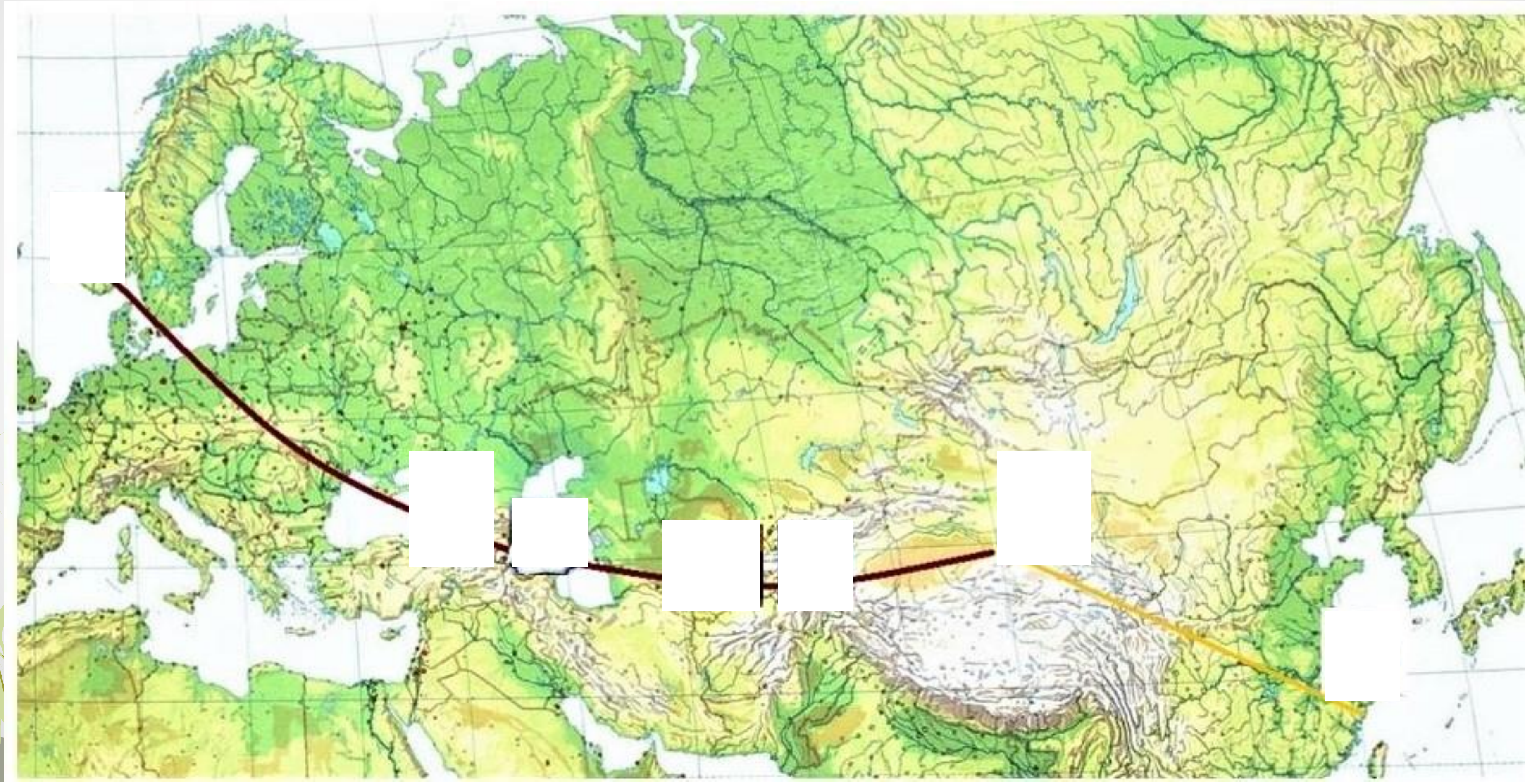
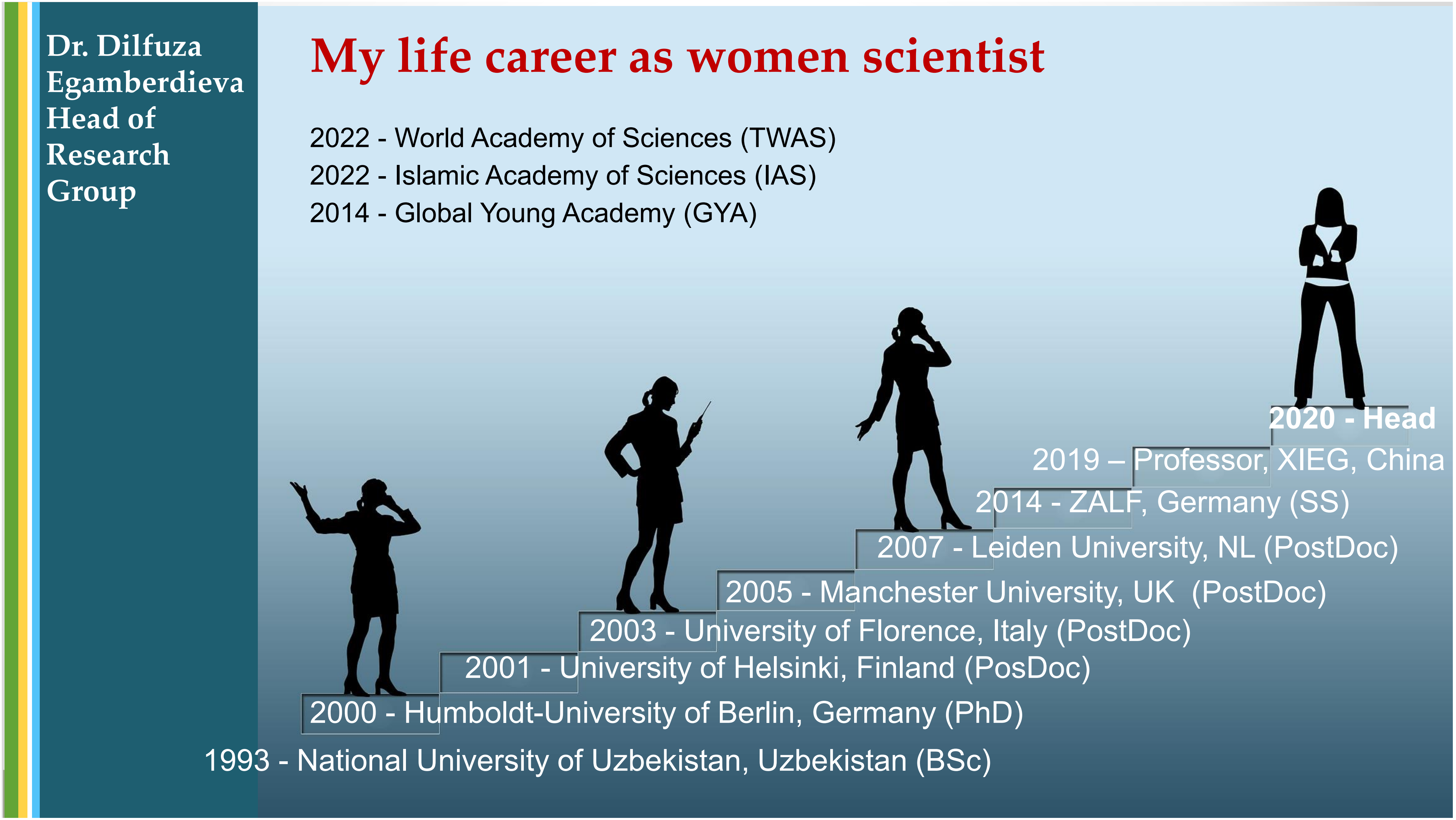
Silk Road Scientific Research Network

Norway - Georgia, Armenia, Kazakhstan, Uzbekistan, Tajikistan, Kyrgyzstan, China




Dr. Dilfuza Egamberdieva Head of Research Group
My life career as women scientist
2022 - World Academy of Sciences (TWAS)
2022 - Islamic Academy of Sciences (IAS)
2014 - Global Young Academy (GYA)
2020 - Head
2019 – Professor, XIEG, China
2014 - ZALF, Germany (SS)
2007 - Leiden University, NL (PostDoc)
2005 - Manchester University, UK (PostDoc)
2003 - University of Florence, Italy (PostDoc)
2001 - University of Helsinki, Finland (PosDoc)
2000 - Humboldt-University of Berlin, Germany (PhD)
1993 - National University of Uzbekistan, Uzbekistan (BSc)

Dilfuza Egamberdieva
Uzbekistan
Microbiology

"Treating research as fun is an important step to building up a successful career as a scientist."

Prof. Gisela Höflich

During my PhD, the daily routine of being a scientist seemed boring to me, and I considered leaving science for a more interesting job. One day my supervisor told me 'Dilfuza, treat science as a hobby, and enjoy doing research – it opens a door through which you find all your dreams.' I tried it, and it works!

Edited by
Rob Jenkins
Jan-Christoph Heilinger
Anina Rich

WORDS OF WISDOM

cherished advice
from academic mentors
around the world

AWARDS

UNESCO-L'OREAL, Women in Science

2006

2013

2019

2020

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THANK YOU FOR YOUR
ATTENTION

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INITIATIVE ON NEXUS Gains CGIAR

zalf

Sustainability Assessment of the Water–Energy–Food–Environment Nexus for Irrigated Agriculture: Interdisciplinary Approaches for Central Asia (WEFECA)

Introduction to Group Work

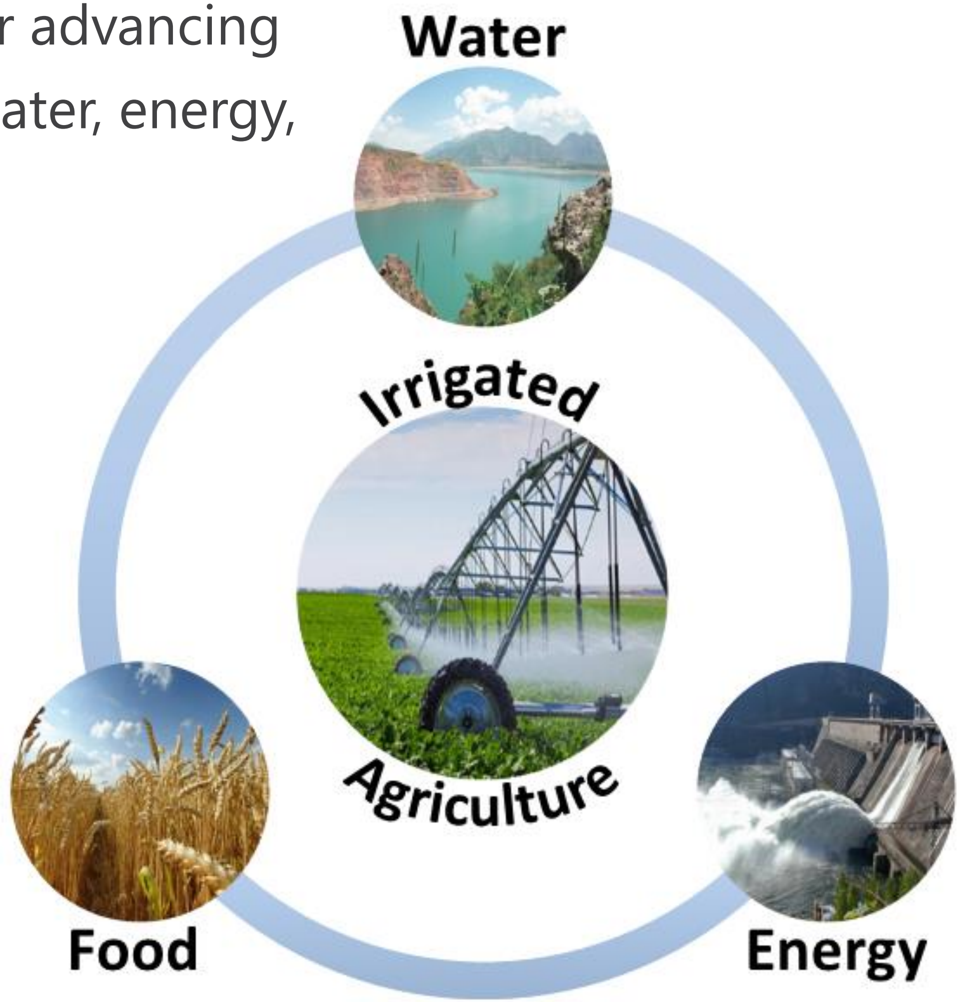
Prof. Katharina Helming and Dr. Ahmad Hamidov

Leibniz Centre for Agricultural Landscape Research (ZALF)

Date: 21 August 2023

Objectives

- Apply interdisciplinary approaches for advancing scientific knowledge in the areas of water, energy, food and environment in Central Asia
- Undertake sustainability assessment of the WEFE nexus, taking into consideration soil quality, ecosystem service maintenance, and resource governance
- Introduce students to research ideas that open cutting-edge research to address sustainability problems



Seite 2

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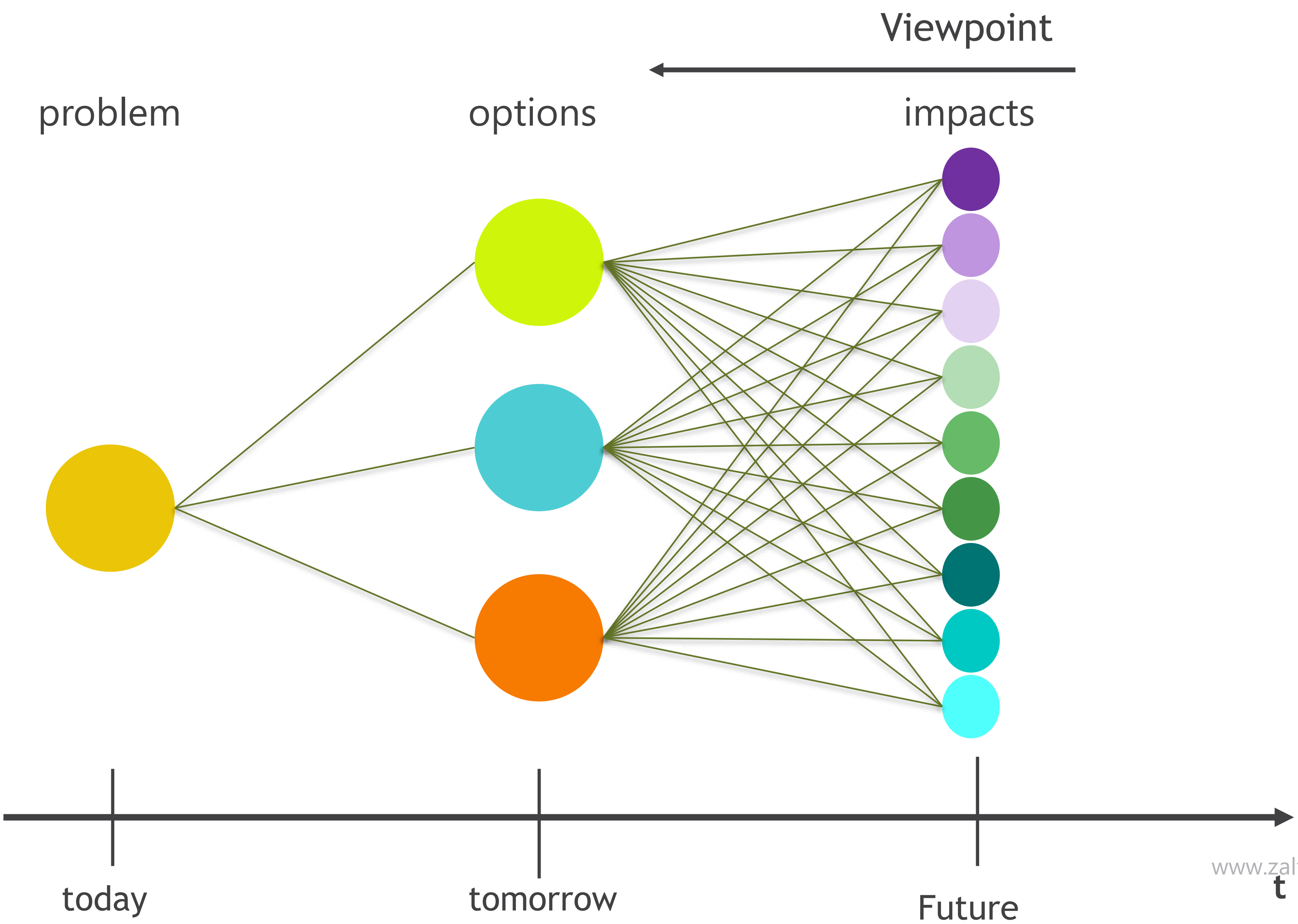
Which direction leads us into a sustainable future?

Ex-ante Impact Assessment



6 Steps of Impact Assessment

1	Identify the problem
2	Define the objective
3	Develop options / scenarios
4	Analyse the impacts
5	Compare the options / scenarios
6	Implement the best option

Group assignment

- Forming working groups and planning
- Developing future scenarios for solutions for the specific problem cases
- Look at the impacts of the different scenarios

Day 1 – Elevator Pitch

Activity:

- Each student presents his/her research project (3 min. max)

Milestone:

- Students get familiarized with each other's research works

Day 1 – Organize Working Groups

Activity:

- Install working groups (5-6 students per group) based on preferences and discuss research ideas
- Identify one common reseach topic per group (e.g. one of the participant‘s research topics)

Milestone:

- An initial sketch (e.g. drawing/chart) to specify the topic
- Scale (e.g. local, provincial, national, and/or international) and agreed study area (an example)
- 2-3 PowerPoint slides: research topic, region, group members

Day 2 – Develop Research Design

Activity:

- Describe problem statement and formulate research objective
- Define impact assessment parameters and indicators

Milestone:

- Relevance, knowledge gaps and specific objectives
- Procedure for systematic review analysis (key words)
- 6 parameters and 6 indicators
- 2-3 PowerPoint slides

Day 3 – Field Visit

Activity:

- Discuss empirical challenges of the WEFE nexus with relevant stakeholders in the field
- Operationalize the developed research design empirically

Milestone:

- Research design is refined based on the field visit

Day 4 – Develop Potential Scenarios

Activity:

- Develop three potential scenarios, which can be solutions to the research problem
- Give criteria to specify the scenarios

Milestone:

- 3 scenarios are developed
- 2-3 PowerPoint slides (incl. sketches, if applicable)

Day 4 – Impact Assessment

Activity:

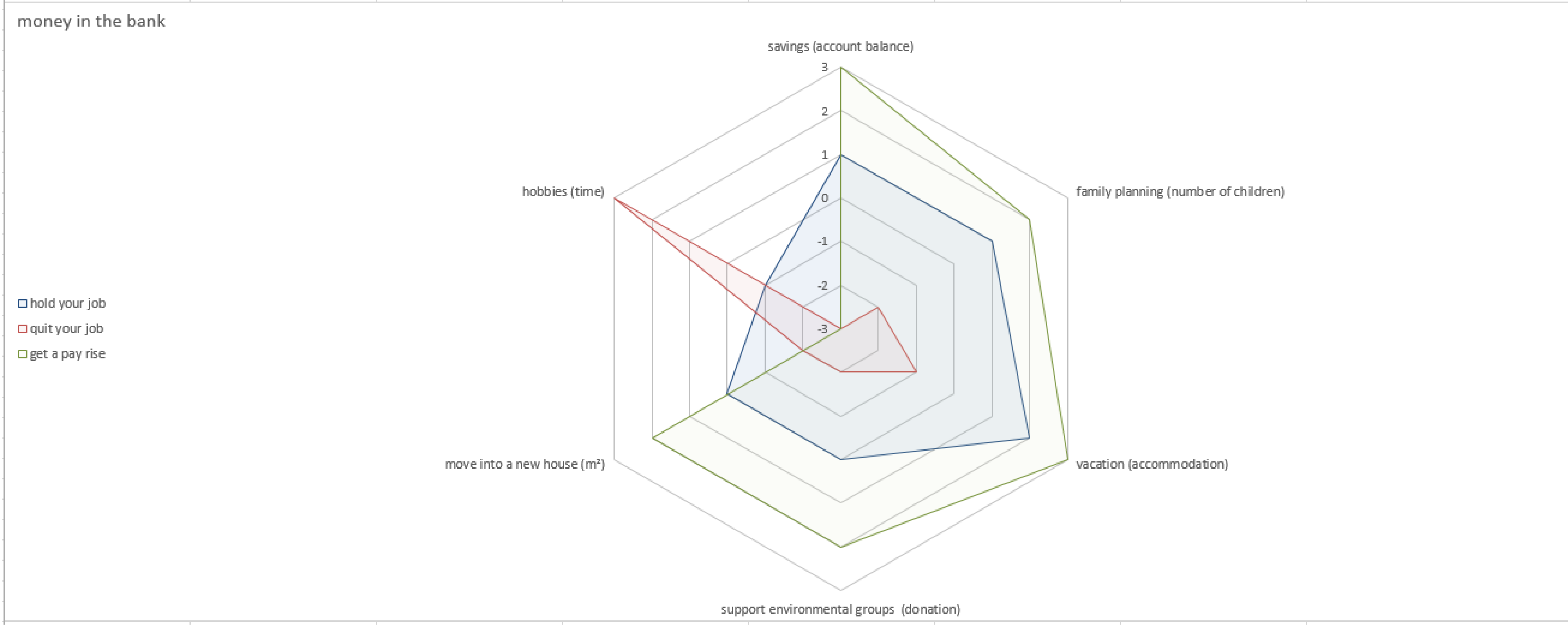
- Conduct participatory impact assessment
- Critical reflection on the assessment (exercise)

Milestone:

- An assessment net (spider) is produced
- Final consultation with senior lecturers
- 2-3 PowerPoint slides
- Preparation of the group presentations

Spider diagram

money in the bank	savings (account balance)	family planning (number of children)	vacation (accommodation)	support environmental groups (donation)	move into a new house (m²)	hobbies (time)	
hold your job	1	1	2	0	0	-1	please insert values between -3 - +3
quit your job	-3	-2	-1	-2	-2	3	please insert values between -3 - +3
get a pay rise	3	2	3	2	2	-3	please insert values between -3 - +3



Spider: Example from WEFCA 2019

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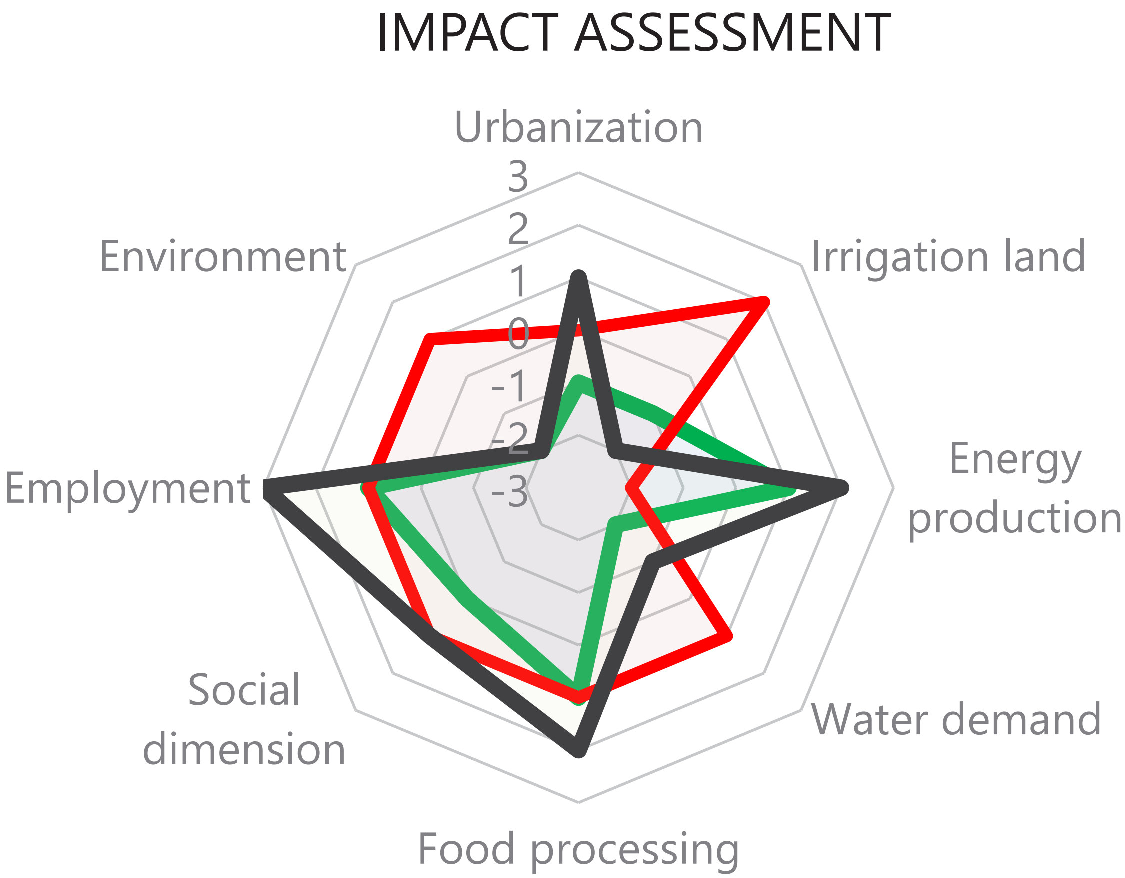
Scenario 1 (No change)

Scenario 2 (Agricultural intensification)

Scenario 3 (Industrial processing)



www.zalf.de

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Day 5 – Group Presentation

Activity:

- Individual group presentation (15 min ppt + 15 min discussion)
- Final remarks about the Summer School

Milestone:

- Comments/feedback from lecturers and peers
- A Certificate of Participation for each participant

Group A

Unlocking water security with renewable energy in Central Asia: Opportunities and challenges

- Aziz Ali Khan
- Makhliyo Nasirova
- Aigerim Karibay
- Maftun Qodirov
- Ilkhom Urazbaev
- Anastasiya Salnikova
- Munisa Burxonova

Group B

Implementation of water- and energy-efficient irrigation technologies: Potential rebound effects

- Shakhnoza Abulkosimova
- Hannah Rakel Ackerman
- Anton Liutin
- Nodirjon Gadayev
- Ardak Nassir
- Jamshid Shukurullaev

Working Groups

Group C

Soil health for improving management practices

- Kamol Khamraev
- Laura Ryssaliyeva
- Gulnaz Jalilova
- Boburjon Najodov
- Zulfiya Kannazarova
- Sardor Khamidov

Group E

Governing the WEFE nexus challenges at the local level, integrating ecosystem perspectives in decision making

- Aslam Qadamov
- Gulchehra Eshmuratova
- Sarvar Melikuziyev
- Shovkat Khodjaev
- Rakhima Malau
- Alla Sabbatovskaya

Group F

Transboundary water management for multiple sectors: Case studies from small hydropower projects

- Sobir Qodirov
- Balzhan Amanbayeva
- Tinatin Olzhobaeva
- Bekhzod Egamberdiev
- Nazar Nurzoda
- Kalina Fonseca
- Akhrorkhon Khamidov

Thank you for your attention !

Questions?

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Water–Energy–Food (WEF) nexus: Concepts and cases

Ahmad Hamidov

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Leibniz Centre for Agricultural Landscape Research (ZALF)

Date: 21 August 2023

Notes: Good morning, and welcome from my side too. I am very glad to see you all in this 2nd summer school. I think we had a very successful in 2019 and it is great to see some of the participants who also took part in the 1st one. They are now seniors and hope to facilitate and support during the event, especially in group works.
It is important to highlight that Kakhramon Djumabaev played a key role in realising this summer school. Unfortunately for all of us, he passed away about 1 month ago.
The main aim of this course is to bring together interdisciplinary group of scientists and work together in operationalizing the WEFE nexus in the region. During the course, you will learn about different tools to analyse WEFE nexus and develop alternative scenarios/options for addressing practical problems.

Outline

- Background
- Water–energy–food (WEF) nexus concept: an overview
- WEF nexus challenges in Central Asia
- Operationalization of WEF nexus in the region during WEFCA 2019 summer school
- Future research → Water- and energy-efficient irrigation technologies in Central Asia: Potential rebound effects

Academic background

- 2010 – 2015: Doctor of Philosophy (PhD) in Agricultural Economics, Humboldt University of Berlin (Germany)
- 2005 – 2007: Master of Science (MSc) in Water and Coastal Management, Erasmus Mundus joint program with University of Cadiz (Spain) and University of Algarve (Portugal)
- 2002 – 2004: MSc in Marketing of Water Resources, Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIIAME)
- 1998 – 2002: Bachelor of Science (BSc) in Management of Water Resources, TIIAME

Researcher and lecturer

Project member:

1. "SusWEF - Sustainable water-saving irrigation technologies for achieving water, energy and food security in the context of climate change in Uzbekistan"

2. "WEF - Sustainability assessment of the water–energy–food nexus in Uzbekistan: Climate change and transboundary water management scenarios" – implemented by Assem Mayar

Lecturer:

- Advanced Empirical Methodology for Social-Ecological Systems Analysis at Humboldt-Universität zu Berlin

WEF nexus – overview

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- The notion of a water–energy–food (WEF) nexus have increased in recent years, following the release of a World Economic Forum report in January 2011
- The 2011 Bonn Conference presenters promoted the WEF nexus as a novel and presented evidence for how a nexus approach can enhance water, energy, and food security

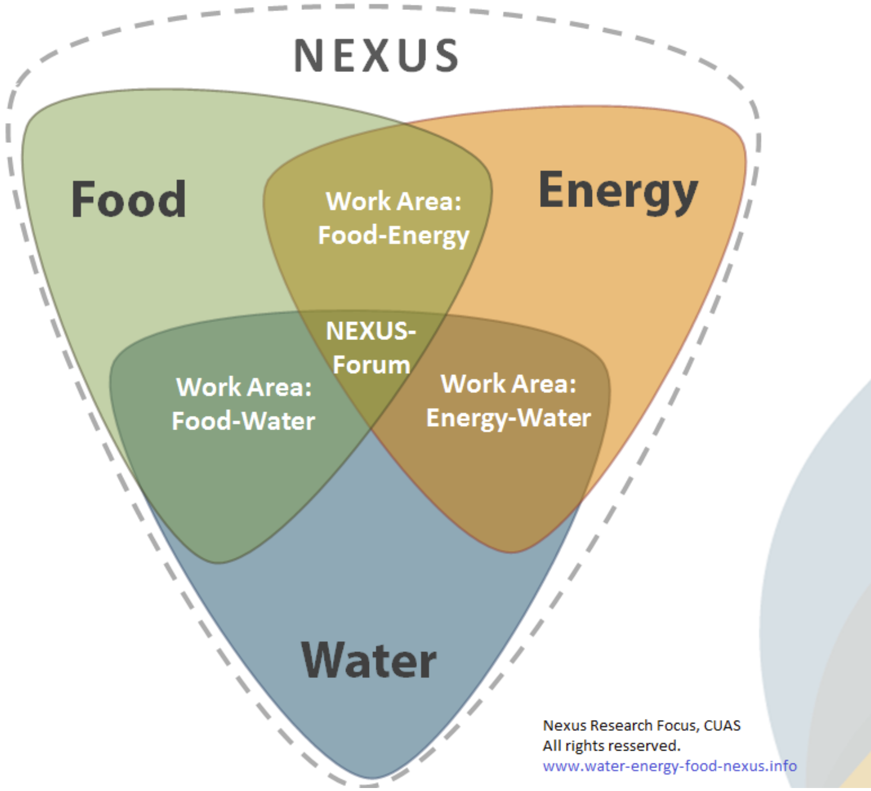
WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

Bonn2011 Conference
The Water, Energy and Food Security Nexus
Solutions for the Green Economy
16–18 November 2011

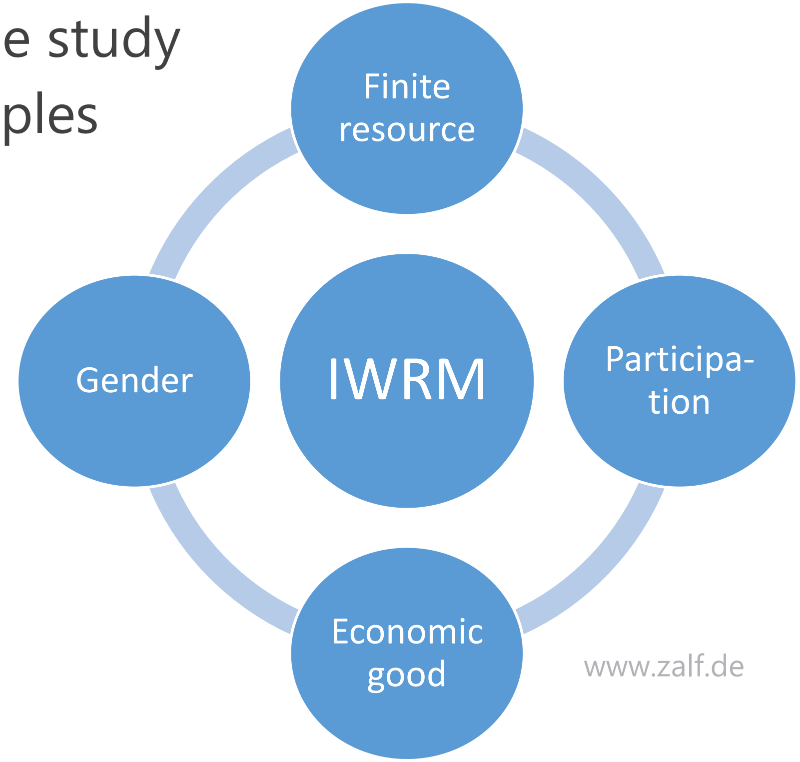
WEF nexus concept

- The WEF nexus has become an important concept to indicate the interconnectedness of the three sectors and to improve cross-sectoral coordination in support of sustainable development
- It has been operationalized to explore the linkages between different sectors as well as tradeoffs across temporal and spatial scales
- Some authors have suggested that a nexus approach should be followed when describing efforts to achieve the SDGs



WEF nexus – INRM & IWRM

- WEF nexus is reminiscent of earlier discussions in the literature regarding INRM and IWRM
- INRM was proposed as a framework for describing how farm-level activities interact with environmental and natural resource goals
- IWRM reflects a systems approach to the study of water resources, based on four principles
- Both INRM and IWRM reflect systems approaches
- However, several authors provided explanations for inability of INRM and IWRM to generate notable results



Notes: INRM suffers from the lack of a common and agreed theoretical basis, relegating the notion to the realm of practice, rather than serving as a guiding principle.
IWRM - water allocation in water-scarce areas is primarily a political decision, and IWRM is not well suited to address political issues, particularly in countries where the institutional responsibility for allocating and managing water resources is not well developed.

Energy and food tradeoff

- Water and energy use in agriculture or competition for water and energy involving agriculture were addressed in many studies
- Global financial crisis of 2008–2009 and the increasing awareness of the impacts of biofuel production on food prices stimulated public concern regarding tradeoffs involving energy and food
- Competition for land and water involving crop production for biofuels and food likely generated interest in the water node of the nexus

Climate change and nexus

- Emerging climate change (e.g., drought, heavy rainfall) may threaten the sustainability of the water sector and cause challenge to increase global food supply
- Thus, the uncertainty associated with climate change has added a new dimension requiring consideration in the nexus

Source: *europal.europa.eu*

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WEF nexus criticism

Some scholars have been critical of the WEF nexus:

- it is not yet a clearly defined concept or tested framework
- few empirical evidence exist
- lacks broader involvement of stakeholders to work collaboratively towards sustainable development
- existing descriptions are largely silent on issues such as soils, crops, nutrients, farm chemicals, and land tenure
- social scientists have to engage in the nexus debates critically, rather than accepting it as a “matter of fact”

WEF nexus in Central Asia

- The perfect storm of competition and trade-offs between WEF as they interact with the environment and climate is illustrated by the catastrophic drying of the Aral Sea basin
- A lack of systemic approaches to natural resource management has resulted in serious environmental degradation and social consequences in the region
- The relative importance of irrigated agriculture, hydropower generation, water diversion for municipal use, and subsequent environmental consequences varies by country
- Examples such as the Aral Sea case call for adopting WEF nexus concepts

Research objectives

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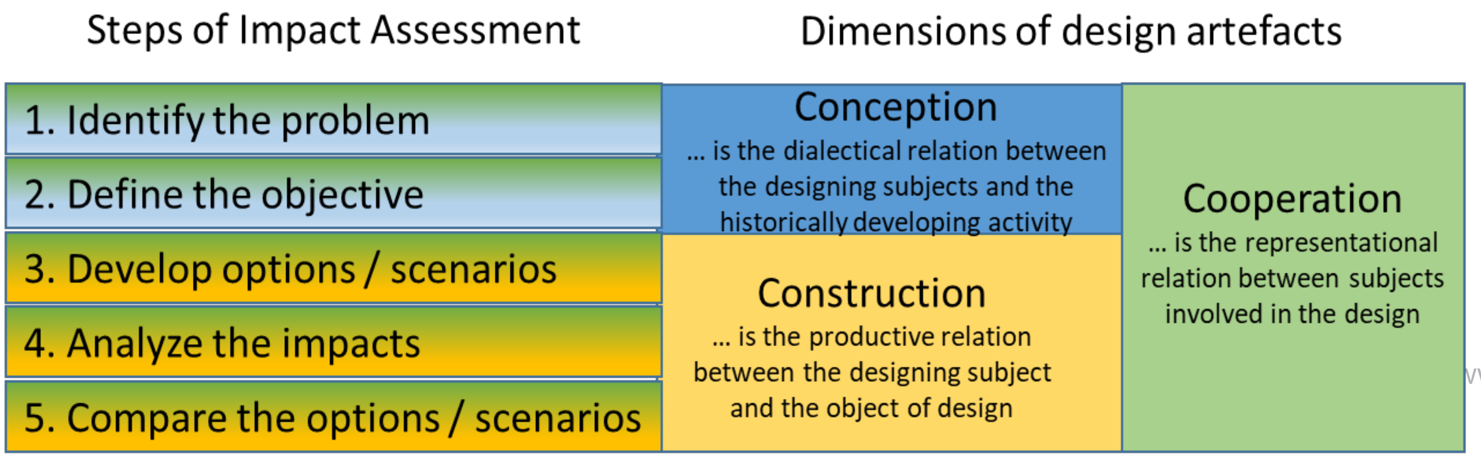
1) The extent to which sustainability impact assessment (SIA) is a suitable learning tool to adopt a systemic, interdisciplinary approach to WEF nexus problems,

2) the degree to which SIA can support sustainable development research in the context of WEF nexus challenges, and

3) whether the implementation of a common SIA protocol supports synthesis across WEF nexus cases.



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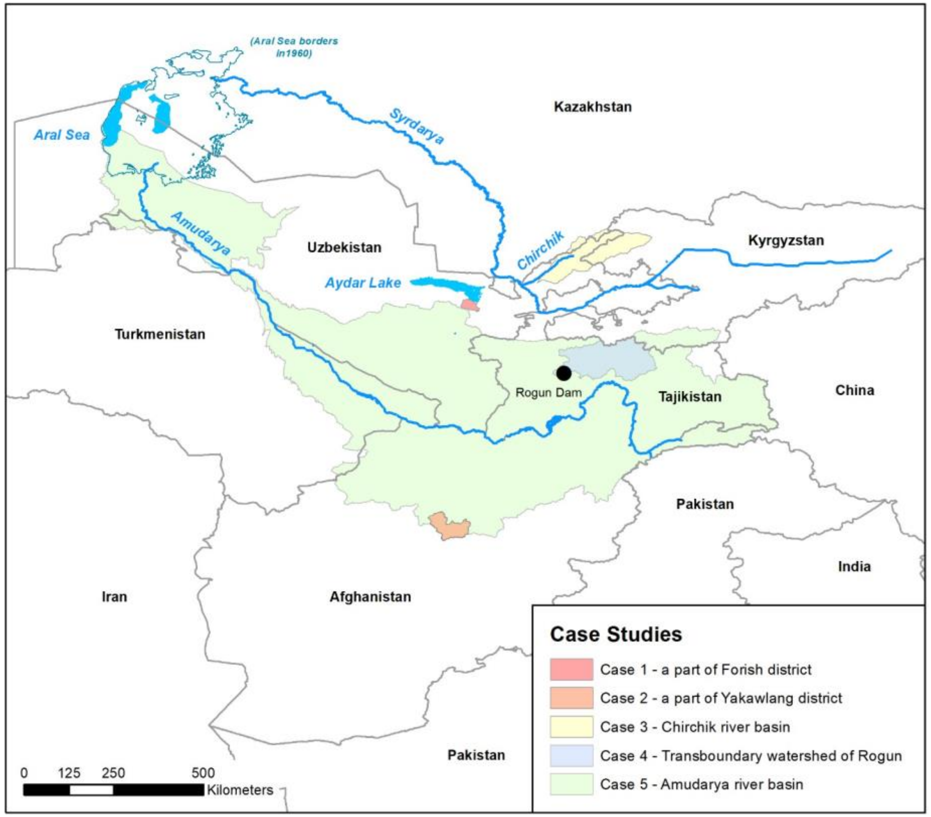
Implementation of SIA protocol in Central Asia

- Five exemplary WEF nexus cases in CA were developed during a week-long international workshop
- Although the case studies represent very close to real world scenarios in the region, they served as mock exercises
- The geographic extent of the cases ranged from international transboundary watersheds to very local scales
- Experts were assigned roles of various individual stakeholders and negotiated based on that role



Source: Location of the five case study areas in Central Asia

Notes: 1) The notion of a water–energy–food (WEF) nexus have increased in recent years, following the release of water security publication at the World Economic Forum (Davos) in January 2011
2) The concept received much attention during the 2011 Bonn Conference titled "The water, energy and food security nexus solutions for the green economy," at which distinguished speakers presented evidence for how a nexus approach can enhance water, energy and food security by increasing resource-use efficiency, building synergies (mutually beneficial outcomes), minimizing trade-offs (which may potentially include non-optimal outcomes) and improving governance across sectors

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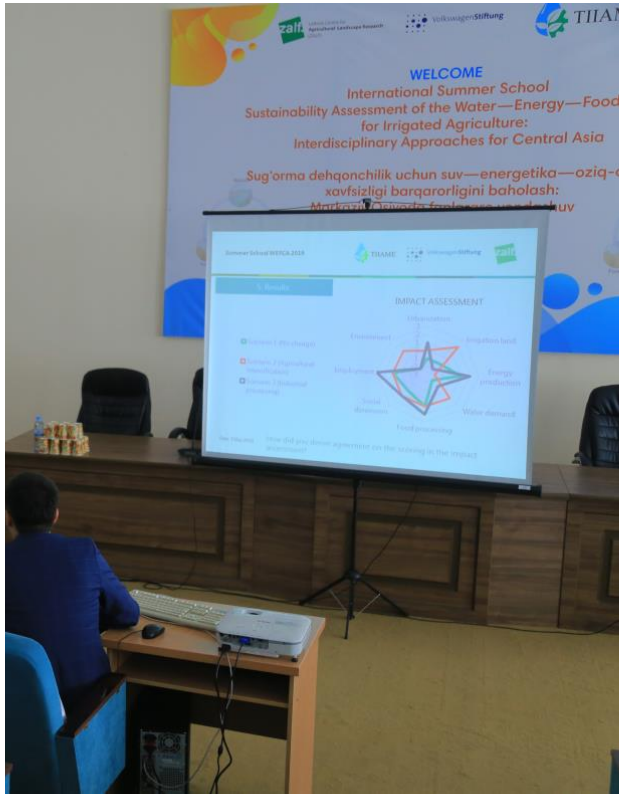
Method


WELCOME
International Summer School
Sustainability Assessment of the Water—Energy—Food
for Irrigated Agriculture:
Interdisciplinary Approaches for Central Asia
Sug'orma dehqonchilik uchun suv—energetika—oziq-
xavfsizligi barqarorligini baholash:
IMPACT ASSESSMENT

Relevance of SIA protocol for sustainability research

- Ex-post evaluation of SIA protocol was used for self-reflection on a research process

Criteria	Characterization
Approach to complexity and uncertainty	Evaluation of emerging risks and societal consequences emerging from dynamic and complex interactions that increase uncertainty in any form of inference
Ethics	Ethical, moral and value related questions affecting the society induced by research results, methodological designs and the determination of the value of science itself
Integrative approach	Consideration of all relevant elements, and interrelations in complex and multifaceted processes of modern societal development that are addressed by the research questions thereby integrating different dimensions (e.g., themes, time, space and knowledge systems)
Interdisciplinarity	Integration of mindsets and methods from different scientific disciplines to develop new methodological approaches and research results
Reflection on impacts	Assessment of the benefits and risks of research outcomes and innovations for the society and for sustainable development (e.g. intended/unintended, positive/negative, ex-ante/post)
Transdisciplinarity	Integration of knowledge via engaging non-scientific actors in specific scientific discourses and research questions, e.g. through participatory methods
Transparency	Clear and user-oriented communication about funding, legitimation, research design, methods and their limits and impacts on research results in all stages of the research process
User orientation	Target-group-oriented knowledge sharing through inclusion of all the relevant users of research results to

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WEF cases related to irrigated agriculture in CA

- All of the five empirical cases addressed the challenge of water resource use for food and/or energy production, although they differed in geographic scope
- From the perspective of WEF constellation, the five cases fall into two groups:
  - the first group includes Cases 1 and 2, in which land management for water saving and water storage purposes was the key component of the WEF nexus
  - Cases 3–5 make up the second group, in which water allocation for food and/or for energy production, and thereby for economic development and well-being, were the main WEF nexus constellations

Conception of WEF nexus cases in CA

	SIA steps	Case 1 (land)	Case 2 (land)	Case 3 (water)	Case 4 (water)	Case 5 (water)
Conception	Step 1 System boundary	Rural area → agricultural community (*shirkat*) in Djizzakh province, Uzbekistan ~ 780 km²	Rural area → watershed in Bamyan province (Yakawlang district), Afghanistan ~ 3,980 km²	Metropolitan area → watershed in Tashkent province, Uzbekistan ~ 14,480 km²	Transboundary → watershed of Rogun dam in Tajikistan and Uzbekistan (~ 17,400 km²)	Transboundary → Amudarya watershed in Afghanistan, Tajikistan, Turkmenistan, Kyrgyzstan, and Uzbekistan ~ 520,000 km²
	Step 1 WEF constellation	Land management Food production Alternative energy use Water availability	Land management Water use Energy (hydropower construction)	Water allocation Food production Energy production	Water allocation Food production Energy production	Water allocation Food production Energy production
	Step 1 Identify the sustainability problem	Pressure on land degradation because water is scarce, use of land for livestock is the only income source, and biomass and manure are the only energy sources	Soil erosion because of overgrazing leads to siltation of the hydropower dam and limits its effectiveness. Dam construction needs to be accompanied by upstream soil conservation measures	Water is the limiting factor for economic development in the Tashkent province	Uncoordinated hydropower dam construction in upstream country affects water utilization options for irrigated food production in downstream country	Water utilization options for food in downstream countries depends on water utilization for energy in upstream countries
	Step 1 Framing the problem	**Rural livelihood:** based on livestock production	**Hydropower dam maintenance:** upstream land management to avoid dam siltation	**Urban and rural livelihood:** local economic development with dam regime management	**Governance: bi-national** cooperation in water management	**Governance: multi-national** cooperation in water management
	Step 2 Define the objective	Improve management of the land to improve resilience of local population (maintain livestock production system)	Improve land management in order to maintain functioning of the water regulation in order to stabilize food and energy production	Utilize water for economic development in most sustainable way	Improve water management to optimize food production in Uzbekistan and energy production in Tajikistan	Optimize water utilization options for all five riparian countries in the watershed

Construction of WEF nexus cases in CA

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	SIA steps	Case 1 (land)	Case 2 (land)	Case 3 (water)	Case 4 (water)	Case 5 (water)
Construction	Step 3 Develop options /scenarios	**Rural development planning** a) Develop public infrastructure (roads, buildings, water) to extend the grazing options to remote places b) Integrated livestock management c) Ecological tourism	**Rural land management** Hydropower constructions and a) No land management b) Government managed forests and pastures (mainly restoration) c) Community managed forests and pastures (restoration plus management)	**Subnational water governance** a) Business as usual (single sectoral planning) b) Water use for energy to industries c) Water use for food production	**Binational water governance** a) No cooperation b) Partial cooperation c) Full cooperation (optimal water allocation, centrally managed)	**Multinational water governance** a) Business as usual: national approaches to water management b) Joint approaches to water management
	Step 4 Analyze impacts: Impact areas and their links to SDGs	6 impact areas: Food production (SDG 2) Quantity of dung for heating or fertilization (SDG 2/7) Availability of drinking water (SDG 6) Alternative energy production (SDG 7) Work opportunities (SDG 8) Carrying capacity of pasture – land degradation pressure (SDG 15)	3 impact areas: Water availability for irrigation (SDG 6) Hydropower production (SDG 7) Soil erosion (SDG 15)	8 impact areas: Food processing (SDG 2/11) Irrigated area (SDG 2/11) Human health & education (SDG 3) Water demand (SDG 6) Energy production (SDG 7) Employment/work opportunities (SDG 8) Urbanization (SDG 11) Environmental health (SDG 15)	6 impact areas: Agricultural production (SDG 2) Water quality (SDG 6) Share of population with clean water supply and access to sanitation (SDG 6) Energy production (SDG 7) Employment rate (SDG 8) Ecosystem services (SDG 15)	6 impact areas: Agricultural land change (SDG 2) Vegetation period change (SDG 2) Change in population's standard of living in each country (SDG 3) Change in ecosystem service provision (SDG 15) Occurrence of extreme events (SDG 15) Biodiversity change (SDG 15)

Construction of WEF nexus cases in CA

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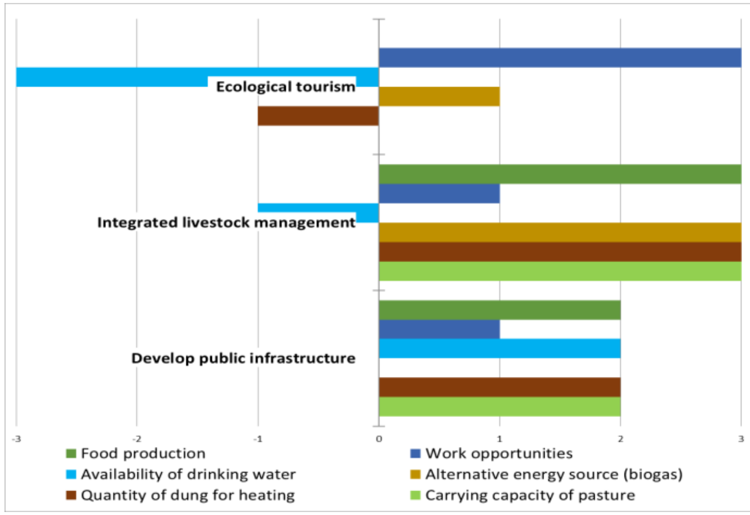
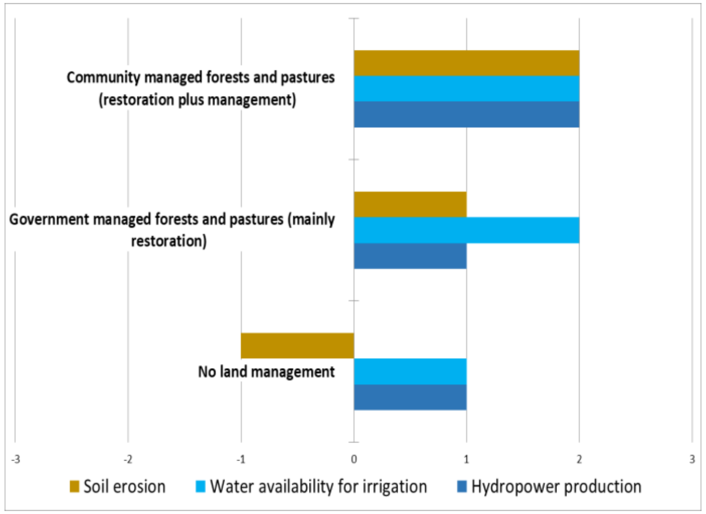
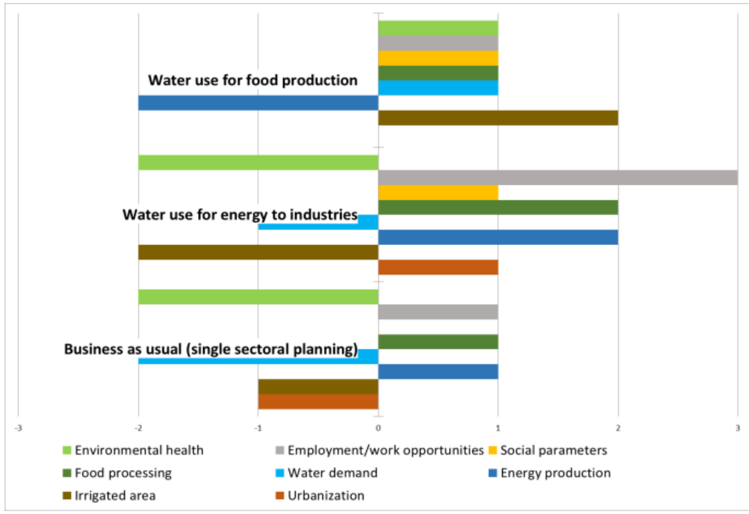
Case 1: Food and energy production in Uzbekistan



Case 2: Hydropower construction impacts on land and water management in Afghanistan



Case 3: Water use across food and energy sectors in Uzbekistan



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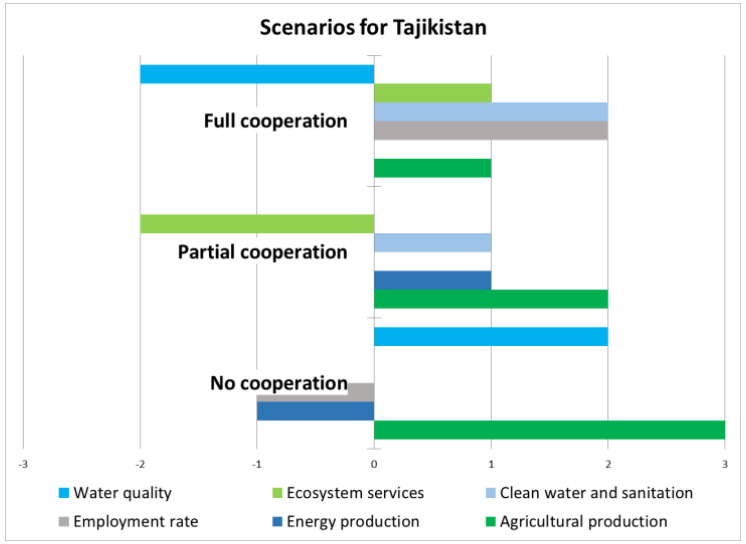
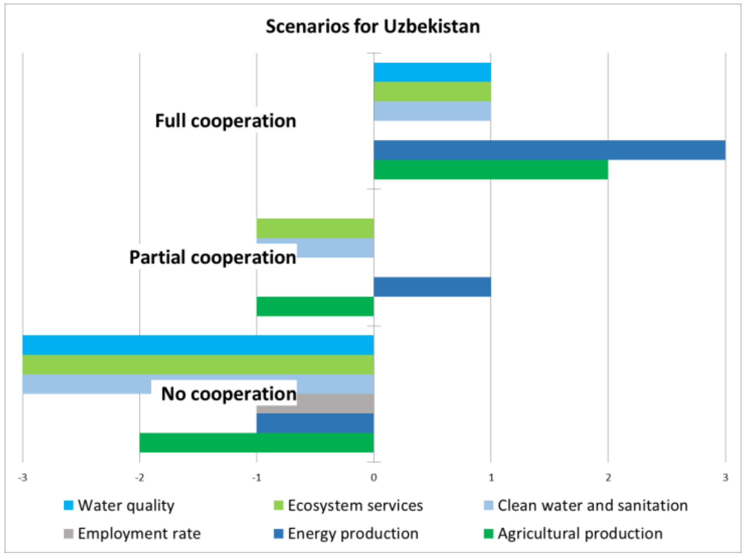
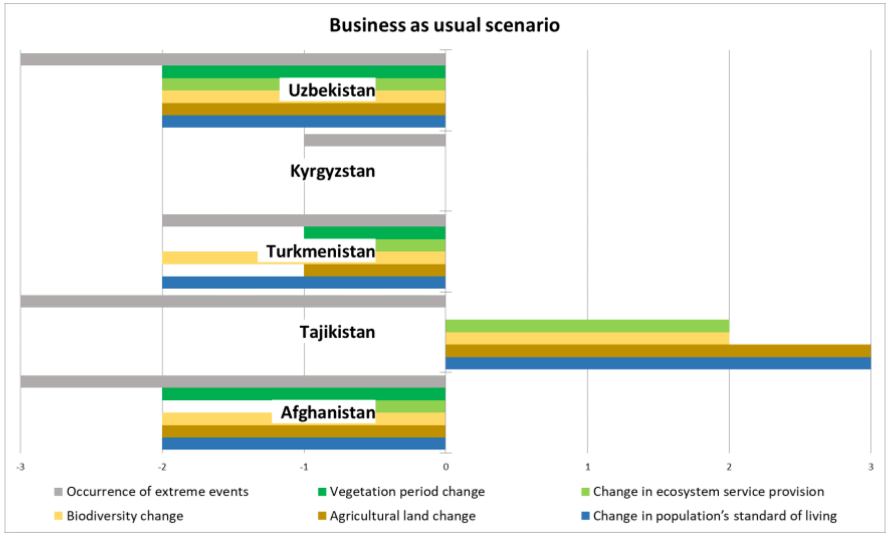
Construction of WEF nexus cases in CA

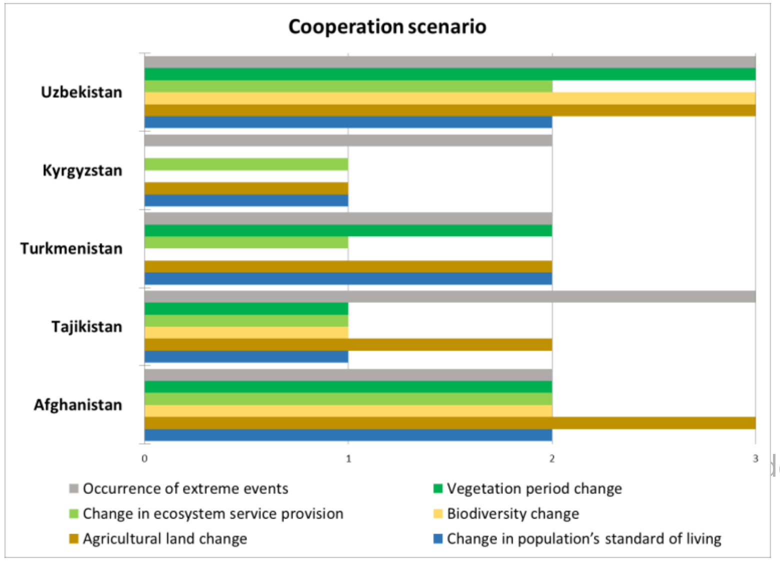
Case 4: WEF nexus governance cooperation between Tajikistan & Uzbekistan: Case of Amudarya river basin





Case 5: Water management across five countries of the Amudarya river basin





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Cooperation of WEF nexus cases in CA

- Some groups played the role of different country policy makers
- Participants struggled with identifying relevant actors to represent during the impact assessment exercise
- The SIA protocol proved to be insufficiently instructive for the design of the cooperation with actors and stakeholders in the WEF research
- SIA protocols need further development to include instructions for stakeholder co-operation

Conclusion

- WEF nexus concept was operationalized for five case studies in CA through SIA protocol
- The SIA protocol is instructive for the conception and construction of WEF nexus research
- It is less instructive for the design of the cooperation with actors and stakeholders
- The use of the protocol facilitates comparative meta-analyses of case studies for synthesis and upscaling
- Applying the SIA protocol for the design of the WEF nexus research helped workshop participants to understand the complexity of the problem and to establish the interdisciplinary cooperation
- It was less instructive in designing the transdisciplinary cooperation

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Operationalizing water-energy-food nexus research for sustainable development in social-ecological systems: an interdisciplinary learning case in Central Asia

Ahmad Hamidov, Katrin Daedlow, Heidi Webber, Hussam Hussein, Ilhom Abdurahmanov, Aleksandr Dolidudko, Ali Yawar Seerat, Umida Solieva, Tesfaye Woldeyohanes, Katharina Helming

https://doi.org/10.5751/ES-12891-270112

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Research

Figures,

ABSTRACT

In social-ecological systems, natural resource management can be characterized by trade-offs across sectors and sustainability targets. The water-energy-food (WEF) nexus concept makes explicit various trade-offs in order to maximize synergies of interventions. However, there are few successful examples of its operationalization in research settings. Here, we explore in a learning setting if sustainability impact assessment (SIA) protocols can be a useful process to be used to adopt a systemic, interdisciplinary perspective to operationalize WEF nexus in research for sustainable development. The process and method adopted of SIA protocol, evaluated for five exemplary WEF nexus cases in Central Asia during a week-long international workshop, adequately addressed the complexity of WEF interrelationships and associated

RebUz – Sustainability assessment of irrigated agriculture: Rebound effects in semi-arid Uzbekistan

- Duration: 36 months, November 2023 – October 2026
- Funded by: German Research Foundation (DFG)
- Objective: Study the sustainability of irrigated agriculture in semi-arid regions of Uzbekistan by evaluating the adoption of water- and energy-efficient irrigation technologies and their rebound effects in light of climate change stresses
- Cooperation partners: ZALF (coordination), Humboldt-Universität zu Berlin, „TIIAME" NRU, IWMI-CA office

Thank you for your attention !

Questions?

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Day 2

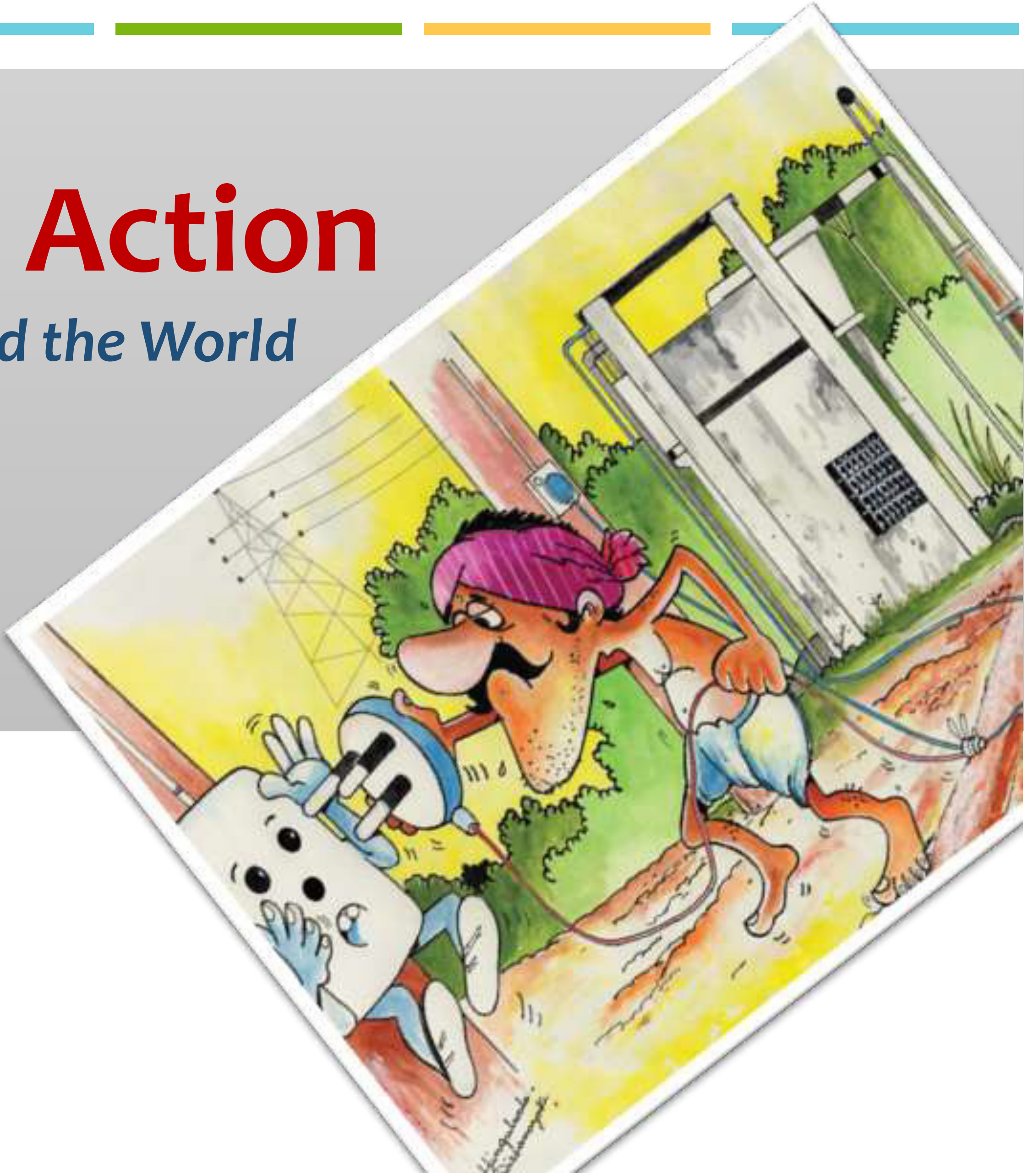
WEF-Nexus in Action

Comparing Notes from around the World

Shilp Verma

Senior Researcher, Water-Energy-Food Policies

| IWMI Anand | shilp.verma@cgiar.org |



2nd International Summer School 2023

Tashkent | 22 August

Six Stories | Six Key Lessons

| WEF Nexus is not unique to a country or region | Every region has found its own way to deal with it, with mixed results | Potential for cross-learning |

Geopolitics drives WEF Nexus in Iran

| Groundwater sustainability sacrificed for food self-sufficiency | Experiment with smart meters to check abstraction – mixed | Hardening of international sanctions might further drive depletion |

CONTEXT

- Increasing reliance on GW over-exploitation for food production
- TWs: <50k (1970) → 500k (2006) → >1m (2016); >800k *illegal wells* (2018)
- 85% wheat procured by govt. above global price
- GW Depletion: 1m per annum; soil salinization; dereliction of *Qanats*

DRIVERS

- National Food Self-sufficiency Policy
- *Procurement of wheat above market prices ($405-425/mt, 2016)*
- *Heavy import duty on grains ($45-50/mt, 2015)*
- *Subsidized energy for pumping groundwater (95% subsidy, 2017)*

RESPONSE

- *Dasht-e-momno* (prohibited plain) – regulation on well permits, acreage, pump size, hours of operations
- Difficult enforcement; Intelligent energy and water meters
- Reduced depletion; 30 → 10 MCM (2008-11); crop shift, adoption of water-saving technologies

PROSPECTS

- Strict enforcement leads to push back from farmers
- Large-scale shift away from wheat untenable
- WEF policy goals at cross-purpose; Political economy of *illegal* tubewells
- **Farmers protect *income*, not *water*!**

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Food Trade drives Nexus *Faux Pas*

| Groundwater exploitation preferred to reliance on food imports | Even reversing 'food self-sufficiency' policy has not reversed groundwater depletion |

CONTEXT

- 1970s oil crisis; large-scale irrigation (1980-2000)
- Invested $83.6b to produce food worth $40b
- 1990's, world's leading wheat exporter; 12.4 BCM of 'virtual water'
- Settlement of poor Bedouin communities into agriculture

DRIVERS

- National Food Self-sufficiency Policy
- Procurement of wheat above market prices ($500/mt, 1984-2000); subsidy of $15b
- Irrigated area: 609k (1980) → 1.12m (2000); CapEx: $35k/Ha
- Net Rainfall: 2 BCM; GW pumping: 6.6 BCM (1996)

RESPONSE

- Economic and ecological disaster, difficult to reverse
- Gradual reduction in wheat procurement; irrigated area declined 23% but GW abstraction reduced by only 9%
- Shift from wheat → fruits and fodder counter-productive; decision had to be reversed

PROSPECTS

- Geopolitics limits (perceived) degrees of freedom
- Irrigation expansion for Bedouin community, but most benefits accrued to large farming companies who own 2/3rd of new irrigated area
- Even giving up food self-sufficiency didn't help! *Price inelastic irrigation water demand?*

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Governments propose, Farmers dispose

| In Mexico, politicians have repeatedly frustrated governance reforms and efforts |

CONTEXT

- Agriculture uses more than 60% of GW
- 100 / 653 aquifers depleted; all aquifers in Guanajuato province withdraw 40% more GW than available
- 500-1000m deep wells, 75-300 HP motors
- Reports of land subsidence

DRIVERS

- Growth model based on agri exports
- Heavily subsidised power to poor ejidatarios farmers
- Subsidy bill: $592m/yr, or $1,600/ha
- Also land-levelling, micro irrigation, fertigation to improve field efficiency – no help to aquifers

RESPONSE

- Regulation (*vedas* – prohibited areas) failed, difficult to enforce
- Participatory self-governance (COTAS) also did not help
- Farm Power Pricing – worked (energy 72 – 57 GWh in '92), but diluted
- Marketable water rights also tried

PROSPECTS

- Energy prices more effective than *Vedas* or COTAS
- Gains from pricing diluted due to farmers' response, concessions, roll-back
- 20% energy subsidy on night irrigation, farmers' refusal to pay electricity bills

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Limits to Government Regulation

| Close the wells, abandon the lands – is this the ultimate solution? |

CONTEXT

- North China plains – breadbasket and GW depletion hotspot
- 30% of water resource, 67% of food production
- Farming very efficient and productive, but doubtful sustainability due to dependence on fossil GW

DRIVERS

- Much fewer subsidies for farm power / equipment
- Population pressure, highly productive farming, well-developed irrigation markets drive depletion
- Household Responsibility System privatized TW irrigation – farmers shifted to more water-sensitive, high value crops

RESPONSE

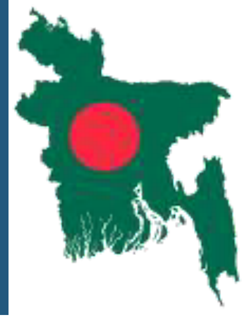
- IWRM, with a *twist*
- Farmers charged high tariffs, vigorously collected
- Party-backed wireman incentivized to collect
- Direct regulation
- Participatory / WUAs
- Outcome-linked-funding

PROSPECTS

- Shiyang basin (Gansu) big success story
- Coercive enforcement led to exodus from farming: '*ecological refugees*'
- High social and transaction costs of controlling depletion, despite strong state

Centrally Managed Distributed Irr. Service

| BMDA has succeeded in centrally managing decentralized irrigation service business | Will this last?



CONTEXT

- 1971: Ag. stagnation, dependence on rice imports
- (delayed) STW adoption and high productivity boro paddy helped
- Thanks to budgetary constraints, no subsidies
- Under-developed resource with limited access to poor

DRIVERS

- Development of a historically 'backward' region
- Relatively less rainfall (1600 mm), rain-fed, low productivity agriculture
- BMDA established (1985) to implement Barind Integrated Area Development Project

RESPONSE

- Public Tubewells Program – moderate to poor success in IN, PK
- Demand-led (not resource / supply driven)
- Pre-paid meters for full-cost recovery
- Incentivised operators
- Innovation and effective service
- Frugal organization
- (delayed) GW Governance regime

PROSPECTS

- Proactive, Holistic – excellent model for early-stage development
- Public investment has spurred private enterprise – how will it shape up?
- Triple Bottom Line: *Productivity, Equity, Sustainability*
- Long-term success remains to be seen

Indirect Approach to Resource Co-Management

| Range of policy experiments in India have applied an '*indirect*' approach to groundwater governance | Some of these *hint* at Nexus Approach – almost all are '*Second Best*' solutions |

CONTEXT

- N-W, Peninsular India has ~12m tubewells accounting for $15b annual farm power subsidy
- Perverse incentives, unhappy farmers, troubled utilities, depleted aquifers
- Clamour for reforms, universal metering, vehement opposition from farmers

DRIVERS

- Groundwater and rural electrification drives
- Water / irrigation service markets
- High TC of metering; sticky flat-tariffs
- Water sector oblivious to GW revolution; energy sector not interested

RESPONSE

- Regulation (ineffective)
- Reduced hours of power supply (ineffective)
- Feeder Separation (JGY) (partly effective; diluted to protect poor farmers)
- Supply-side measures (effective in parts)
- SPaRC / SKY (to be seen)

PROSPECTS

- Dynamic equilibrium that needs proactive responses
- Smartly overcame farmer resistence – *political* ~~will~~ *skill*
- Improved GW regime, agri growth – model interim solution?

Key Lessons from Nexus Stories

| Are Nexus Solutions transferable and replicable? | Are there ‘design principles’ that can be replicated? |
| Are there lessons for finding local Nexus solutions? |

- Institutional Capacity and Transaction Costs
  - Direct Regulation will struggle due to excessive Transaction Costs or limited capacity for enforcement
  - Not ineffective, just not practical

- Strategic Coherence, at the top!
  - Sectoral priorities are often defined in silos
  - Conflicting objectives → confusing signals
    - *Conserve GW, but here’s some free power!*
  - Target audience for Nexus solutions is ‘Top Leadership’

- Missing the woods: Treating Symptoms
  - Grain procurement above-market prices
  - Price elasticity of irrigation water demand?
  - Micro irrigation, Energy efficient pumps / field-level efficiency?

Key Lessons from Nexus Stories

| Are Nexus Solutions transferable and replicable? | Are there 'design principles' that can be replicated? |
| Are there lessons for finding local Nexus solutions? |

- ## Political Context and Constituencies
  - Farmers are powerful constituencies – protect short-term income over long-term resource

- ## Hierarchy of Policy Priorities
  - Is the obsession with food self-sufficiency rational?
    - *India did the same in 1960s, Saudi Arabia has now moved away after 2000, Iran persists with food self-sufficiency*
  - Should GW depletion be checked at any cost?
    - *Will China replicate the success achieved in Shiyang?*

- ## Contingency Theory
  - Impossible to define a common governance pathway…?
  - Buzzword: *Is 'WEFE Nexus' the new IWRM?*
  - Nexus Ideal vs. Nexus Optima
    - *Are nexus solutions only temporary / transitionary 'second-best' solutions that constantly need to be tweaked?*

CGIAR | INITIATIVE ON NEXUS Gains | TIIAME NRU | zalf Leibniz Centre for Agricultural Landscape Research (ZALF) | Alliance Bioversity & CIAT | ICARDA | IWMI International Water Management Institute | IFPRI International Food Policy Research Institute | IWMI-TATA Water Policy Program

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International Water Management Institute

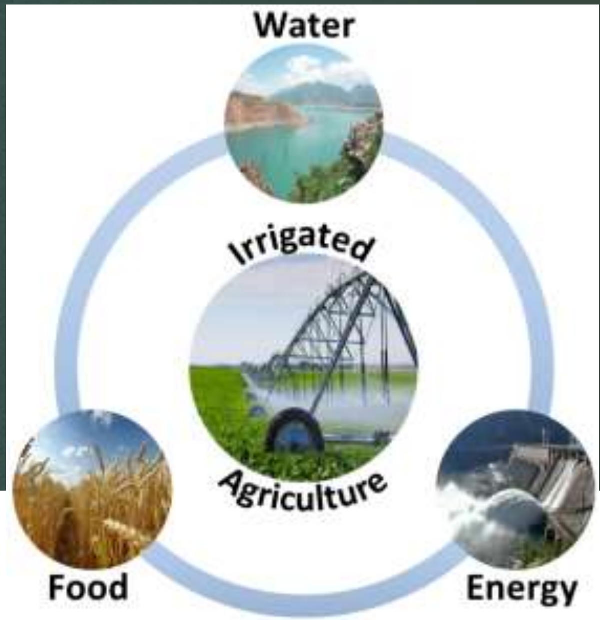
Thank You...

Innovative water solutions for sustainable development

Food·Climate·Growth

Centre for Agricultural Landscape Research (ZALF)

Participatory Sustainability Assessment



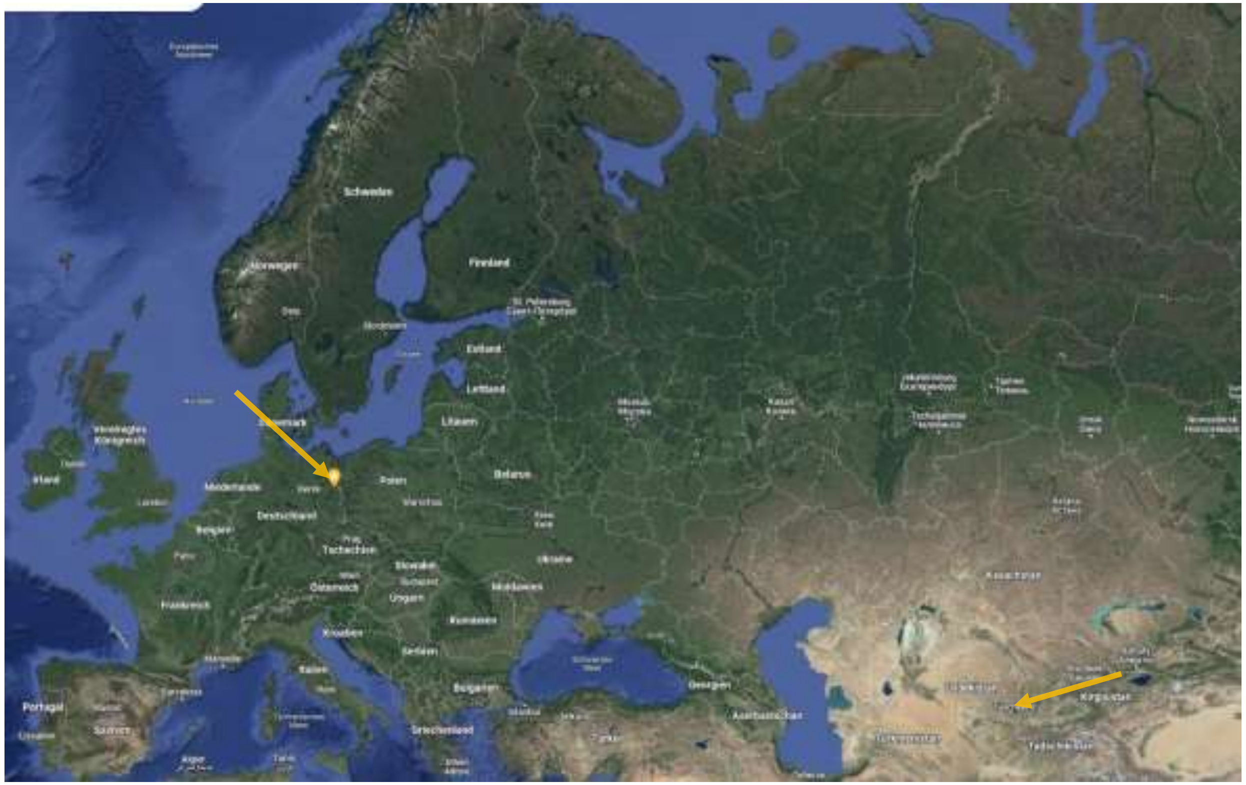
WEFECA Summer School Tashkent 21-25 August 2023

Prof. Dr. Katharina Helming,
Co-Chair Agricultural Landscape Systems, ZALF
Professor University for Sustainable Development, Germany

Datum: 22.08.2023

1

Leibniz Centre for Agricultural Landscape Research (ZALF)



Quelle: Archiv

2

Notes: Average forecasts assume that in 2050, around 9.7 billion people will be living on earth.
In addition, the average income will increase.
An increased demand for resource-intensive products and rising greenhouse gas emissions per capita are the result.

Global trends and challenges: Food security

Notes: To satisfy the growing demand for food, about 50 % more must be produced by 2050.
At the same time, it is important to reduce waste: Around 1/3 of all food produced currently ends up in the trash.

Global trends and challenges: Climate change

Notes: Worldwide, yields are threatened by increasing weather extremes such as heat, drought and flooding as well as rising temperatures and ozone levels.
Agriculture must adapt better, but it can also play a more active role in climate protection because plants and soils bind large amounts of carbon, for example.

Global trends and challenges: Biodiversity

Notes: Biodiversity is massively affected by land use: One million species are currently considered endangered. The intensification of agriculture has a direct impact on the occurrence and survival of many animal and plant species.

Notes: Agriculture directly influences ecosystem services such as clean drinking water, insect pollination and the experience of nature. Degradation is already causing global damage of between 5.5 and 9.3 trillion euros each year due to ecosystem services that are no longer provided. Every year, 12 million hectares of land are lost for agricultural use due to degradation. Landwirtschaft beeinflusst direkt Ökosystemleistungen wie sauberes Trinkwasser, die Bestäubung durch Insekten oder auch das Naturerlebnis. Durch Degradation entsteht schon heute weltweit jährlich ein Schaden durch nicht mehr bereitgestellte Ökosystemleistungen in Höhe von 5,5 bis 9,3 Billionen Euro. 12. Mio Hektar jährlich gehen an Landfläche durch Degradation für die landwirtschaftliche Nutzung verloren.

Global trends and challenges: Digitalization

Notes: With the help of digitalization and new technologies, sustainable and climate-resistant cultivation systems can be developed. Through the collection and intelligent networking of environmental data, we can better adapt cultivation, harvesting and farm planning to the respective site conditions and thus protect ecosystem services, biodiversity and counteract unwanted climate changes.

Challenges to agriculture

9


Our mission
Leibniz Association
zalf
Reshaping Landscapes by Rethinking Agriculture
„Mission of ZALF is to deliver solutions for an economically, environmentally and socially sustainable agriculture – together with society.“
Photo: Jörg Schmalenberger / Photocase
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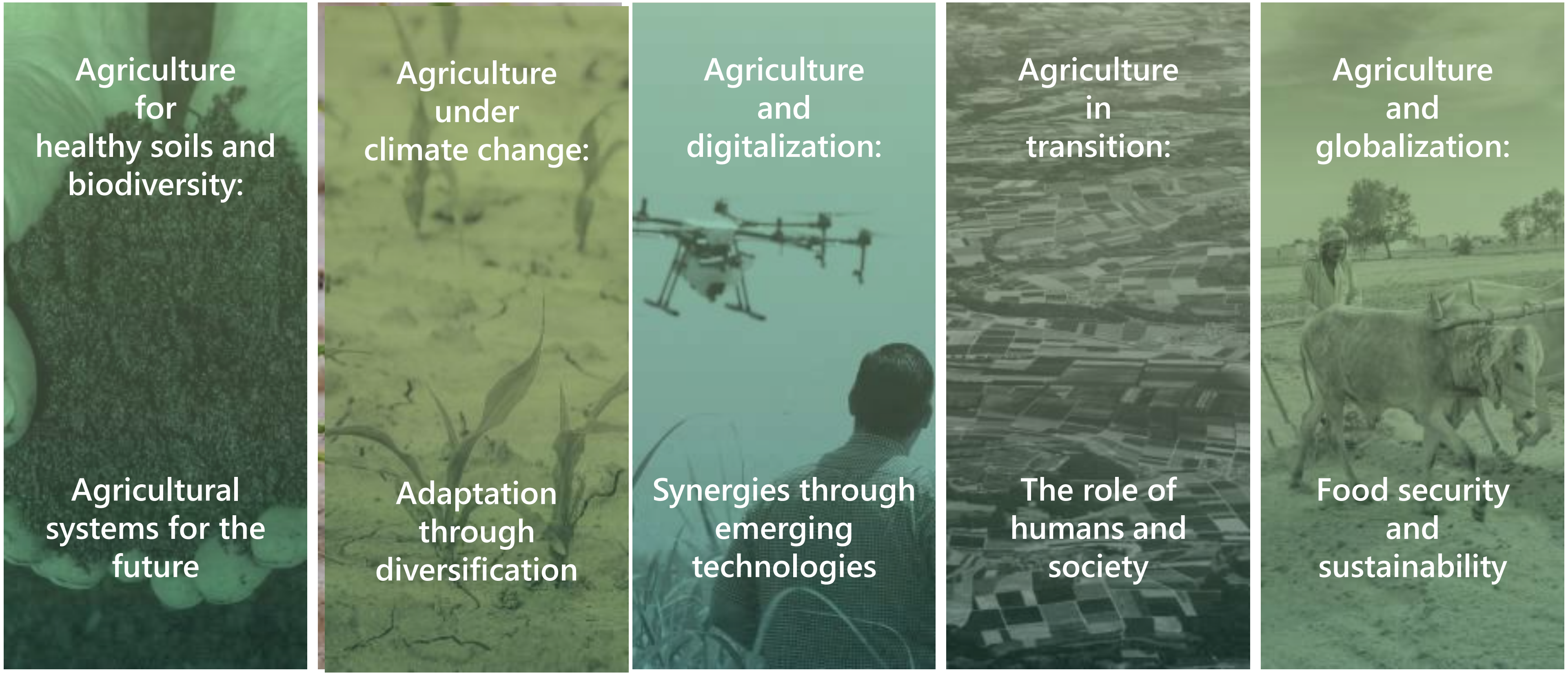
Our research topics



Photos: Andreas Schulze / iStock; Pixabay; Pixabay; marqs / Photocase; habibshad; iStock / ZALF

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Research Partners Worldwide (selection)

Leibniz Association

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WAGENINGEN UNIVERSITY & RESEARCH

INRA SCIENCE & IMPACT

CIMMYT

ETH zürich

ICRISAT

International Institute for Applied Systems Analysis IIASA

CGIAR

SLU

SRUC

JRC EUROPEAN COMMISSION

cirad

ROTHAMSTED RESEARCH

IFPRI

The James Hutton Institute

CSIRO

BOKU

USDA

中国科学院 CHINESE ACADEMY OF SCIENCES

FAO

NIBIO

TIIAME

UNIVERSITY OF COPENHAGEN

University of Reading

TAT

AARHUS UNIVERSITY

12

Research Partners Worldwide (selection)

Leibniz Association
zalf

WAGENINGEN UNIVERSITY & RESEARCH
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NIBIO
TIIAME
UNIVERSITY OF COPENHAGEN
University of Reading
TAT
AARHUS UNIVERSITY

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UN Sustainable Development Goals

United Nations (193 Member States)

World summit New York, 2015

Agenda 2030
17 Sustainable Development Goals
169 Targets

- ✓ Commonly agreed targets
- ✓ National specifications
- ✓ Indicators and monitoring systems
- ✓ Identification and management of trade-offs
- ✓ Progress reports

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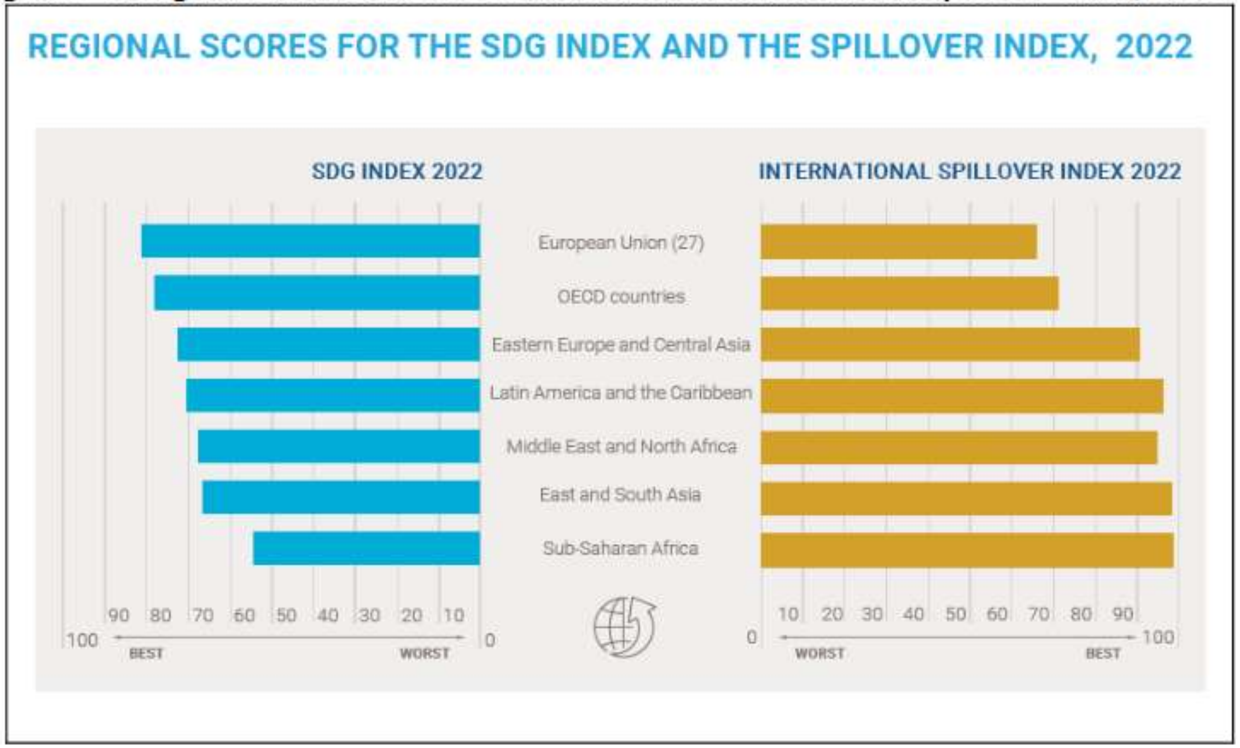
Sustainable Development Solutions Network
SD Report, June 2023
https://dashboards.sdgindex.org/profiles

Sustainable Development Solutions Network
SD Report, June 2023
https://dashboards.sdgindex.org/profiles

Figure 2-9: Regional scores for the SDG index and the International spillover index, 2022

SDG Index



Spill-over Index

GDP per capita

A comparison between the regional average SDG Index score (https://dashboards.sdgindex.org/rankings) and the International Spillover Index score (https://dashboards.sdgindex.org/rankings/spillovers). The comparison illustrates how countries perceived to perform well on the SDGs nationally are the same countries that hamper SDG progress elsewhere. Source: Sachs, J., Kroll, C., Lafortune, G., Fuller, G., & Woelm, F. (2022a). *Sustainable Development Report 2022* (1st ed.). Cambridge University Press. https://doi.org/10.1017/9781009210058.

a) SDGs are **common goals** of worldwide relevance

b) Each country has to implement the SDGs

c) Measurement and monitoring is important

d) Trade-offs between SDGs exist

Multifunctional role of agriculture and related policy indicators

Biodiversity &
Ecosystem Services
Soil health

Disaster Control

Climate Change
Mitigation

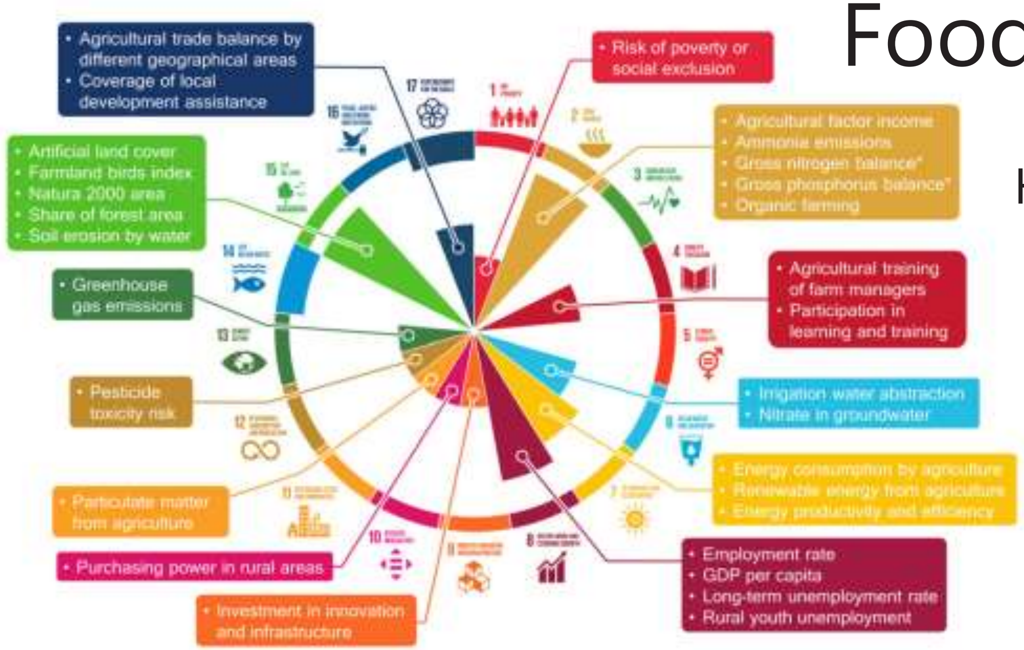
Rural Development

Food Security

Health

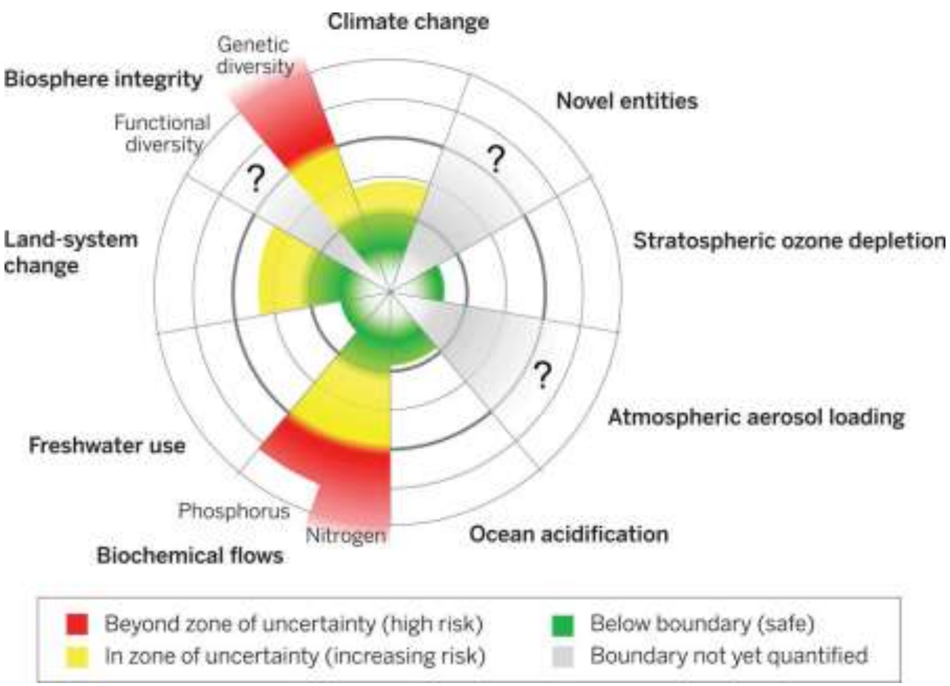
Clean Water

Clean Energy

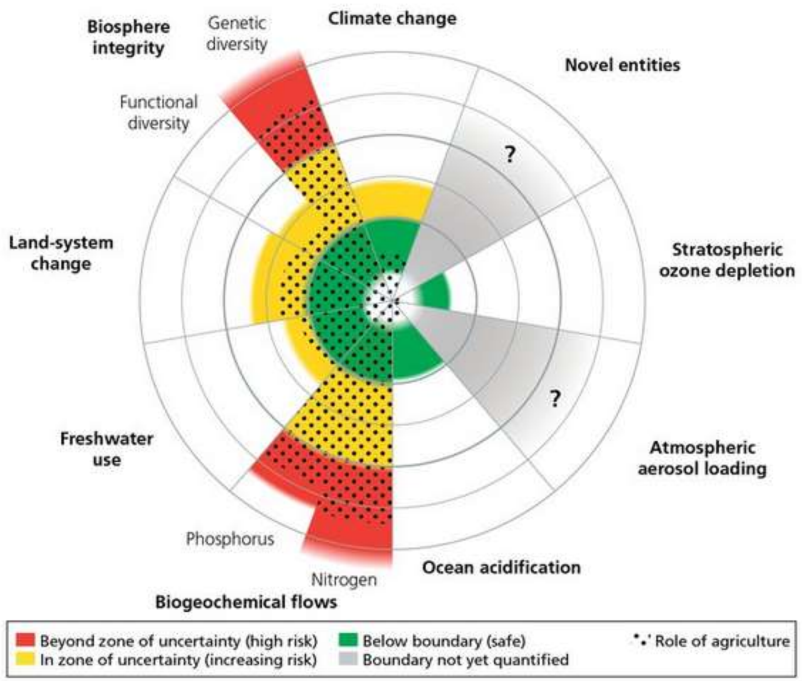


Agricultural policy indicators related to SDGs. Source: Scown and Nicholas, Global Sustainability 2020

Concept of Planetary Boundaries



Source: Rockström, et al., 2009



Campbell et al. 2017

www.zalf.de

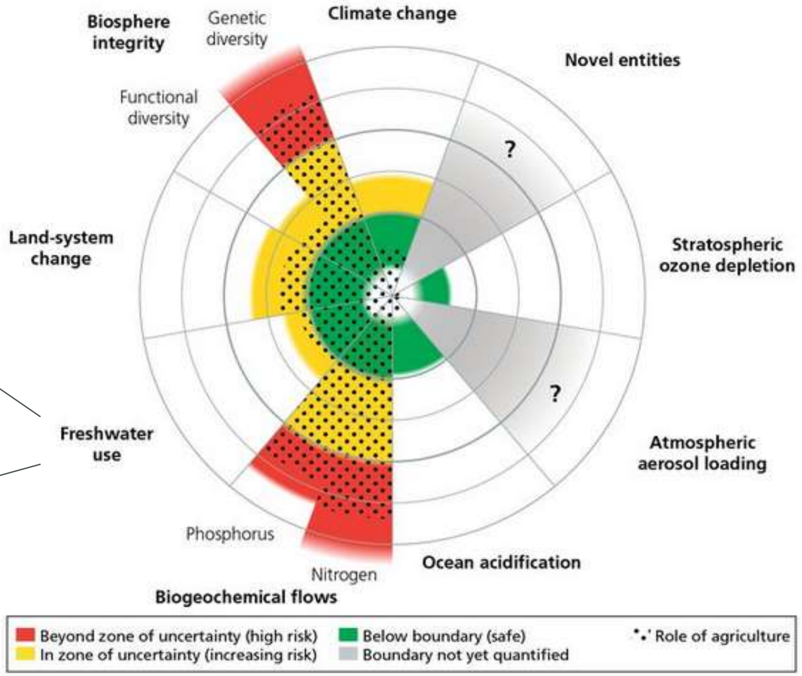
Concept of Planetary Boundaries

Exceeding boundaries

Green Water:
- **Soil moisture**
- **Evaporation**
- **Terrestrial precipitation**

Blue Water:
- **Rivers**
- **Lakes**
- **Ground Water**

Wang-Erlandsson et al., 2022
Nature Reviews



Campbell et al. 2017

www.zalf.de

A closer look on land

www.zalf.de

Soil Functions

Biomass production

Habitat for biological activity

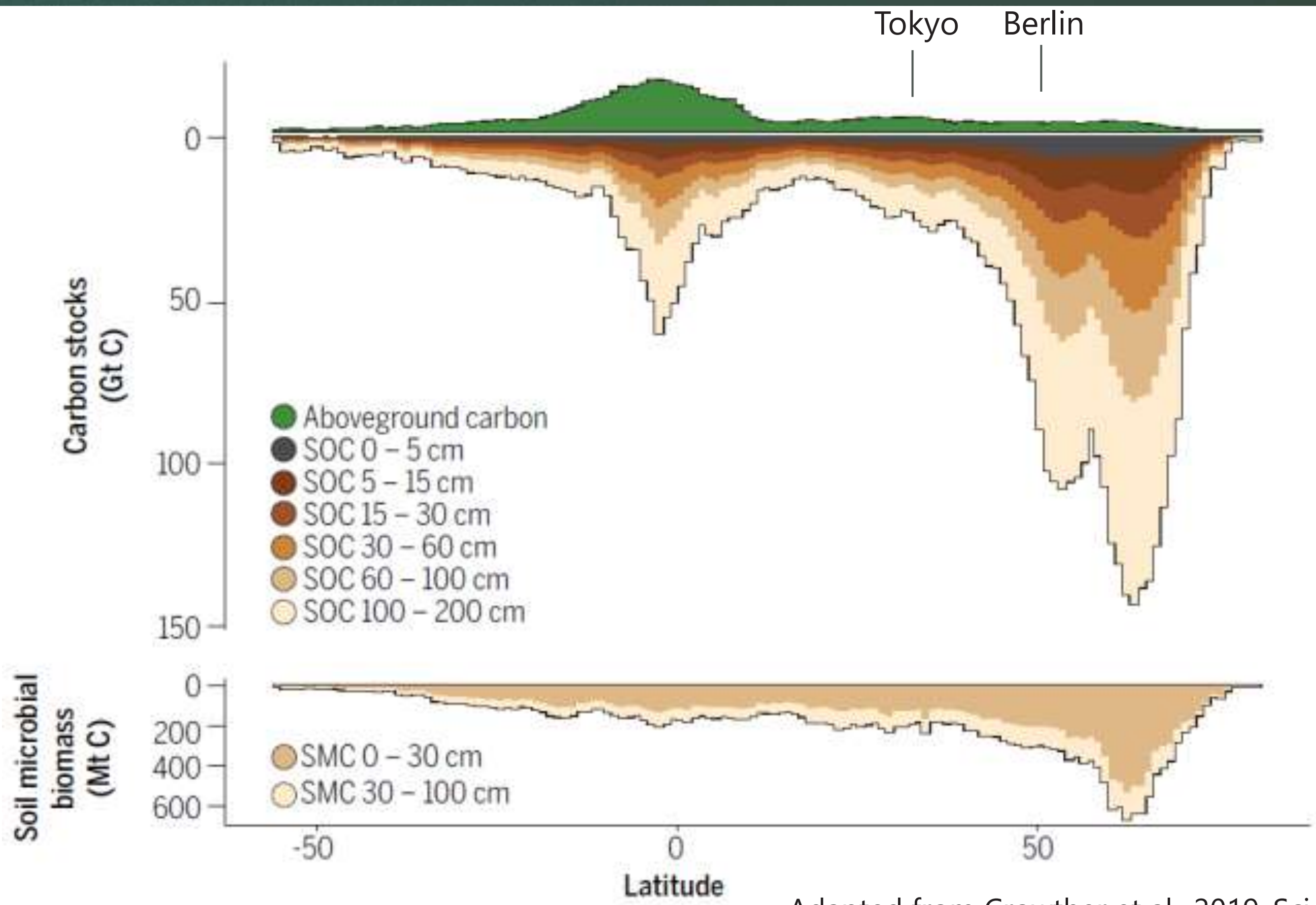
Filtering and storage of water

Carbon sequestration

Storage and recycling of nutrients

Globale Carbon Stocks

~1500 Gt **Soil**
~750 Gt Atmosphere
~560 Gt Vegetation



Adapted from Crowther et al., 2019. Science

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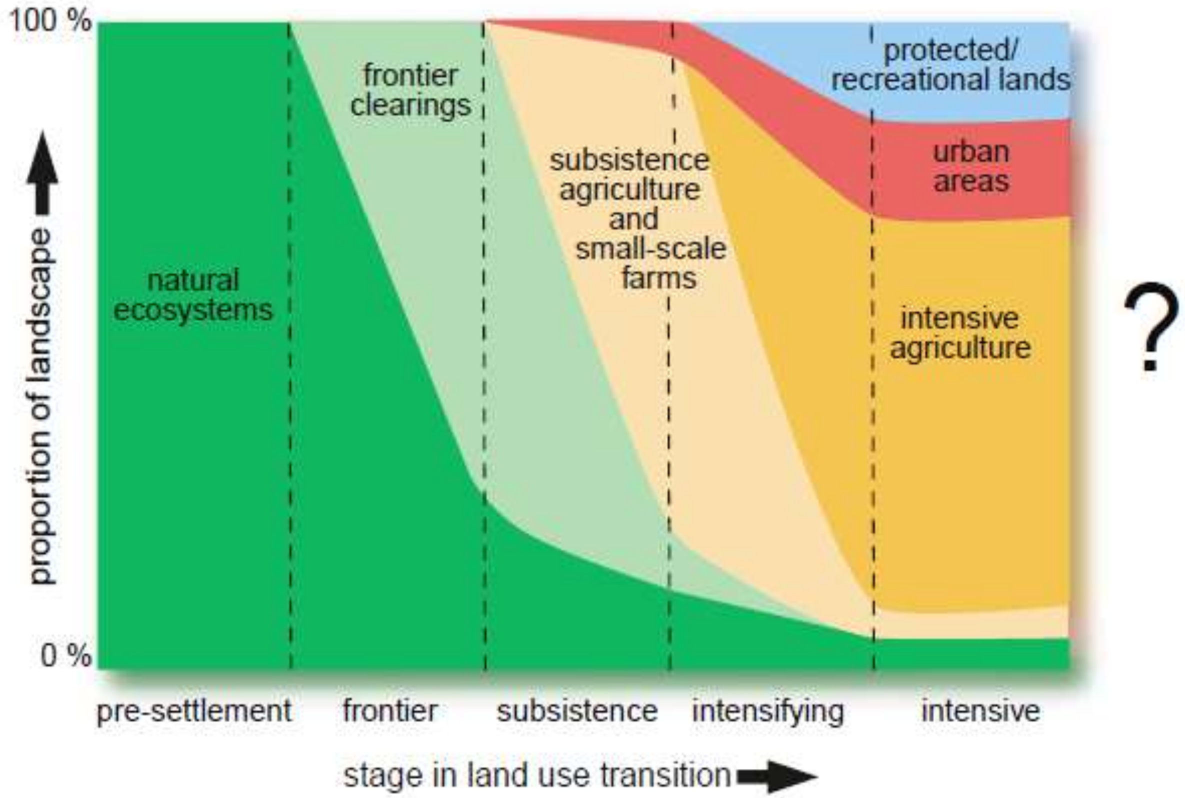
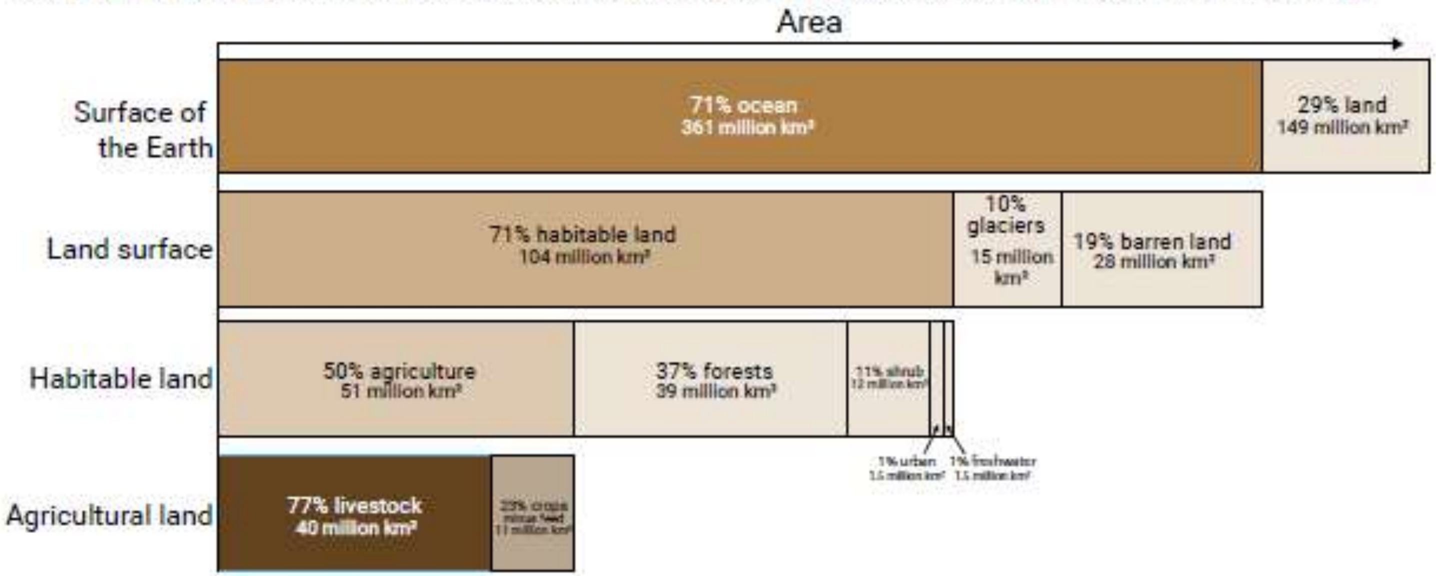
Global Dynamics of Land Use



www.sciencemag.org SCIENCE VOL 309 22 JULY 2005

Figure 8.6: Global area allocation for food production

The breakdown of the surface of the Earth by functional and allocated uses, down to agricultural land allocation for livestock and food crop production, measured in millions of square kilometres. The area for livestock farming includes land for animals, and arable land used for animal feed production.

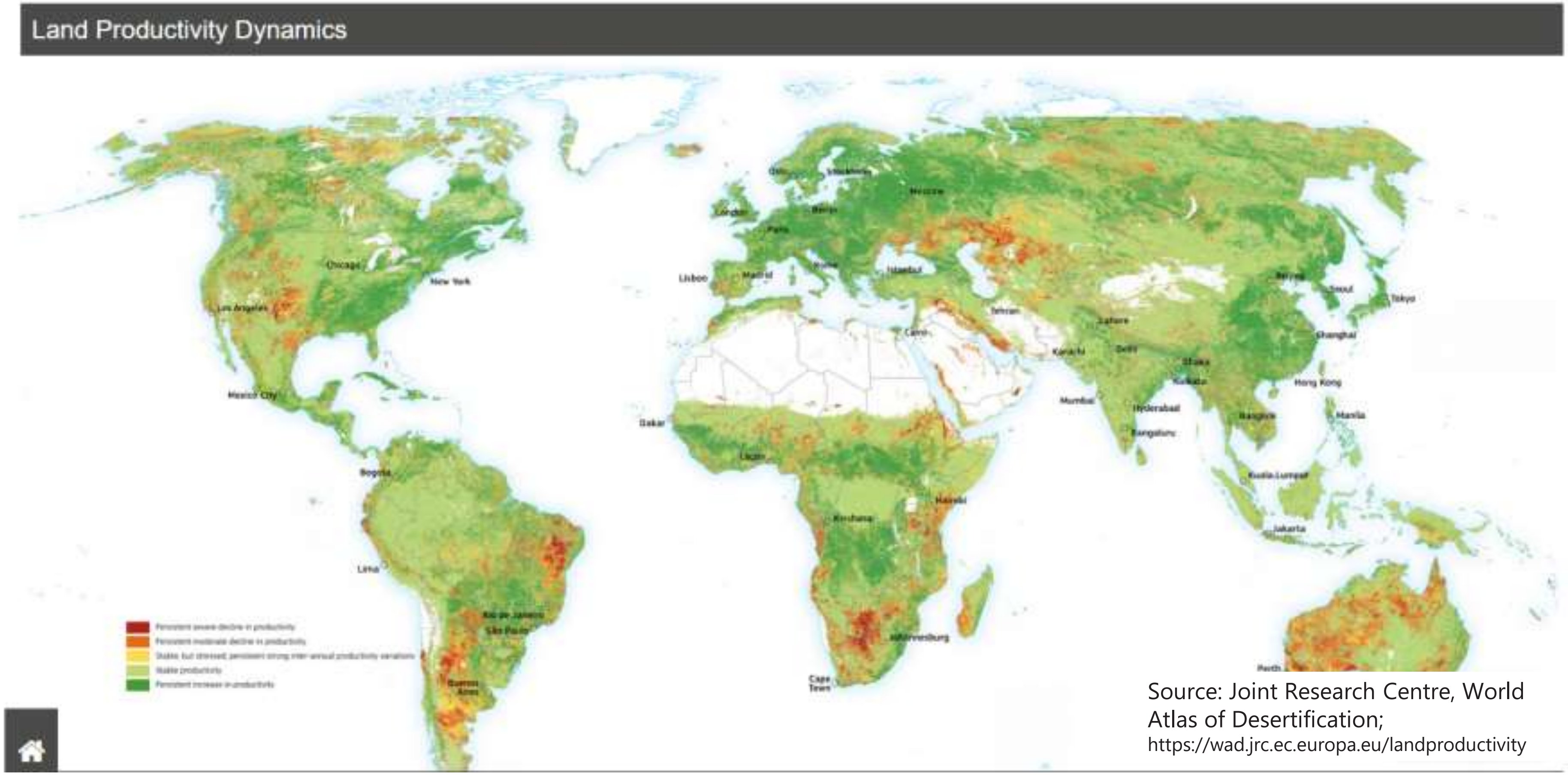


Source: FAO (2017b); Roser and Ritchie (2018).

www.zalf.de

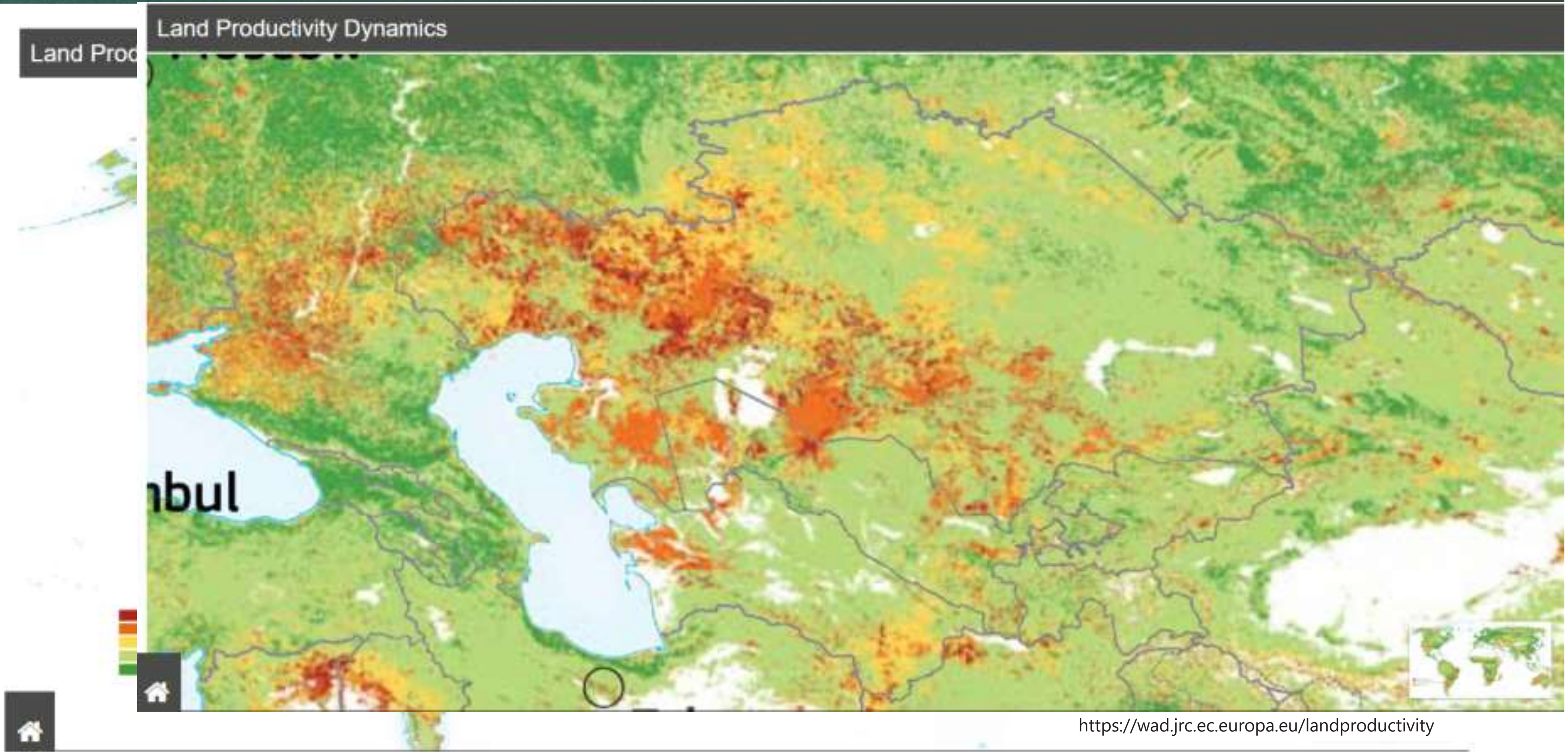
Source: UN Global Environmental Outlook 2019

Atlas of Desertification
Dynamics of land productivity 1999-2013



Source: Joint Research Centre, World Atlas of Desertification; https://wad.jrc.ec.europa.eu/landproductivity

Dynamics of land productivity 1999 - 2013



https://wad.jrc.ec.europa.eu/landproductivity

Soil degradation: key processes

Erosion (1)
20% of soils

Biodiversity loss
widespread

Compaction (3)
36% of subsoils

Salinization (1)
Ca. 3.8 mio ha

Sealing (1)
>275 ha/d

Loss of organic carbon (1)
45% of soils <2% OC

Contamination (2)
ca. 3 Mio. sites

Numbers for EU-Europa:

(1) Jones et al., 2012 EEA State of Environment Report

(2) Panagos et al., 2003. J. Environ. Public Health

(3) Jones et al. 2003. Soil Tillage Research

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Soil erosion: key processes

Soil erosion: key processes

Soil erosion: key processes

The land dilemma

a) Land for agriculture is **scarce**

b) Land for agriculture is **overused** and degrading

c) Land for agriculture has to fulfill **multiple functions**

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Participatory Sustainability Assessment

Which direction leads us into a sustainable future?

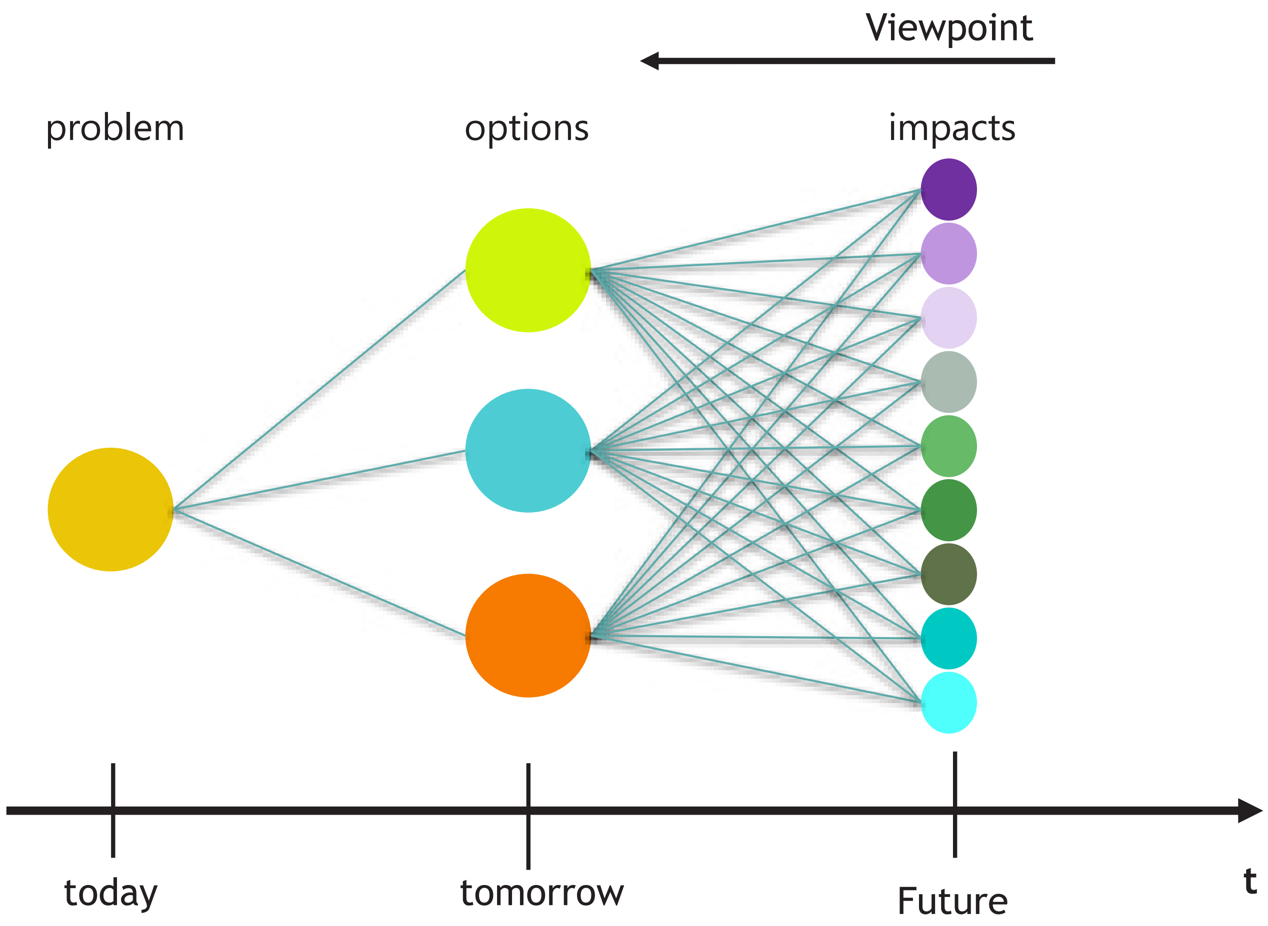
Participatory Sustainability Assessment

What will be the impacts?

- Explore the future
- Identify alternative development pathways
- Identify opportunities, threats and trade-offs
- Consider all aspects of sustainable development:

- Provide evidence for decision makers

Participatory Sustainability Assessment



6 Steps of Impact Assessment

Degree of
Stakeholder involvement

1	**Identify the problem**	Disourse Analysis
2	**Define the objective**	Participatory
3	**Develop options / scenarios**	Scenarios
4	**Analyse the impacts**	Physical Analysis Modelling Indicator Sets
5	**Compare the options / scenarios**	Multicriteria Analyis Cost Benefit Analysis Cost Effectiveness Analysis
6	**Implement the best option**	Action

6 Steps of Impact Assessment

1 Identify the problem

- What is the current situation?
- Economic perspective?
- Environmental perspective?
- Social perspective?
- Who is affected by the problem? Where, when, how?
- Source(s) of the problem?
- Driving forces and future development?

6 Steps of Impact Assessment

2 Define the objective

- What do you want to achieve?
- Does everyone want to achieve the same?
- What are the obstacles?

6 Steps of Impact Assessment

3 Develop options / scenarios

- Alternative options of problem solving and development (including no action)
- What exactly are the variables you want to change?
- Consider external driving forces as well as variables you can change

6 Steps of Impact Assessment

4 Analyse the impacts

- What are the parameters for which impacts are to be analysed?
- Intended and unintended impacts
- Short term and long term impacts
- Direct and indirect impacts
- WEF nexus
- Relevant sustainability targets
- Which indicator do you chose for each parameter?

6 Steps of Impact Assessment

4	Analyse the impacts

Examples:

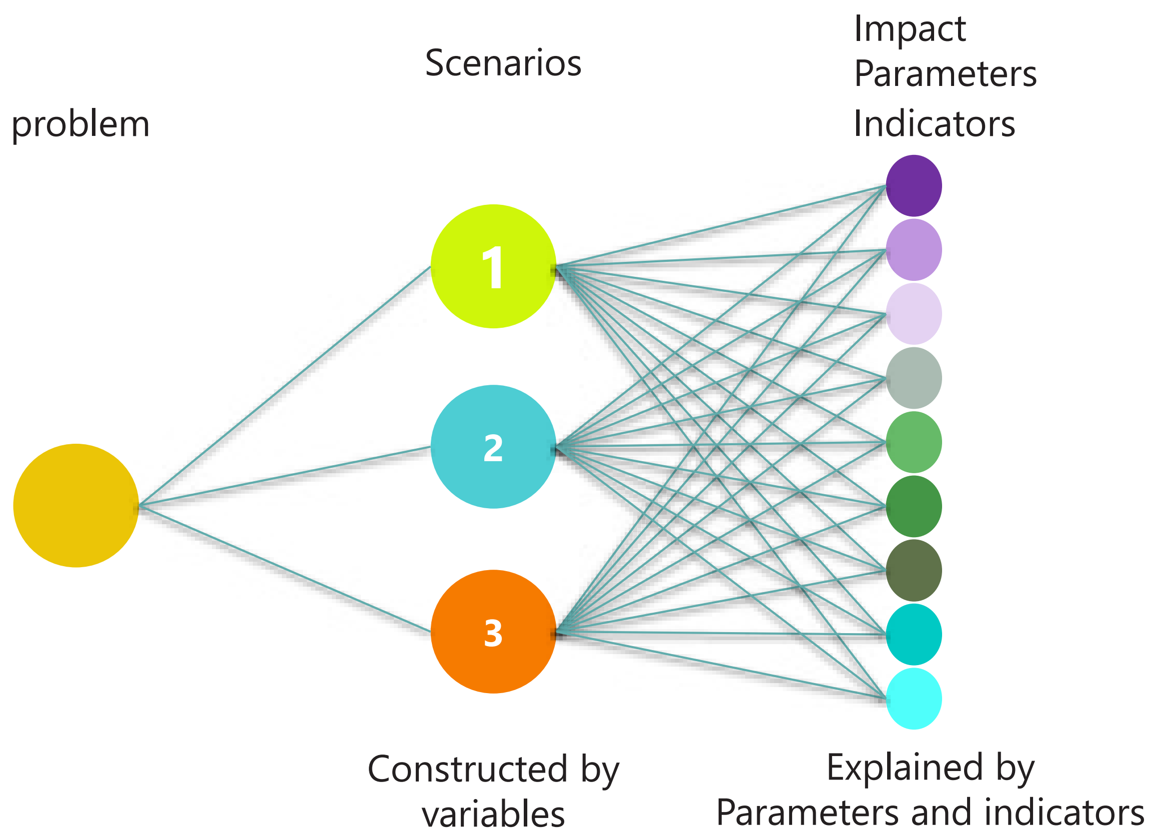
Parameter:	Indicator:
Profit	Revenue per ha land
Efficiency	Revenue per m^3 water
Acceptance	number of jobs
Soil quality	Electric conductivity

Indicators

Critera for indicator selection

- A clear representation of the indicandum (parameter)
- A clear proof of relevant cause – effect relations
- An optimal sensitivity of the representation
- Adequate spatio-temporal scales
- High transparency of the definition
- Validity of representativesness (offical data)
- Comparability with indicator sets
- Optimal degree of aggregation
- Good fulfillment of statistical requirements

Participatory Sustainability Assessment



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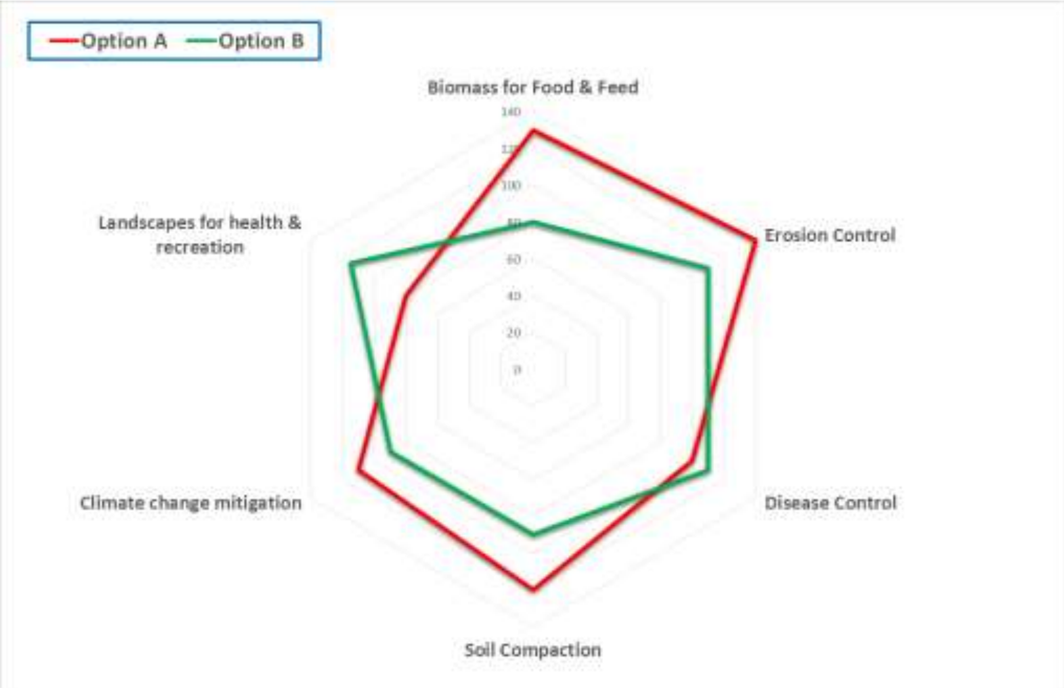
1 Identify the problem
2 Define the objective
3 Develop options / scenarios
4 Analyse the impacts
5 Compare the options / scenarios
6 Implement the best option

5 Compare the results



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Wish you good success!

Thank you for your attention.

Leibniz Centre for
Agricultural Landscape Research
(ZALF)

Contact:

CGIAR

NEXUS Gains:
Realizing Multiple Benefits
Across Water, Energy, Food
and Ecosystems

NEXUS Gains

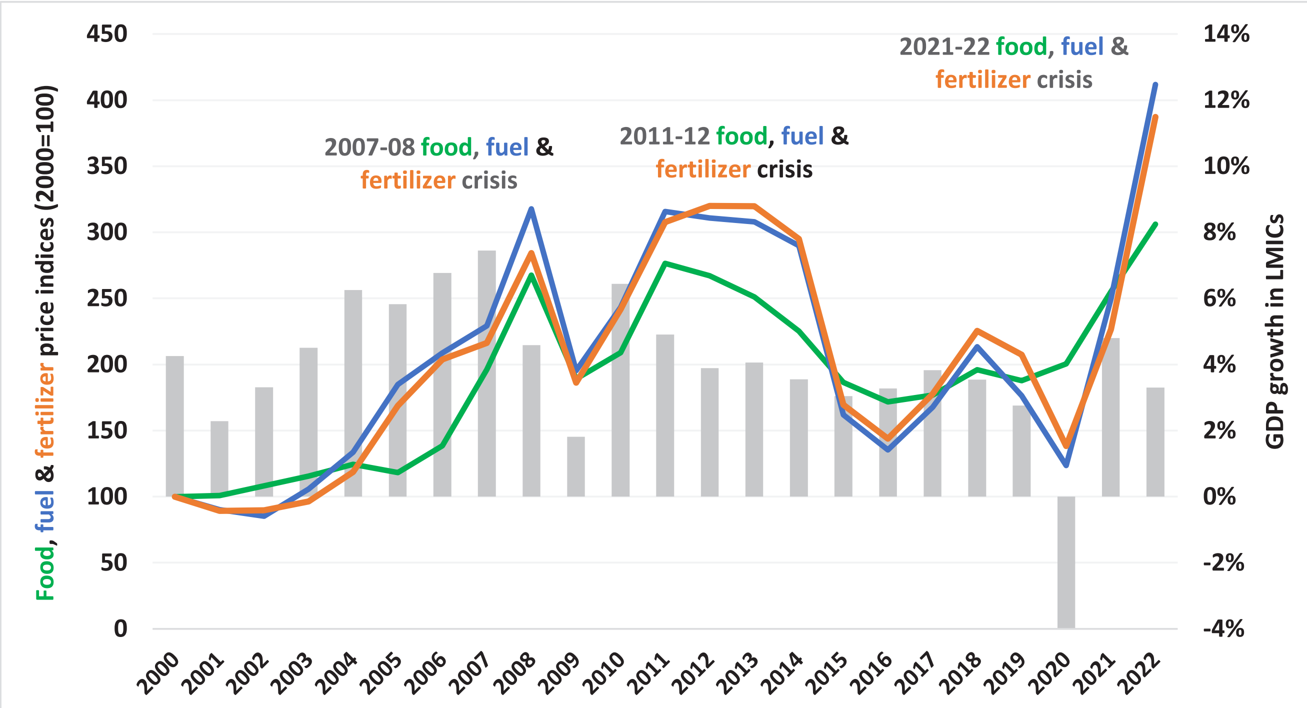
Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems (Forests, Biodiversity)

Mohsin Hafeez, Director Water Food and Ecosystems
NEXUS Gains WP1 Lead

Tashkent | August 22, 2023

Water–Energy–Food–Environment (WEFE) nexus challenges in a climate crisis

CGIAR
NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems



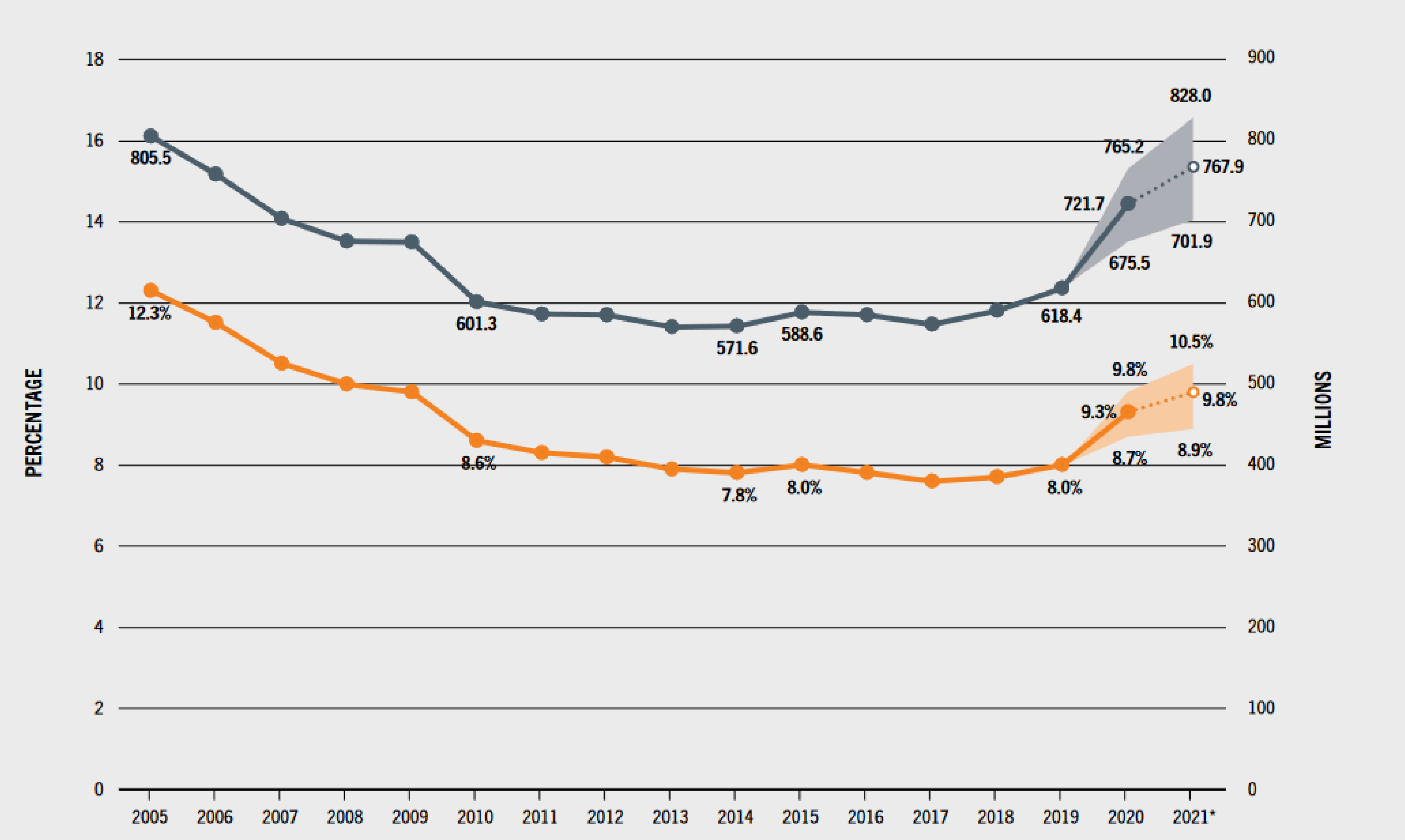
Source: [Headey and Hirvonen (2022)] using data from FAO, the World Bank and the IMF

Notes: Global crises across the food and agricultural sectors are becoming more frequently and are worsening. All are exacerbated by climate change, biodiversity loss, environmental degradation and increasing water insecurity. Recent global fora (UNFCCC COP 27, CBD 15 and UN water conference) have all indicated that business as usual will not suffice; we need new, innovative ways to address the challenges and transform systems.

Globally, water, energy, food and ecosystems are increasingly stressed with negative impacts for people. These systems are inextricably linked, yet most efforts to deal with contemporary societal challenges consider single issues and neglect the complexity, often exacerbating rather than solving underlying problems. The NEXUS Gains Initiative promotes systems thinking to better understand the interlinkages and to promote interventions to boost sustainable water resource management, protect biodiversity and provide clean and inclusive access to energy for our agrifood systems.

The initiative analyzes alternative, practical interventions at different scales – from farms to watersheds to river basins – to enhance water, energy and food security and environmental sustainability. It seeks to improve understanding of WEFE interdependencies and trade-offs, engaging vulnerable groups such as women, youth and other marginalized communities that bear the brunt of poorly managed WEFE systems and have little say in decisions that affect them. NEXUS Gains is using integrated biophysical and socio-economic tools to support policy design, investment planning and improved governance.

150 million more people hungry in 2021 compared to 2019

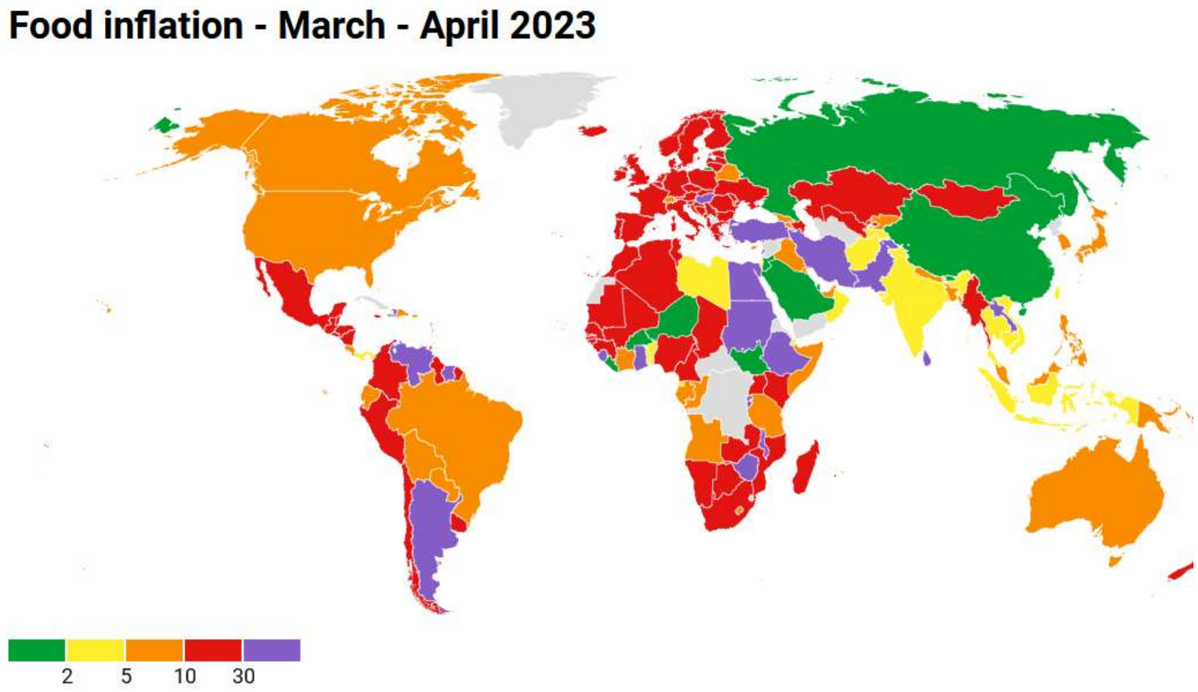


Source: SOFI (2022).

Do we still have a food/fuel crisis? Yes

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

- Price spikes came on the heal of low GDP growth in LMICs
- Food inflation levels increased in the last few months over levels earlier in the yea
- Prices remain above levels prior to COVID19
- New export bans (f.ex. India for rice)
- The war has not ended, more adverse food impacts well possible
- Growing adverse climate extremes furthe push up food prices
- Examples include the 48% (April 2023) year-on-year food price increase in Pakistan linked to an acute balance-of-payment crisis and political uncertainty
- Share of traded calories restricted due to export restrictions: 8% (May, 2023)



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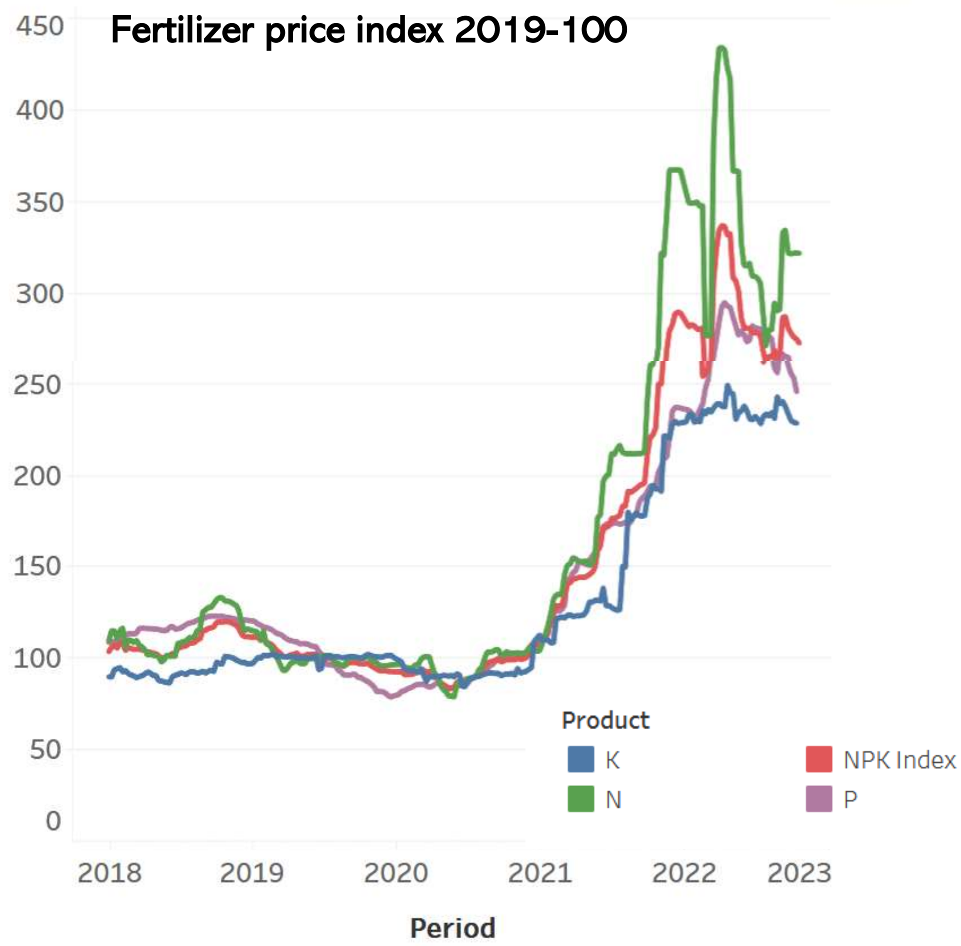
Agricultural productivity in peril *(before the floods)*

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

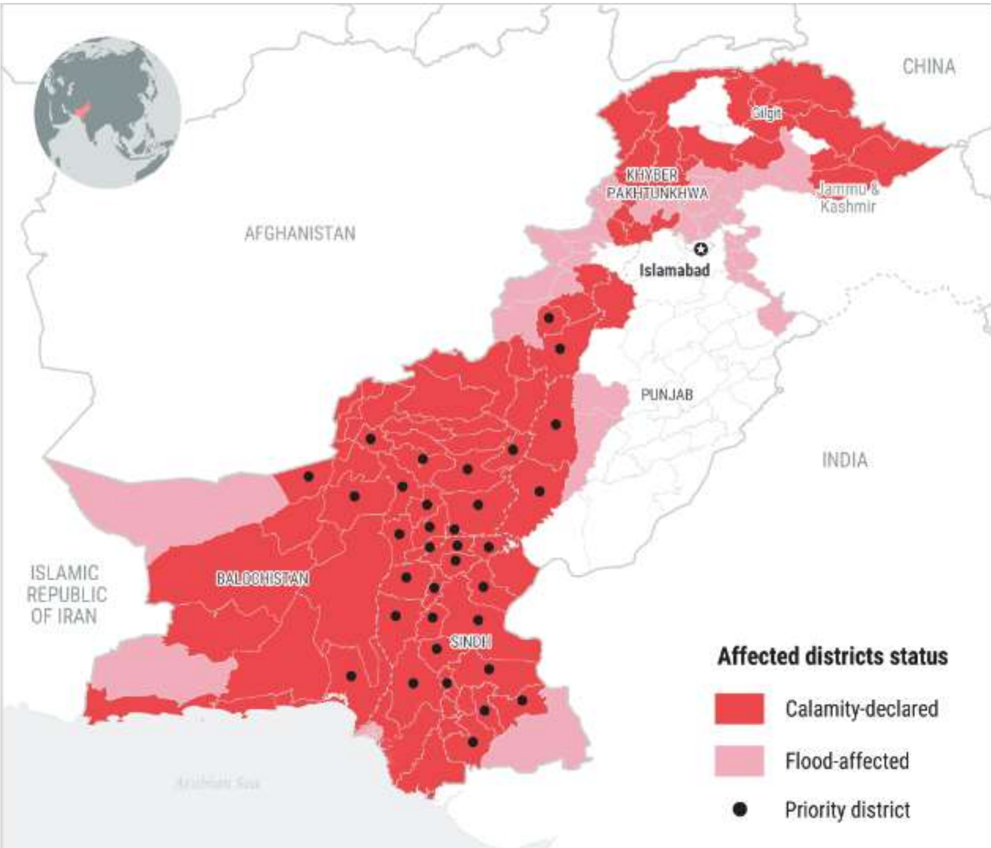


- Continued high fuel & fertilizer prices dampen agricultural productivity and production, suggesting lasting impacts
- Countries relying on groundwater (GW) irrigation also have to deal with high diesel prices (f.ex. Bangladesh/ Pakistan)
- In GW depending areas, household water security is also negatively affected

Source: Statistic by IFPRI (2022).

Climate extremes—a crisis multiplier

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems



- 33 million people affected, mostly in the poorer provinces
- 1,717 people died, including 639 children, and an additional 12,867 were injured
- Rural infrastructure destroyed
- $30 bn reconstruction costs and economic damage (equivalent to 10% of GDP)
- Long-term effects: childhood undernutrition and disease, a new generation that has to live below its potential

www.cgiar.org

Source: UNOCHA Oct 4, 2022.

Water/Energy/Food/Ecosystems (WEFE) Nexus Challenges

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

•WEFE nexus is critical to rural livelihoods, food and nutrition security & economies, and systems which are **strongly interconnected**

•Extreme pressure due to **climate change** and other changes

•**National & regional institutions struggle**, particularly in transboundary basins

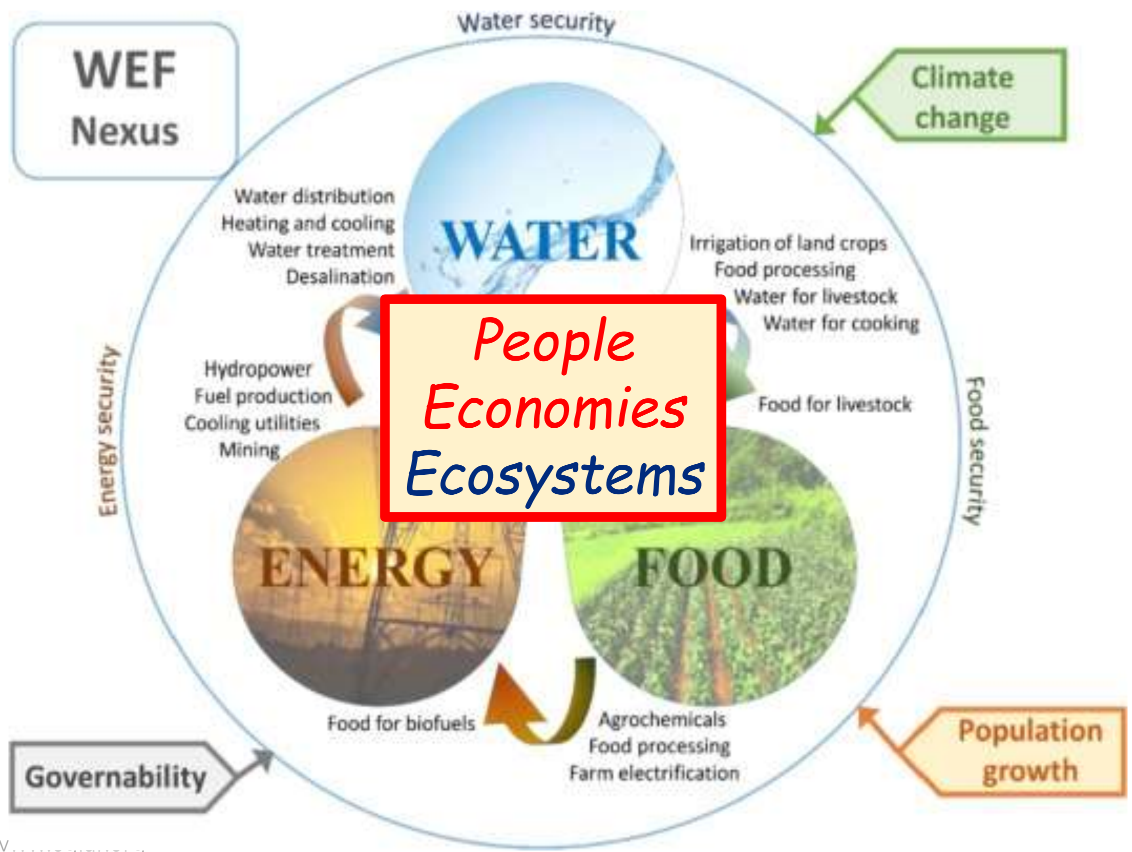
•**Investors are uncertain** where & how best to retain forests and biodiversity, and support sustainable irrigation, clean energy and agro-processing needs

•**Women, girls, and vulnerable groups** face the greatest adverse consequences

Water-Energy-Food-Ecosystem (WEFE) Nexus

Manage trade-offs and build synergies

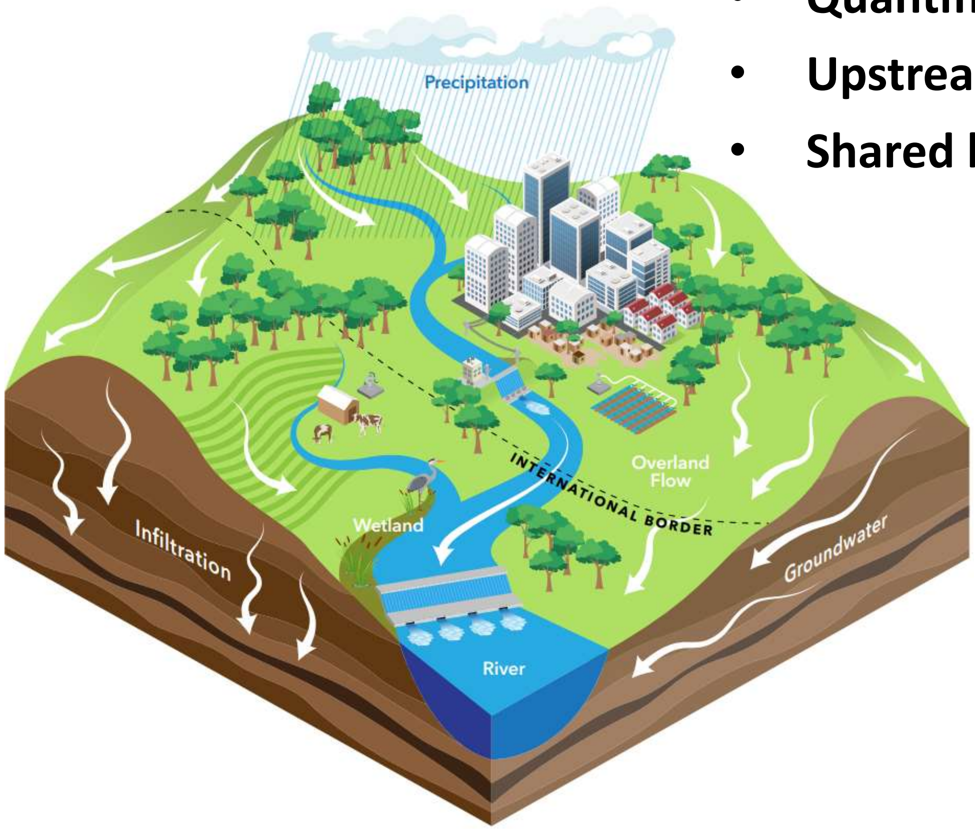
CGIAR
Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems



Source: Mahlknecht et al., 2020; adapted

1. **Systems approach, truly integrated**
2. **Nexus goes beyond IWRM approach**
3. **Many actors and stakeholders**
4. **Importance of political economy**
5. **Scale dependencies of processes: Farm to landscape/watershed to basin scale**
6. **Multi-level and multi-centric governance**
7. **Gender, youth and inclusion**

Nexus Challenges in Transboundary River Basins



Basin approach:

- **Quantification, accounting of WEFE resources**
- **Upstream-downstream inter-dependencies**
- **Shared benefits and trade-offs across countries**

Overview

NEXUS Gains:
Realizing Multiple Benefits
Across Water, Energy, Food
and Ecosystems

Focus Basins: Limpopo/Incomati, Blue Nile, Aral Sea, Indus and Ganges

Target countries: Ethiopia; India; Nepal; Pakistan; South Africa; Sudan; Uzbekistan; Zimbabwe

www.cgiar.org

Notes: Five WPs – all going well – all marked green in the traffic lights of the annual report

- Co-developing and scaling NEXUS innovations using foresight methodologies and trade-off analyse;
- Boosting water productivity across scales (farm to watershed to basin) and sectors using a whole systems lens;
- Energizing food and water systems sustainably and inclusively;
- Strengthening cross-sectoral, multi-stakeholder governance at community, national and regional levels; and
- Develop technical (WEFE) and leadership capacity of emerging woman leaders.

NEXUS Gains Workstreams

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

Photo credit: Anton Jankovoy / Shutterstock.com

1. **Co-developing and scaling NEXUS innovations** using foresight methodologies and trade-off analyses
2. **Boosting water productivity across scales** (farm to watershed to basin) **and sectors** using a whole systems lens
3. **Energizing food and water systems** sustainably and inclusively
4. **Strengthening cross-sectoral, multi-stakeholder governance** at community, national and regional levels
5. **Developing Capacity for WEFE Actors**, Including Emerging Women Leaders

What NEXUS Gains can contribute

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

Photo credit: Hamish John Appleby, IWMI

1. **Stakeholders use integrated modeling tools to assess tradeoffs and synergies** and develop prioritized nexus innovations in at least 2 focal regions
   - Tool for **comprehensive large-scale WEFE assessment** (indicators dashboard, maps, time series etc.)
   - **E-flow analysis tool** coupled with basin models
   - Scale **Agro-biodiversity Index** to national/ basin levels

2. **Water productivity across scales** and **storage diagnostic tools are used** to significantly improve water security in at least 2 focal regions
   - **Decision support system** for (bundled) interventions to boost water productivity at basin scale
   - **Strategic diagnostic** to design, evaluate and implement **integrated water storage** solutions

End of Initiative Outcomes and Examples of Core Innovations

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

3. Private investors and policymakers **use scalable gender-sensitive clean energy business and finance models** to accelerate sustainable rural clean energy access in at least 3 focal regions
   - **Inclusive business models** for sustainable **clean energy access** in agri-food systems
4. Policymakers and other stakeholders are using science-policy dialogues, multi-stakeholder forums, co-developed groundwater governance toolbox and guidelines to **strengthen nexus governance** across systems, sectors and boundaries in all basins
   - **Groundwater governance toolbox** to address growing competition, degradation and depletion of resources in hotspots
   - Establish and facilitate cross-sectoral, inclusive **multi-stakeholder platforms** to leverage integrated
5. At least **40 emerging women leaders** in government, private sector, investors, research and NGOs have increased capacity **to identify, assess and implement one or more nexus innovations**

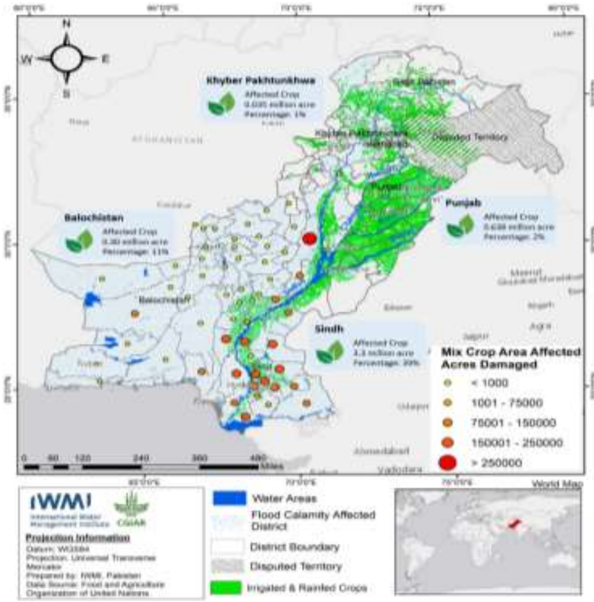
Photo credit: Hamish John Appleby, IWMI

EOI1: Tradeoffs and synergies

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

Pakistan – floods

- Direct support to the government on flood extent, crop, and irrigation infrastructure damage
- Support to Ministry of Finance, Punjab to target emergency relief based on size of loss; method now adopted by Punjab Disaster Management Authority
- Contribution to breakthrough agreement on "Loss and Damage" fund for vulnerable countries at COP27 through support to Pakistan's Vice-Presidency and G77 chairmanship



Flood in Pakistan 2022, District-wise crops affected area

Pakistan (Balochistan) – groundwater

- Evaluating the impact of different policies on costs: provincial GDP and household income of groundwater depletion

-3.39% Provincial GDP declines due to groundwater depletion

Notes: Facilitated high-level ministerial platform to share best practices on future floods across Australia, Egypt and Pakistan during COP27
Simulations
1. Groundwater Depletion reduces fruit production by 20%
2. Agricultural Policy - Switch to Less-Water Intensive Crops
3. Tube-well Subsidy Rationalization, which captures decline fruit, wheat and vegetables due to 40% and 90% increases in price of electricity, and lower income for tube-well owners
4. Investment in Groundwater Recharge and Management, which captures the impact of investment in recharge mechanisms
5. Increasing water to non-agricultural sectors with a 5% increase in the water used in manufacturing, processing, and services.

*Taken from IFPRI Discussion Paper 02013
Farm households are most affected by tube-well subsidy rationalization. Non-farm rural & urban households are also affected due to indirect production linkages.
Investment in recharge mechanisms and switching to non-agricultural sectors benefit non-agricultural households more.

EOI2: Integrated water productivity and storage

Central Asia

- Comprehensive inventory of water–land management practices for improving water productivity
- Co-design of user-friendly DSS dashboard to guide identification of best practices in particular contexts

India

- Physical, Economic, Nutritional, Energy and Water Footprint Atlas

Limpopo

- Mapped and characterized benefits of sand dams (alternative under-utilized storage option) in partnership with NGO (Dabane Trust) and catchment councils

Notes:
Rice
Results presented to Limpopo Watercourse Commission, & Botswana and Zimbabwe governments

EOI3: Equitable clean energy access

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

South Asia

- Women's Empowerment in Energy Index (WEEI) piloted in 3 countries (India, Nepal, Pakistan)
- Conceptual paper on WEEI drafted with GENDER Platform
- Working with World Bank on "Roadmap for solarization of agriculture in Punjab"
- Solar irrigation pump sizing tool in India; investigating opportunities of take-up in Nepal

Ethiopia

- Direct support to Ministry of Water and Energy on co-localizing irrigation and energy infrastructure
- Assessed gendered benefit streams from electricity access at household and village levels

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Notes: Promoting a just and inclusive and gender responsive energy transition

- Pilot energy intervention areas identified in India and Nepal (i.e. pilot/scaling partners)
- Women-energy source/access/use framework papers (various), i.e. India and Nepal
- Women's Empowerment in Energy Index (WEEI) piloted in 3 countries (India, Nepal, Pakistan) as part of baseline surveys
- Conceptual paper on WEEI drafted with GENDER Platform
- Some advances linked to past work on Nexus in India (SPaRC) and Uzbekistan

EOI4: Improving governance across WEFE systems

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

Multi-stakeholder platforms (MSPs)

- Established community of practice across CGIAR Initiatives
- Guidelines provide guidance for NEXUS Gains researchers on how to improve (gender) inclusiveness and effectiveness in MSPs

Groundwater Governance Toolbox

- Review paper and international workshop on institutional tools for groundwater governance
- Working with stakeholders to combine tools in India, Nepal, Pakistan, Uzbekistan

Shaping global discourse on systems transformation via multilateral environmental agreements

- Climate Change COP27
- Convention on Biological Diversity (CBD) COP15
- Ramsar COP14
- UN 2023 Water Conference

Notes: No panaceas—need to adapt to context
Backstopping and technical support to global multinational environmental agreements:

- Presence on the Ramsar STRP as well as the Informal Advisory Group of the CBD and focal point for IPBES
- Contributed to resolution negotiations and side-events at the Ramsar COP 14 (November 2022)
- Contributed to the IWMI global stocktaking submission, prior to the UNFCCC COP27 (November 2022)
- Contributed to a number of technical inputs in the consultations that led to the Kunming-Montreal Global Biodiversity Framework (GBF), including explicit recognition for the first time of "inland waters" in the targets (December 2022).

Carolina Navarette Frias of the Alliance (partly supported by NEXUS Gains is establishing a Global Convention Nexus Group (within CGIAR – across initiatives and platforms) to strengthen coherence and coordinated action relate to NDCs, NBSAPs and Food Systems transformation. We will be part of this group.
Significant input to Nepal government's position paper on enhancing water security in Nepal – produced for the UN water conference

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EoI5: WEFE capacity building

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

Nepal

- Delivery of demand-driven training on nexus approaches to government of Nepal irrigation department to support revised irrigation policy
- Development of innovative nexus leadership program targeting women professionals

Pakistan

- Development and piloting of scorecard to assess institutional and staff capacities to address WEFE nexus among professionals

Southern Africa

- Implementation of multi-partner WEF Nexus Master-class/Winter School targeting SADC practitioners
- South-to-South exchange between Africa and Asia on solar irrigation deployment strategies, business models and decision support tools


ELSEVIER

Water Security

Volume 17, December 2022, 100126

Elevating the role of water resilience in food system dialogues

Nathanial Matthews[a,1], James Dalton[b], John Matthews[c], Holly Barclay[d], Jennie Barron[e], Dustin Garrick[f], Line Gordon[g], Saleemul Huq[h], Tom Isman[i], Peter McCornick[j], Alqayam Meghji[k], Naho Mirumachi[l], Shehnaaz Moosa[m], Mark Mulligan[l], Andrew Noble[k], Olga Petryniak[n], Jamie Pittock[o], Cibele Queiroz[a,g], Claudia Ringler[p], Mark Smith[q]...Louise Whiting[r]

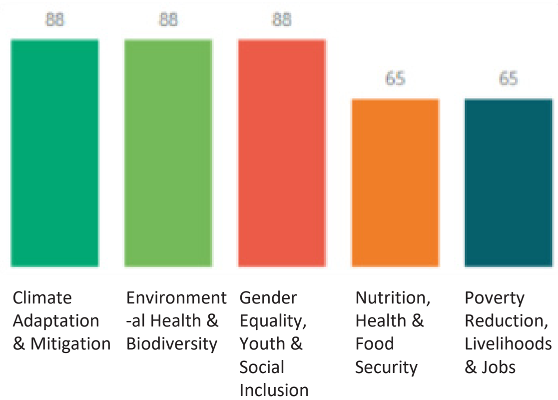
Progress on results

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

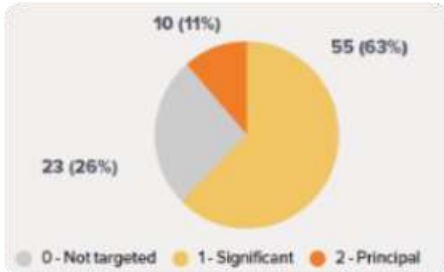
88	13	19	12	44	7	1	2	3	13
Results	SDGs	Capacity sharing for development	Innovation development	Knowledge products	Other outputs	Innovation use	Policy change	Capacity change	Centers

Results by country

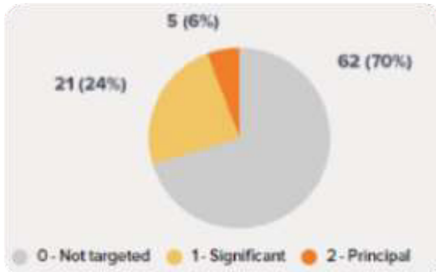
Impact Area contributions



Results by gender tag



Results by climate tag



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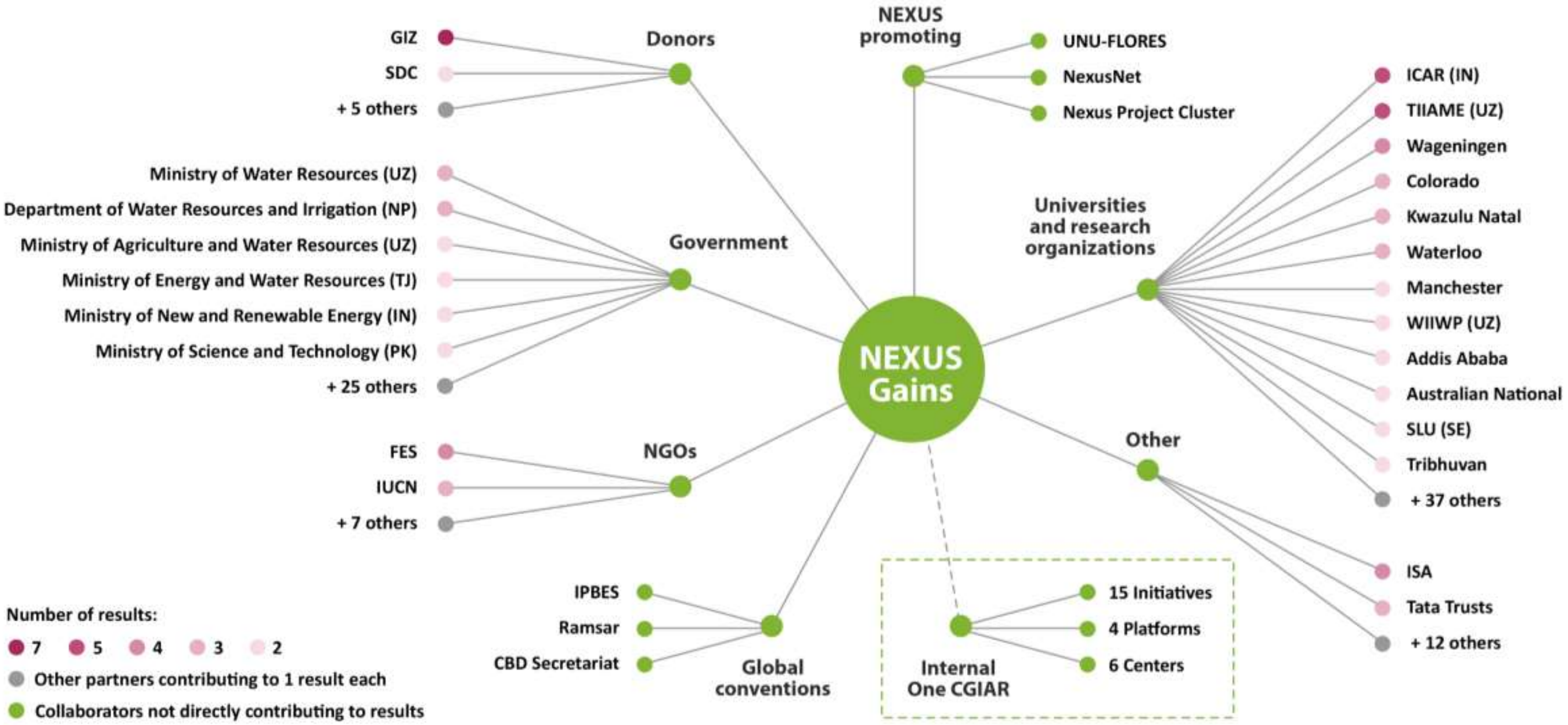
Innovation portfolio

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

- Economywide effects of water and energy interventions tool
- WEFE capacity building tool
- Environmental Flow Tool
- Agrobiodiversity Index
- Water Storage Diagnostic
- Water Productivity Assessment Tool
- South Asia Drought Monitoring System
- Groundwater governance toolbox
- Business Model: Solar Irrigation Enterprises
- Business Model: SPaRC (Solar Power as Remunerative Crop)
- Solar Irrigation Pump (SIP) Sizing Tool – Replication in Nepal

Partnerships



NEXUS Gains:
Realizing Multiple Benefits
Across Water, Energy, Food
and Ecosystems

Thank you!

More information at:

cgiar.org/initiative/nexus-gains

Systematic review of WEF nexus research for the case of irrigated agriculture

Ahmad Hamidov

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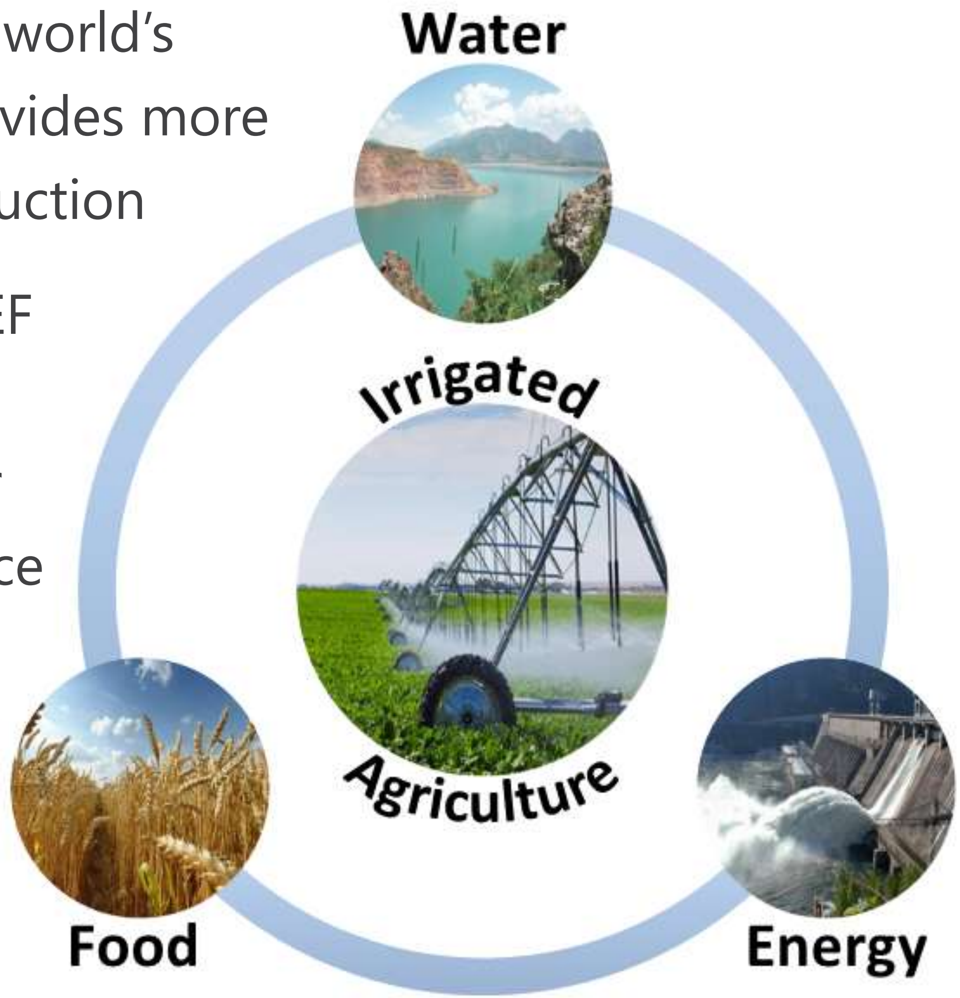
Leibniz Centre for Agricultural Landscape Research (ZALF)

Date: 22 August 2023

WEF relevance to irrigated agriculture

- Occupying nearly one-fifth of the world's cropland, irrigated agriculture provides more than 40% of the global food production
- Irrigation is at the heart of the WEF nexus, due to strong competition between water used for energy or for food production in water-scarce areas of the world
- Role of irrigation is increasing in response to food demand, an increase in the world's population



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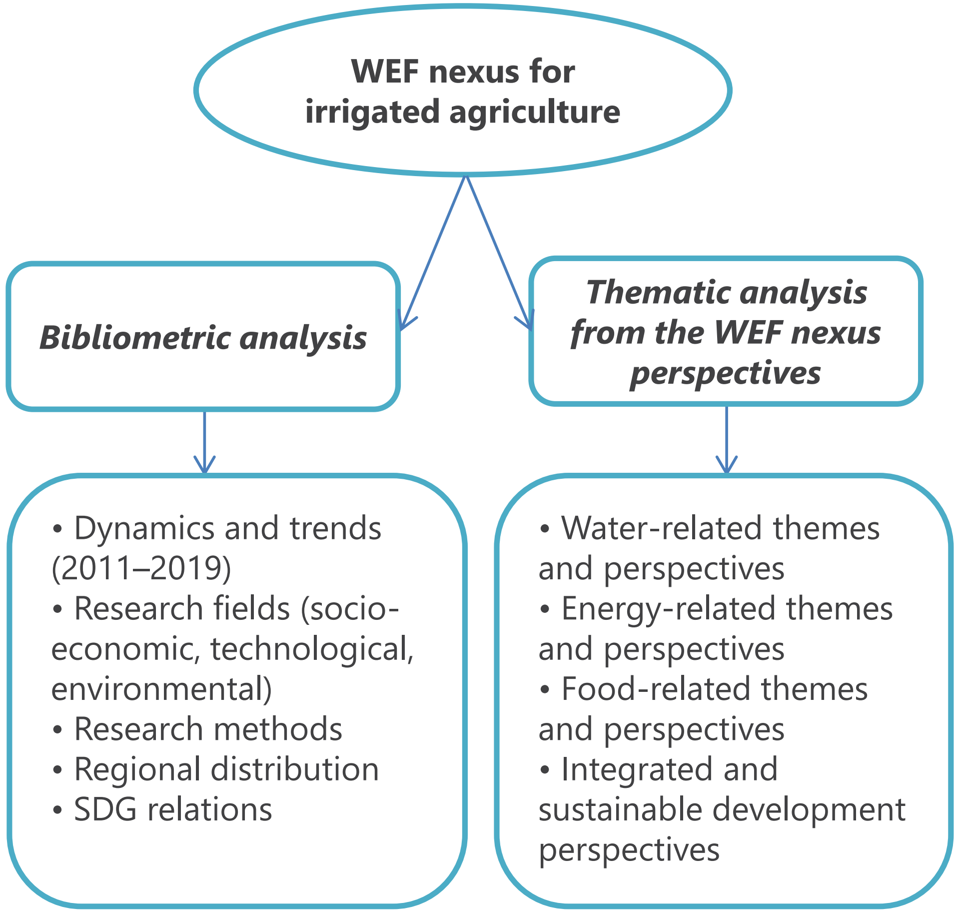
WEF relevance to irrigated agriculture

- In particular, improving irrigation efficiency is a major constraints for sustainable agriculture in drought prone regions
- Construction of power plants for energy may have environmental impacts, as there is a recent discussion on increased carbon dioxide (CO_2) and methane (CH_4) emissions
- Food security is a further challenge with the decrease of water resources and increasing threats from climate change
- Soil salinization is another key drawback of irrigation in regions with a negative climatic water balance

Systematic review

- At ZALF, we conducted a systematic review on the WEF nexus for the case of irrigated agriculture
- We only selected international journal articles
- The study period ranged from 2011 to 2019
- The selection of this study period was driven by the 2011 Bonn Conference on the nexus

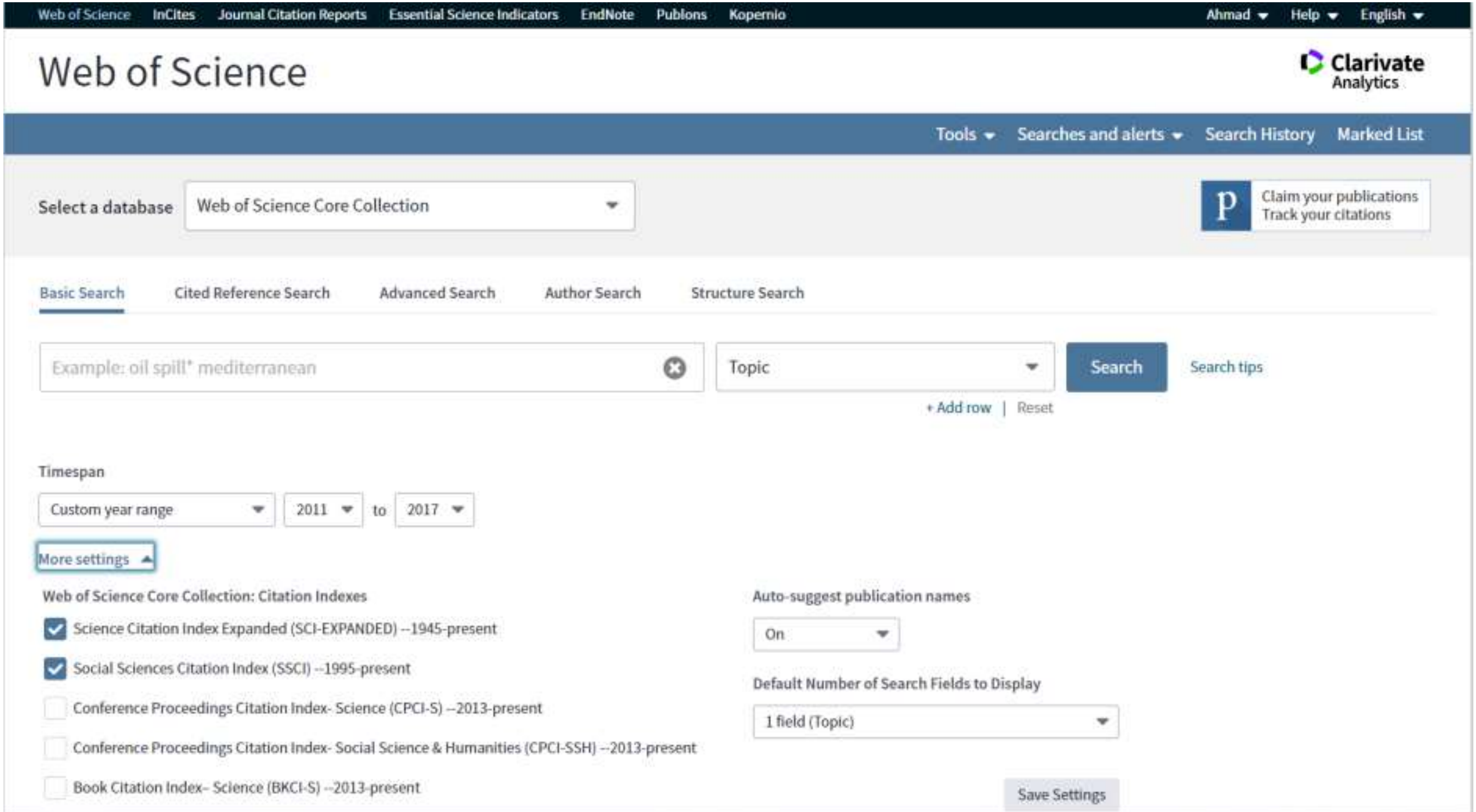


Analytical approach to the review of WEF nexus literature related to irrigated agriculture

Recent systematic review

- Primary objective was to analyze current international literature on WEF nexus for irrigated agriculture and its relevance to sustainable development goals (SDGs)
- It explored the state of knowledge with regard to the use of WEF nexus for the sustainability assessment of irrigated agriculture
- The study synthesized existing knowledge and identified existing knowledge gaps and the need for future research on sustainable WEF nexus for irrigated agriculture

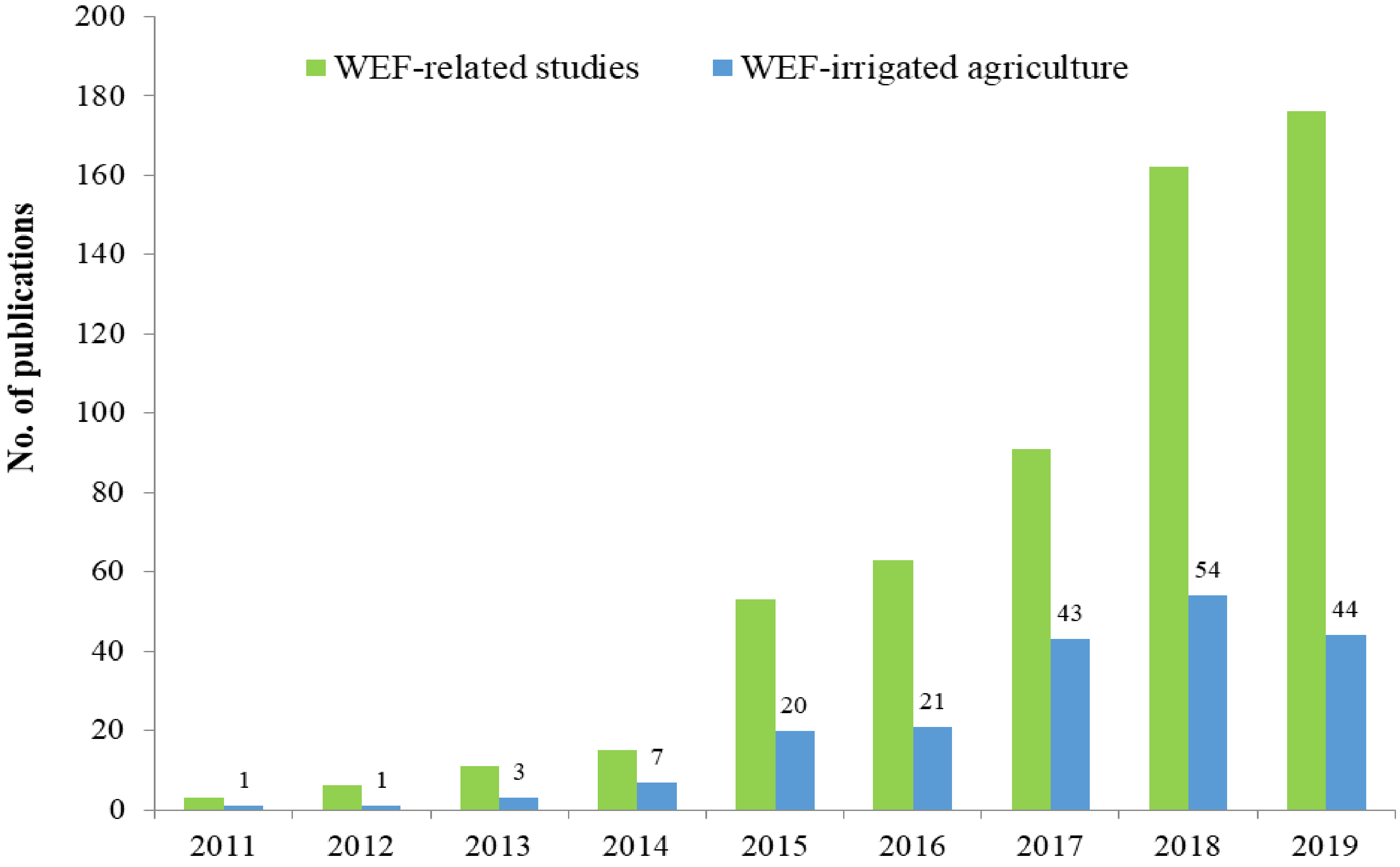
Web of Science



Method

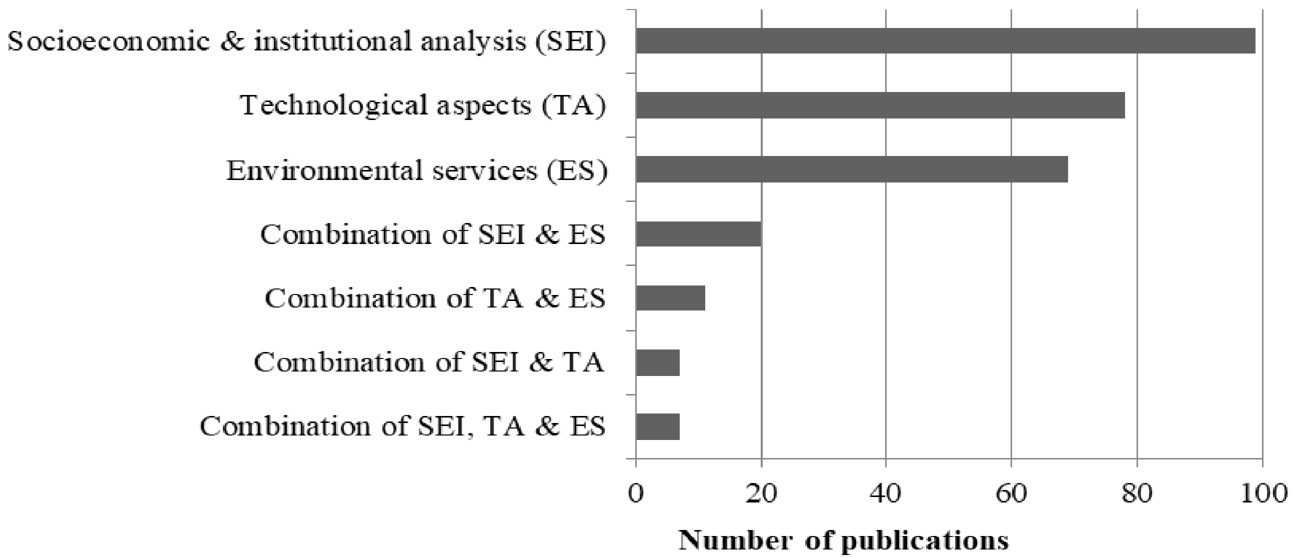
- We used the following search terms in the database: "water–energy–food nexus" AND agriculture or irrigation or soil
- The WEF nexus terms were used in derivation
- Downloaded documents were transferred to an open EndNote library
- Types of scientific methods employed in the papers, the geographic scope of the studies and SDGs were analyzed
- Finally, we carried out a detailed content analysis of the papers to understand the thematic focus of each paper

Dynamics of WEF papers



Research themes

- Most papers discuss the WEF nexus from socioeconomic and, in particular, institutional perspectives
- Water use, irrigation, agricultural management, and power generation were discussed under technological aspects
- Soil & water quality, WWT and vegetation were under environment



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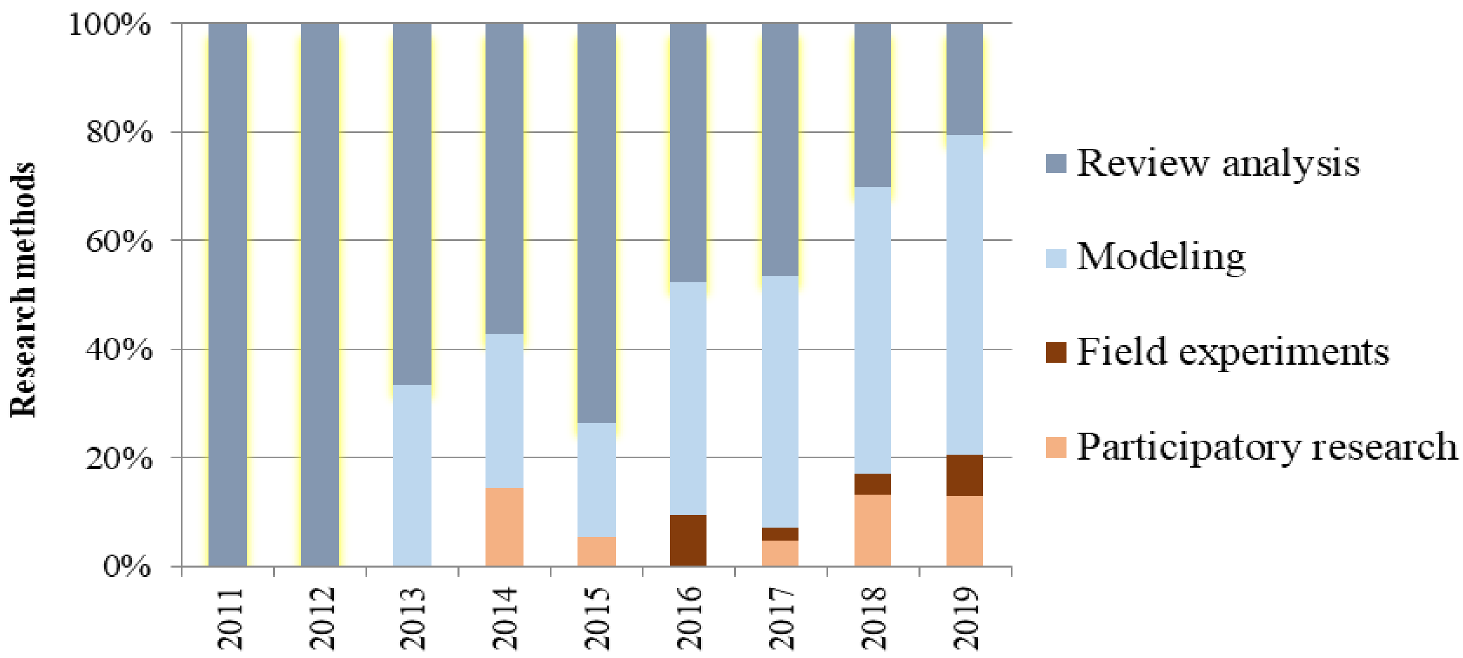
Scientific methods

- Share of research methods in WEF nexus publications
- Review analysis dominates the sample set until 2016. This indicates that the WEF nexus is still at a conceptual level



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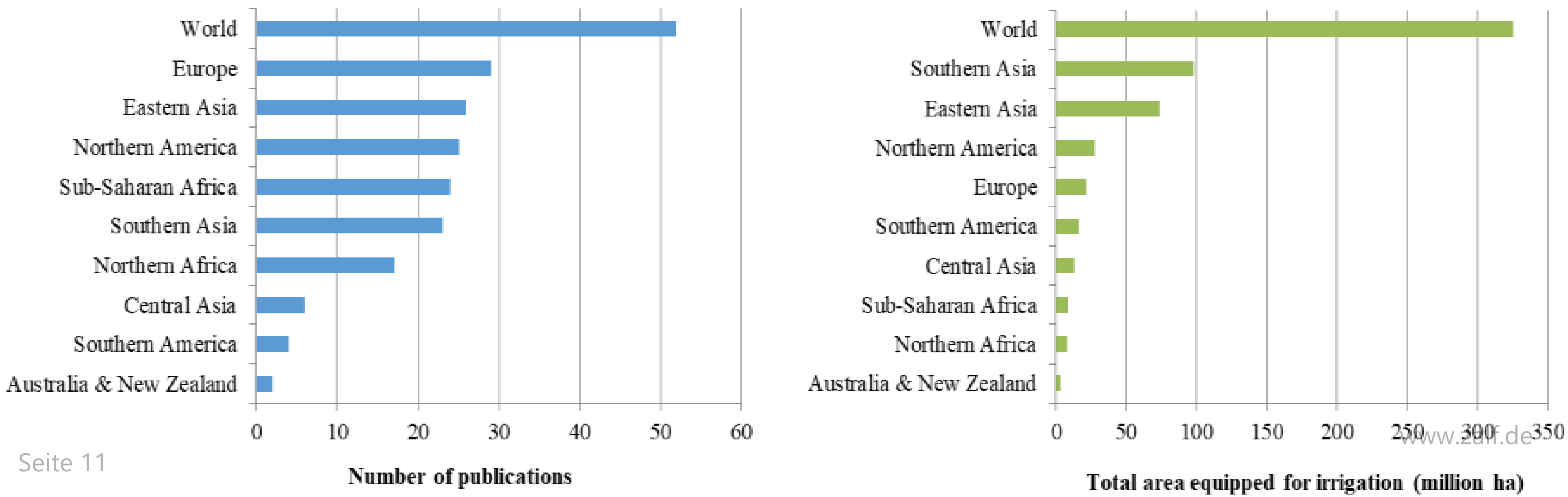
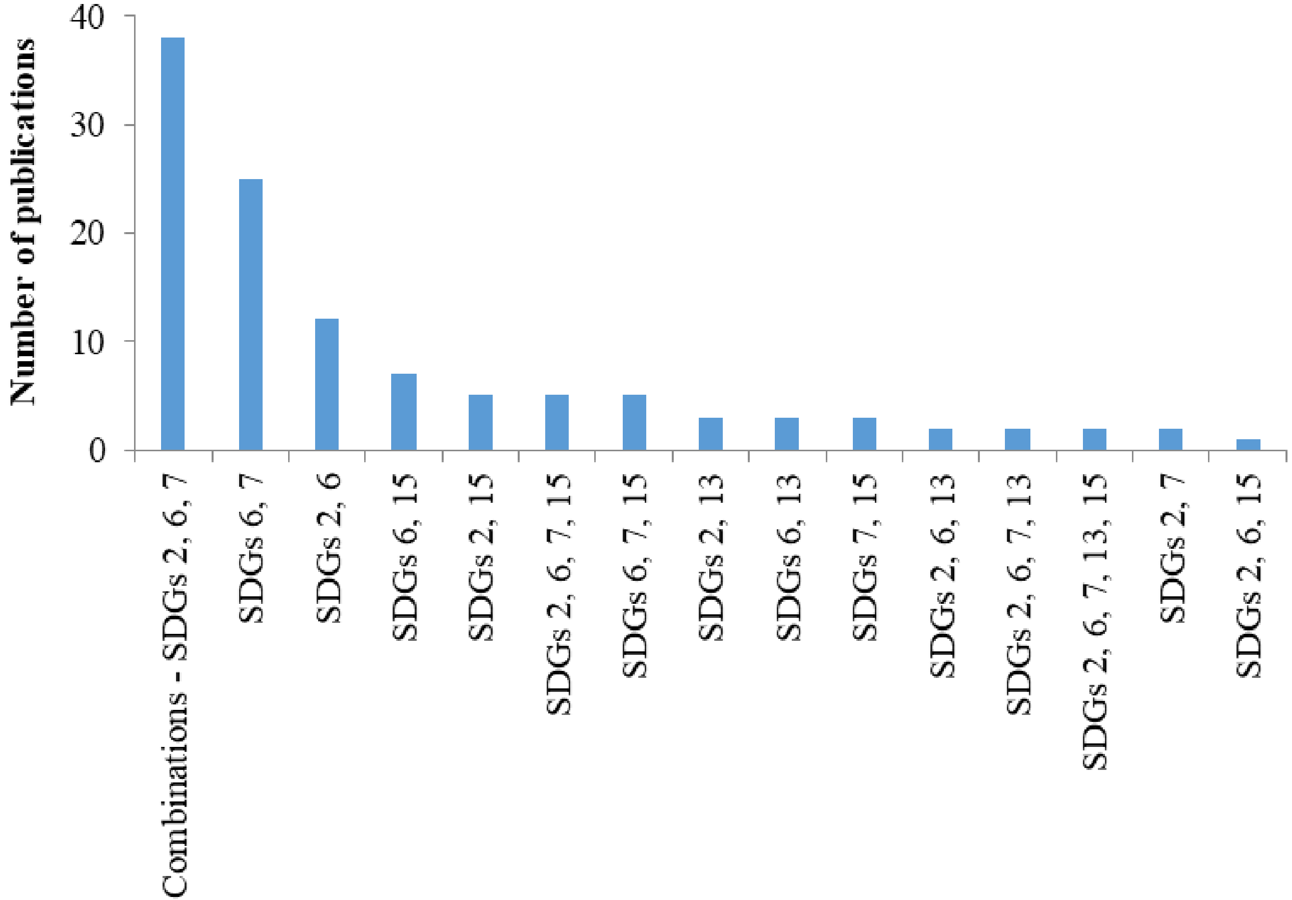
Geographic scope

- Geographic scope and potential irrigated land around the world
- South Asia has the largest irrigated land (~98 million ha), but only about 10% apply the concept of WEF nexus in this region
- Published WEF nexus papers are generally disproportionally represented in terms of total irrigated areas



SDGs

- The SDG classifications were used to analyze the thematic perspectives of the papers



Content analysis

WEF nexus	Activities	Geographical groups	References
Water	Water availability for agriculture	Central Asia, Eastern Asia, Europe, Southern Asia, Sub-Saharan Africa, World	Closas and Rap (2017), Damerau *et al* (2016), Dhaubanjar *et al* (2017), Guillaume *et al* (2015), Jalilov *et al* (2016), Jiang (2015), Karabulut *et al* (2016), Khan *et al* (2017), Olsson *et al* (2015), Sishodia *et al* (2017), Zamft and Conrado (2015), Zeng *et al* (2017)
	Groundwater management	Central Asia, Europe, Northern Africa, Northern America, Southern Asia, World	Barik *et al* (2017), Bekchanov and Lamers (2016), Closas and Rap (2017), de Vito *et al* (2017), Mukherji and Das (2014), Pradeleix *et al* (2015), Shifflett *et al* (2016), Siddiqi and Wescoat (2013), Sishodia *et al* (2017), Smidt *et al* (2016), Talozi *et al* (2015)
	Floods and droughts	Europe, Northern America, Southern Asia, World	Abumhadi *et al* (2012), Barik *et al* (2017), Berardy and Chester (2017), Daccache *et al* (2014), DeLonge and Basche (2017), Holt *et al* (2017), Lal (2015), Van Ginkel *et al* (2017), Wong (2015), Zeng *et al* (2017)
	Water use efficiency	Northern Africa, Southern Asia, World	Jobbins *et al* (2015), Pradeleix *et al* (2015), Rasul (2014), Ravi *et al* (2016), Sishodia *et al* (2017), Smidt *et al* (2016), Walsh *et al* (2016)
	Wastewater treatment	Northern America, Southern Asia, World	Holt *et al* (2017), Miller-Robbie *et al* (2017), Mohareb *et al* (2017), Mortensen *et al* (2016), Wolfe and Richard (2017)
	Water footprint	Europe, Northern Africa, Northern America, Southern Asia, World	Chini *et al* (2017), Daccache *et al* (2014), Ramaswami *et al* (2017), Vanham (2016), Zhang *et al* (2017)
	Water pollution	Eastern Asia, Northern America, World	Avellan *et al* (2017), Chen and Zhang (2015), DeLonge and Basche (2017), Jiang (2015)
	Water infrastructure	Central Asia, Southern Asia	Bekchanov and Lamers (2016), Siddiqi and Wescoat (2013), Yapiyev *et al* (2017)
	Water-related diseases	Southern Asia	Rasul (2016)

Content analysis

WEF nexus	Activities	Geographical groups	References
Energy	Renewable energy (solar power) infrastructure	Eastern Asia, Europe, Northern Africa, Northern America, Southern Asia, Sub-Saharan Africa, World	Chen and Zhang (2015), Closas and Rap (2017), Kilkis and Kilkis (2017), Ravi *et al* (2016), Salah *et al* (2017), Schwanitz *et al* (2017), Taseli and Kilkis (2016), Wong and Pecora (2015),
	Energy productivity	Europe, Northern Africa, Southern Asia	AbdelHady *et al* (2017), Perrone and Hornberger (2016), Villamayor-Tomas *et al* (2015), Zanon *et al* (2017)
	Energy footprint	Europe, Northern Africa, Northern America, Southern Asia	Daccache *et al* (2014), Holt *et al* (2017), Ramaswami *et al* (2017), Talozi *et al* (2015)
	Energy efficiency	Eastern Asia, Northern Africa, Northern America	Foran (2015), Jobbins *et al* (2015), Mohareb *et al* (2017), Pradeleix *et al* (2015)
	Energy for water supplies	Europe	Kilkis and Kilkis (2017), Villamayor-Tomas *et al* (2015)
	Hydropower development	Central Asia, Southern Asia, World	Dhaubanjar *et al* (2017), Jalilov *et al* (2013), Jalilov *et al* (2016), Rasul (2014), Zeng *et al* (2017)
	Bioenergy production	Northern America, Europe, World	Shifflett *et al* (2016), Villamayor-Tomas *et al* (2015), Walsh *et al* (2016)
	Subsidized energy	Northern Africa, Southern Asia	Doukkali and Lejars (2015), Rasul (2016)

Content analysis

WEF nexus	Activities	Geographical groups	References
Food	Maintenance of food security	Eastern Asia, Europe, Southern Asia, Sub-Saharan Africa, World	Barik *et al* (2017), De Fraiture *et al* (2014), De Laurentiis *et al* (2016), Hurford and Harou (2014), Kattelus *et al* (2014), Mirzabaev *et al* (2015), Olsson *et al* (2015), Rasul and Sharma (2016), Vanham (2016), Wallington and Cai (2017), Zhang and Vesselinov (2017)
	Increase in food production	Eastern Asia, Europe, Northern Africa, Southern Asia, Sub-Saharan Africa, World	Daccache *et al* (2014), De Fraiture *et al* (2014), De Laurentiis *et al* (2016), Khan *et al* (2017), King and Jaafar (2015), Villamayor-Tomas *et al* (2015), Walsh *et al* (2016), Zeng *et al* (2017), Zhang and Vesselinov (2017)
	Food supply chains	Northern America, World	Abumhadi *et al* (2012), Berardy and Chester (2017), Damerau *et al* (2016)
	Crop patterns	Northern Africa	El-Gafy *et al* (2017), Talozi *et al* (2015)
	Food trade networks	Northern America	Vora *et al* (2017)

Review - Conclusion

- Irrigated agriculture makes up 40% of all WEF nexus papers
- WEF nexus papers mainly address socioeconomic research
- Recently, the WEF nexus has started to be operationalized in modeling and empirical research
- Only about 10% of the studies address South Asia, even though the region occupies ~30% of the world's total irrigated land
- Only 20% of the papers discuss the combination of the three SDGs (2, 6, 7)
- Few papers also address climate change (SDG 13) or the maintenance of terrestrial ecosystems (SDG 15)

Going forward

- Inclusion of grey literature is suggested and would help to increase the validity of the study and overcome the potential problems of publication bias
- Substantial synthesis work on the WEF nexus, also in the field of irrigated agriculture, done by international organizations like the United Nations or FAO, as well as UNU Flores
- Adding “ecosystems”, “biodiversity”, “climate” and other relevant terms in the database search could further provide a comprehensive overview of WEF nexus studies relevant to irrigated agriculture

Open Access Review

Sustainability Considerations in Water–Energy–Food Nexus Research in Irrigated Agriculture

by Ahmad Hamidov [1,2,*] and Katharina Helming [1,3]

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(This article belongs to the Special Issue Natural Resources Management and Conflicts in the Context of Sustainability Transformation)

Abstract

Irrigated agriculture is essential to satisfying the globally increasing demand for food and bio-based products. Yet, in water scarce regions, water-use for irrigation aggravates the competition for the use of water for other purposes, such as energy production, drinking water and sanitation. Solutions for sustainable food production through irrigated agriculture require a systemic approach to assess benefits and trade-offs across sectors. Here, the water–energy–food (WEF) nexus has become an important concept in natural resource management. It has been conceptualized to analyze linkages and trade-offs between the three sectors, across temporal and spatial scales. However, the concept has so far mainly been conceptual, with little empirical evidence or proof of concept in real world cases. The objective of this paper was to take stock of the rapidly advancing literature on the WEF nexus in irrigated agriculture, and to analyze how the concept was actually implemented in research studies, and how the nexus between water, food and energy was actually dealt with. The study period ranges from 2011 to 2019, and includes 194 articles. Results showed that the WEF nexus is indeed very relevant in irrigated agriculture, and the respective literature makes up one third of all WEF nexus papers. Modeling and empirical research have caught up with conceptual synthesis studies during the last four years, thereby indicating that the WEF nexus concept is indeed increasingly operationalized. However, most studies addressed the WEF nexus from a perspective of either socioeconomic, technological or environmental categories, and they place one of the dimensions of water, food or energy into the foreground. To address sustainable development, there is a need to fully integrate across research disciplines and thematic dimensions. Such studies are only starting to emerge. These findings are an important evidence-base for future WEF nexus research on irrigated agriculture, in support of sustainable solutions for water scarce regions, especially in settings undergoing transformations. View Full-Text

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Thank you for your attention !

Questions?

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Day 4

| 2nd International Summer School 2023, Tashkent | 24th August |

Harvesting the Sun

Agri. Solarization and the WEFE Nexus

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SE4RL Solar Energy for Rural Livelihoods | IWMI-TATA Water Policy Program | CGIAR Initiative on NEXUS Gains | TIIAME NRU | zalf Leibniz Centre for Agricultural Landscape Research (ZALF) | Alliance Bioversity & CIAT | ICARDA | IWMI International Water Management Institute | IFPRI International Food Policy Research Institute

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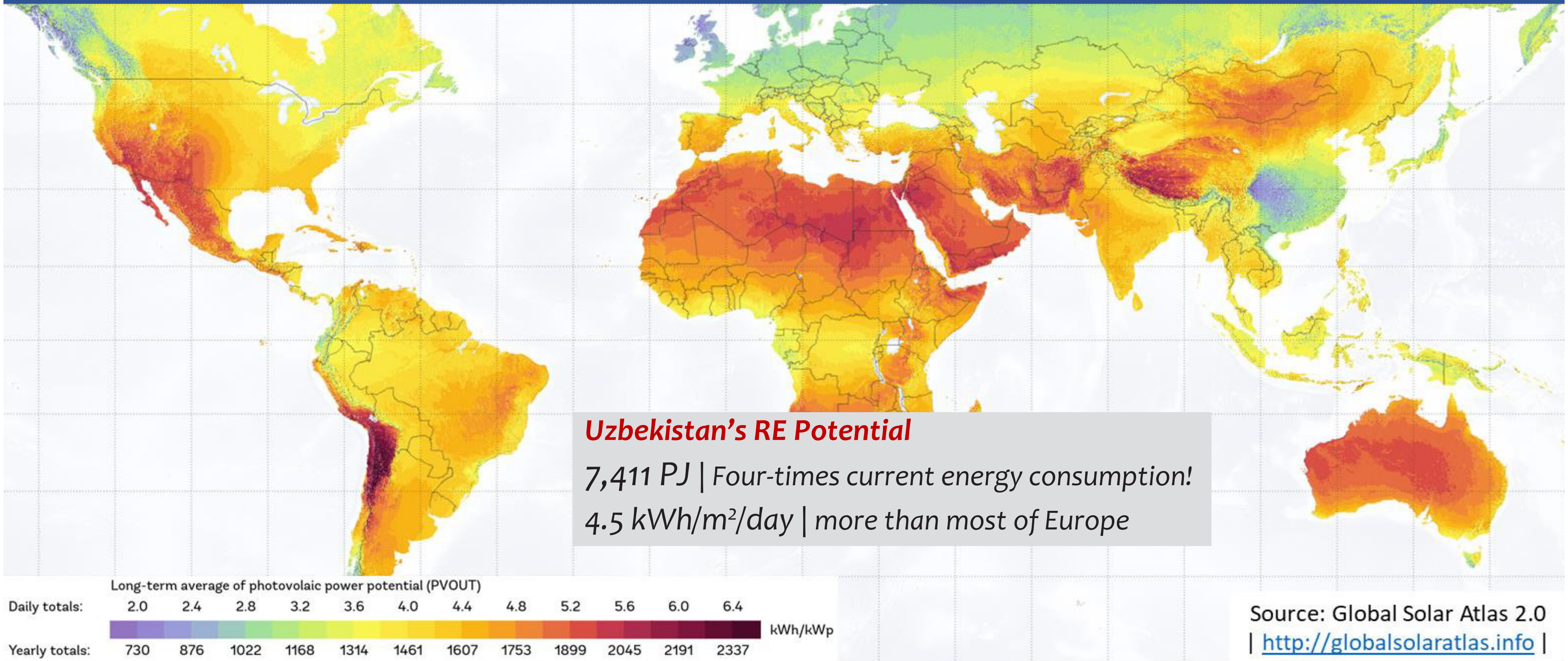
Brighter Sun: Plentiful Solar Resource

Much of the *Developing World* can harvest 1,400 – 2,000 peak-hour equivalent of sunshine to *conservatively* generate 3.8 – 5.6 kWh of energy per kWp of installed capacity | Central Asia is no exception…



Uzbekistan's RE Potential

7,411 PJ | Four-times current energy consumption!

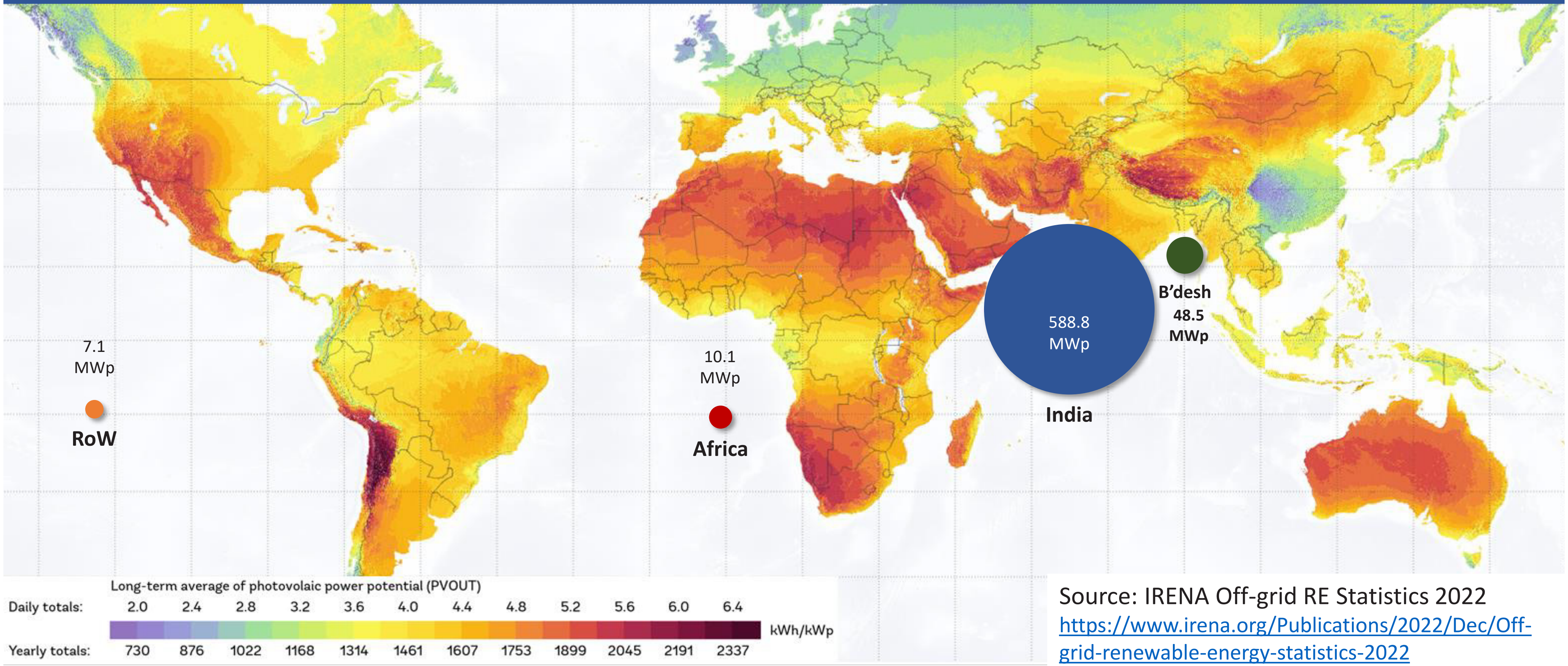
4.5 kWh/m²/day | more than most of Europe

Source: Global Solar Atlas 2.0 | http://globalsolaratlas.info |

Solarization of Agriculture: Global Overview

| Bulk of the *early investments* have been made in South Asia |

| Tremendous untapped potential in Africa, Central Asia and Latin America |



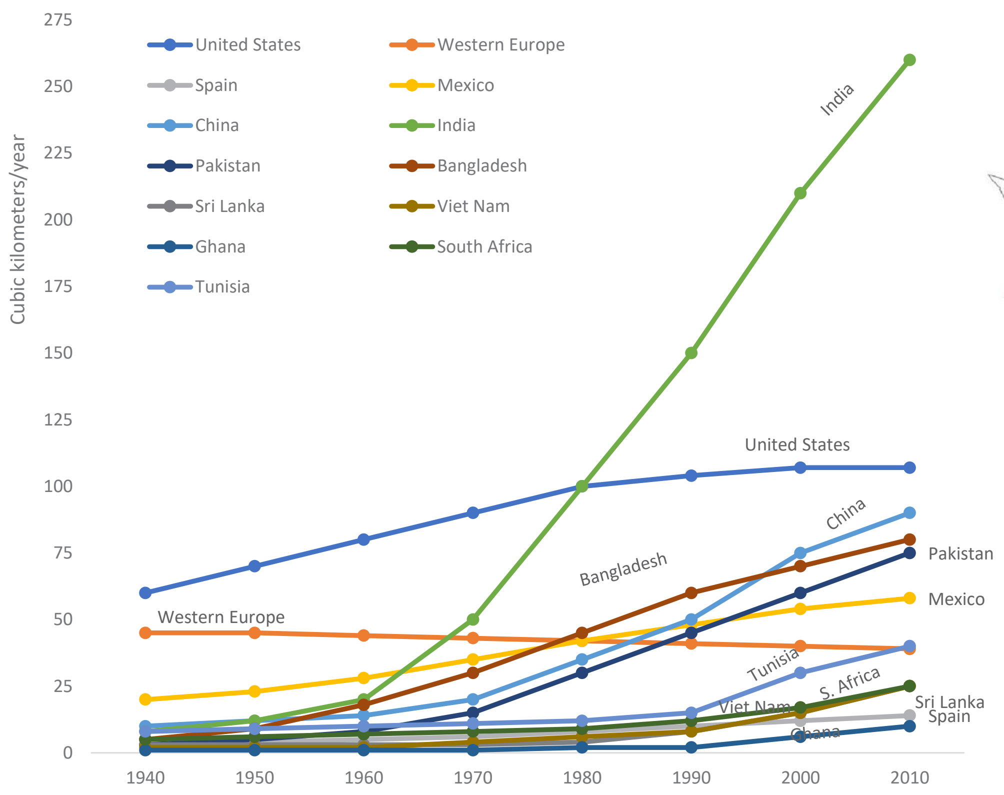
Source: IRENA Off-grid RE Statistics 2022
https://www.irena.org/Publications/2022/Dec/Off-grid-renewable-energy-statistics-2022

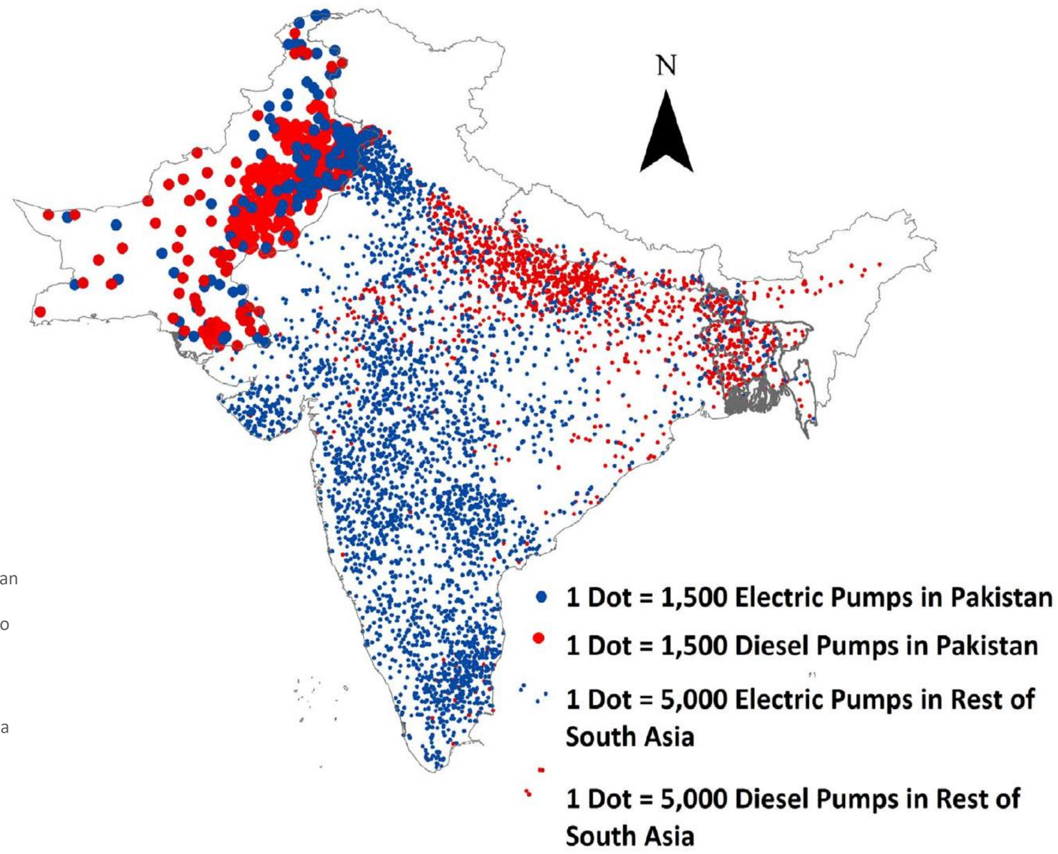
Solar Pumps are reconfiguring the WEFE Nexus in South Asia…

SE4RL Solar Energy for Rural Livelihoods | IWMI-TATA Water Policy Program | CGIAR Initiative on NEXUS Gains | TIIAME NRU | zalf Leibniz Centre for Agricultural Landscape Research (ZALF) | Alliance Bioversity & CIAT | ICARDA | IWMI International Water Management Institute | IFPRI International Food Policy Research Institute

South Asia is Ground Zero for ‘Pump Irrigation’

The region has >30 million irrigation wells and tubewells with ~1-2m new pumps added each year
IN has more electric pumps (~15m); PK, NP and BD rely more on diesel pumps





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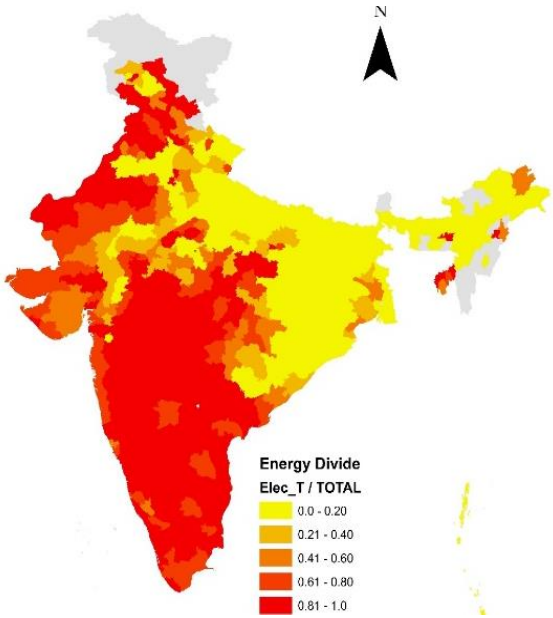
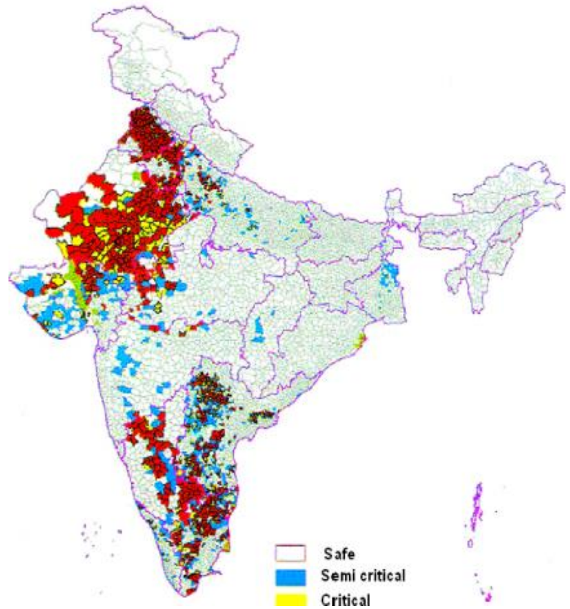
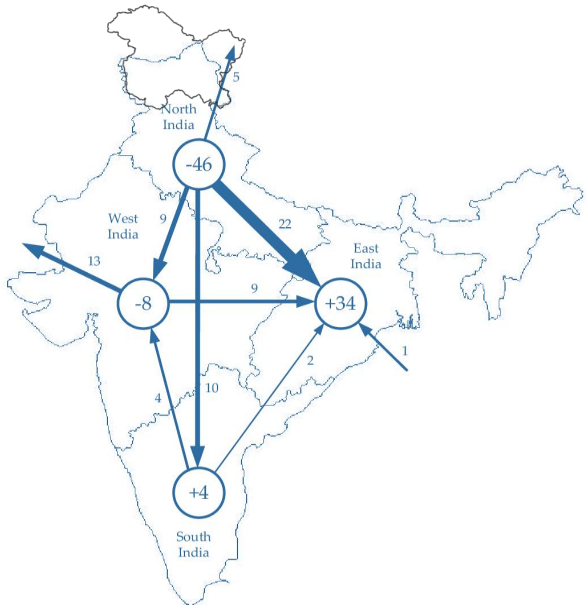
Water-Energy-Food Nexus in India

Farm Power Subsidies | Energy Divide | GW Depletion | Perverse VW Flow



India's Energy Divide
Farm Power subsidy: ~$20 Billion/y

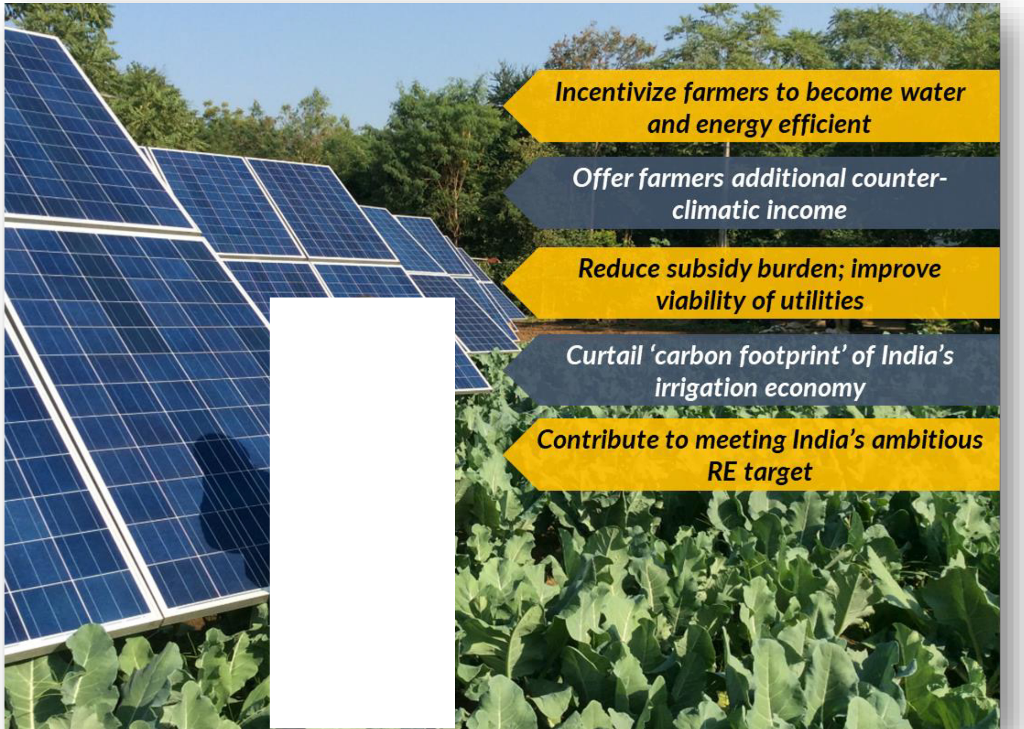


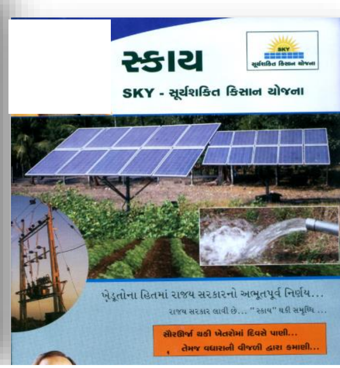


Populist Energy and Agriculture policies drive GW over-exploitation and have led to perverse direction of *internal* virtual water flows

SPaRC: Solar Power as Remunerative Crop

Grid-connected Solar Pumps as a 'Nexus Solution'



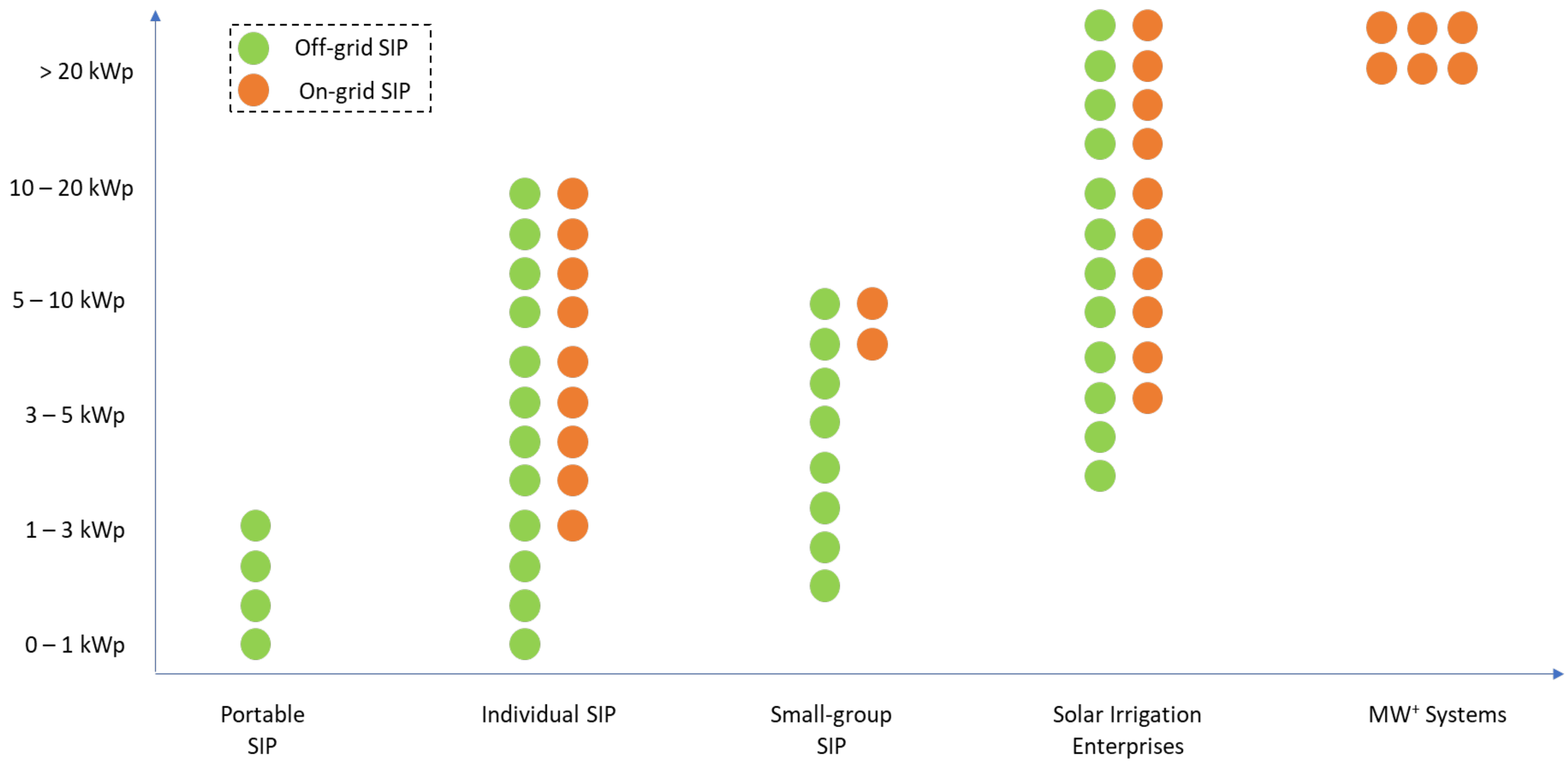


https://www.youtube.com/watch?v=SneJ3plzz5I

Solar Irrigation Business Models and Deployment Strategies

Solar Pumps come in all shapes and sizes

Techno-Economic and Techno-Managerial Configurations



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Solar Irrigation Business Models

Individual, Off-grid SIPs dominate… but other models critical to scaling

Individual | Off-grid

- Mainstream
- Equity | Targeting
- High CapEx
- Surplus Capacity
- Perverse Incentives

SPaRC: Solar Power as Remunerative Crop

- Full Utilization (IN)
- Right Incentives
- IWMI experiment
- Scaling in India
- Replication: NP, BD

Solar Irrigation Service Providers

- Farmer ISPs (IN)
- Diesel replacement
- Fragmented land holdings
- Intensive Irrigation

Solar Enterprises

- Village-scale (BD)
- Diesel replacement
- Fragmented land holdings
- Intensive Irrigation

Feeder Tail-end Solar Plants for Agriculture

- Piloted in Mah. (IN)
- Private sector driven
- Fixing incentives

Some Emerging Business Models

Canal-top | Flotovoltaics | AgriPV | Mobile SIPs

+ Land, evaporation, energy generation
- Significantly higher costs

Do the benefits outweigh the additional cost? Will 'floating solar' crowd this out?

+ Land, crop productivity
- Significantly higher costs; energy-led

Need farmer-centric business models…

+ Mobility
+ Couples well with drip
- Higher unit costs
- Time to irrigate

Technological and design improvements will spur deployment

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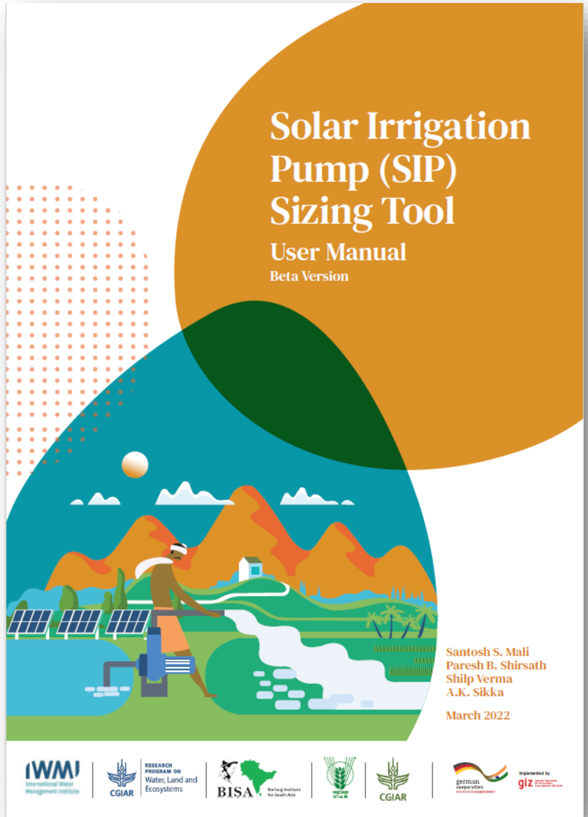
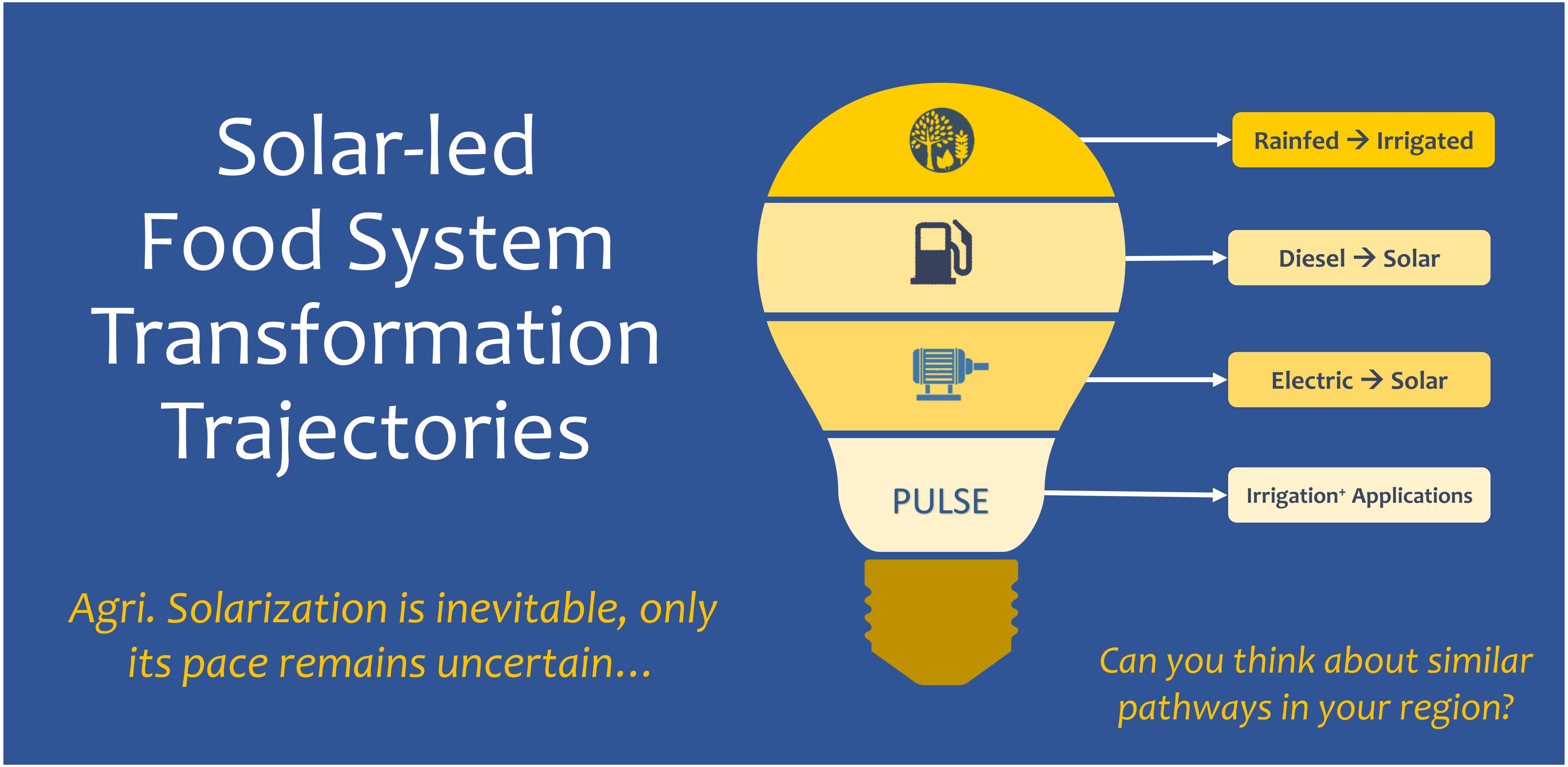
IWMI’s On-going work on Solar Irrigation

Building on a decade of experiments and experiences

- Supporting Ag. Solarization in India
  - *SPaRC: Solar Power as Remunerative Crop (Gujarat)*
  - *Solar Irrigation Entrepreneurs (Bihar, B’desh)*
  - *Supporting MNRE: Solar Irrigation Expansion*
  - *SE4RL: Solar Energy for Rural Livelihoods*
  - ***SIP Sizing Tool – Beta Version***
- Supporting Ag. Solarization in the Global South
  - *SDC-IWMI SoLAR (South Asia)*
  - *World Bank-IWMI Roadmap (Pak. Punjab)*
  - *ADB-IWMI Scoping Study (South Asia)*
  - *Leveraging partnership with International Solar Alliance*
  - *NEXUS Gains (South Asia – Central Asia – Africa)*
  - *Farm/er-centric AgriPV*





Solar-led
Food System
Transformation
Trajectories
Rainfed → Irrigated
Diesel → Solar
Electric → Solar
PULSE
Irrigation+ Applications
Agri. Solarization is inevitable, only its pace remains uncertain...
Can you think about similar pathways in your region?

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Thank You...

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Gender equality and social inclusion in the water–energy–food–ecosystems (WEFE) nexus

Marlène Elias, Alliance of Bioversity International and CIAT

WEFECA International Summer School, 24 August 2023

Notes: Welcome to the learning module on gender equality and social inclusion in the water–energy–food–ecosystems nexus. The module provides frameworks and tools for moving from resource-centric to people-centric nexus approaches.

Outline

1: Introduction	
2: From resource- to people-centric WEFE nexus approaches	▪ **Current WEFE nexus thinking: focus on resources over people** ▪ **Gender equality and social inclusion: the missing links in WEFE nexus approaches**
3: A social equity framework for addressing gender equality and social inclusion in the WEFE nexus	▪ **Recognition** ▪ **Representation** ▪ **Redistribution**
4: Case study	
5: Synthesis	

Notes: This learning module is divided into five chapters.
Chapter 1 introduces the module and identifies some key terms.
Chapter 2 provides an overview of the social dimensions of resource access.
Chapter 3 introduces the social equity framework for addressing gender equality and social inclusion in the nexus.
Chapter 4 uses a case study in Indonesia to understand gender equality and social inclusion considerations in the nexus project cycle.
Chapter 5 is a summary of the learning objectives.

1: Introduction

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Imagine a hydropower plant, an industrial farm and a small agricultural community relying on the same water resource.

Now, what if that water resource becomes scarce? How will it be managed?

Who will decide what's most important?

Will representatives from each stakeholder group sit down to create a fair use agreement?

Will the stakeholders with the most economic and political influence leverage their power?

Will the needs of vulnerable community members be represented? 4

Notes: It is easy to see how politics and underlying power structures will play a major role in the management of the water–energy–food–ecosystems nexus, and how the most marginalised stakeholders risk losing out on the key resources that sustain their livelihoods.

Politics and power dynamics play a major role in managing the **water–energy–food–ecosystems (WEFE) nexus**.

The most marginalised stakeholders risk losing out on critical resources.

5

Notes: Past examples show how competition over resources within this nexus has played out, with stakeholders with less power losing out. For e.g, in the Mekong Delta of Viet Nam, hydropower dams benefit distant communities in China but are producing harmful effects on local fisheries and livelihoods.
Addressing these challenges in an integrated way to meet multiple stakeholders' needs will require moving away from a narrow, technical resource focus to consider aspects of gender equality and social inclusion.

2: From resource- to people-centred WEFE nexus approaches

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Current WEFE nexus thinking: focus on resources over people

WEFE nexus approaches **seek to manage trade-offs, reduce inefficiencies and increase synergies at a systems level among water, energy, food, ecosystems and other land use sectors**.

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Notes: Nexus thinking has traditionally been resource-focused and has overlooked the social, economic, political and cultural dynamics that shape resource use.

Gender equality and social inclusion: the missing links in WEFE nexus approaches

Around the world, we see persistent gender inequalities in access to resources and decisions over how to use and manage these.

Too often, women are left out of development and environmental initiatives, since they are not seen as legitimate stakeholders.

Women (and men) are heterogeneous groups and may have vastly different experiences based on other social factors.

Many categories of men also experience marginalisation.

By addressing these inequalities across sectors in policy and practice, nexus approaches can enable more equitable access to WEFE decisions, services and benefits for all.

Notes: But once we start looking at the people, we see the vast diversity that must be considered in nexus approaches because it shapes resource management. Rural women and men particularly rely on land and other natural resources for their livelihoods. But often, only men are recognised as the authorities, providers, farmers and resource managers of their households and communities – even though women, too, are responsible on a daily basis for providing and managing food, water, fuel, cash and other resources.

In general, patriarchal norms give more status, influence and rights to men than women.[1,2] Too often, women are left out of development and environmental initiatives, since they are not seen as legitimate stakeholders.[3] In reality, in their communities, women have unique knowledge of and priorities for the management of resources. They also face different and often unequal risks and rewards than men when it comes to accessing and controlling, governing, using and managing these resources.

There are many gender- or inclusion-specific barriers that make it difficult for women to access and progress in decision-making spaces, from underlying societal norms to practical constraints such as time availability and mobility outside of the home. Professionally (i.e., in the workplace), the water, energy and food sectors as they are considered very technical and, thus, due to societal norms, typically associated with men.

Importantly, women (and men) are heterogeneous groups and may have vastly different experiences based on other social factors. For example, poor women in rural areas have different needs and realities with respect to energy or water use than better-off women in cities. Age, marital status, and in some areas, caste or ethnicity, among other factors, will influence their access to resources and how they use and prioritise these. Overall, however, women, in all their diversity, have limited control over management decisions at all levels compared to men.

Many categories of men also experience marginalisation. Men in disadvantaged groups (such as ethnic minorities, lower castes or landless men) may struggle to have their voices heard in their communities and in higher-level governance spaces that shape their local opportunities and resource access in significant ways.

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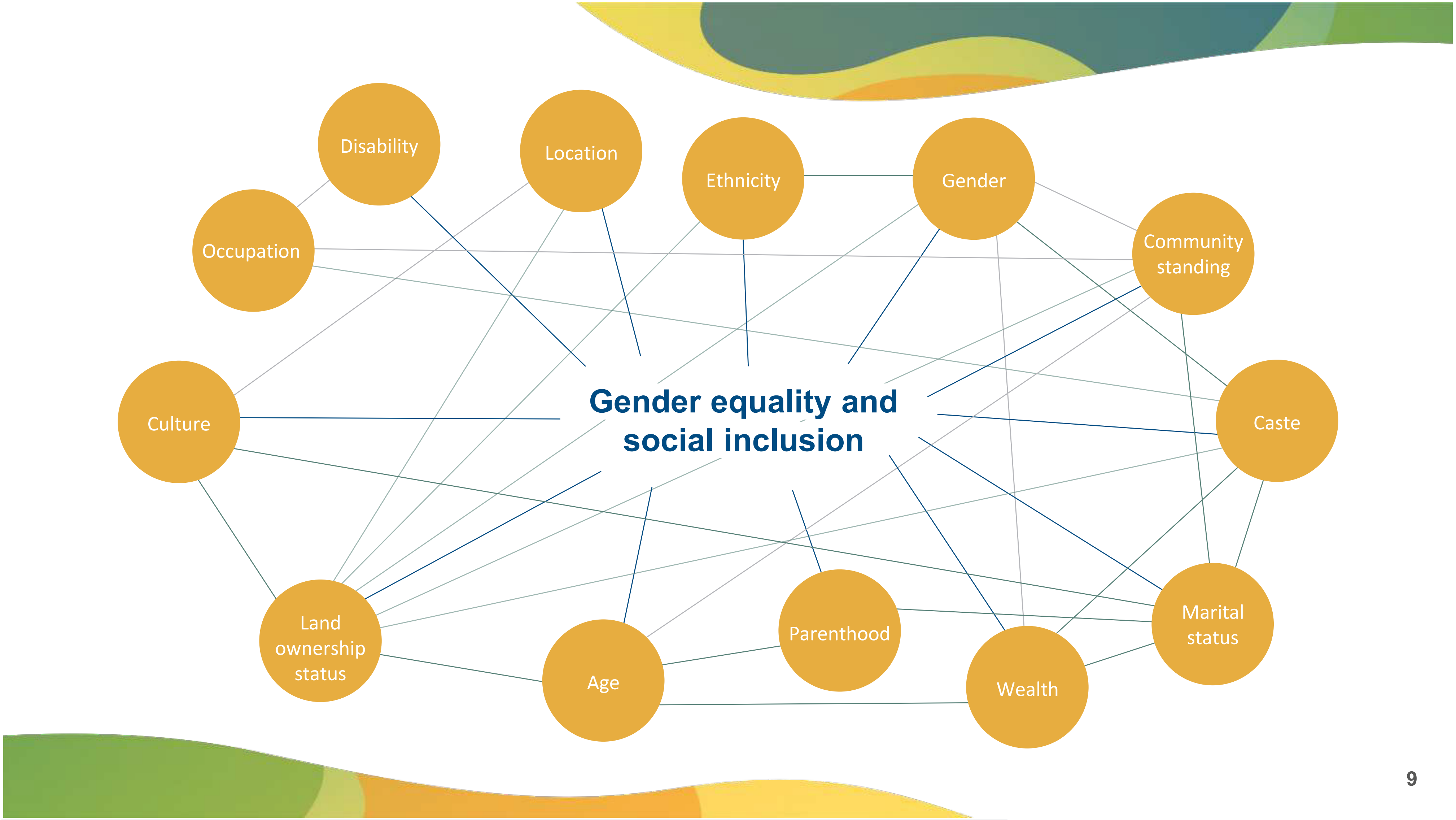

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Notes: This web shows many different aspects of a person's identity that, together, can lead to their exclusion or inclusion in decision-making and benefit-sharing related to water, energy, food and ecosystems. Advancing gender equality and social inclusion in the WEFE nexus requires recognising who is excluded and on what basis, to challenge that discrimination.
By addressing these inequalities across sectors in policy and practice, nexus approaches can enable more equitable access to resource decisions, services and benefits for all.

3: A social equity framework for addressing gender equality and social inclusion in the WEFE nexus

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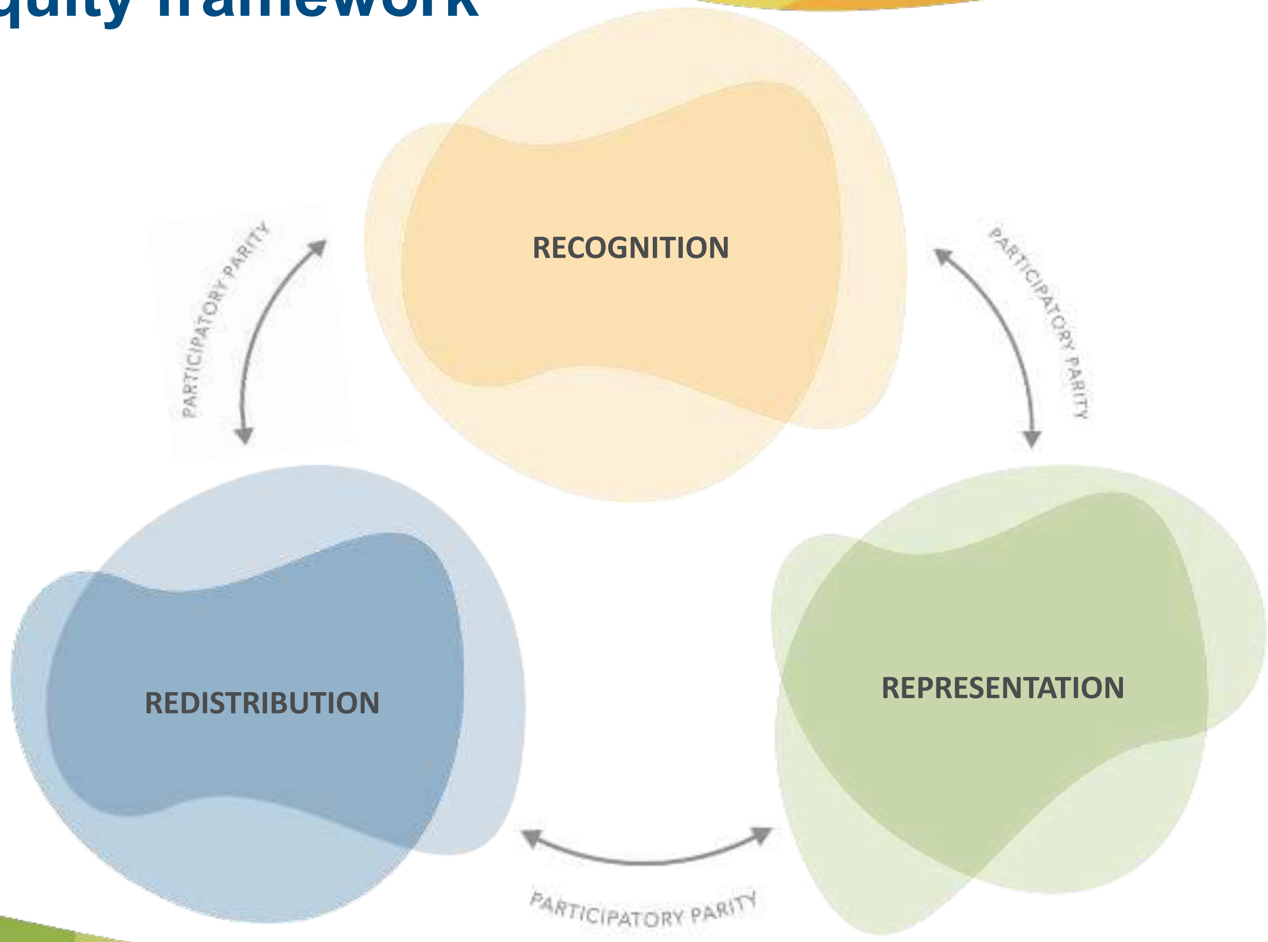
A social equity framework



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Notes: Framework draws attention to the who, the how and why to achieve equitable outcomes in nexus initiatives.
A social equity framework features three pillars:

- Recognition, or the right of those who are affected by, in this case, the WEFE nexus, to be recognised as legitimate and dignified stakeholders, and to have the value of their knowledge, voices and priorities recognised
- Representation, or the right to equally participate in and influence decision-making processes
- Redistribution, or more equal rights to the resources and benefits from, in this case, the WEFE nexus.

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Recognition

Recognition refers to **when people or social groups have equal opportunities to be seen and valued as legitimate, respected and dignified participants in society.**

WEFE nexus initiatives must identify which social groups will affect and be affected by WEFE nexus interventions.

Notes: The recognition a person or social group receives is influenced by the (often hidden) attitudes that society holds towards gender and other social categories, such as age, ethnicity, caste or occupation. For example, many rural women do as much or more farm work than their spouses but are not recognised as farmers in their own right, and their knowledge and skills are undervalued. As such, they are frequently not considered legitimate (justified or valued) stakeholders in agricultural interventions. 12

Nexus initiatives must identify which social groups will affect, and be affected by, nexus interventions. This broad range of stakeholders may include:

- Policymakers
- Staff of national and local government agencies participating in the implementation of interventions
- Intended beneficiaries in all their diversity
- Persons or groups who may be affected adversely by the interventions in the short- or long-term, which includes private sector actors, interest groups, civil society organisations and donors.

Recognition

Among stakeholder groups, there are highly unequal power relations. This means that the knowledge and priorities of some may be perceived as having more legitimacy than those of others.

Importantly, from the perspective of social equity, the needs, rights, knowledge systems and priorities of different groups– particularly those most marginalised – must be recognised and legitimised.

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Notes: These stakeholders, who come from many levels – from local to national and international – are not all usually present in the same water, energy, food and ecosystem decision-making spaces. Typically, stakeholders with less social and financial capital are the ones who are left out. For example, a decision made in a capital city about rural resources may not include any spokespeople from the impacted rural area. If interventions do not intentionally seek to recognize all stakeholders genuinely, they risk stripping specific communities of their resources to benefit other, more powerful groups. From a rights-based perspective, those who live near the resources in question and whose livelihoods are directly linked to them deserve particular recognition and protection. In this sense, it is important to make the distinction between two categories. First are rights-holders: those with customary and historical rights to determine the use and access to natural resources in ways that are fundamental to their human rights, such as Indigenous peoples and marginalised groups in local communities. Second are other stakeholders: individuals or groups claiming a stake in a decision-making process, such as political elites or private companies interested in using the resources.
A 'do-no-harm' principle means that initiatives must ensure, at a minimum, that they do not pose undue risks to local people and marginalised community members (that is, rights-holders) and do not jeopardise their livelihoods and well-being. Nexus initiatives will also have to be accountable to these rights-holders.

Recognition – stakeholder analysis

To make sure that all relevant groups are included in WEFE nexus decision-making, intervention planning should begin with a **stakeholder analysis**.

Stakeholder analysis = identifying social groups who may affect and be affected by WEFE nexus interventions.

Notes: A basic stakeholder analysis should be done before interventions are designed. It should then be revisited and deepened throughout the design process as more information is gained.
For example, a study aiming to inform the design of agricultural development projects in Kenya's arid and semi-arid lands examined stakeholders' participation in agricultural innovation projects. This included:

- Their roles in the agricultural sector and interactions with other stakeholders
- Their knowledge of agricultural technologies
- Their positions on agricultural innovations and potential conflicts with other stakeholders
- Their ability to mobilise collective action
- Their access to other resources that they could use to support or oppose change, and power to effect change as a combination of all these factors.

It is often difficult to define and identify 'legitimate' stakeholders. Consequently, many projects avoid clearly defining stakeholders. The researchers in the Kenyan study assumed this position: that the legitimacy of a group's claim as a stakeholder was less important than their ability to affect change in the system.5 The study found that farmers who were not affiliated with farmer groups were particularly marginalised. They had little interaction with extension officers and researchers, who were important stakeholders in the system, through whom marginalised farmers could have accessed information on improved agricultural practices. Other agricultural development projects prefer to work with existing farmer groups to capitalise on the existing trust and cooperation among group members – but this may result in further marginalisation of farmers who do not belong to groups.
The study also underlined that village chiefs in Kenya are powerful stakeholders who can call local meetings and make announcements to advance different issues around agricultural development. However, other stakeholders lamented that the chiefs' interest in engaging in community development varied widely. This affected which communities agricultural extension officers chose to work with. Communities with disinterested chiefs were losing out on access to innovation projects and related human, social and financial capital.

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Representation

Representation relates to how ***different stakeholders can shape agendas and influence the critical decisions that impact their lives.***

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Notes: Measures are needed to ensure that the diverse stakeholders we were just discussing – and particularly communities and their members whose livelihoods depend directly on WEFE resources – are adequately represented across all phases of a nexus initiative: from planning to implementation and monitoring.

Representation

A GESI approach should **ensure that marginalised groups can have influence in decision-making at different levels.**

Those with the most to gain or lose from WEFE nexus interventions often have the most limited influence.

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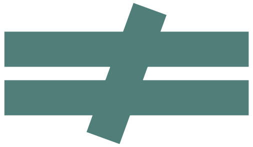
Notes: A gender equality and social inclusion approach should ensure that women and marginalised social groups can have a voice and influence in the processes shaping resource access and use at the household, community and higher decision-making levels.1
Unfortunately, the stakeholders with the most to gain or lose from nexus interventions often have the least influence in intervention planning.

Representation: recognizing and fostering higher forms of participation

Six levels of participation

Form of participation	Characteristic features
Interactive (empowering) participation	Having voice and influence in the group's decisions
Active participation	Expressing opinions, whether or not solicited, or taking initiatives of other sorts
Activity-specific participation	Being asked to (or volunteering to) undertake specific tasks
Consultative participation	Being asked an opinion in specific matters without guarantee of influencing decisions
Passive participation	Being informed of decisions ex post facto; or attending meetings and listening in on decision-making, without speaking up
Nominal participation	Membership in the group

Not all participation is created equal



Notes: This table[1] shows that not all participation in decision-making is equal in nature. There are many forms or levels of participation. Some participation can be quite nominal – for example, when someone is part of a group or project, but they do not actually engage actively or influence decisions. In contrast, in the most interactive or empowering form of participation, everyone is able to interact as peers and to express views with equal weight. This is also called 'participatory parity'.

Achieving such interactive or empowering participation requires ongoing negotiation and management of unequal power relations and conflicting interests. This is a challenging process, particularly as there are often limited resources, skills and trust among different participants.[2]

References:

[1] *Agarwal, B. (2001). Participatory exclusions, community forestry, and gender: An analysis for South Asia and a conceptual framework. World Development, 29(10), 1623-1648. https://doi.org/10.1016/S0305-750X(01)00066-3*

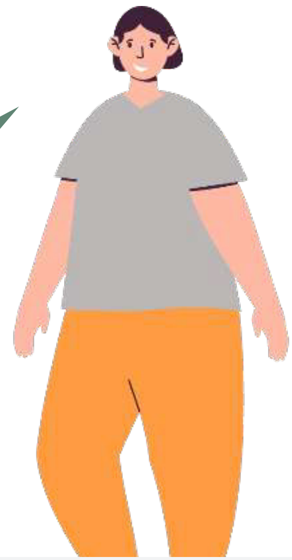
[2] *Vermunt, D.A., Verweij, P.A., & Verburg, R.W. (2020). What hampers implementation of integrated landscape approaches in rural landscapes? Current Landscape Ecology Reports, 5(4), 99-115.*

Representation: recognizing and fostering higher forms of participation

Meaningful participation requires addressing context-specific barriers.

Empowering participation and bottom-up learning requires continuously asking:

What voices are being heard at the different stages of decision-making processes, and what is the weight given to diverse voices?



Notes: Enabling marginalised groups to meaningfully participate in nexus initiatives requires addressing the barriers they face, which depend on the group, place and time. To understand and lift these barriers, interventions must carefully consider the local context, including power relations and the history of water, energy, agriculture and environment sector development in the project area.
Targeted measures are needed to ensure that women and other less powerful actors can express their voices and priorities and that their views are meaningfully considered (i.e., what is called active and inter-active/empowering participation in the participation visual just presented). Inviting these groups to attend a multi-stakeholder meeting is not enough, as they may not be able to express their views, influence the agenda, or engage on equal footing with other, more powerful groups. Participation then remains as nominal, passive or consultative only.
Interactive (or empowering) participation can be supported, for example, by a combination[1] of:

- Centering meetings on issues that are important to women and other marginalised groups
- Establishing quotas for women's and men's participation, consultation, decision-making and voting
- Giving enough space and time for collective learning, including in informal settings, smaller and single-gender groups
- Being explicit and deliberate about how and why various inclusive tactics are being used
- Allocating adequate financial and technical resources to supporting inclusion from the beginning
- Mobilising the right skills to support a rigorous action learning initiative
- Strengthening local capacities for conflict mediation and negotiating power imbalances.

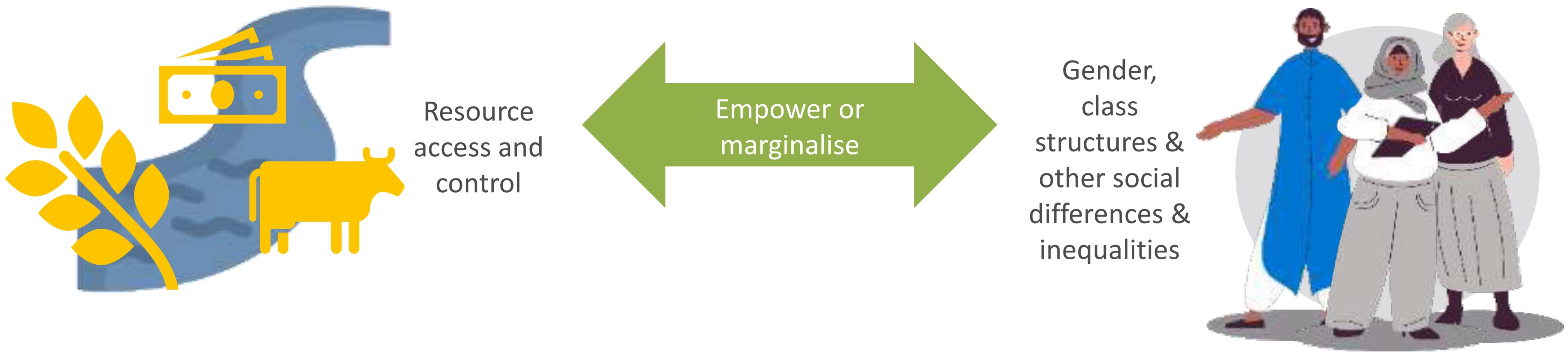
The case study at the end of the lesson gives more examples of how to support interactive/empowering participation.

References:

[1] *Zaremba, H., Elias, M., Devi, J.T., & Priyadarshini, P. (2021). Inclusive participatory approaches: A facilitator's guide. Rome (Italy): Bioversity International. 24 p. ISBN: 978-92-9255-234-3 https://cgspace.cgiar.org/handle/10568/117461*

Redistribution

Redistribution refers to **bringing more equity to how rights and goods, as well as costs, risks and responsibilities, are distributed in a society.**



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Notes: Resource access and control shape and are shaped by gender, class structures and other social differences and inequalities that empower some people and groups while marginalising others.
Recognition and representation are goals in and of themselves, as they are essential to fairness and human dignity. They are also important to ensure that the costs, benefits and risks of nexus initiatives are equitably distributed – which generally implies a need for redistribution.

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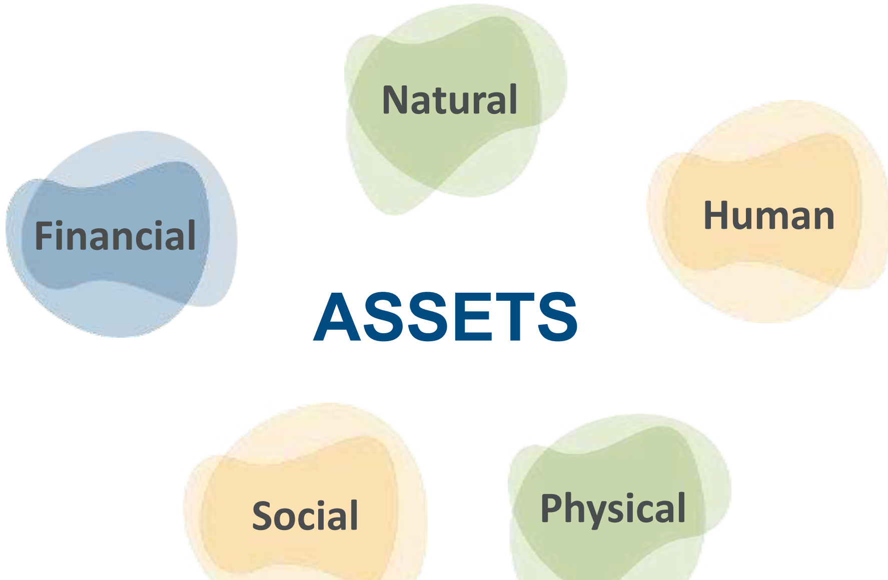
Redistribution: understanding different types of livelihood assets

A **Sustainable Livelihoods Framework** can be used to examine the distribution of costs, benefits and risks in WEFE nexus interventions, and help identify ways to achieve a more equal distribution.



Notes: The Sustainable Livelihoods Framework illustrates the different types of tangible and intangible assets that resource users can draw upon to secure their livelihoods, and how these assets interact with each other.

Assets can take many forms, including:

Natural capital such as land, water, fuelwood, wild food sources, or genetic resources

- Physical capital such as irrigation and road infrastructure, transport, electricity, tools and machinery, storage, or production inputs like seed, fertilizers, and pesticides.
- Financial capital such as regular income, savings, liquid assets, or formal and informal credit facilities.
- Human capital such as knowledge and skills, education and training, health, nutrition, or capacity to work.
- Social capital such as membership in formal and informal groups like Water User Associations and producer groups, collaboration, or access to opportunities through social networks.

The framework helps understand how costs (or loss of assets), benefits (or gains in assets), and risks are distributed among different stakeholder groups. It also helps grasp the trade-offs and synergies among assets that may result from nexus interventions.

Key characteristics

- Assets are interdependent and partially interchangeable
- Access to human, social, and political assets is relational
- Social structures and norms that impact resource users' options have been shaped through historical processes, policies and mechanisms
- In an interconnected world, changes in an asset in one location are affected by resource use and decision-making in other geographies.

Redistribution

To identify **how WEFE nexus interventions** may **affect the distribution of costs** and **benefits** among **different social groups**, key questions include:

Which groups would gain which types of assets or resources?

Which groups would lose access to and control over assets or resources as a result of interventions?

How do the planned interventions affect the availability, flows and distribution of different types of assets among diverse social groups?

Notes: In addition to asking these questions at the planning stage of an intervention, to shape intervention design, these questions should also be asked throughout the intervention.

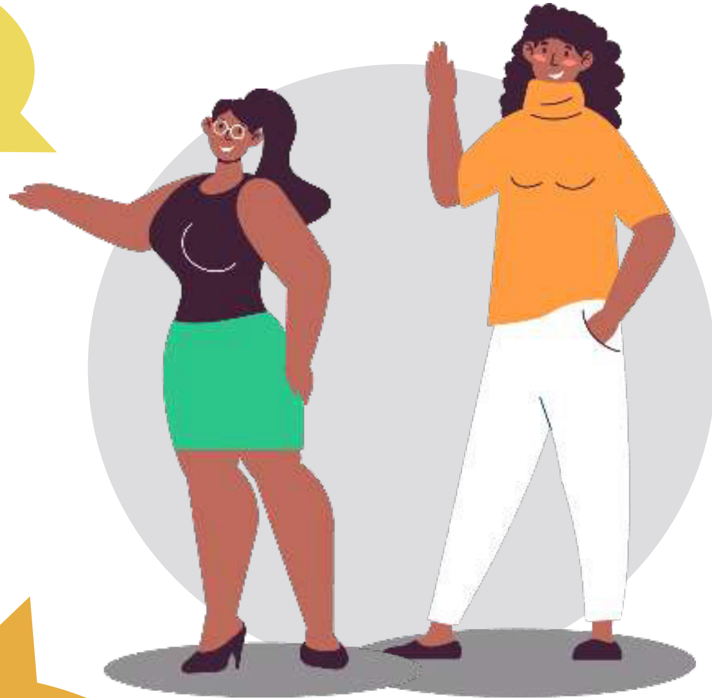
Redistribution

What indicators can help understand the effects of interventions on gender equality and social inclusion?

What participatory monitoring approaches can support adaptive learning toward more equitable outcomes?

What alarm systems and safeguards are needed to mitigate and address unintended negative consequences?

Which trusted actors can play a part in these early warning systems to ensure interventions harm no one?



Monitoring and evaluation

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Notes: Systematic monitoring is needed to reduce risks of harm to women or vulnerable social groups that may arise from an intervention.

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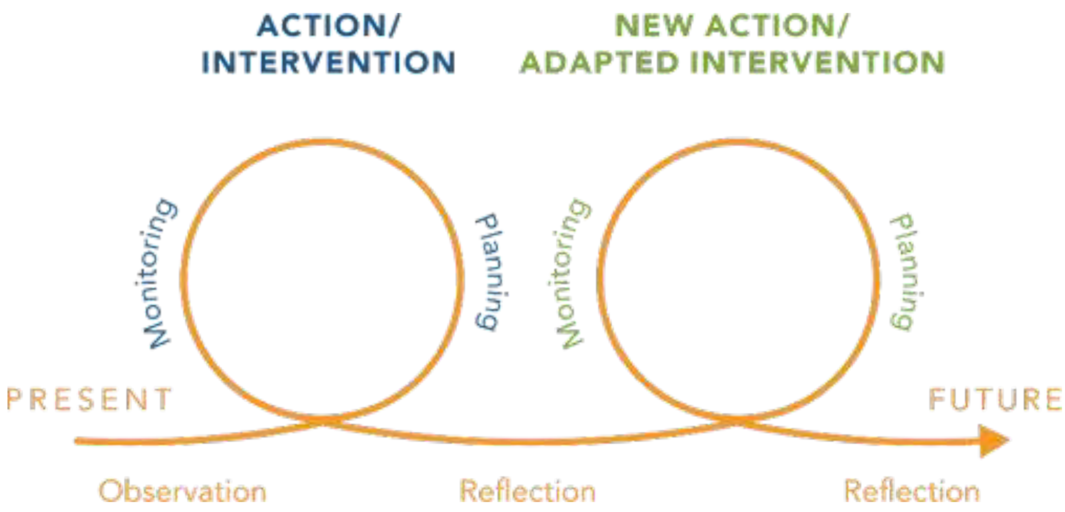
4: *Case study*
Adaptive collaborative management in Indonesia for empowering community members in natural resource management

Notes: This case study demonstrates collaborative process approaches that can be used to strengthen resource users' capacities and empower them to identify and implement their own solutions for sustainable resource management.
These approaches place local people living closest to WEFE nexus resources at the heart of decision-making, in collaboration with other key stakeholders.
They contribute to a sense of ownership among participants, which is crucial for sustainability after project support ends.

Adaptive collaborative management (ACM)

Adaptive collaborative management (ACM) is a participatory process that centres on cycles of shared action, learning and reflection. It relies on the active participation – in this case, that of local forest users – including those who are marginalised from decision-making, as well as other stakeholders.



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Notes: This learning cycle engages all three pillars of the social equity framework – recognition, representation and redistribution – to achieve sustainable and equitable nexus solutions.

Recognition

In three Indonesian communities, stakeholder analysis was included in an early step in the learning process to support multiple users to co-manage forest resources through ACM. The analysis asked, among other questions:

- Who are the stakeholders in forest management in this area?
- Who should be involved in the process?

Baru Pelepat Village, Jambi	Rantau Layung and Rantau Buta Villages, East Kalimantan
• Nomadic *Orang Rimba* (women and men) • Original community (women and men) • Settler community (women and men) • Village elite • Youth • Customary institution • Village government • Religious institution • Women's groups	• Farmer groups (women and men) • Youth (women and men) • Forest workers (all men) • Elderly (all men) • Village elite (formal government officials and customary leaders)

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Notes: ACM was used to empower multiple users to co-manage forest resources in three communities in Indonesia.
This table illustrates key actors identified through the stakeholder analysis activities conducted in each community. The facilitation team spent months visiting each community to get to know the local contexts and to build trust with the many different segments of each community.
These key stakeholders were then involved throughout the intervention, and their knowledge systems, experiences and priorities were considered as equally valid and important throughout the planning and reflection process.

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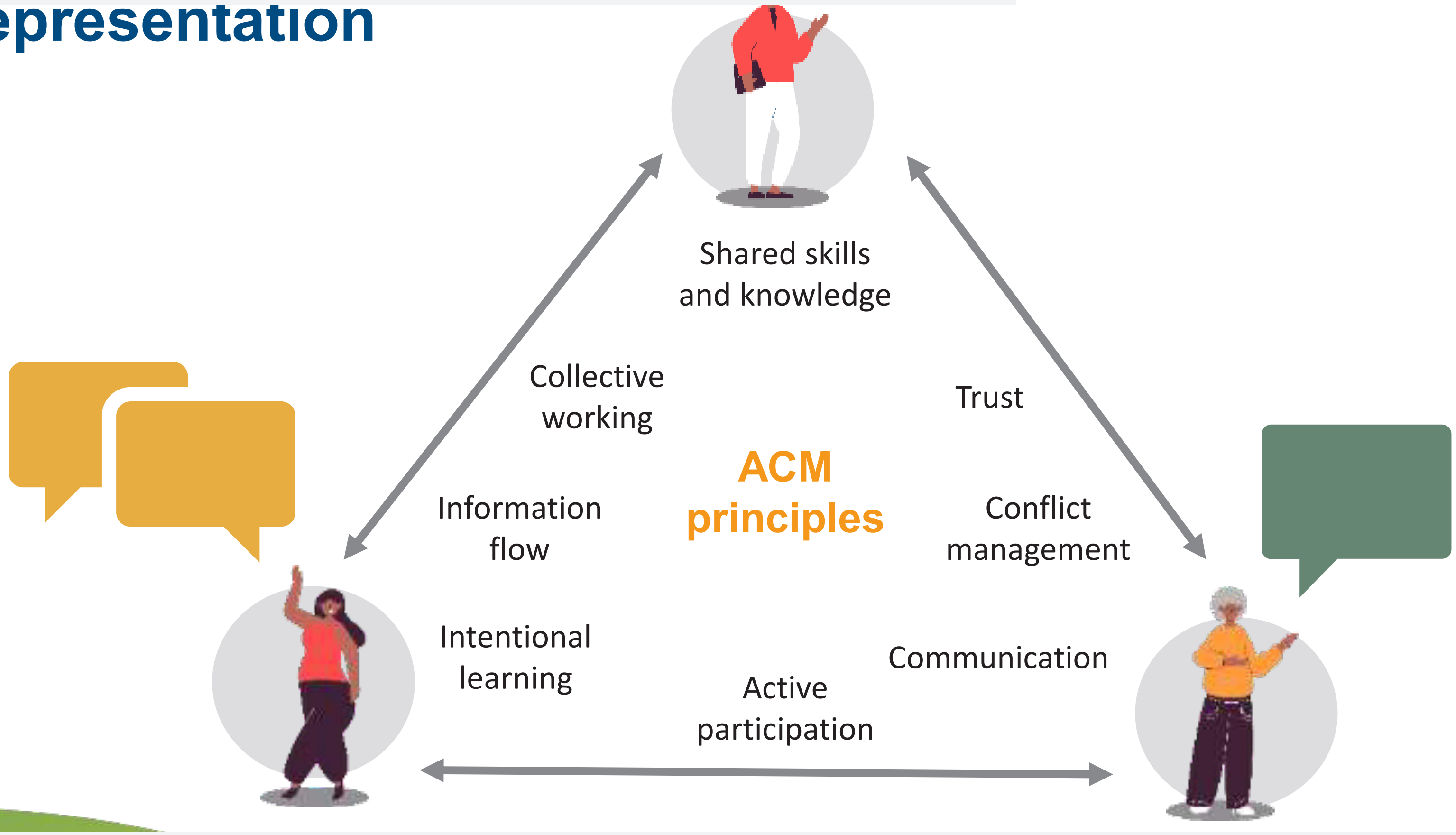
Notes: This learning cycle engages all three pillars of the social equity framework – recognition, representation and redistribution – to achieve sustainable and equitable nexus solutions.

Representation



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Notes: ACM is particularly well suited to advance representation as it is designed to enable action learning among community members with different understandings and experiences. Active participation of all key stakeholders throughout the entire ACM intervention is central to learning and progressing toward the desired resource management goals or shared vision. Along this iterative cycle, ACM principles focus on the following:

- Effective communication and information flows among stakeholders
- Active participation and wider representation in decision-making and negotiation of all important stakeholders
- Mechanisms to manage conflicts and adapt to rapid changes, surprises and uncertainty
- Intentional learning and experimentation
- Institutional willingness (that is, attitudes) and capacity (that is, skills and resources) to learn and respond to learning
- High mutual respect, trust and transparency
- Shared knowledge and skills
- Collective planning, decision-making, action and monitoring, including attention to relationships within and between human and natural systems.

Representation

Inclusive decision-making = collective understanding of current socio-ecological processes and interactions related to resource management

Shared learning strengthened capacity and confidence to:

- Manage new information
- Negotiate
- Organise and gain institutional competence
- Problem-solve

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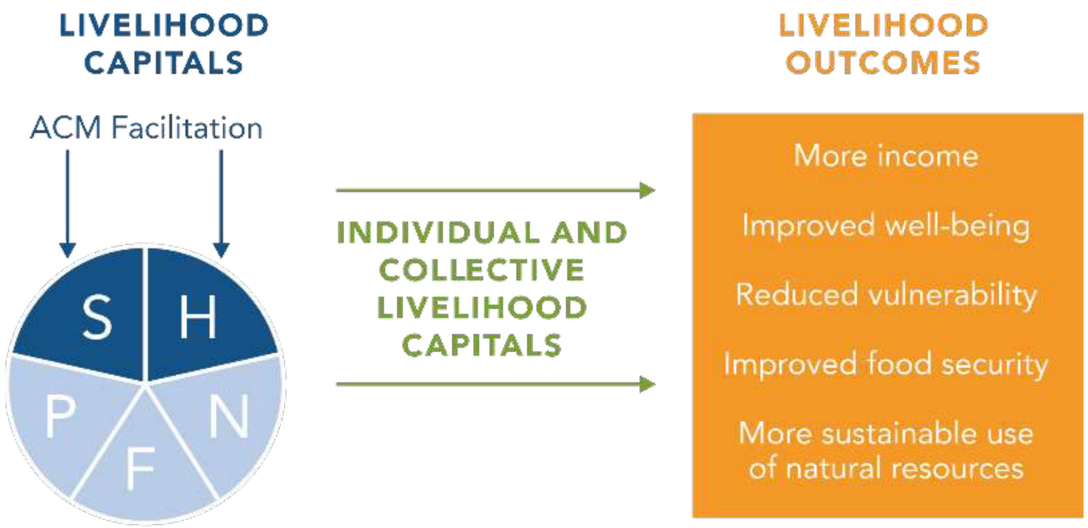
Notes: In this case study, tools used to support inclusive decision-making included participatory boundary or social mapping exercises, and small-group meetings among different sets of stakeholders to undertake shared visioning and priority-setting exercises that addressed livelihood needs or resource scarcities.
Over time, as more and more was shared, participants developed a collective understanding of the issues. These included current socio-ecological processes (for example land degradation), as well as interactions and power struggles related to natural resource management (for example land claims, pressures from the palm oil industry, and settler groups' differing needs and interests).
The processes of shared learning, including about different authority systems, strengthened the capacity and confidence of marginalised groups.
Among other changes observed, village women were represented in local resource management decision-making for the first time. Villagers (both women and men) also observed greater trust and ability to communicate and network with other communities and with representatives of logging companies and the government.

Redistribution

The ACM process drew on the Sustainable Livelihoods Framework to monitor changes in and the distribution of the capitals of the three communities



S = social capital; H = human capital; N = natural capital; F = financial capital; P = physical capital

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Notes: The process was designed to monitor changes in the social, human, natural, financial and physical capital in the three ACM intervention communities.
The most evident benefits included:

- Human and social capital (including in participants' leadership skills)
- Technical knowledge (including mapping skills and recording and analysing data)
- Communication and negotiation abilities.

Stakeholders of different social status developed the motivation and confidence to improve their relationships with each other.
ACM's bottom-up agenda-setting and shared learning approach also inspired changes in other types of capital by supporting livelihood strategies that not only improved incomes but also reduced vulnerability, increased community members' well-being, improved food security and led to more sustainable use of natural resources.
Outcomes across capitals should be assessed for different stakeholders, including those most marginalised, to support their equitable distribution.

Lessons learned

This case study shows that it is possible, over time, to build collective learning and trust in WEFE interventions by being interactive, interdisciplinary, multilevel, multistakeholder, collaborative and iterative.

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Notes: In summary:

- Marginalised groups with a stake in nexus interventions should be recognised as legitimate actors.
- These stakeholders should actively participate in decision making about processes that affect their lives.
- Specific measures will be needed to support the interactive participation of these groups.
- Defining a clear monitoring strategy, with GESI indicators, is crucial for tracking progress, commitments and agreements.
- By placing gender and inclusion at the heart of nexus interventions, it is possible to advance a more equal and sustainable management of the WEFE nexus.

Reference:

Kusumanto, T., Yuliani, E.L., Macoun, P., Indriatmoko, Y. & Adnan, H. (2005). Learning to adapt: Managing forests together in Indonesia. Bogor (Indonesia): Center for International Forestry Research (CIFOR). https://doi.org/10.17528/cifor/001780

5: Synthesis

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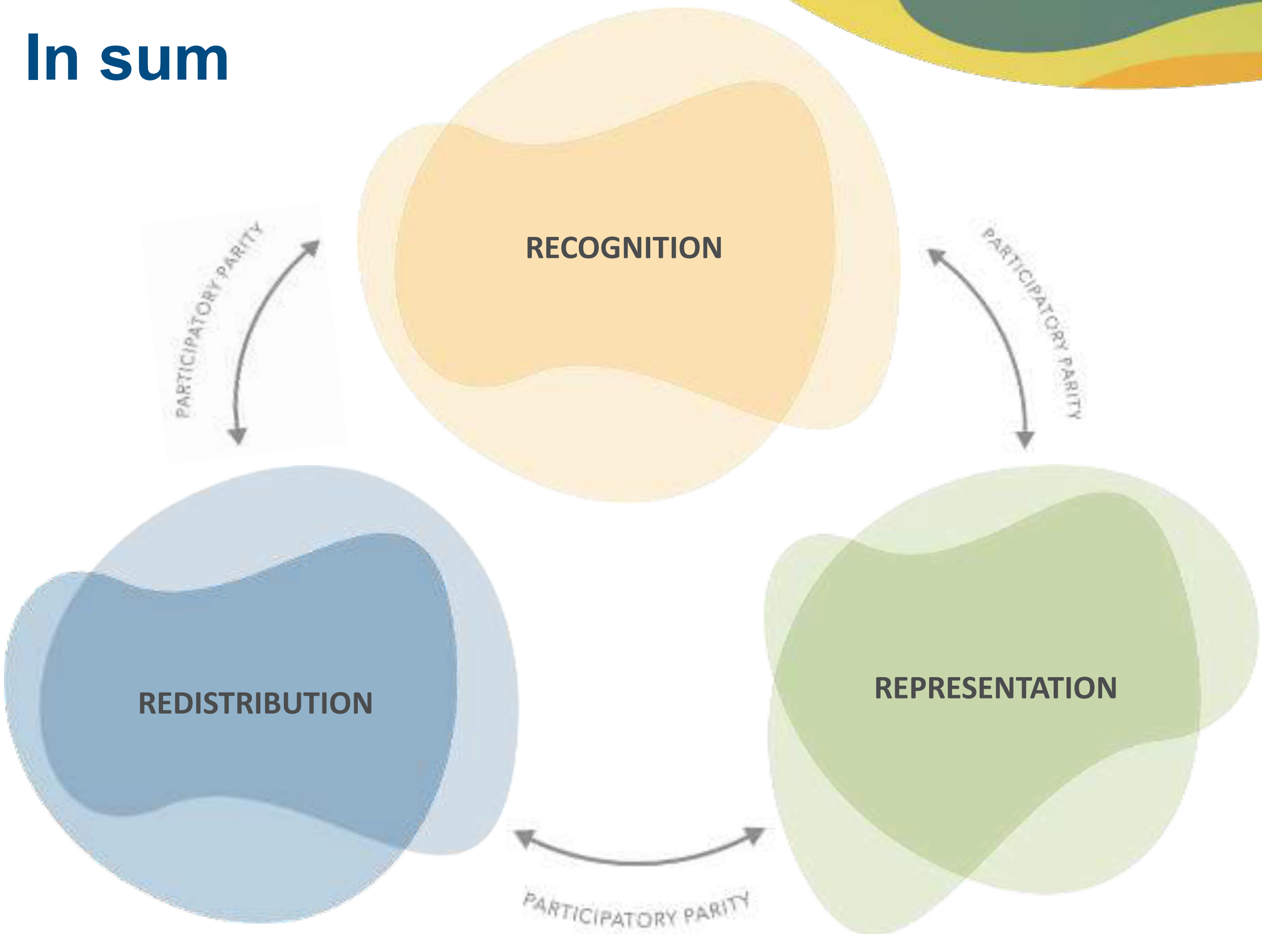
In sum



A GESI lens and the **social equity framework can help to understand how interventions can have unequal effects on the many social groups who depend on WEFE nexus resources.**

For more socially equitable and resilient nexus solutions.

Notes: The social equity framework's principles of recognition, redistribution and representation, together with its overarching concern for participatory parity, can offer entry points to identify and address these gender and inclusion considerations.
Recognition is the starting point for enabling participation, accountability and inclusion processes. Stakeholder analysis is a useful tool to identify relevant stakeholders, including those most marginalised, so that they can be engaged in the identification and implementation of solutions.
Marginalised and other actors should be represented as equals in the governance and management of WEFE resources, allowing all to express their needs and priorities for resource management. This calls for reflection throughout the implementation of interventions on whose voices shape the agenda and ensuring that there are sufficient resources to enable cycles of reflection, action and learning in favour of more marginalised groups.
Finally, the potential benefits, costs and risks of interventions for different stakeholder groups must be assessed. The Sustainable Livelihood Framework offers a multidimensional perspective on assets to illuminate these potential or actual outcomes. Outcomes will vary for different stakeholders and must be examined for each group to support their equitable distribution. Gender equality and social inclusion approaches should include systematic monitoring to reduce risks of harm to women or vulnerable social groups that may arise from an intervention.

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Thank you!

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Photo credits: Anggit Rizkianto / Unsplash; Bobby Mc Leod / Unsplash; CGIAR Research Program on Water, Land and Ecosystems; David Brazier / IWMI; J. van de Gevel / Bioversity International; Jason Cooper / Unsplash; Manon Koningstein / IWMI; Marc St / Unsplash; Nanang Sujana / CIFOR; Paolo Nicolello / Unsplash; Patrick Drown / IWMI; S Subedi / LI-BIRD; Samurdhi Ranasinghe / IWMI; Tom van Cakenberghe / IWMI; Tomáš Malík / Unsplash

Notes: This lesson is based on a guideline developed by the CGIAR Initiative on Nexus Gains:
Jalonen, R., Zaremba, H., Petesch, P., Elias, M., Estrada-Carmona, N., Tsvuura, S., Koirala, S. 2022. Gender equity and social inclusion in the water-energy-food-ecosystems (WEFE) nexus: Frameworks and tools for moving from resource-centric to people-centric WEFE nexus approaches. Alliance of Bioversity International and International Center for Tropical Agriculture (CIAT), Rome, Italy.
Available at: https://hdl.handle.net/10568/127383
Citation for this lesson: Jalonen, R., Zaremba, H., Petesch, P., Elias, M., Estrada-Carmona, N., Tsvuura, S., Koirala, S. 2023. Gender equity and social inclusion in the water-energy-food-ecosystems (WEFE) nexus: Frameworks and tools for moving from resource-centric to people-centric WEFE nexus approaches. Online learning module. Alliance of Bioversity International and International Center for Tropical Agriculture (CIAT), Rome, Italy.

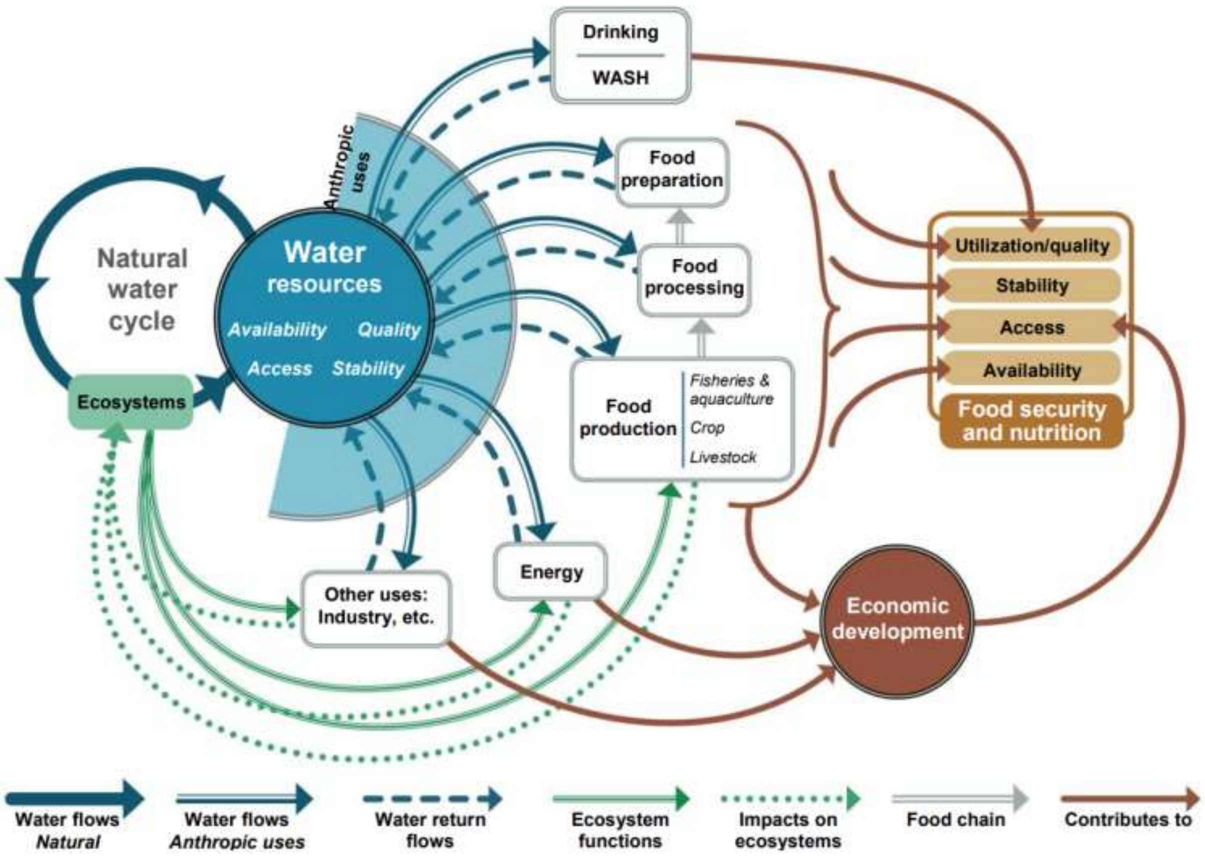
NEXUS Gains:
Realizing Multiple Benefits
Across Water, Energy, Food
and Ecosystems

Strengthening WEFE Nexus Approach for Managing Trade-offs and Synergies of Irrigation Management in Transforming Agri-Food Systems

Dr Mohsin Hafeez
Director – Water, Food and Ecosystems
Country Representative (Pakistan)
Regional Representative (Central Asia)

Multiple interfaces between water and food security and nutrition

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems



Water is essential for food and nutrition security

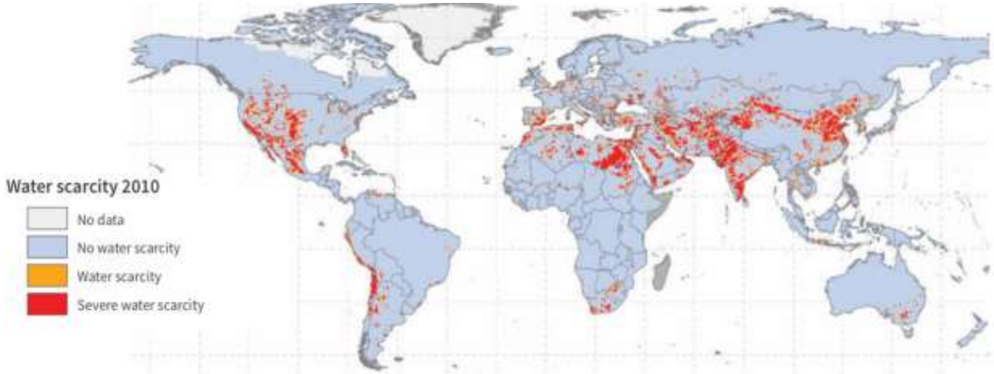
Water is a system connector for ecosystem, food, energy and economic activities

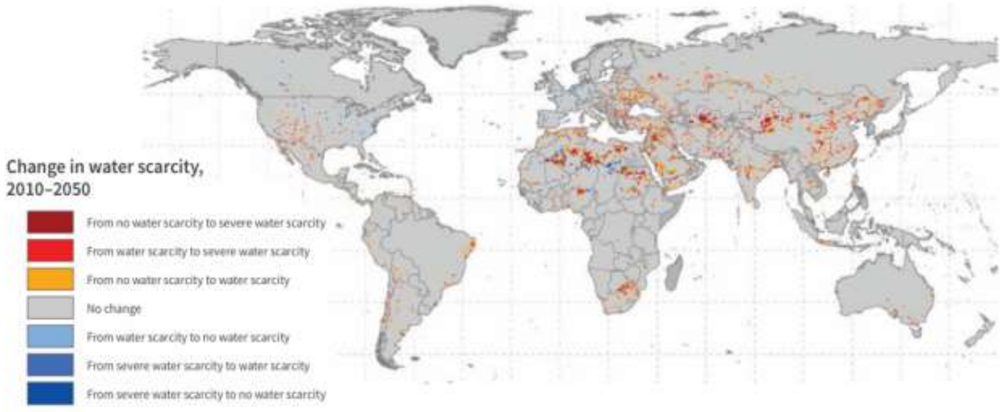
70 percent of freshwater withdrawals for agriculture

Water could be potential for conflict in transboundary river basins

Global Context

- Rising water demand
- Increasing water scarcity



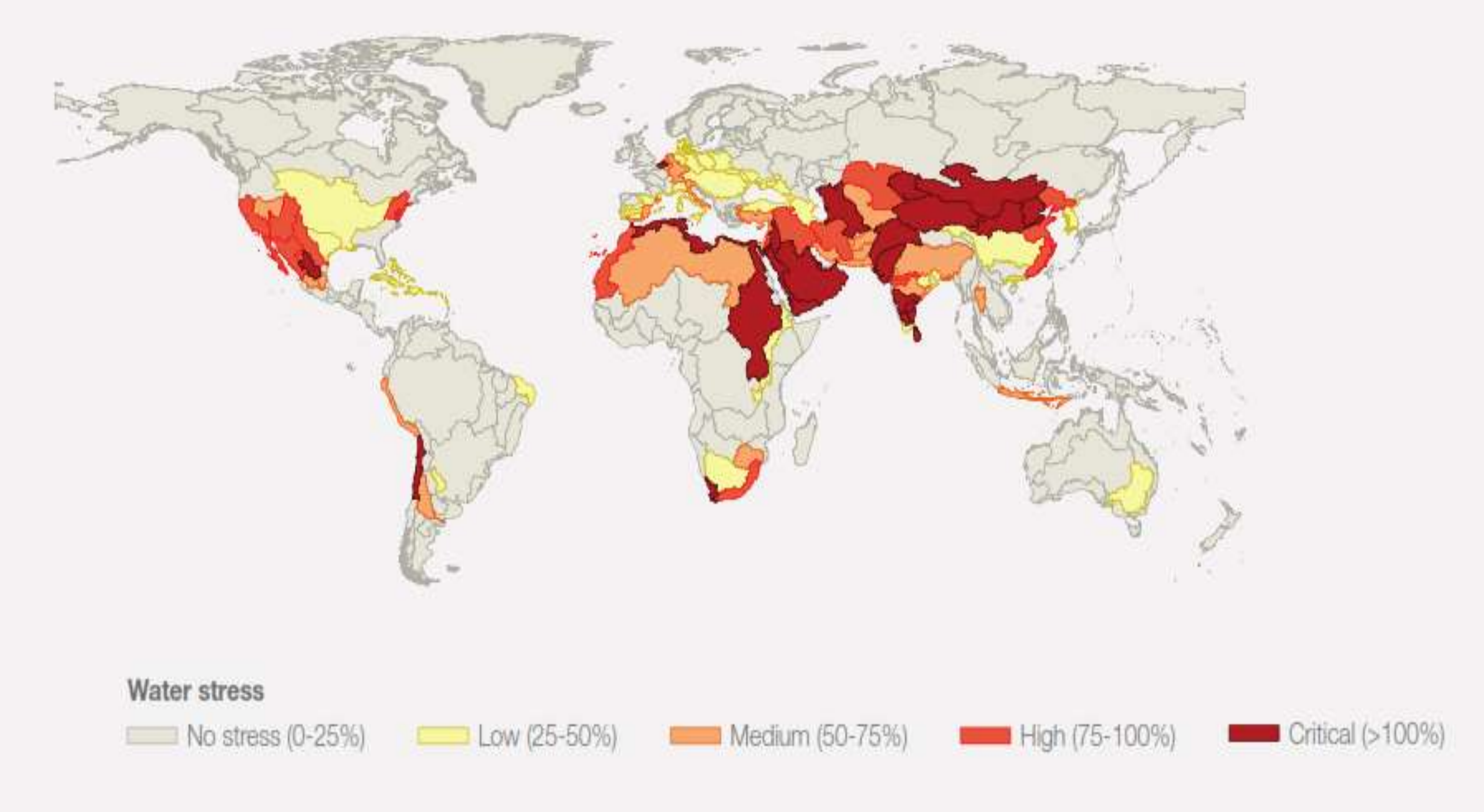


Source: Burek et al. (2016)

At present, an estimated **3.6 billion people** live in areas that are potentially **water-scarce** at least one month per year.
This population could increase to some 4.8 to 5.7 billion by 2050

Notes: The global demand for water has been increasing at a rate of about 1% per year over the past decades as a function of population growth, economic development and changing consumption patterns, among other factors, and it will continue to grow significantly over the foreseeable future. Industrial and domestic demand for water will increase much faster than agricultural demand, although agriculture will remain the largest user overall. The vast majority of the growth in demand for water will occur in countries with developing or emerging economies. Groundwater also increasingly over abstracted – often for irrigation.

Water Stress Levels - Major River Basins

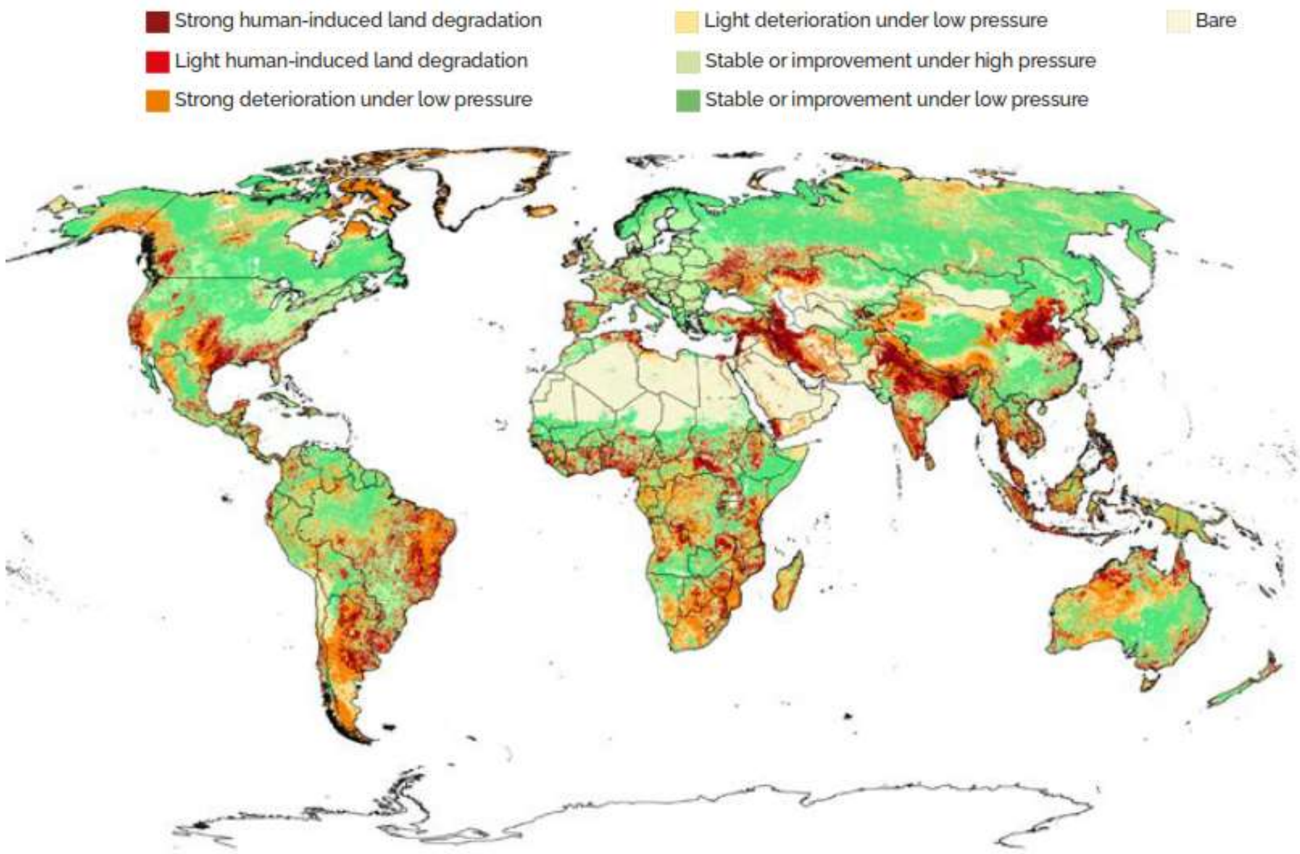


Source

FAO, Aquastat database, 2022.[13]

Notes: Lets have a quick look on water stress levels for all major river basins where the CGIAR program is working.

Land Degradation



Note: Global distribution of land degradation. Overall trend combined with cumulative pressure by direct human drivers. Human-induced land degradation refers to a negative trend, which is caused by human activity. Deterioration refers to a negative trend caused by natural phenomena, or by human action where status is low.

Source: Coppus, forthcoming, modified to comply with UN, 2021

Notes: Similarly, this pictorial maps also shows that the river basin already have land degradation issues. Therefore, the Business as usual is not possible and we need to develop new integrated water system solutions to address these complex challenges.

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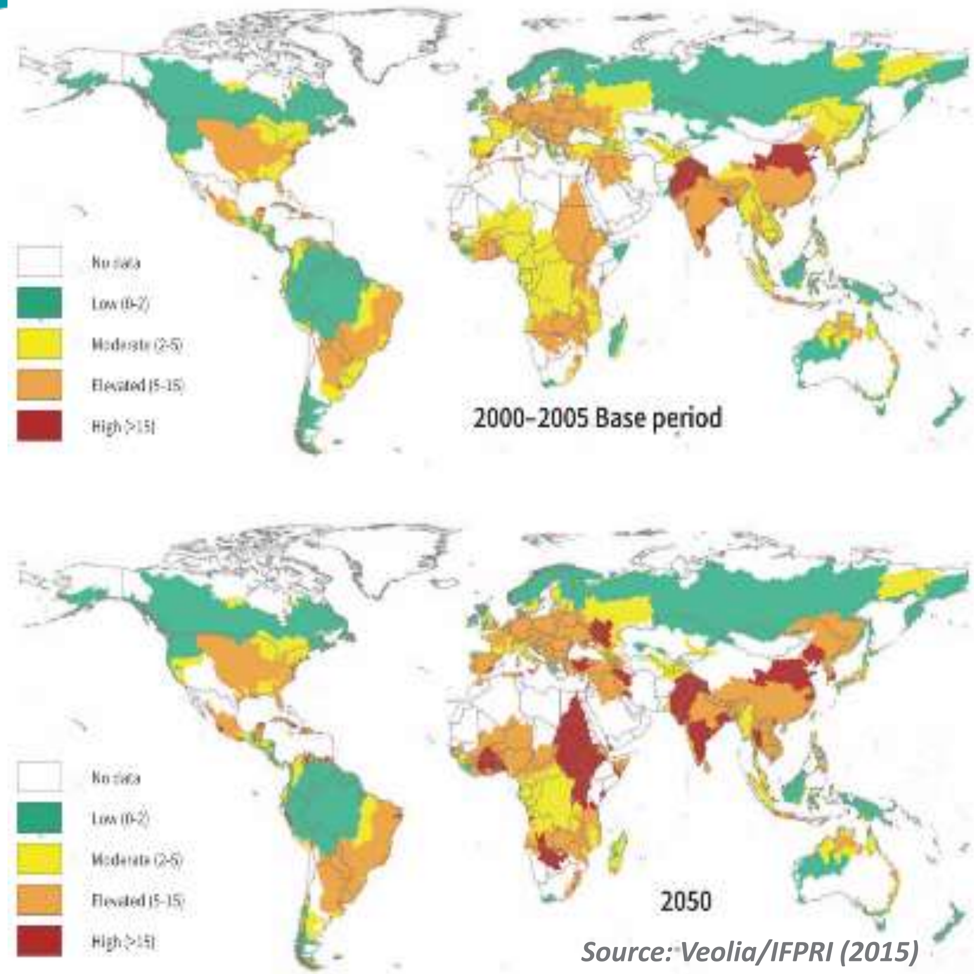
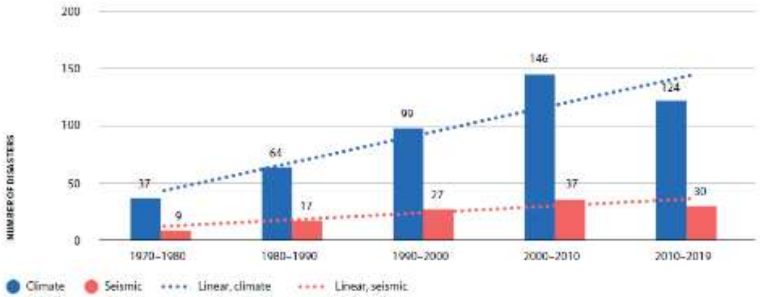
Water quality degradation



Source: Veolia/IFPRI (2015)

Notes: Water pollution has worsened worldwide since the 1990s, particularly in (the majority of) rivers in Latin America, Africa and Asia. The deterioration of water quality is expected to further escalate over the next decades.
Globally, the most prevalent sources of water quality challenges are nutrient loadings from agriculture and nutrient and pathogen loadings from untreated domestic wastewater. Hundreds of water-born chemicals, mainly from industry, are also impacting on water quality.
Extreme weather events increasing in intensity and frequency.
Intensification of disasters is the new "normal".

Climate Change – increasing frequency of extreme events (floods and drought)



Source: ESCAP, based on EM-DAT (Accessed on 30 May 2019).
Note: seismic hazards are composed of earthquake, landslide triggered by tsunami, and tsunami.

Disaster events in Asia-Pacific Region – average per decade

IPCC AR6: South Asia regional findings:

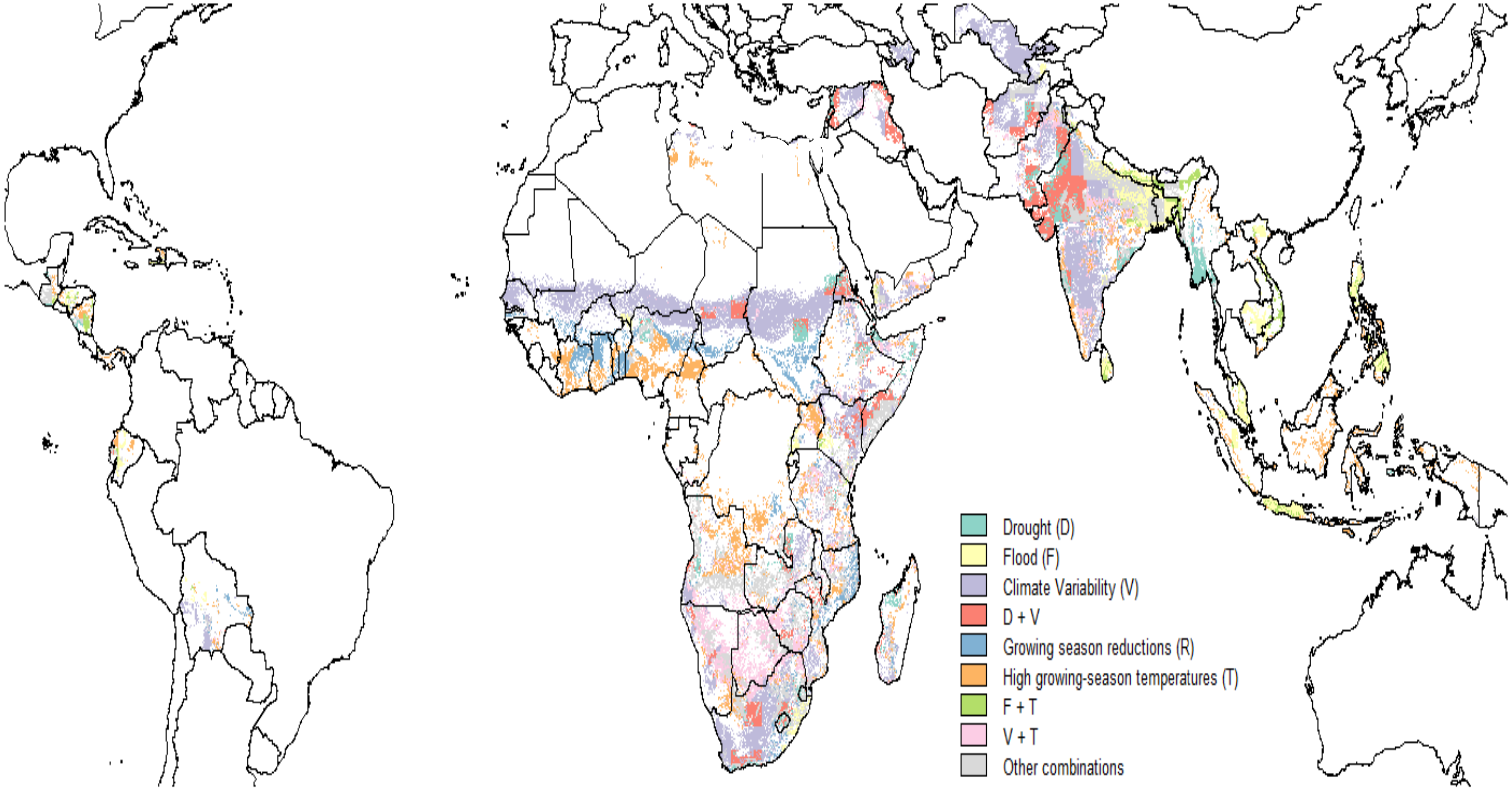
- Heatwaves and humid heat stress will be more intense and frequent during the 21st century
- Both annual and summer monsoon precipitation will increase during the 21st century, with enhanced interannual variability.

Climate change will exacerbate floods and droughts in South Asia, severely stressing an already stressed waterscape.

International Water Management Institute

Notes: Flooding in 2010 in Pakistan – 2000 people died
Flooding in 2017 affected almost 41 million people across Nepal, Bangladesh and India. Nearly 1,400 people killed
Flooding in 2020 – South Asia floods -floods due to heavy monsoon rains. The floods caused $105 billion USD of damage ($88.5 billion in India,[1] $15 billion in Sri Lanka,[2] and $1.5 billion in Pakistan[2] – over 6,000 people died
Flooding in 2022 in Pakistan - floods in Pakistan killed 1,739 people, and caused $14.9 billion of damage, $15.2 billion of economic losses. Affected 33 million people. 2.1 million left homeless
Climate change will exacerbate floods and droughts in South Asia, severely stressing an already stressed waterscape. Other consequences will cascade through the hydrological cycle: more intense rainfall events; more frequent floods, droughts, and increased humidity; depleting snow and ice systems; and greater risk of glacial lake outbursts floods.
Environmental degradation (e.g. loss of wetlands) is exacerbating the consequences and increasing the vulnerability, particularly of the poorest and women,

Areas of Current and Future Climate risk for Agriculture

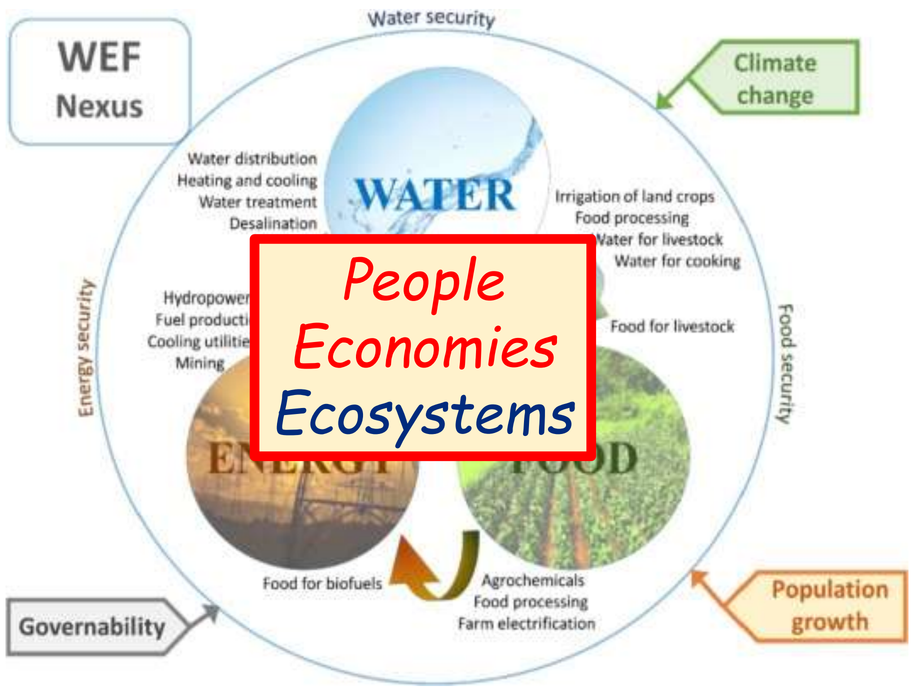


Source: GCF, 2022

Notes: Lastly, the Green Climate Fund also highlighted that the climate risk for agriculture sector is very high in the CGIAR focused regions. Therefore, it is important to develop integrated and climate resilient solutions for these regions.

Water/Energy/Food/Ecosystems (WEFE) Nexus Challenges

NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

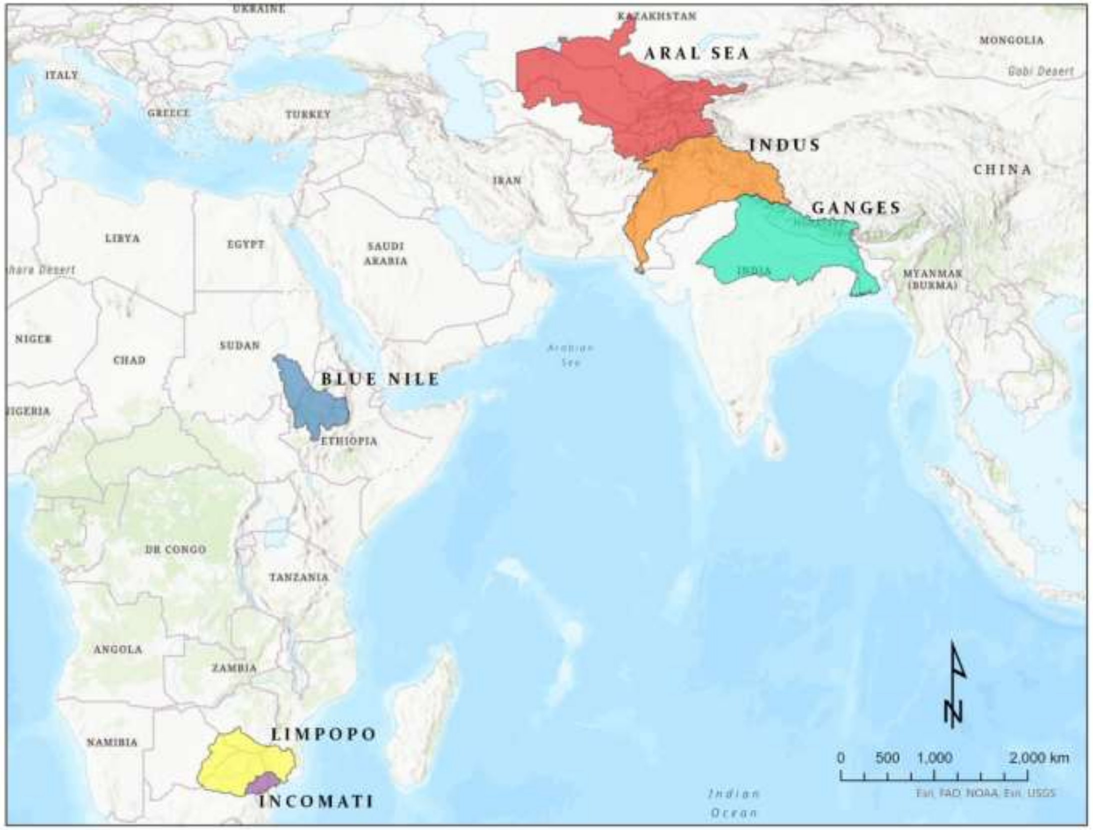


- WEFE nexus is critical to rural livelihoods, food and nutrition security & economies, and systems are **strongly interconnected**
- **National & regional institutions struggle**, particularly in transboundary basins
- Nexus goes beyond IWRM approach
- Scale dependencies of processes: Farm to landscape/watershed to basin scale
- **Women, girls, and vulnerable groups** face the greatest adverse consequences

www.cgiar.org

Source: Mahlknecht et al., 2020; adapted

NEXUS Gains Geographies: Taking a basin approach



Basin approach:

- **Quantification and accounting of WEFE resources**
- **Upstream-downstream inter-dependencies**
- **Synergies, trade-offs and shared benefits across countries**

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NEXUS Gains - End-of-Initiative outcomes (2022-2024) and Examples of INNOVATIONS

CGIAR | NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

1. **Stakeholders use integrated modeling tools to assess tradeoffs and synergies** and develop prioritized nexus innovations in at least 2 focal regions
   - Tool for **comprehensive large-scale WEFE assessment** (indicators dashboard, maps, time series etc.)
   - **E-flow analysis tool** coupled with basin models
   - Scale **Agro-biodiversity Index** to national/ basin levels
2. **Water productivity across scales** and **storage diagnostic tools are used** to significantly improve water security in at least 2 focal regions
   - **Decision support system** for (bundled) interventions to boost water productivity at basin scale
   - **Strategic diagnostic** to design, evaluate and implement **integrated water storage** solutions

www.cgiar.org

NEXUS Gains - End-of-Initiative outcomes (2022-2024) and Examples of INNOVATIONS

3. Private investors and policymakers **use scalable gender-sensitive clean energy business and finance models** to accelerate sustainable rural clean energy access in at least 3 focal regions
   - **Inclusive business models** for sustainable **clean energy access** in agri-food systems

4. Policymakers and other stakeholders are using science-policy dialogues, multi-stakeholder forums, co-developed groundwater governance toolbox and guidelines to **strengthen nexus governance** across systems, sectors and boundaries in all basins
   - **Groundwater governance toolbox** to address growing competition, degradation and depletion of resources in hotspots
   - Establish and facilitate cross-sectoral, inclusive **multi-stakeholder platforms** to leverage integrated approaches

5. At least **40 emerging women leaders** in government, private sector, investors, research and NGOs have increased capacity **to identify, assess and implement one or more nexus innovations**

Future of Water in South Asia

South Asia among **fastest growing** economies

Among the **fastest urbanizing**

Shifting **sectoral & spatial water** demands coupled with climate change call for efficient water use for sustainable agriculture

About 23% more people by 2050 in South Asia

Domestic **water demand** to **almost four times (3.7)**

Industrial **water demand** to almost **triple** by 2050

Irrigation water demand to increase while water diversion to agriculture will reduce

By 2050, almost 1 billion population exposed to severe water stress in South Asia

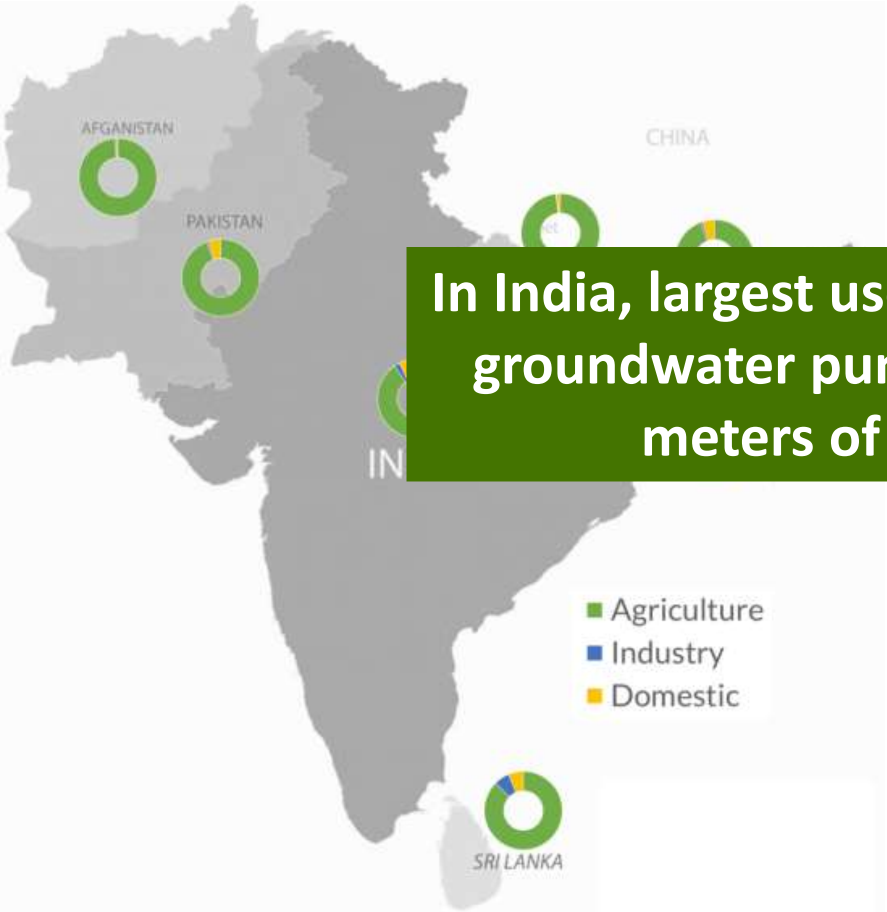
Two-thirds of which will be living in India, Pakistan, and Bangladesh

https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016EF000503

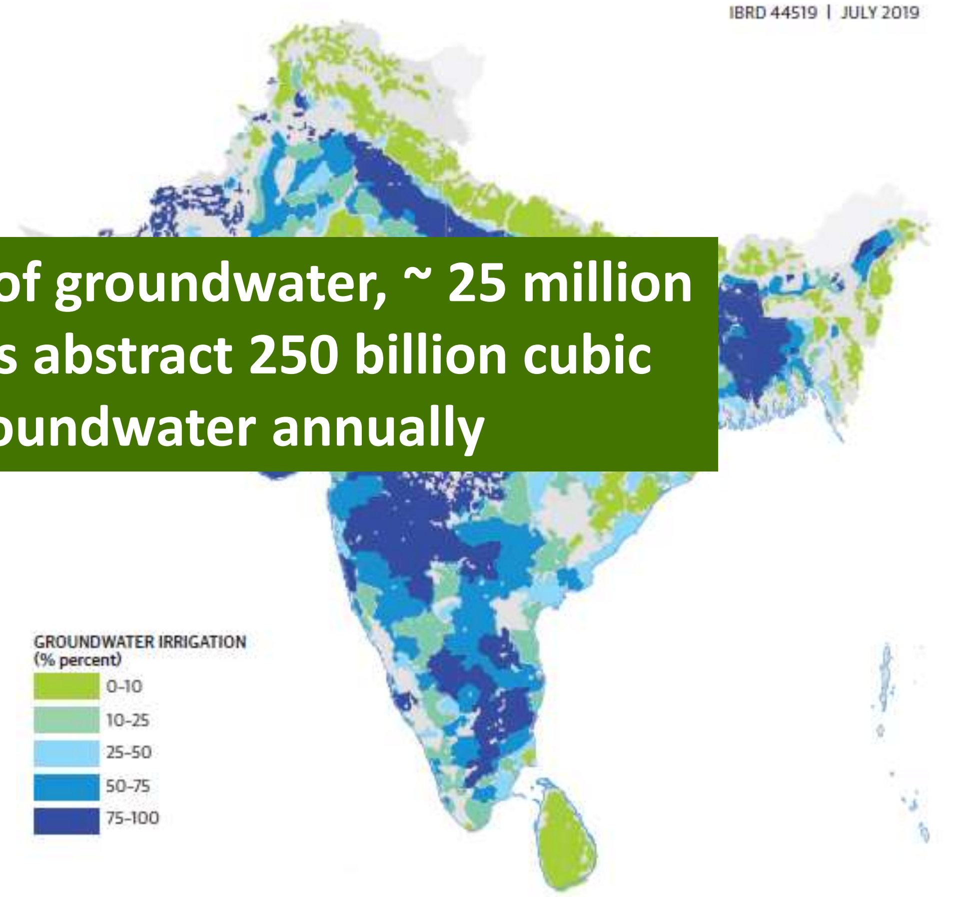
IWMI International Water Management Institute

South Asia: Water Use by Sector and Share of GW Irrigation

In India, largest user of groundwater, ~ 25 million groundwater pumps abstract 250 billion cubic meters of groundwater annually



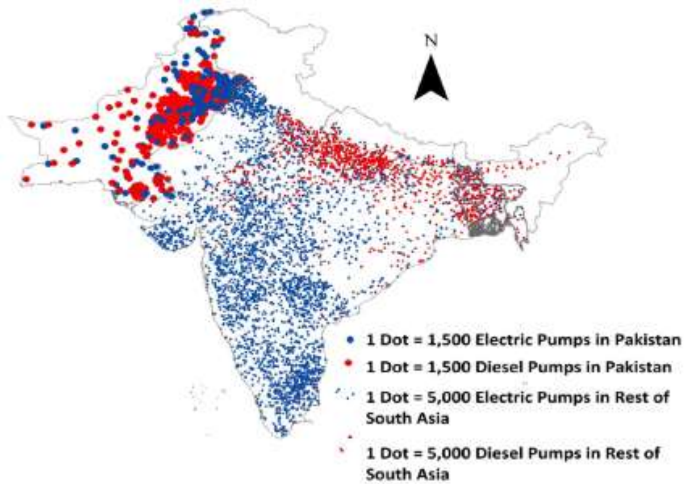
Shah and Verma (2017)

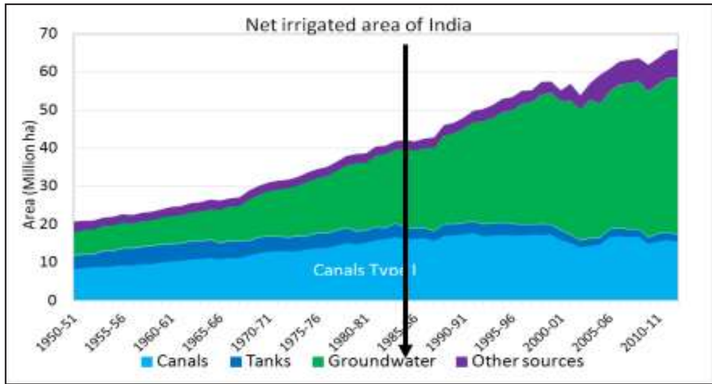


World Bank (2020)

Water and Energy Intensive Food Production

- South Asia- is challenged to support **25% world population** with just **4.6% of world's water resources**
- Expanded **groundwater boom,** leading to GW depletion, increased energy demand
- Number of wells and tube wells has increased from 11.4 million in 1986-87 to about **30 million**
- Contributing over 60% to irrigation, withdrawing 300 BCM of GW annually
- About **20% of the energy** is used in agriculture (majorly in pumping water) with **5-6% of the region's** total GHG emissions
- Smart water management within the framework of **water-energy-food nexus-** entry point for sustainable agriculture intensification





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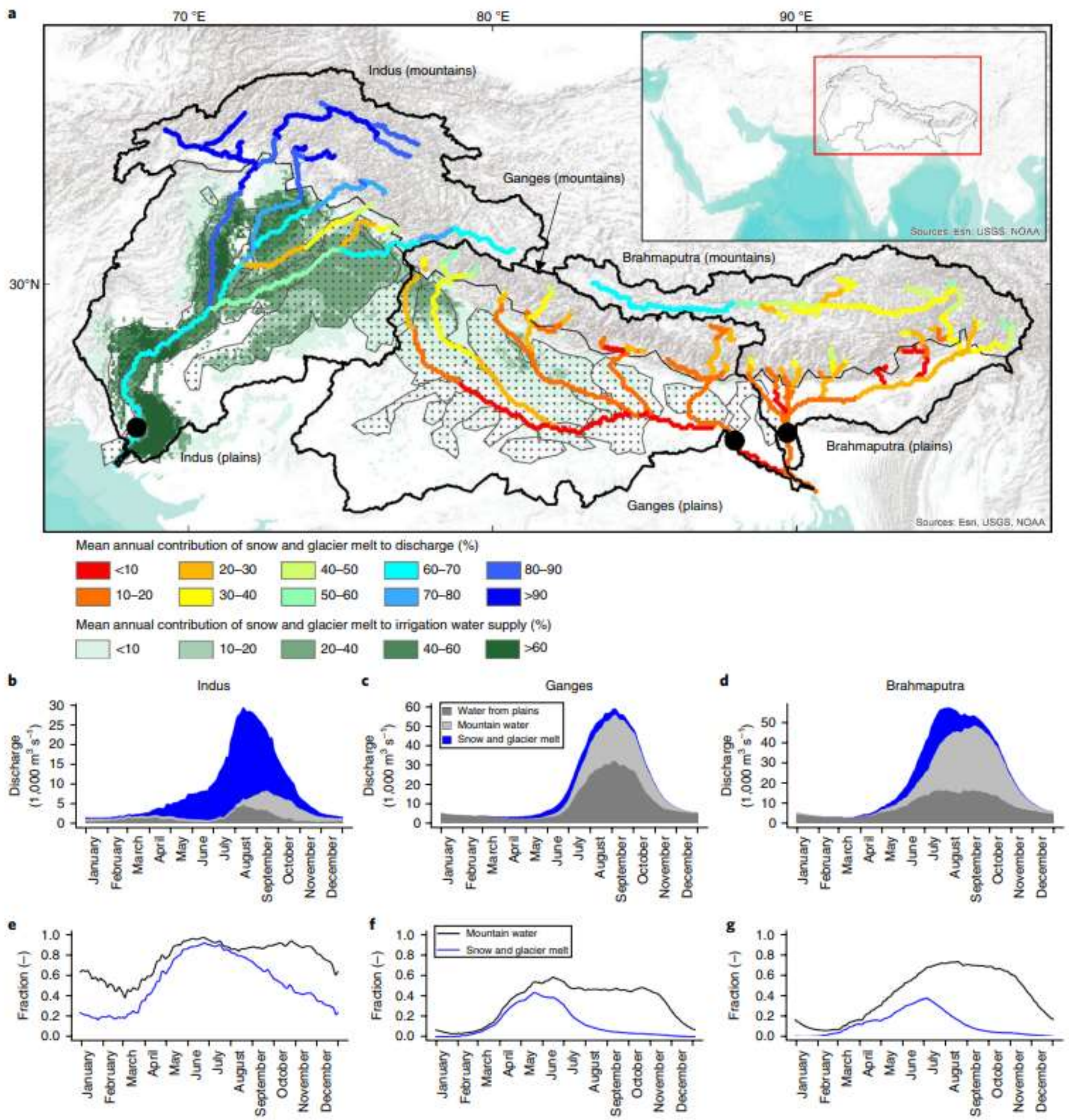
Climate crisis .....
causes cross-sectoral impacts
www.shutterstock.com

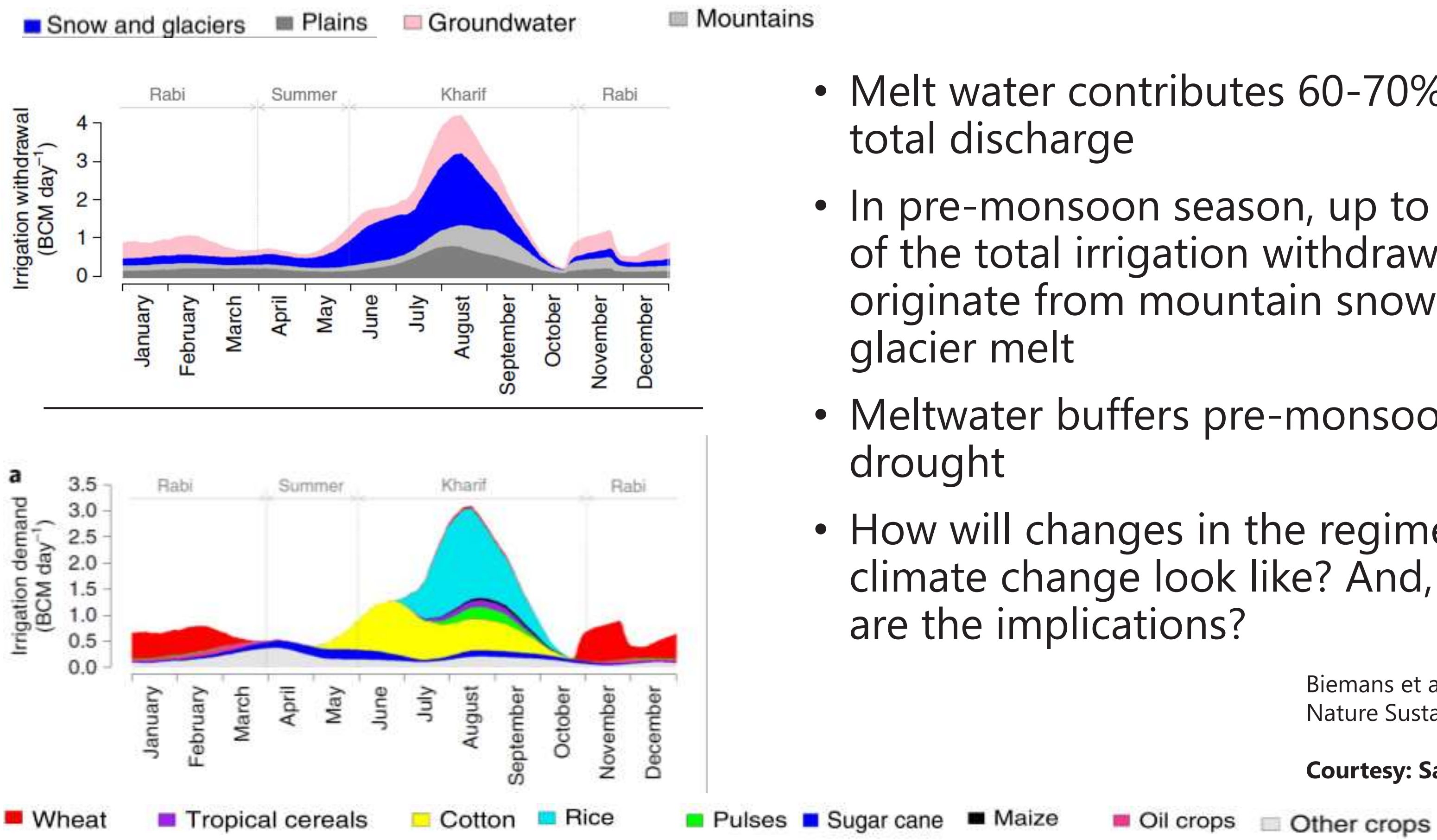
Challenges in the Indus Basin *vs.* Ganges *vs.* Brahmaputra



Biemans et al., 2019;
Nature Sustainability

Notes: Indus – most vulnerable and critical water tower units globally (Immerzeel, 2020)
Almost 1 Billion people

Importance of meltwater for crop production in the Indus Basin



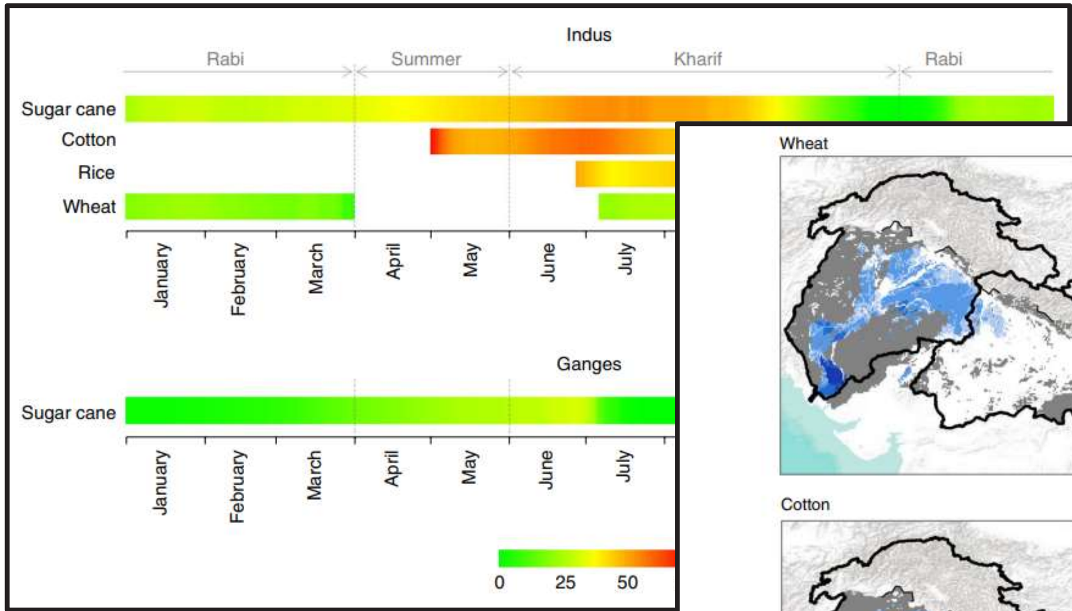
- Melt water contributes 60-70% of total discharge
- In pre-monsoon season, up to >60% of the total irrigation withdrawal originate from mountain snow and glacier melt
- Meltwater buffers pre-monsoon drought
- How will changes in the regime under climate change look like? And, what are the implications?

Biemans et al., 2019;
Nature Sustainability

Courtesy: Santosh Nepal, 2021

Notes: In pre monsoon season, up to 60% of the total irrigation withdrawal originate from mountain snow and glacier melt and that it contributes ad additional 11% to total crop production.
Sugarcane: 17% of total 53 million tons is attributed to meltwater in INdus
Cotton: 28% of 4 million tons cotton is attributable to meltwater in INdus

Meltwater use for irrigation in the Indus – TODAY



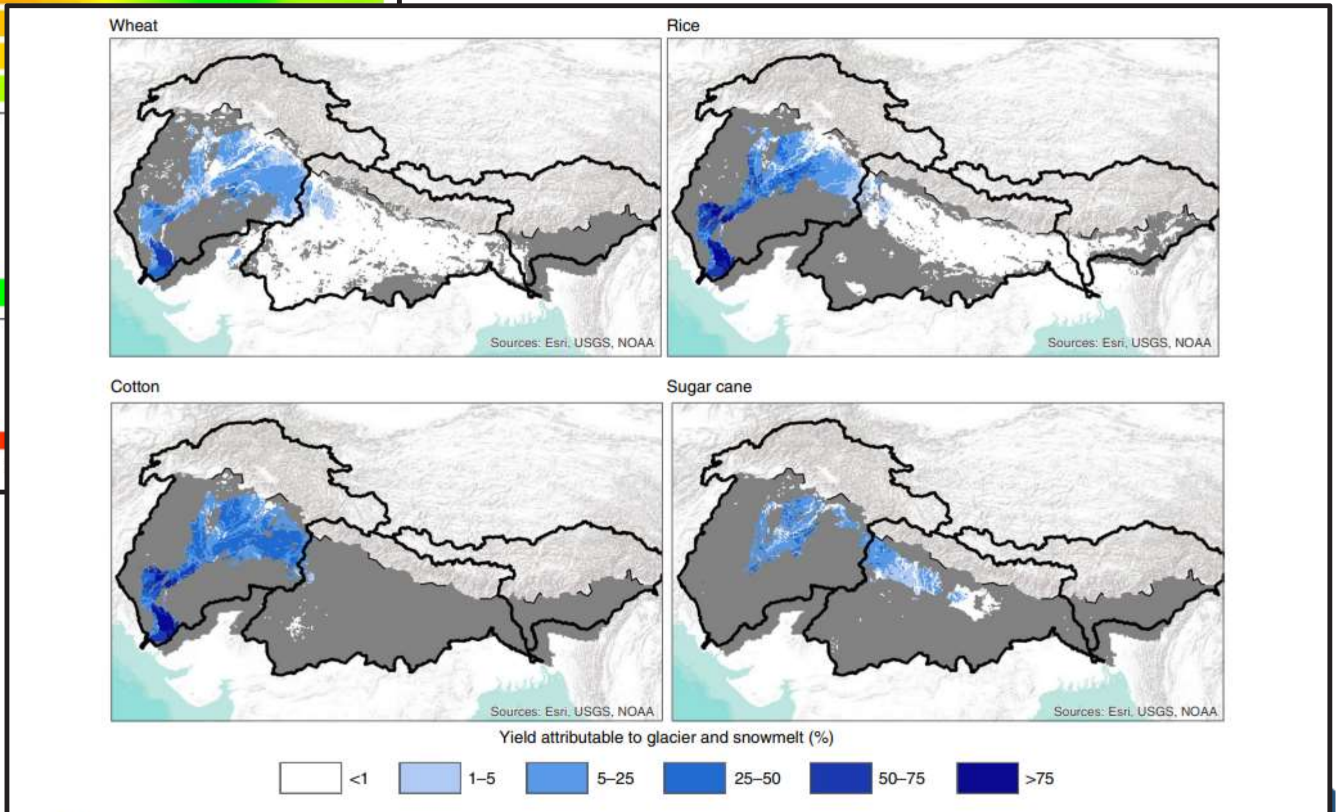
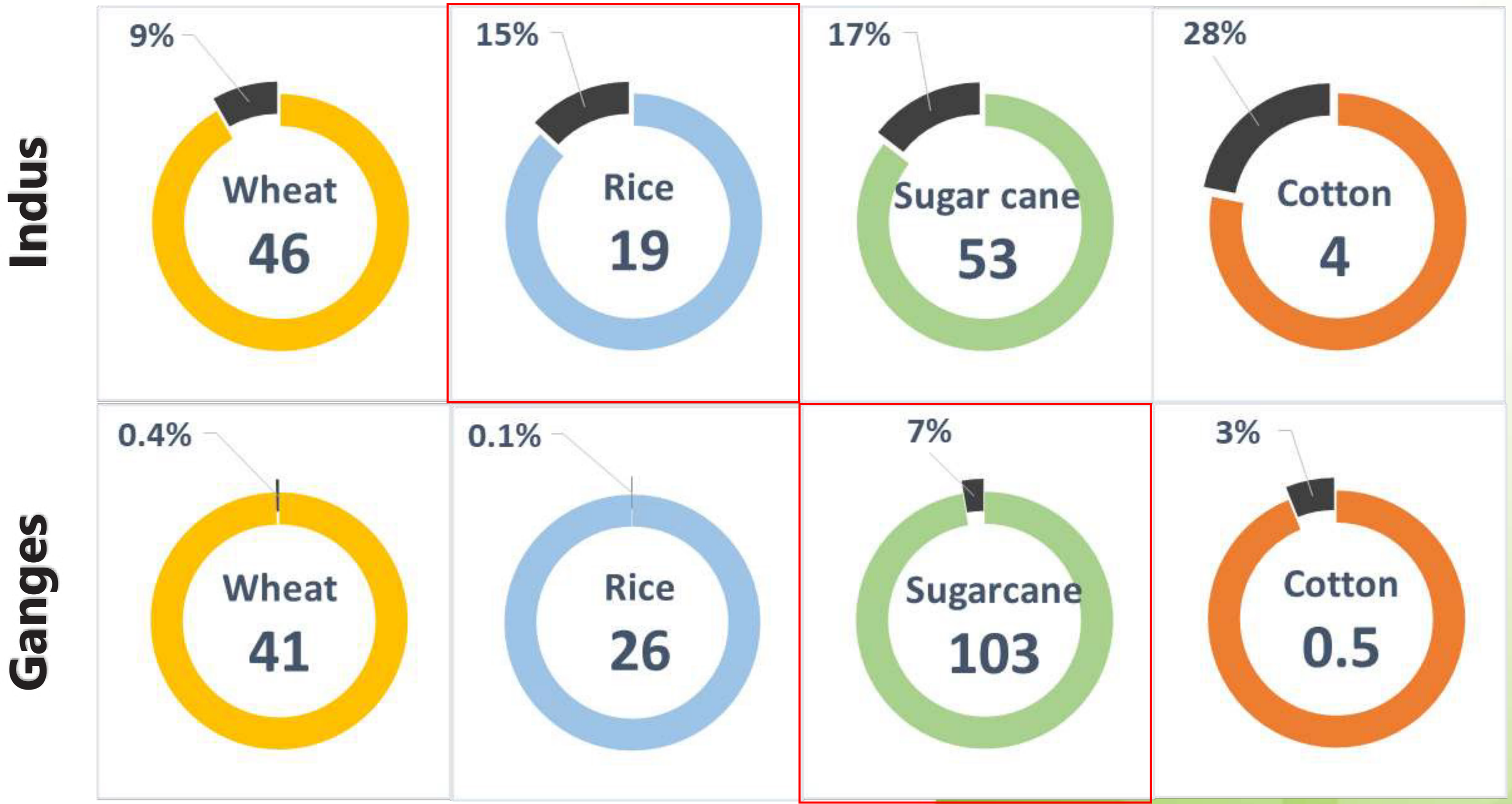


Fig. 4 | The percentage of production attributable to upstream glacier and snowmelt for major crops. Regions with no or very small areas cultivated with respective crops are shaded grey (the source of the map refers to the background only).

Biemans et al., 2019;
Nature Sustainability

Meltwater contribution (%) in agriculture production (million tons per year)



Biemans et al., 2019;
Nature Sustainability

Indus Basin: 15% of annual 19 million tons of rice production can be attributed to glacier and snowmelt

Ganges Basin: 7% of annual 103 million tons of sugarcane production can be attributed to glacier and snowmelt

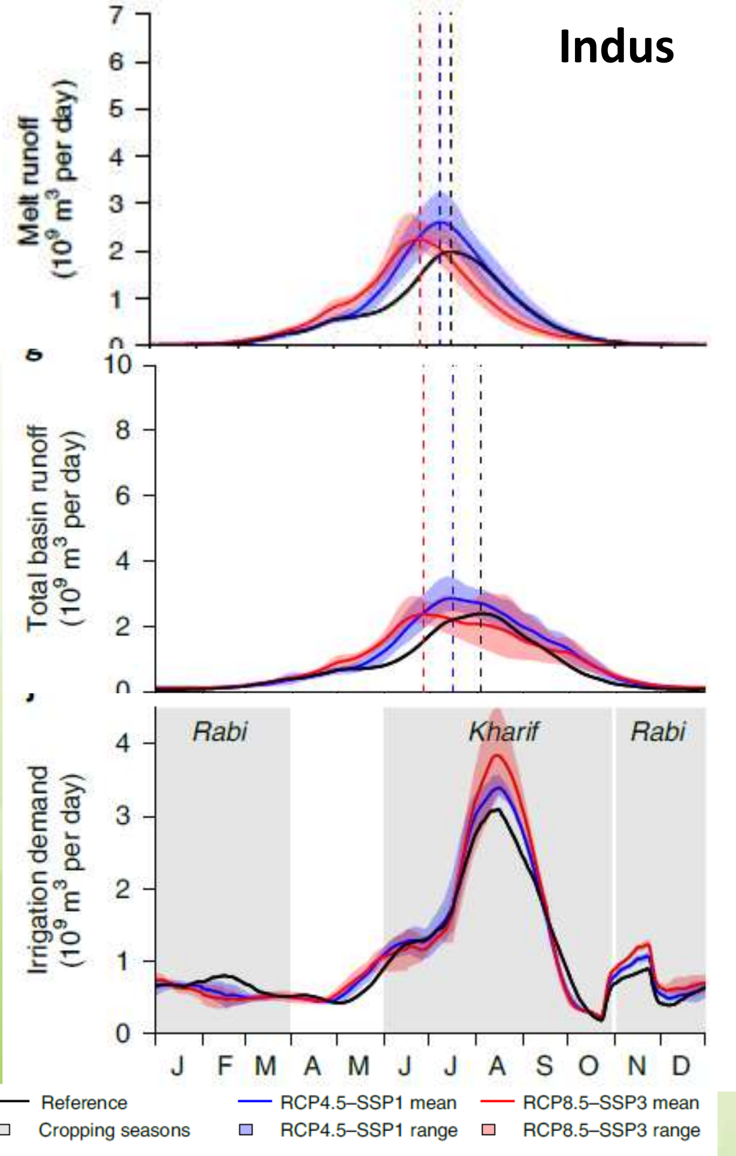
Future irrigation water demand

Overall increase in irrigation water demand due to expansion of irrigated areas and higher crop water demand in a warmer climate

A projected increase in runoff during high flow season as a result of enhanced melt in Indus coincides with an increase in water demand during the onset and middle of the kharif season

Irrigated agriculture in South Asia will get more dependent on both meltwater and groundwater in the future

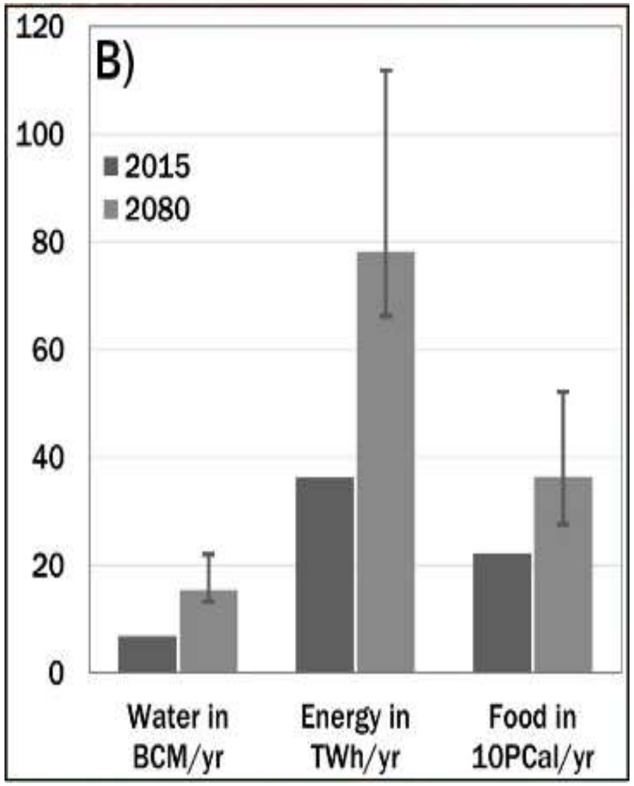
Increase in groundwater withdrawal, particularly in warm scenarios



Lutz et al. 2022, Nature Climate Change

Future Indus: More people, more resources

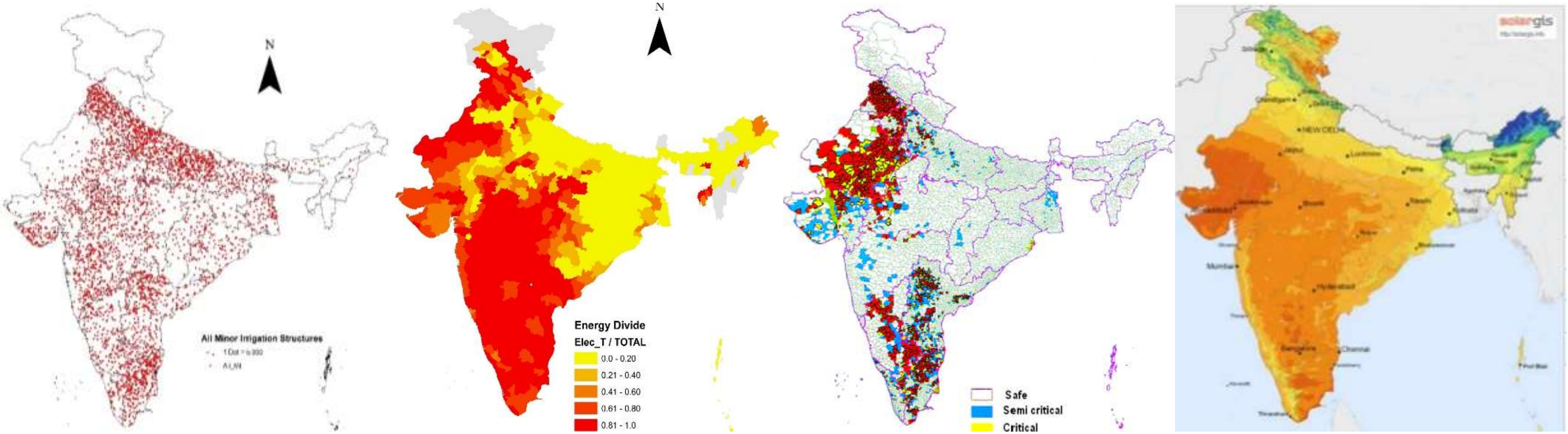
- **Population** of 206 million (2016) will increase by 50% by the 2050s
- **Basin's GPD** is projected to increase by eight-fold by mid-century & temp increase by 1.9 °C
- Strong growth in population and economic development and **demand for fresh water** and other WEFE resources
- **Hydro political tension** considering upstream-downstream water uses
- Most vulnerable and **critical water towers** on the global scale



Considerable increase in domestic water uses, energy and food requirements to sustain the increased population and economic growth in the future

Smolenaars et al., 2020.

WEF Nexus in Action: Solar Irrigation Expansion in India



India is the world's largest user of groundwater

Free / subsidized farm power → GW depletion in western India

Lack of farm power → Under-irrigation and low productivity in Eastern India

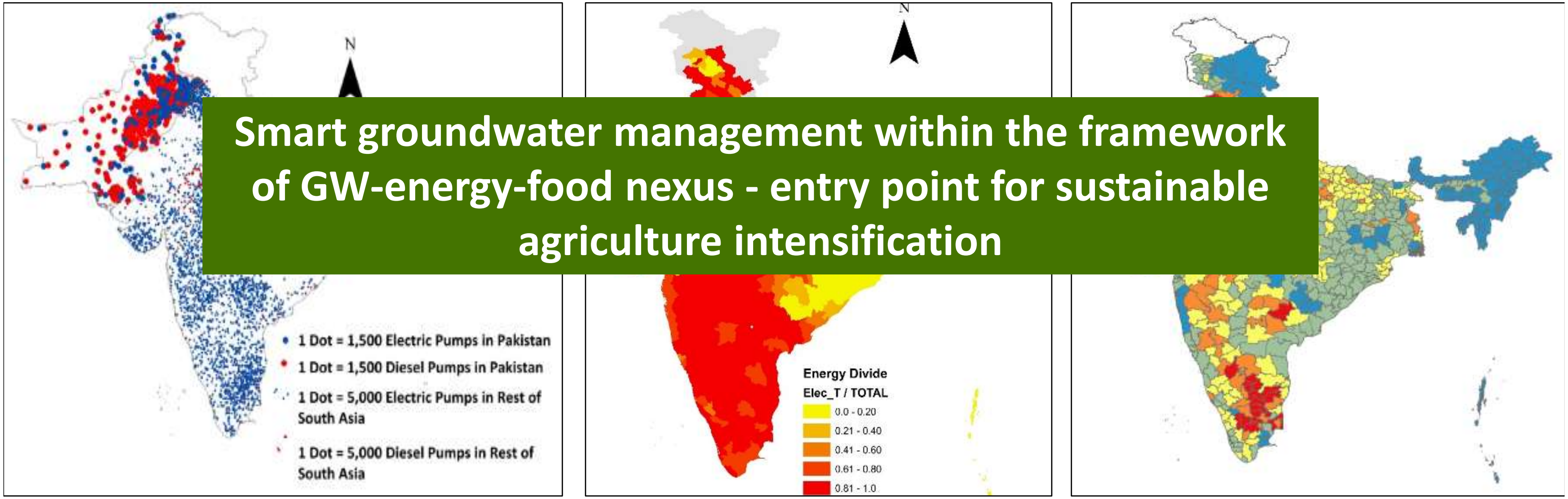
IWMI International Water Management Institute | IWMI-TATA Water Policy Program | ICAR | CGIAR | Research Program on Climate Change, Agriculture and Food Security | CCAFS | CGIAR | Research Program on Water, Land and Ecosystems

Managing the GW-Energy: Nexus

- About **20% of the energy** is used in agriculture (majorly in pumping water)
  - **5-6% of the** total GHG emissions

Free / subsidized farm power → GW depletion in western and Southern India

Lack of farm power → Under-irrigation and low productivity in Eastern India



Smart groundwater management within the framework of GW-energy-food nexus - entry point for sustainable agriculture intensification

Salient Features of Pumping Practices in Punjab

- Irrigated area in Punjab – 7.4 Mha
- Allocation of surface water to Punjab as per 1991 Water Accord = 55.94 MAF per annum
- Low canal water allowance compared to other provinces ~ 3 cfs/1000 acres
- Canal water supplies in Punjab can only meet 40 % of the crop water requirements.
- Groundwater use in Punjab is around 85% of the total groundwater use in Pakistan.
- Conjunctive use of surface and GW in more than 50% of irrigated land in Punjab
- More than 1.1 Million private tube wells in Punjab – severe groundwater depletion
- In Punjab, 23% of the area has poor groundwater quality
- Around 2.5 Million farmers depend on tube wells water for irrigated agriculture.
- Diesel powered tube wells contribute 5.025 million metric tons of CO_2 emissions annually

IWMI International Water Management Institute

Groundwater – Looming Situation

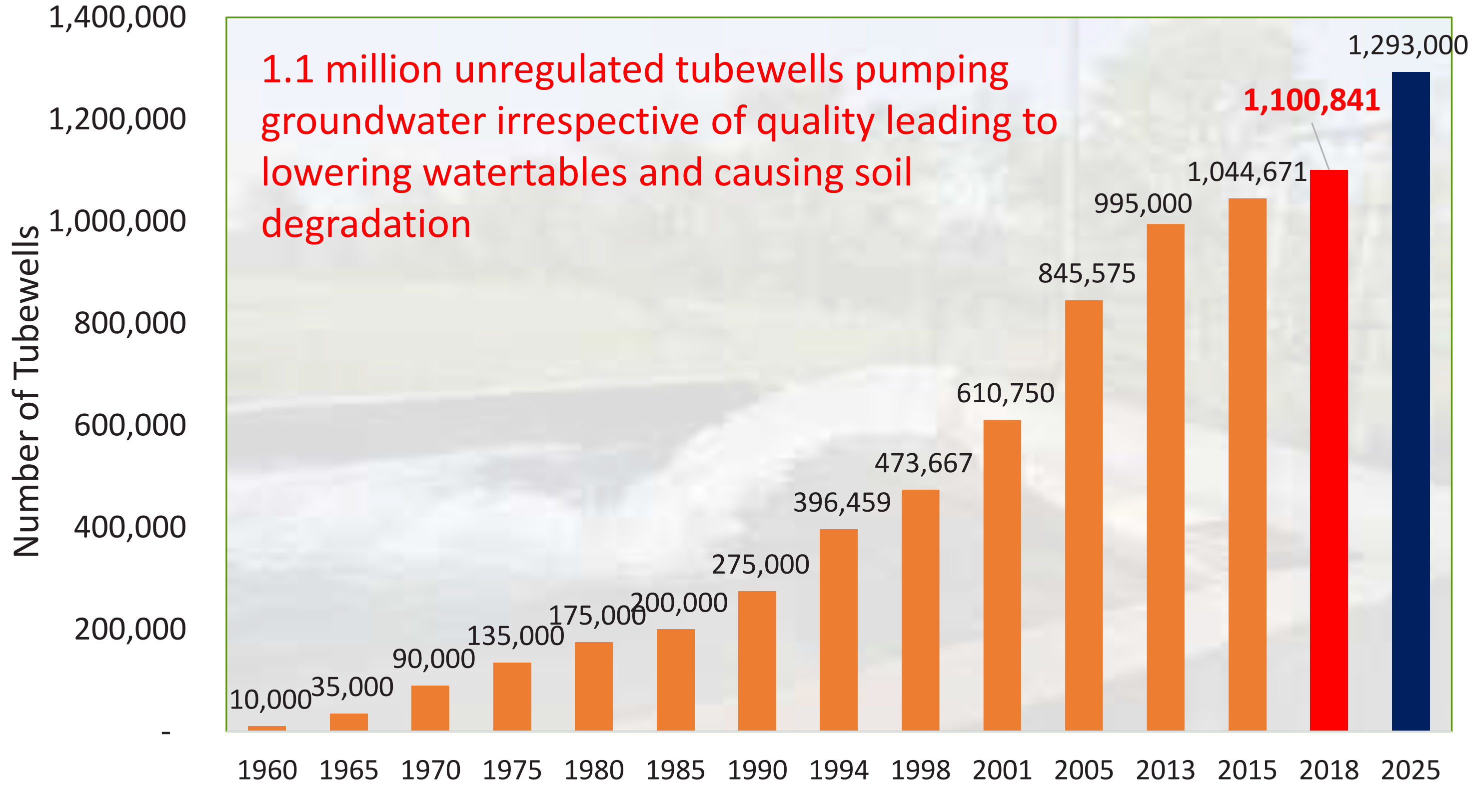
Persian wells/water wheals – Around 3-12 m groundwater depth

Around 30 m groundwater depth

Around 100 - 300 m depth

Sustainable GW Management = Balance between GW abstraction - Recharge

Tube Wells Population in Punjab



Source: Punjab Development Statistics and OFWM (2021)

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Impact on Environment

Total GHG Emissions from Ground Water Pumping using Electrical Pump for Irrigation at the Survey Points

Districts	No. of Tubewells	Total Energy Use Rate (MWh/m^2)	GHG Emission rate (Rabi Season) tons	GHG Emission rate (Kharif Season) tons	Total GHG Emissions (tons)
Chakwal	80	5.42	2.12	3.01	5.14
Jhang	50	3.37	0.92	2.27	3.19
Rahim Yar Khan	14	0.76	0.21	0.51	0.72
Total	144	10.96	3.62	6.77	10.39

Total GHG Emissions from Ground Water Pumping Using Diesel Pump For Irrigation at the Survey Points

Districts	No. of Tubewells	Total Energy Use Rate (MWh/m^2)	GHG Emission rate (Rabi Season) tons	GHG Emission rate (Kharif Season) tons	Total GHG Emissions (tons)
Chakwal	20	3.51	1.46	1.87	3.33
Jhang	47	4.33	0.97	3.13	4.10
Rahim Yar Khan	88	10.55	3.13	6.87	10.00
Total	155	32.56	11.02	19.84	30.86

IWMI International Water Management Institute

Impact on Environment

Based on the primary data collected by IWMI in three districts of Punjab in 2021 - 22, the following calculations are presented below for GHG emissions and carbon credits

Total GHG emissions of all electrical pumps used from ground water pumping in the selected districts and Punjab

Districts	No. of Tube wells	Rabi Season (hr/month)	Kharif Season (hr/month)	Total Energy Use Rate (MWh/m²)	GHG Emission rate (Rabi Season) tons	GHG Emission rate (Kharif Season) tons	Total GHG Emissions (tons)
Chakwal	4667	211	299	316.15	123.96	175.66	299.62
Jhang	7897	76	188	531.58	145.03	358.77	503.80
Rahim Yar Khan	5064	79	196	275.73	75.07	186.25	261.32
Punjab	162723	122	228	18434.47	6089.86	11381.05	17470.90

Total GHG emissions of all diesel pumps used from ground water pumping in the selected districts and Punjab

Districts	No. of Tube wells	Rabi Season (hr/month)	Kharif Season (hr/month)	Total Energy Use Rate (MWh/m²)	GHG Emission rate (Rabi Season) tons	GHG Emission rate (Kharif Season) tons	Total GHG Emissions (tons)
Chakwal	3470	148	190	609.59	252.97	324.76	577.73
Jhang	42947	35	113	3952.40	885.83	2859.98	3745.81
Rahim Yar Khan	47805	71	156	5729.72	1698.44	3731.78	5430.22
Punjab	962502	85	153	202218.51	68445.91	123202.64	191648.55

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Impact on Environment

carbon credit while replacing 5, 10 and 15% of the non-solar electric and diesel tube wells with solar tube wells

Carbon credit by replacing 5, 10 and 15% of electric pumps with solar pumps

District	GHG Emission Rate (tons)				Carbon Credit (tons)		
	Total	5% scenario	10% scenario	15% scenario	5% scenario	10% scenario	15% scenario
Chakwal	299.62	284.60	269.64	254.68	-15.02	-29.98	-44.94
Jhang	503.80	478.60	453.40	428.20	-25.20	-50.40	-75.60
Rahim Yar Khan	261.32	248.27	235.21	222.10	-13.06	-26.11	-39.22
Punjab	17470.90	16597.37	15723.84	14850.32	-873.53	-1747.06	-2620.59

Carbon credit by replacing 5, 10 and 15% of diesel pumps with solar pumps

District	GHG Emission Rate (tons)				Carbon Credit (tons)		
	Total	5% scenario	10% scenario	15% scenario	5% scenario	10% scenario	15% scenario
Chakwal	577.73	548.76	519.96	490.99	-28.97	-57.77	-86.74
Jhang	3745.81	3558.55	3371.20	3183.94	-187.26	-374.61	-561.87
Rahim Yar Khan	5430.22	5158.74	4887.14	4615.66	-271.48	-543.08	-814.56
Punjab	191648.55	182066.14	172483.73	162901.32	-9582.41	-19164.81	-28747.22

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Impact on Environment

- The overall results show that the emissions of diesel pumps are higher than the electric pump, hence replacing more diesel pumps with solar will reduce more carbon emissions.
- GHG emissions from agriculture and livestock sectors accounted for about 38.2% of Pakistan's total GHG emissions in 2015
- These emissions are essentially all Methane (CH4) and Nitrous Oxide (N_2O) , i.e. 79%, and 21% respectively (MoCC,2018).
- Diesel powered tube wells contribute 5.025 million metric tons of CO_2 emissions annually

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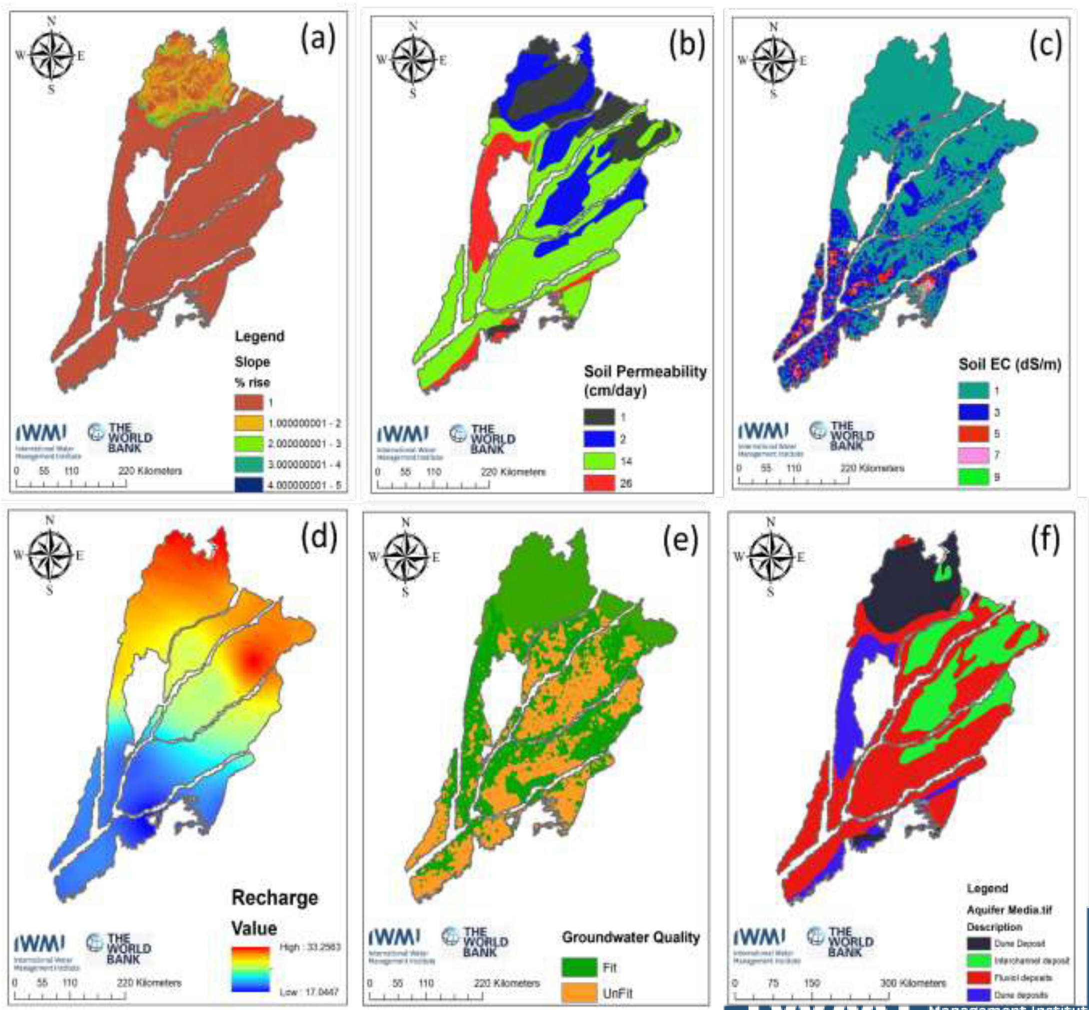
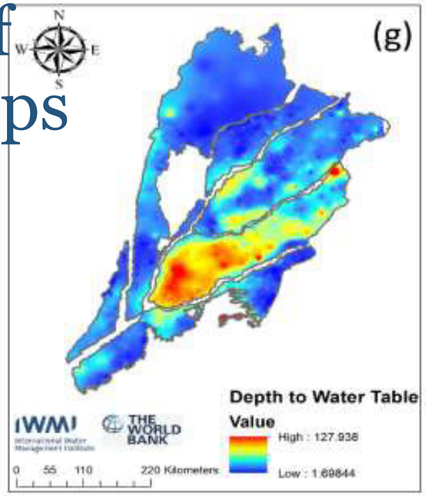
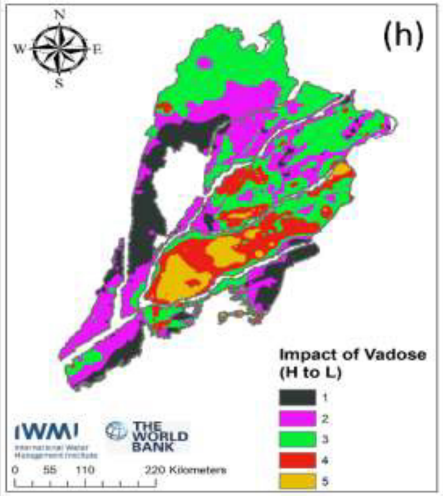
Vulnerability of Groundwater Maps

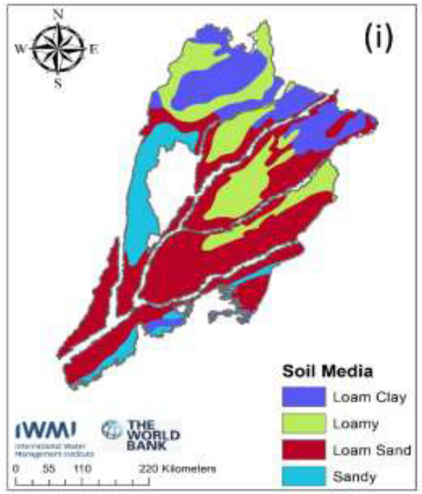
- Depth to water table
- Groundwater Recharge
- Aquifer Media
- Soil Media
- Topography
- Impact of vadose zone
- Drainage Density
- Land use and Land cover
- Soil Permeability
- Soil Salinity
- GW quality

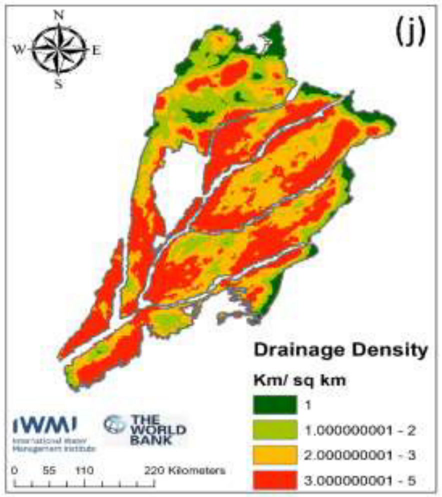


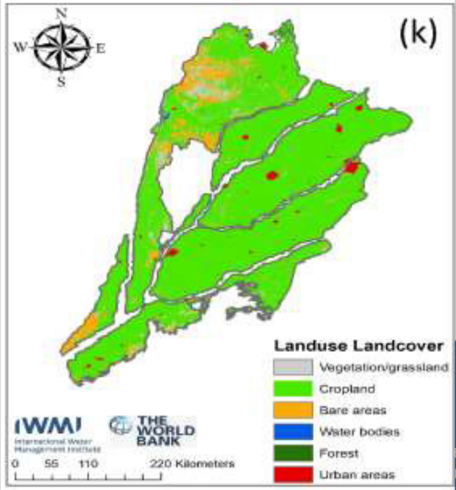
Vulnerability of Groundwater Maps











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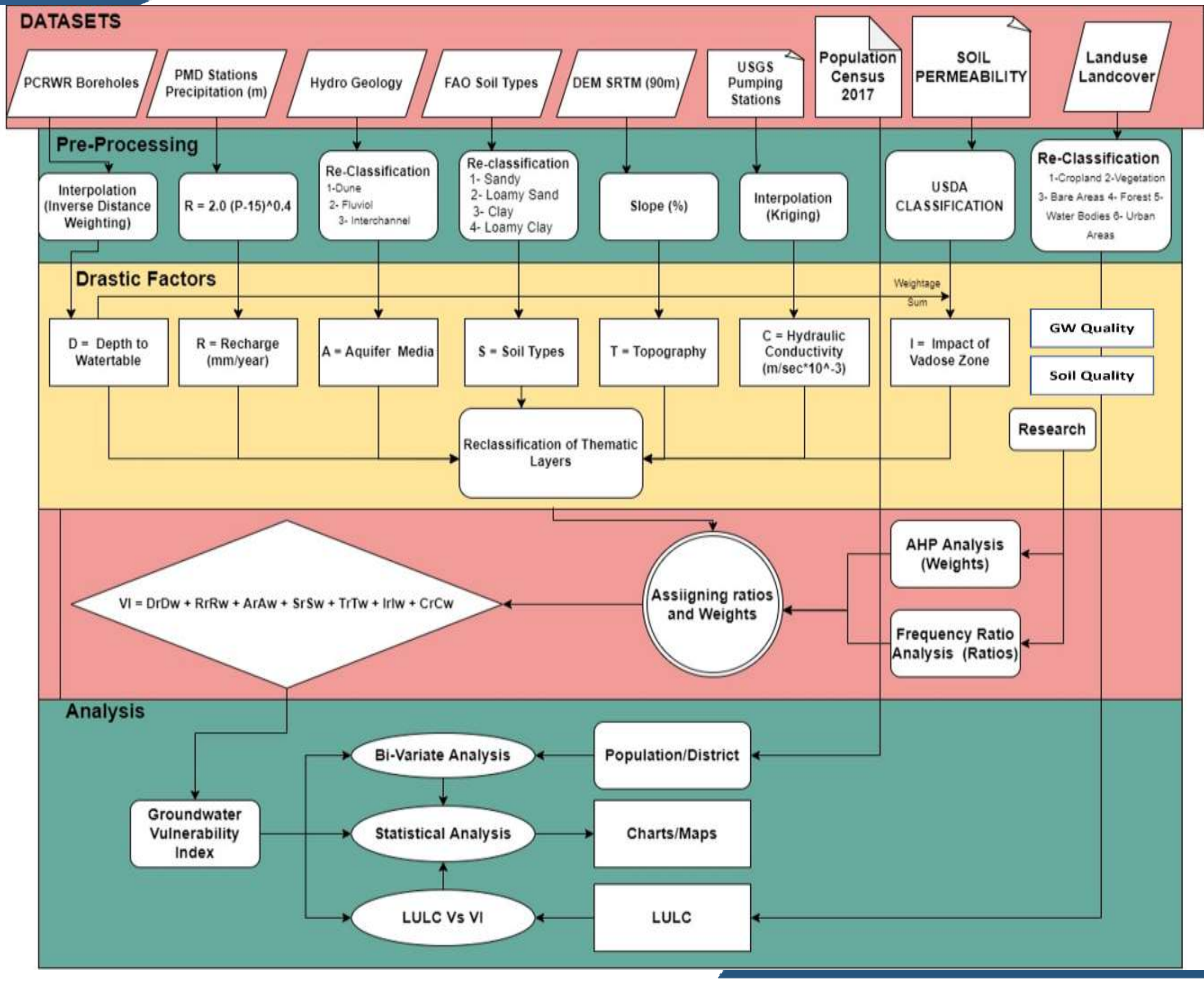
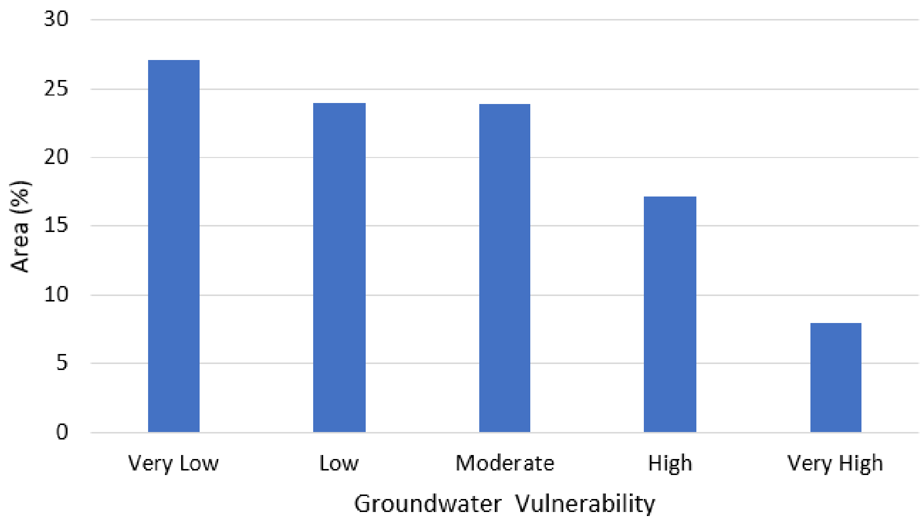
DRASTIC Model



Groundwater Vulnerability Assessment in Punjab

- Groundwater vulnerability shows that almost 8.2%-17% of Punjab is high to very high vulnerable. The northern part of Punjab is a low to moderate vulnerable area (23–27 percent). The southern regions are more seriously affected, where vulnerability values are high.



THE WORLD BANK

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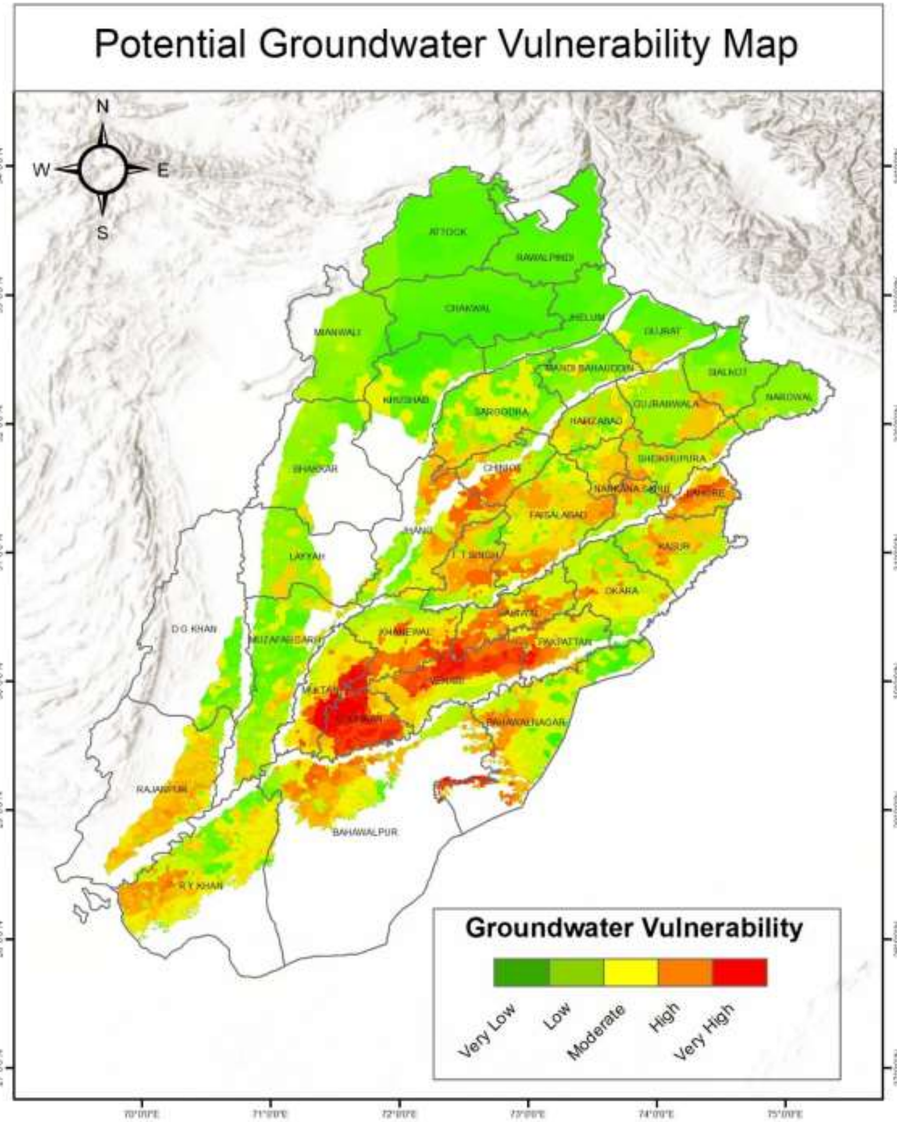
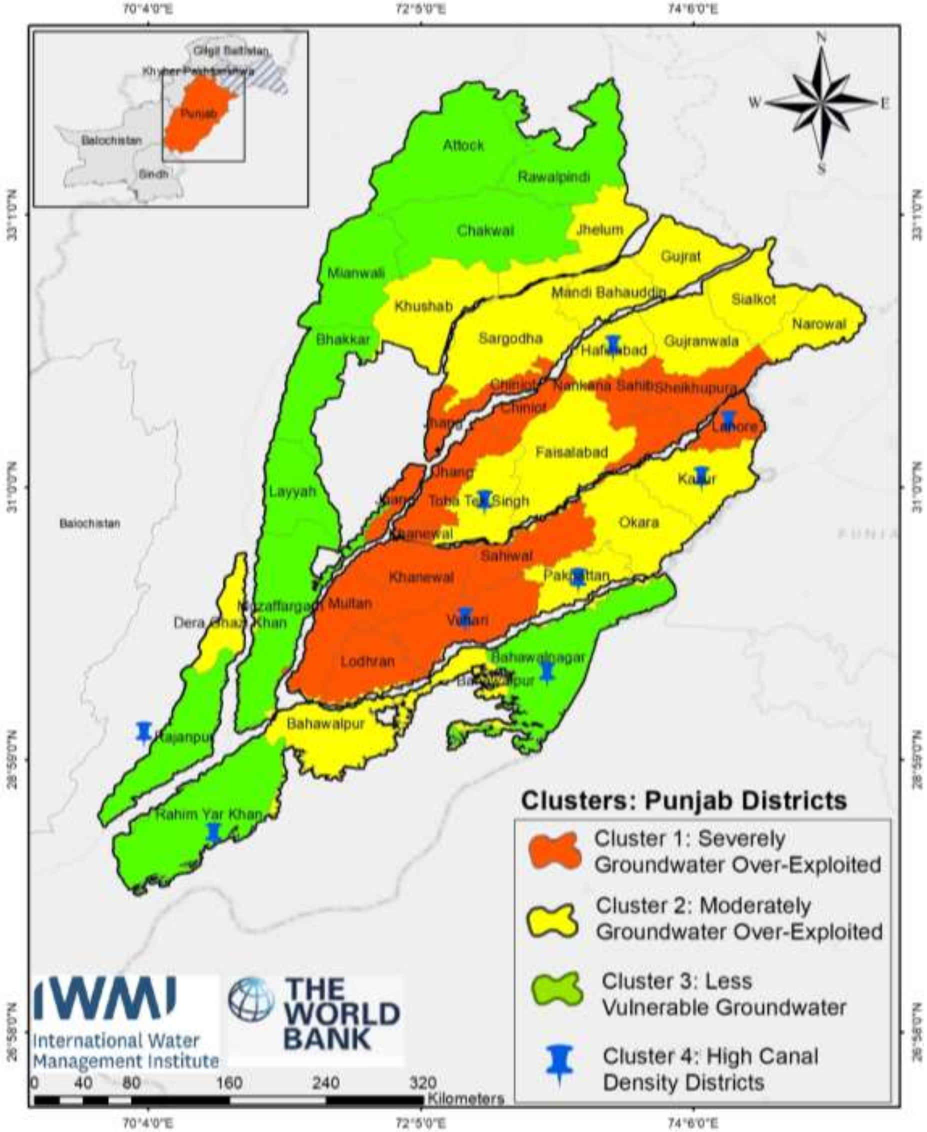
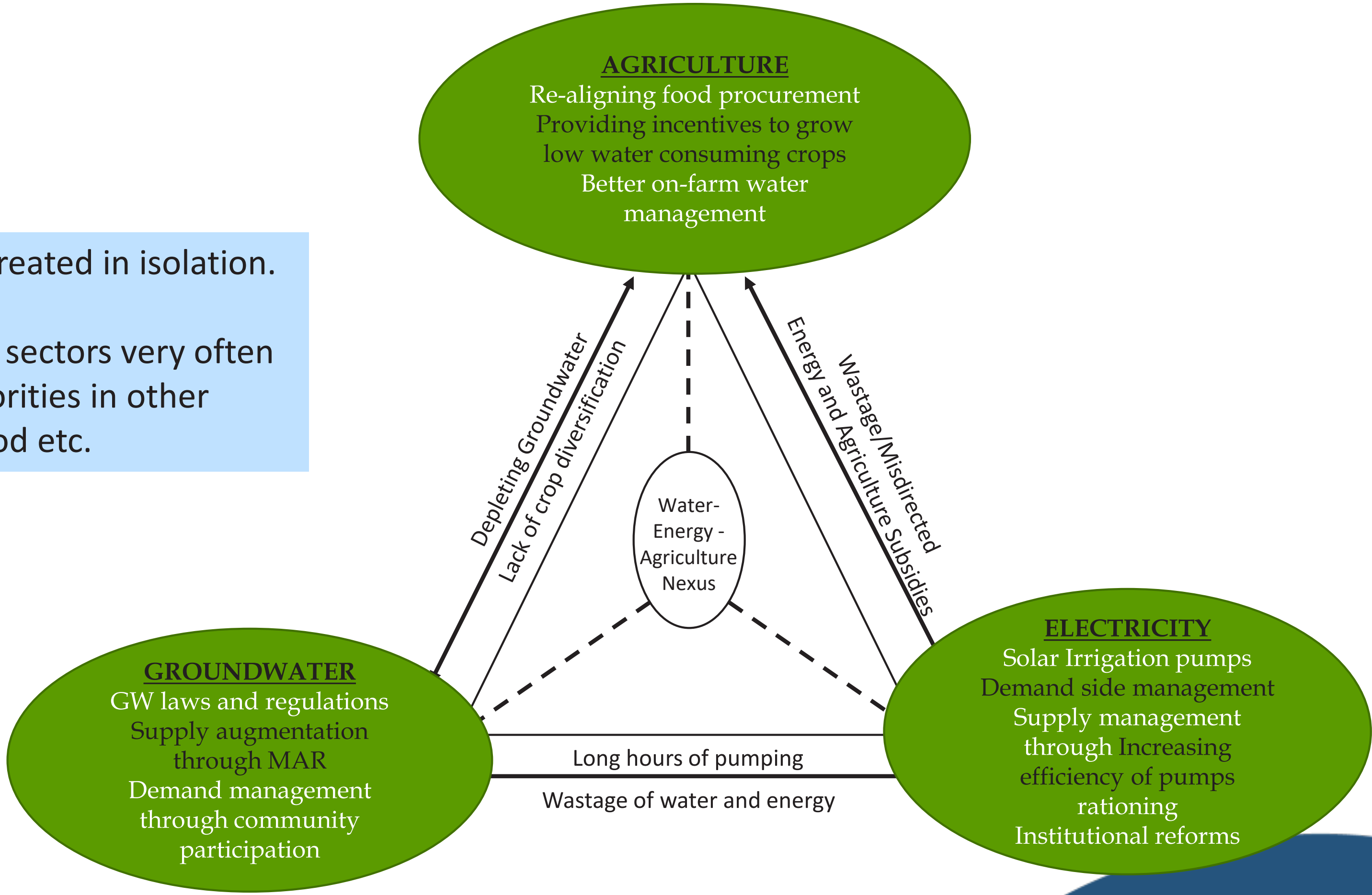


Notes: The northern Punjab and southern Punjab are seriously affected as compared to the central Punjab where vulnerable values are moderate but the conditions in future will lead it to high vulnerability.


Clusters: Punjab Districts
Cluster 1: Severely Groundwater Over-Exploited
Cluster 2: Moderately Groundwater Over-Exploited
Cluster 3: Less Vulnerable Groundwater
Cluster 4: High Canal Density Districts
Attock
Rawalpindi
Chakwal
Jhelum
Gujrat
Mianwali
Khushab
Mandi Bahauddin
Sialkot
Narowal
Bhakkar
Sargodha
Gujranwala
Nankana Sahib
Sheikhupura
Faisalabad
Layyah
Okara
Sahiwal
Khanewal
Multan
Lodhran
Bahawalpur
Rahim Yar Khan
Balochistan
International Water Management Institute
THE WORLD BANK
0 40 80 160 240 320 Kilometers
70°4'0"E
72°5'0"E
74°6'0"E

A Nexus Approach to Water Policy & Management

- Water cannot be treated in isolation.
- Decisions in water sectors very often emanate from priorities in other sectors-energy, food etc.



Adapted from Sinha, Sharma and Scott, 2006

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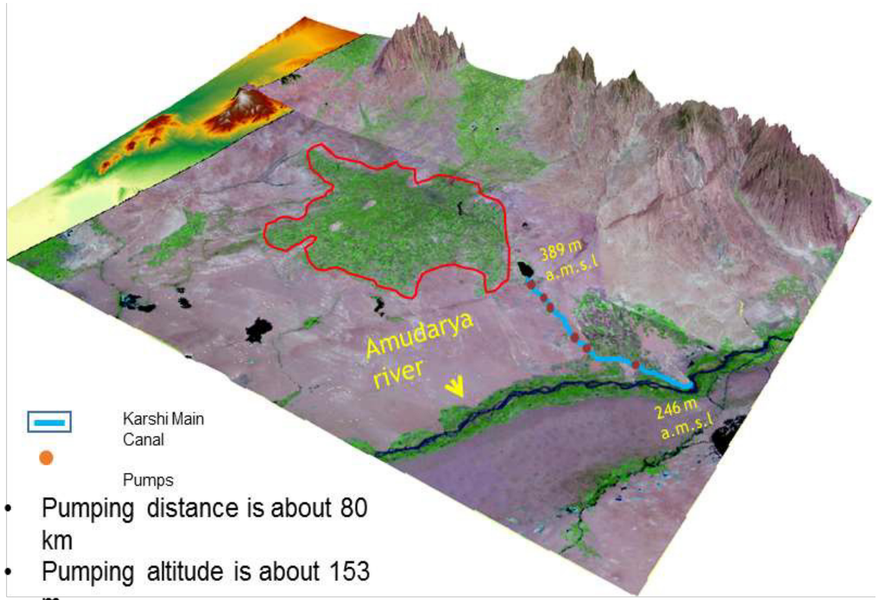
Water Resources Management Challenges in Central Asia

- ✓ Population growth along with emerging climate change has resulted in rising demand for **water**, **energy**, and **food** production;
- ✓ According to climate scenarios, Amu Darya river flow might be reduced 15% and Syr Darya 10% by 2050;
- ✓ Farmers use conventional irrigation practices that lead to excess drainage water runoff;
- ✓ Inefficient irrigation practices have led to water losses and caused excessive consumption of energy by outdated pumps.



- Pumping distance is about 80 km
- Pumping altitude is about 153 m
- Irrigated area is about 335,000 ha

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98

Water and Energy Use in Karshi Steppe of Amu Darya River Basin

Crop	Total pumped area, ha	Irrigation application, mm		Total water use, MCM		Total water saving, MCM	Electricity consumption, GWh		Total energy saving, GWh	GHG emissions, Kton		CO_2 reduction, Kton of GHGs
		Current	Improved irrigation practices	Current	Improved irrigation practices		Current	Improved irrigation practices		Current	Improved irrigation practices	
Wheat	102600	1011	587	1037	602	**435**	468	272	**196**	219	127	**92**
Cotton	119681	765	648	916	776	**140**	413	350	**63**	194	164	**30**
Total	222281	N/A	N/A	1953	1378	**575**	880	621	**259**	413	291	**122**

Research Results from Zafarabad District of Syr Darya Basin

Crop	Total pumped area, ha	Irrigation application, mm		Total water use, MCM		Total water saving, MCM	Electricity consumption, GWh		Total energy saving, GWh	Pumping cost, USD		Pumping cost, USD
		Current	Improved irrigation practices	Current	Improved irrigation practices		Current	Improved irrigation practices		Current	Improved irrigation practices	
Wheat	6388	662	546.8	42	35	**7**	41	34	**7**	237864	196471	**41393**
Cotton	12220	1302	885.2	159	108	**51**	127	87	**41**	737078	501123	**235956**
Alfalfa	5975	1367	1320.8	82	79	**3**	71	68	**2**	409272	395440	**13832**
Maize	1047	1040	850.7	11	9	**2**	12	9	**2**	67067	54860	**12208**
Vegetable	932	1289	619.1	12	6	**6**	10	5	**5**	59417	28538	**30880**
Melon	1172	1289	767.9	15	9	**6**	13	8	**5**	74903	44622	**30281**
Trees	1849	730	535.1	13	10	**4**	12	8	**3**	66831	48988	**17843**
Rice	200	3600	2491.9	7	5	**2**	4	2	**1**	20623	14275	**6348**
Total	29783	N/A	N/A	341.8	260.6	**81**	289	222	**67**	1673055	1284316	**388739**

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← Contents

Policy Dialogue Workshops Organized in CA Countries

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Policy Uptake in Uzbekistan

- The results demonstrated multi-benefits of promoting new irrigation technologies in lift irrigated areas that were communicated to stakeholders from the presidential administration and the Ministries of Water Resources and Economy in Uzbekistan;
- The government has adopted a strategy to expand drip irrigation areas by up to 253,381 ha during 2019-2022, which will cover farmers' ~50% of drip irrigation installation costs and exempt them from land tax for five years;
- Our key recommendations helped government officials in Uzbekistan to expand the program target on water saving technologies including drip irrigation, sprinkler irrigation and laser levelling up to 450,000 ha in 2021. This program came into effect on December 11, 2020 through a Presidential resolution;
- The project interventions have led to the improvement of water use efficiency in transboundary rivers in Central Asia.

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Key Messages

NEXUS Gains:
Realizing Multiple Benefits
Across Water, Energy, Food
and Ecosystems

- **Changes in climate and other socio-economic changes will have a marked impact on water and food security**
- **Improve surface & groundwater management and governance given growing sccity**
- **Reassess the need to export rice and grow sugarcane in the highly water-scarce region**
- **Monitor water productivity and consider a broad range of interventions for improvement**
- **Scientific evidence based solutions – key success to the investment**
- **Holistic water resource management - water and food security**
- **Research and Knowledge partnership for achieving water, food and energy security in a changing climate**

www.cgiar.org

Thank you for your attention!

m.hafeez@cgiar.org

CGIAR NEXUS Gains: Realizing Multiple Benefits Across Water, Energy, Food and Ecosystems

Day 5

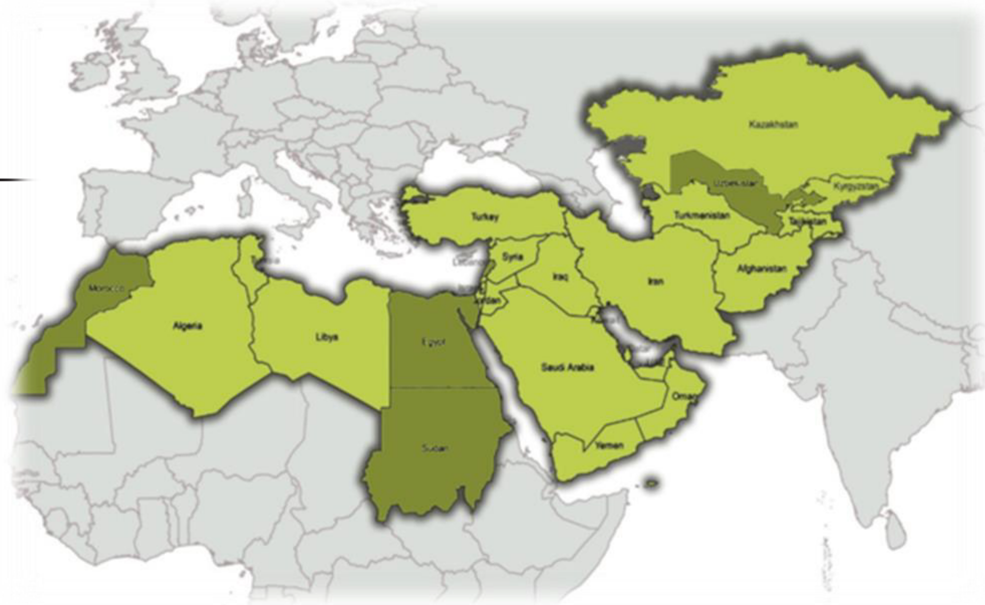
From Fragility to Resilience in Central and West Asia and North Africa (F2R-CWANA)

ICARDA, IWMI, CIMMYT, WorldFish
IFPRI, ABC, CIP, IRRI

Nexus Gains Summer School in Uzbekistan 2023

Nature Resources Fragility

WATER-ENERGY-FOOD AND ENVIRONMENT NEXUS: CASE-STUDY FROM KASHKADARYA REGION

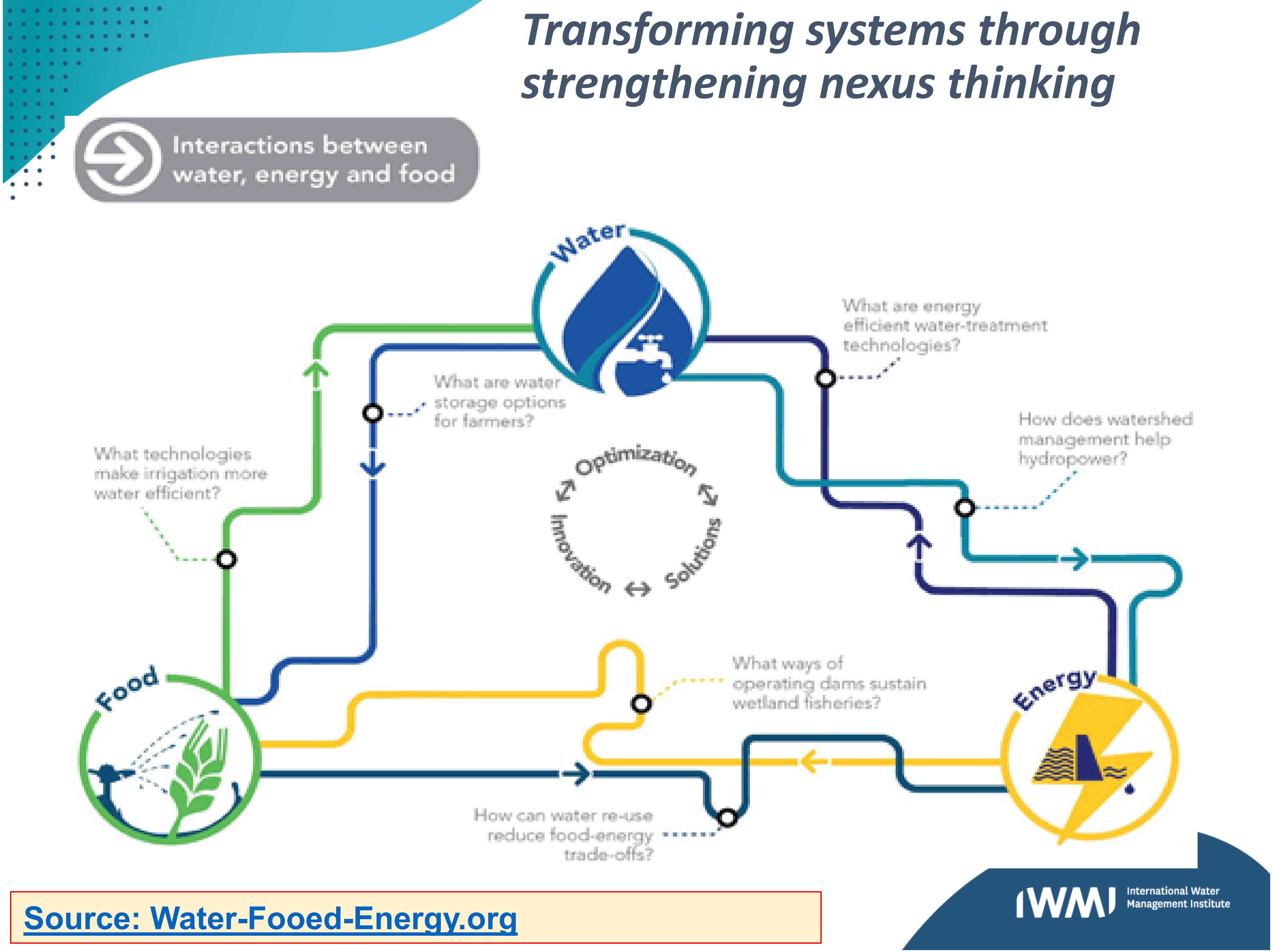


Oyture Anarbekov

IWMI-Central Asia

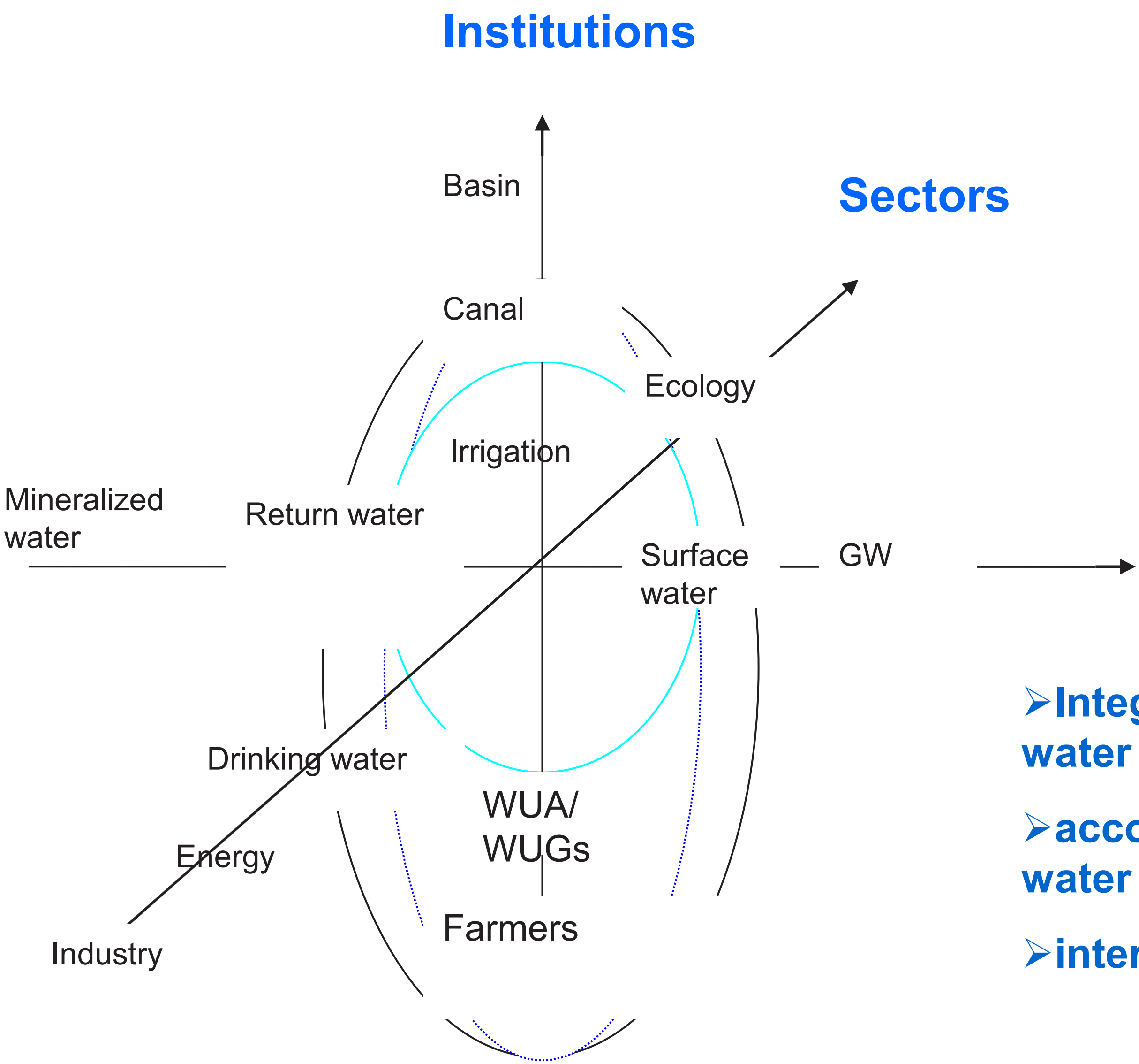
25 JAugust 2023, Tashkent, Uzbekistan

Transforming systems through strengthening nexus thinking



Source: Water-Fooed-Energy.org

IWRM principles – integration of three axis



- **Integration all levels of water mgt hierarchy,**
- **accounting all types of water sources &**
- **inter-sectoral linkages**

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Nexus and IWRM

- IWRM is mainly about the distribution of water between competing users, while Nexus aims to find the best solution and trade-offs among the three sectors;
- IWRM does not address broader aspects such as security; - IWRM is limited to a basin and thus has narrower boundaries;
- Nexus coverage is not limited by location or scale;
- IWRM often leads to a financial burden on ministries and agencies that are directly involved in water use and distribution, while Nexus reduces the burden on the budget of any single line ministry due to the distribution of investment costs among other involved stakeholders;
- Nexus helps to increase the economic return on a certain investment due to the possibility of obtaining multidimensional benefits.

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Understanding Nexus approach

- The Nexus approach integrates decision-making, planning and management of various sectors at various levels.
- Understanding the interrelationships between sectors is essential to improve planning, optimize resource use, and find trade-offs to reduce possible costs.
- The Nexus approach allows for a more effective implementation of the SDGs.
- Nexus and Integrated Water Resources Management (IWRM) are complementary concepts.
- Integrating the nexus approach into planning and decision-making processes can bring significant benefits to the region.

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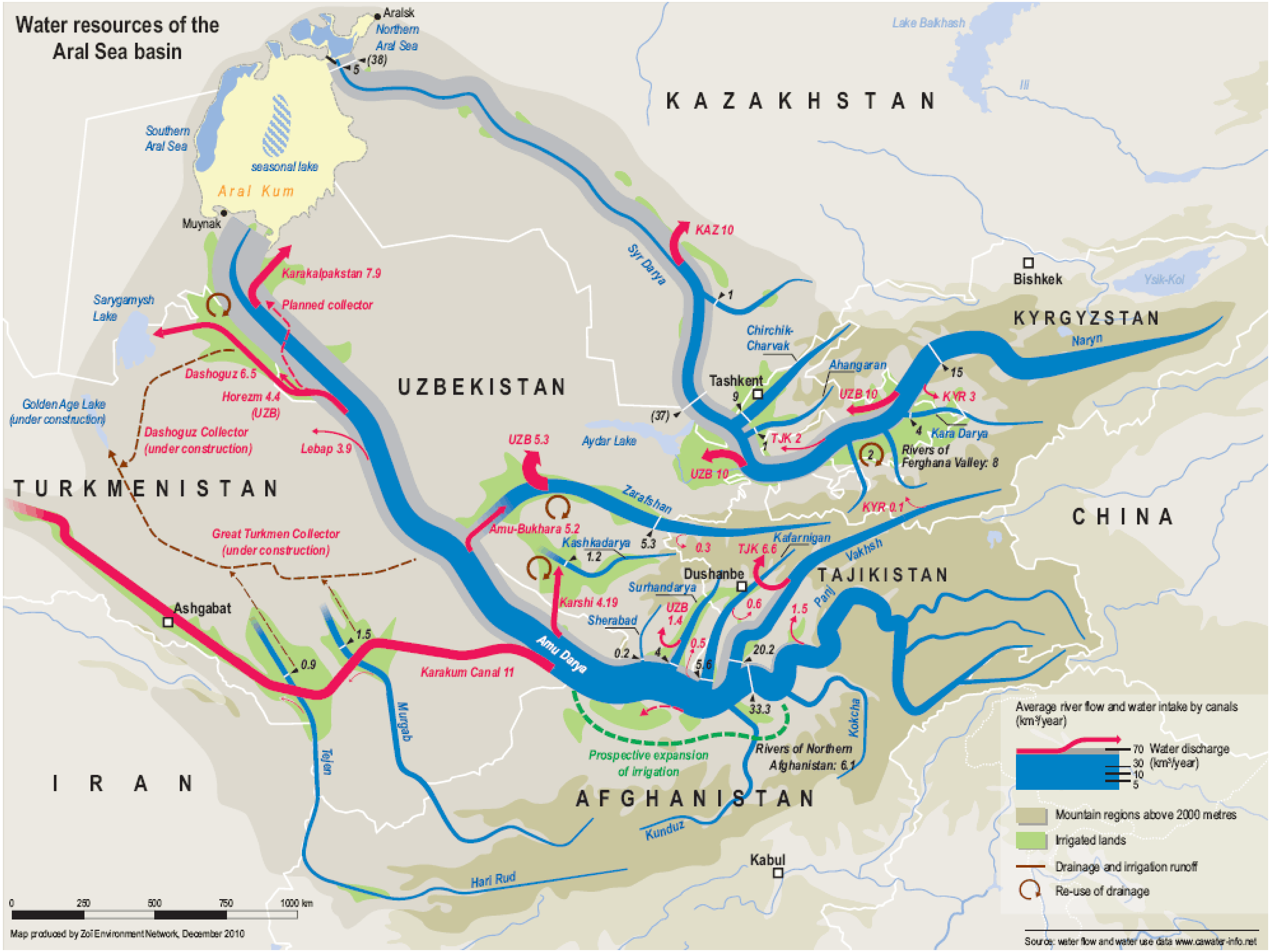
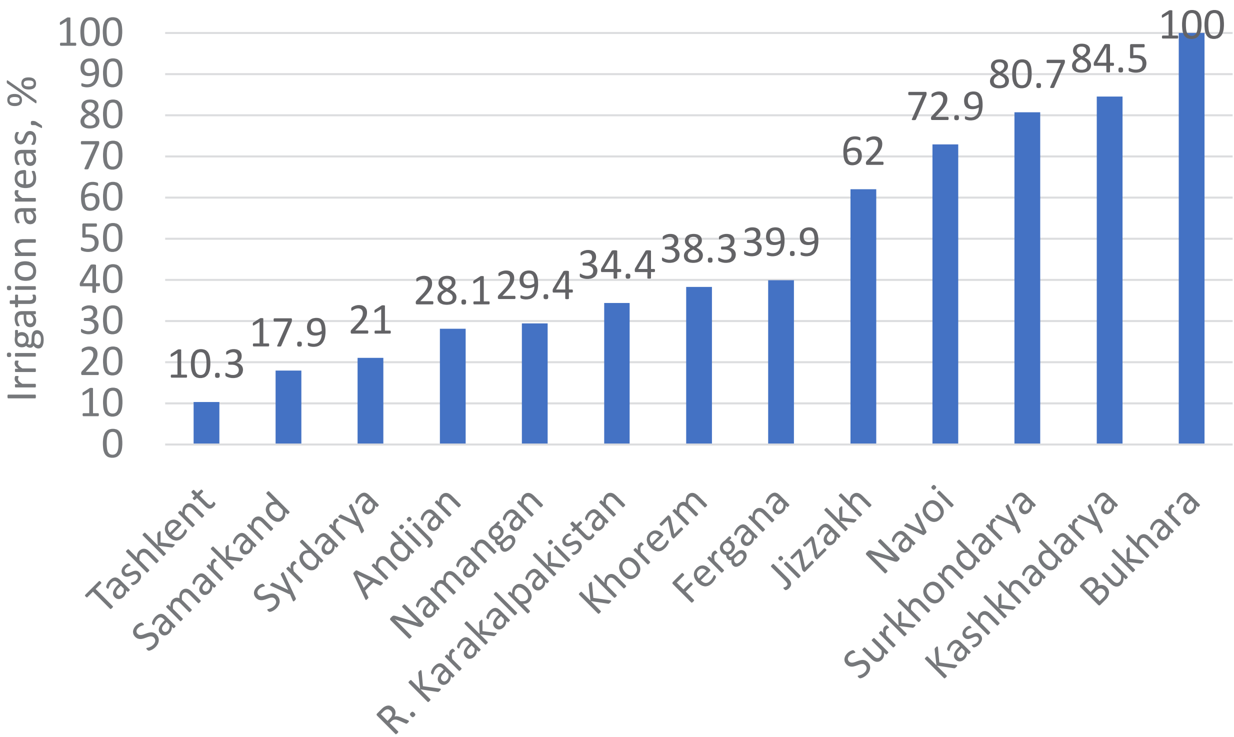


Water resources of the Aral Sea basin
Aralsk
Northern Aral Sea
Southern Aral Sea
seasonal lake
Aral Kum
Muynak
Lake Balkhash
KAZAKHSTAN
UZBEKISTAN
TURKMENISTAN
KYRGYZSTAN
TAJIKISTAN
CHINA
AFGHANISTAN
IRAN
Bishkek
Tashkent
Dushanbe
Ashgabat
Kabul
Syr Darya
Amu Darya
Zarafshan
Naryn
Kara Darya
Vakhsh
Panj
Kokcha
Kunduz
Murgab
Tejen
Hari Rud
KAZ 10
Karakalpakstan 7.9
Planned collector
Sarygamysh Lake
Dashoguz 6.5
Horezm 4.4 (UZB)
Golden Age Lake (under construction)
Dashoguz Collector (under construction)
Lebap 3.9
UZB 5.3
Aydar Lake
Chirchik-Charvak
Ahangaran
UZB 10
KYR 3
TJK 2
Rivers of Ferghana Valley: 8
KYR 0.1
Amu-Bukhara 5.2
Kashkadarya
Great Turkmen Collector (under construction)
Kafarnigan
TJK 6.6
Surhandarya
Karshi 4.19
Sherabad
Karakum Canal 11
Prospective expansion of irrigation
Rivers of Northern Afghanistan: 6.1
Average river flow and water intake by canals (km³/year)
Water discharge (km³/year)
Mountain regions above 2000 metres
Irrigated lands
Drainage and irrigation runoff
Re-use of drainage
0 250 500 750 1000 km
Map produced by Zoi Environment Network, December 2010
Source: water flow and water use data www.cawater-info.net

Water and energy losses



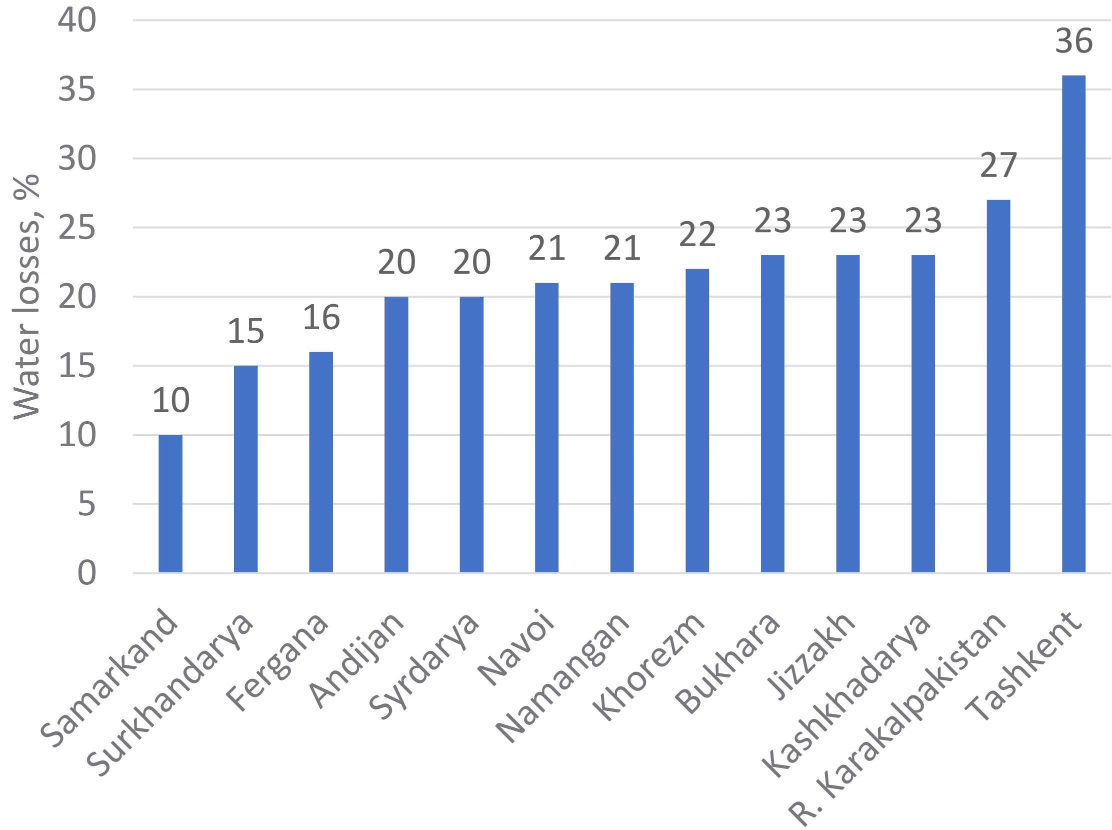
Pumping stations are physically worn out.
The service life of more than 60% of pumping equipment life cycle is expired.

The areas under the lift irrigation by region, %
Source: MWR of Uzbekistan

Water and energy losses as well as carbon emissions (water-energy-food nexus)

The level of energy and water consumption is rather high in growing cotton and grain crops.
8 billion kilowatt-hours of power and USD 228 Mln budgetary funds are spent annually to ensure the operation of more than 5 thousand pumps for irrigation of 2.5 million hectares of land.

Water loss on the state irrigation system during transportation by region, % (data 2018)



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Challenges of on-farm O&M in Uzbekistan

- ***Outdated infrastructure***
- ***Low Coefficiency of efficiency of canals***
- ***Water losses***
- ***Absence of water control and metering facilities, eyes measurements***
- ***Accountability and Transparency***
- ***no incentives, ISF area based, questions of full cost recovery***
- ***Conflicts and disputes btw WCAs and water users***
- ***No linkages btw water use and water charge/Irrigation service fee***

as if 01.04.2019	Electricity debt	Tax debts and other obligatory payments	Total
Total Debt of 1503 WCAs, mln $	16.8	3.46	20.26
	1 USD = 8354 UZS (Source: Ex Rate Oanda.com)		

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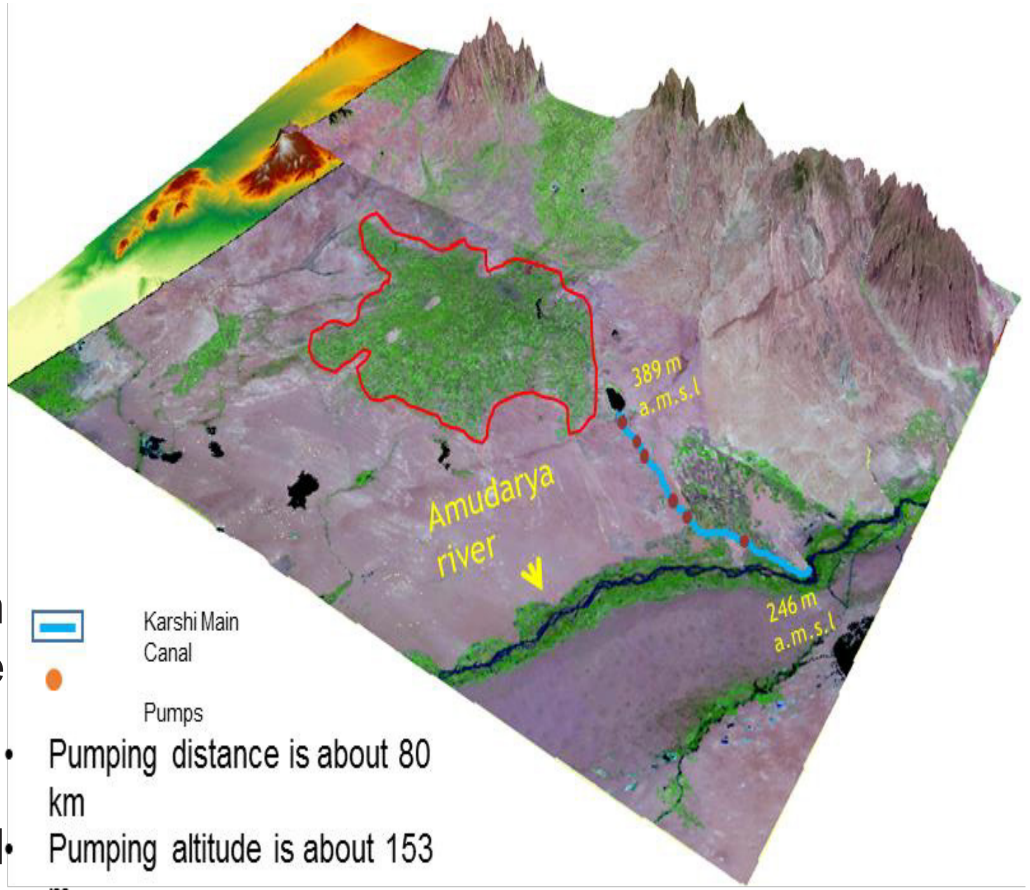
Lack of WEF Nexus approaches results in high energy and water use in agricultural production

✓ 2.2 million hectares land out of 4.3 million hectare under pump irrigation. **70% of pump units outdated and have low efficiency**. About **21% of generated energy of Uzbekistan** is used for pump operations

✓ Farmers use conventional irrigation practices that lead to excess drainage water runoff;

✓ Inefficient irrigation practices have led to water losses and caused excessive consumption of energy by outdated pumps.



- Pumping distance is about 80 km
- Pumping altitude is about 153 m
- Irrigated area is about 335,000 ha

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Afghanistan -Amu Darya River
Situation with the availability of water in CA

Source: https://eurasianet.org/uzbekistan-pursues-dialogue-with-afghanistan-on-fraught-canal-project

Afghanistan is rapidly building a huge canal to draw water from the Amu Darya River. This could potentially affect the water availability situation in Uzbekistan and Turkmenistan.

The Kosh-Tepa canal, named after the Kosh-Tepa district in Jowzjan province, will be 285 km long and 100 meters wide. It will be designed to irrigate 550,000 hectares of land (1.35 million acres, or 5,500 square kilometers).

More than half of the work on the first stage has been completed, and this 100 km stage will be ready by June 2023, about two months ahead of schedule.

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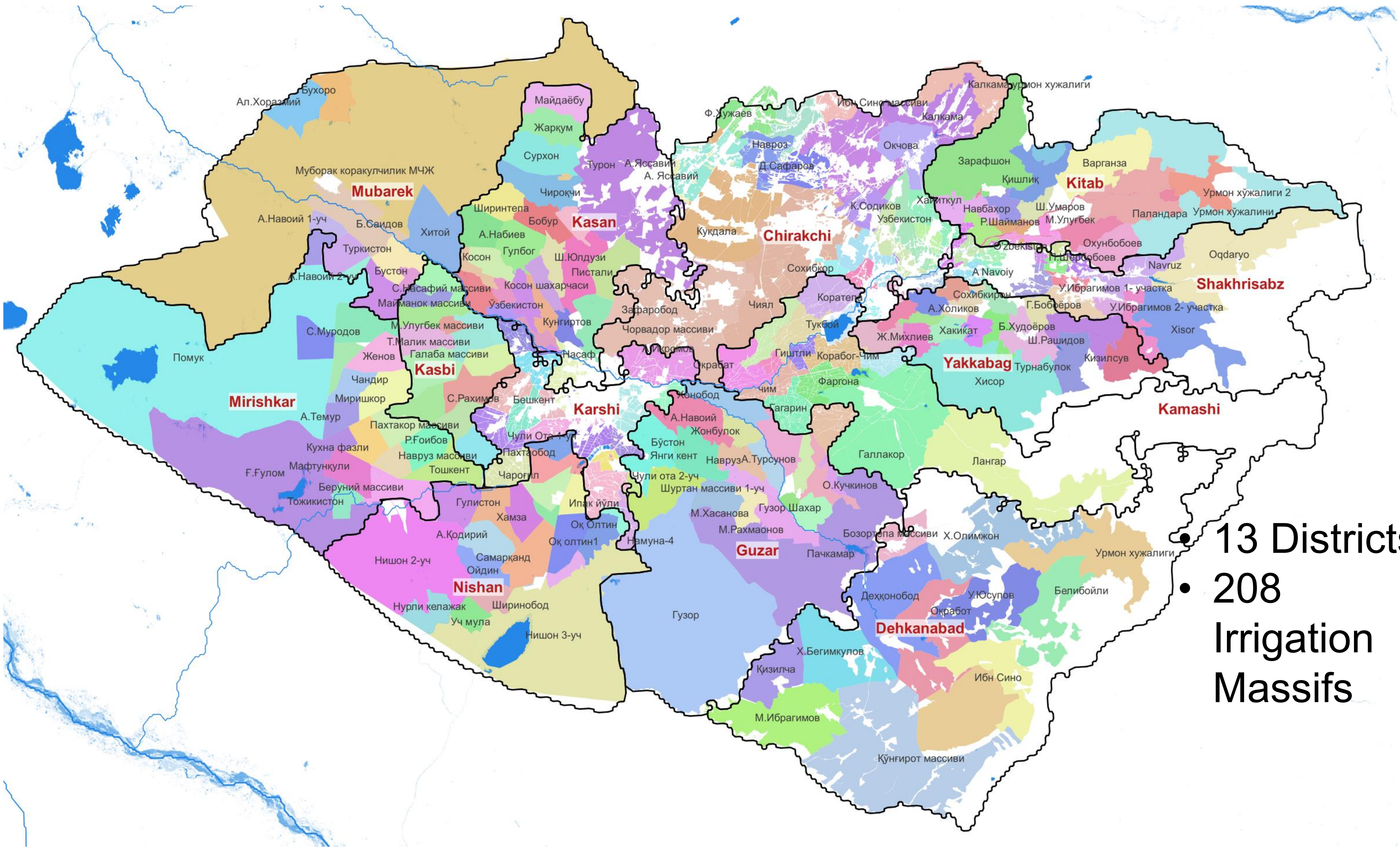
Spatial Units: Irrigation Massifs and Districts



- 13 Districts
- 208 Irrigation Massifs

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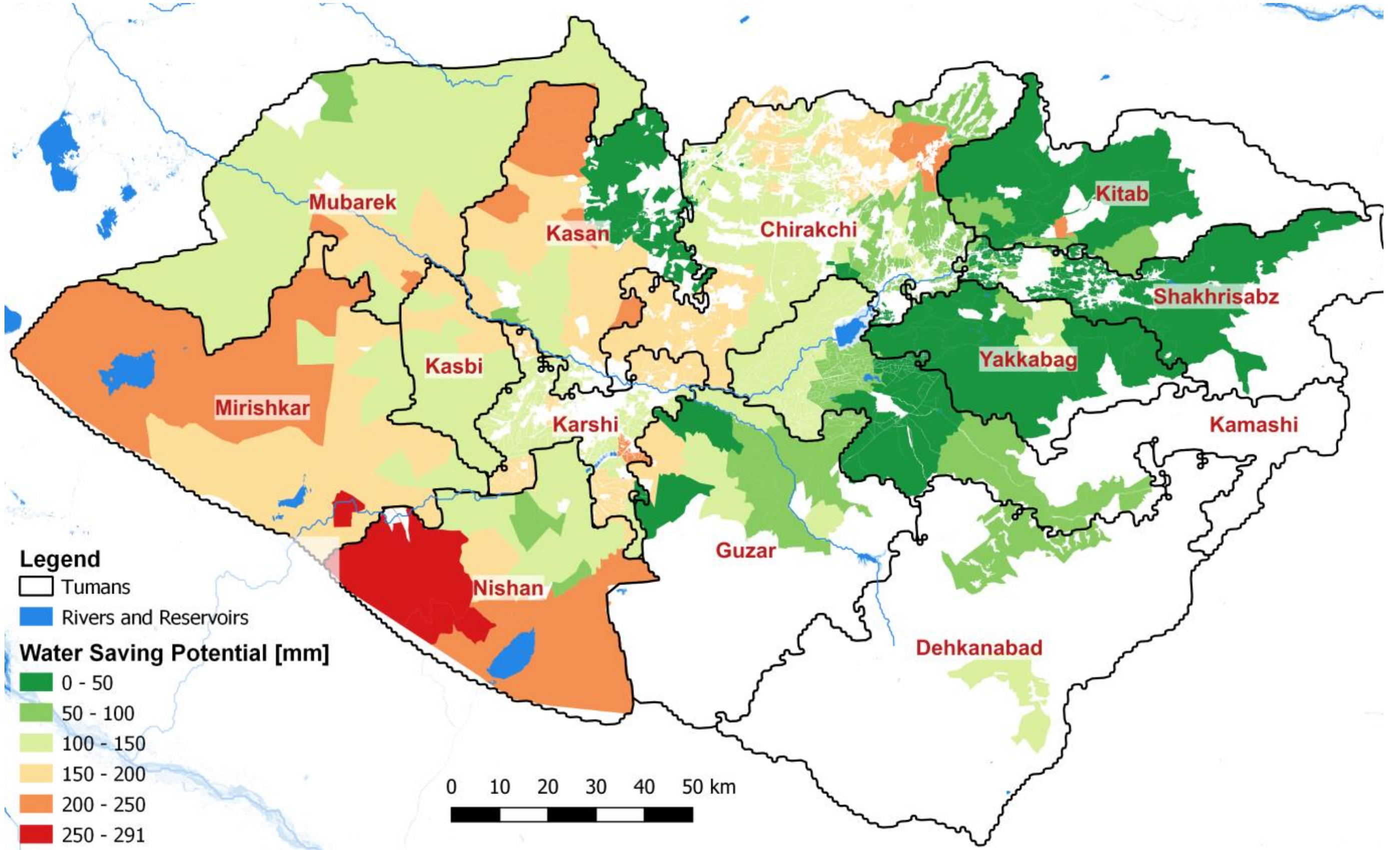
Water Saving Potential

Water Saving Potential:
Average water use minus the minimum average water use of all schemes



About 10% of the schemes have a water saving potential that exceeds the critical level (200 mm). This means, these schemes use much more water for the same yield, and the water saving potential is therefore very high.

The water saving potential in upstream areas is smaller, where schemes need less water than schemes in the more arid downstream areas for the same yield.

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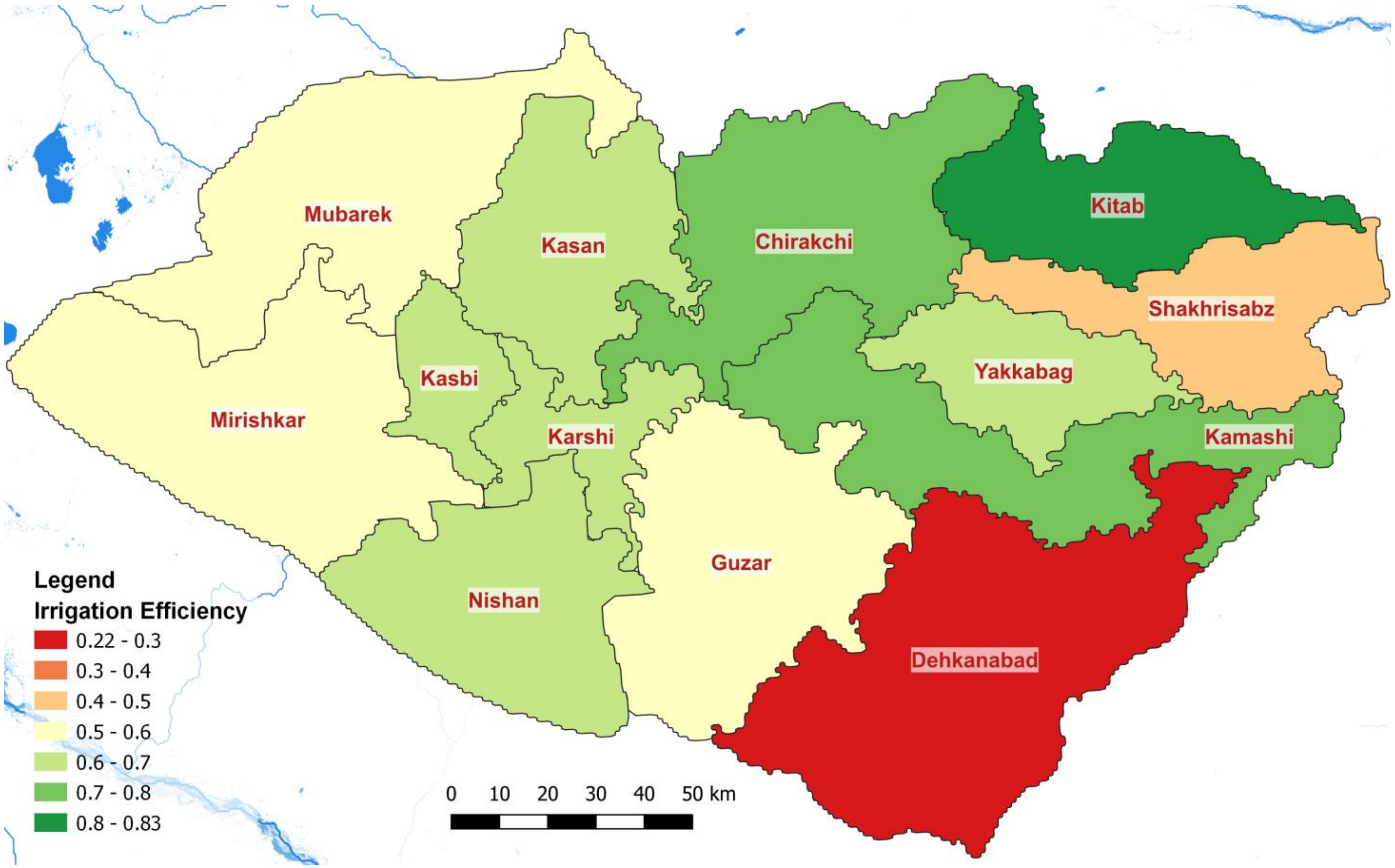
Irrigation Efficiency (2/2)

Irrigation Efficiency:
ET blue total volume divided by volume of water obtained on the border of districts, average 2017-2021 (data source: BISA Amu Kashkadarya)



Unrealistically high values of irrigation efficiency (>60%) are a sign of agricultural water use from unaccounted sources (e.g., groundwater)

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Potential efficiency gains, Karshi

Crop	Total pumped area, ha	Irrigation application, mm		Total water use, MCM		Total water saving, MCM	Electricity consumption, GWh		Total energy saving, GWh	GHG emissions, Kton		CO_2 reduction, Kton of GHGs
		Current	Improved irrigation practices	Current	Improved irrigation practices		Current	Improved irrigation practices		Current	Improved irrigation practices	
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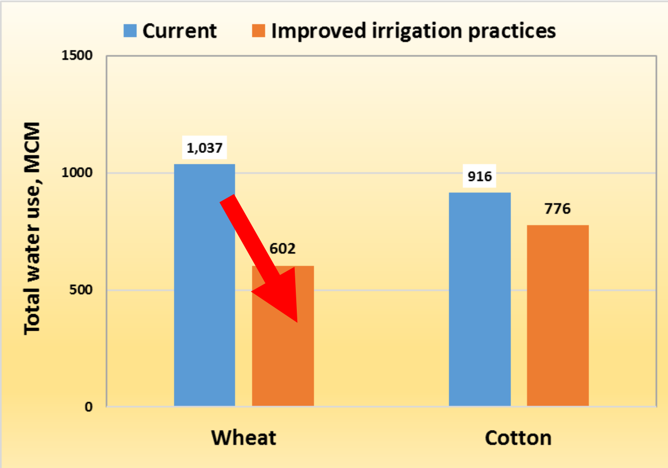

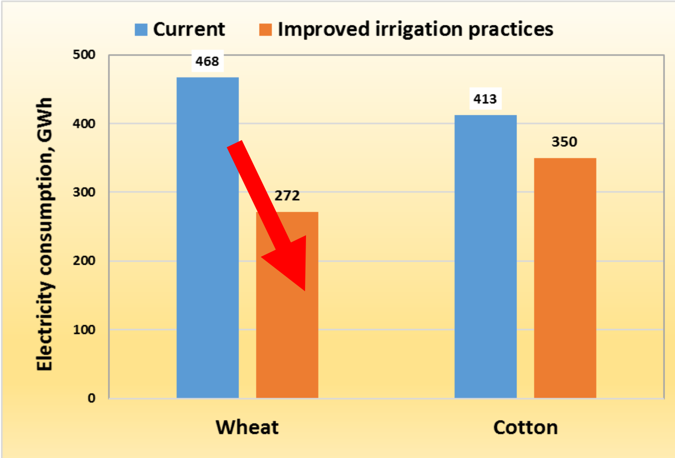

- **Potentially 25-30% savings in water, electricity, carbon emissions, and some increase in yield (findings of PEER Cycle 4 project)**

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Action areas in Kashkadarya

1. Data, analytics and evaluation tools:

- Trade-offs in water losses (coefficiency 65%) for energy, environment, food;
- Old norms or irrigation specifically in strategic crops – revision of norms;
- Integration of different data collection interventions: KOICA, SmartWater

2. Governance & policy coherence:

- Requires more science-evidence based reforms (intersector cooperation;
- Creation of different actors (Ag clusters; independent farmers; kitchen-gardens) – clear separation of roles & responsibilities as well as conditions when on-farm as well as off-farm water mgt responsibilities

3. Science-policy dialogue:

- Demonstration of low-cost crowd-sensed technologies for data collection and water measurements;
- Water Accounting Plus modelling;

4. **Stakeholder engagement and outreach:**

- Keep established branches of previous WCAs;
- River basin Councils and bottom-up approach (bring non water profes)

Action areas

Capacity Building:

- Increase professionals and integration of automation; CB; decrease of staff – but volume?
- Building capacity of importance intersectoral cooperation & coordination at the level of Province: Ag, Water, Energy, Environment, Health – water use planning

Scaling up successful innovations:

- Knowledge and evidence for tech/enabling conditions for water-savings tech
- Low examples of Start-ups/SMEs promoting WEF tools and innovations – due to low prices for water savings and energy: low access to finance/water.
- Keep demonstration of WEFE tools and innovations by right institutions

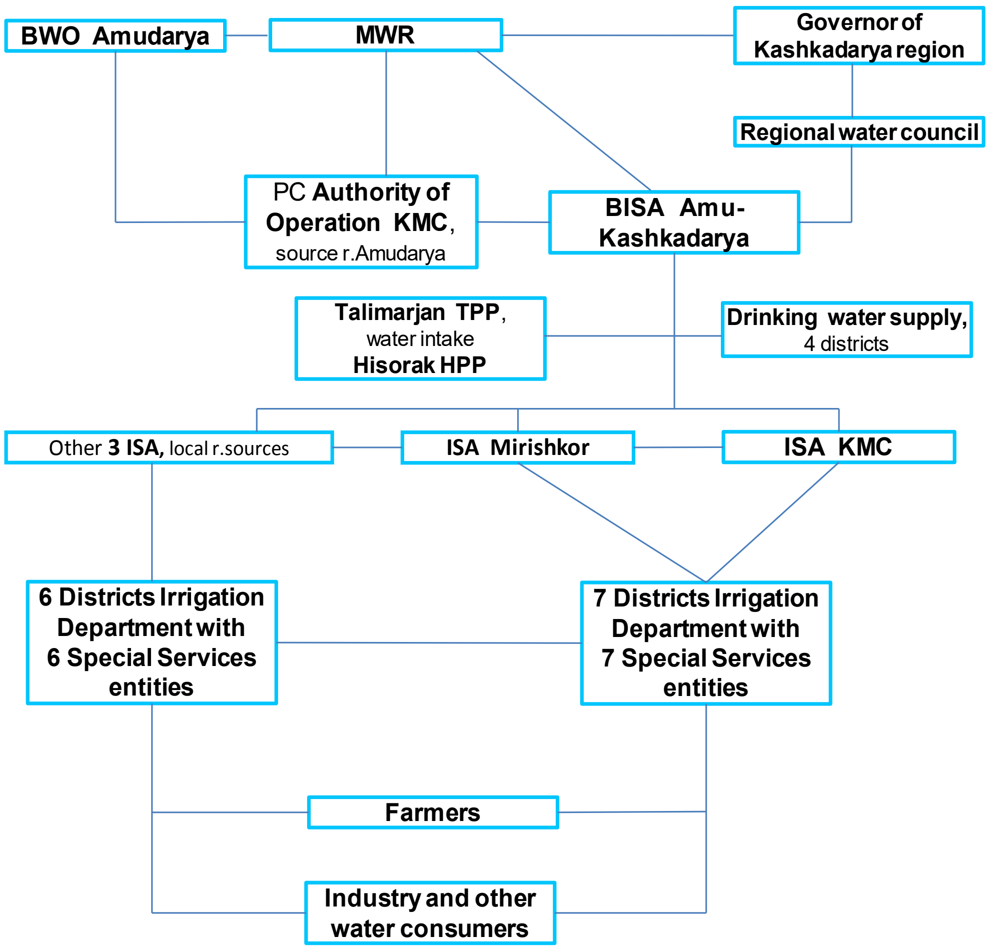
Financing and investment:

- Low ISF collection plus collection btw different agencies – need to introduce incentives, including differentiated tariffs – volumetric payment
- Equip with knowledge and tools of Special Service (agency instead of WCA)
- Correct/best practice of boundaries of Public-Private Partnerships

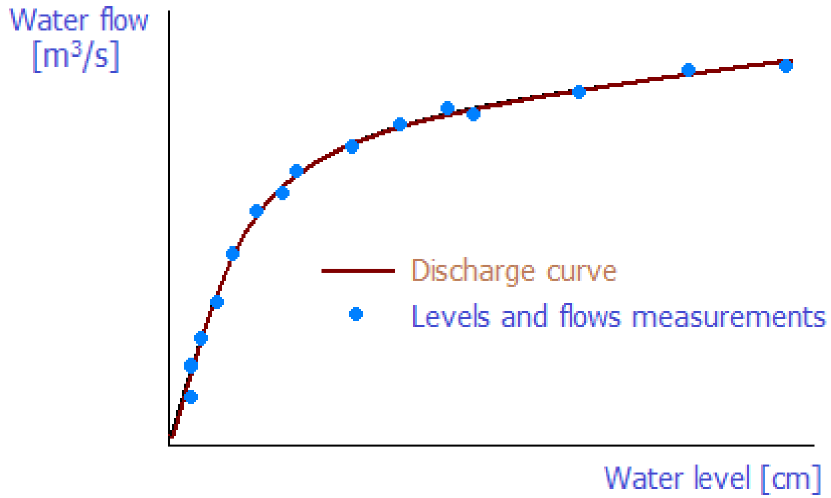
Complexity of Institutional set-ups

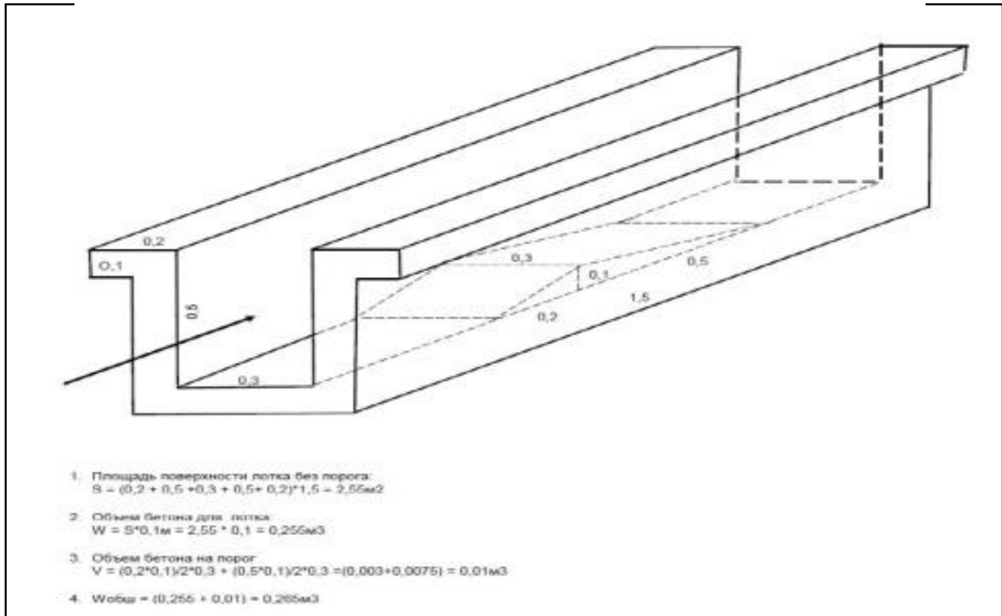
- Boundaries of Responsibilities
- Water Governance
- Intersectoral Cooperation
- Ownership of infrastructures

The scheme of interaction organizations of water sectors and water consumers on Kashkadarya region



Water measurement and accounting in WCAs gauging stations





By a simple level measurement and use of the discharge curve of the canal, it allows to determine its flow rate

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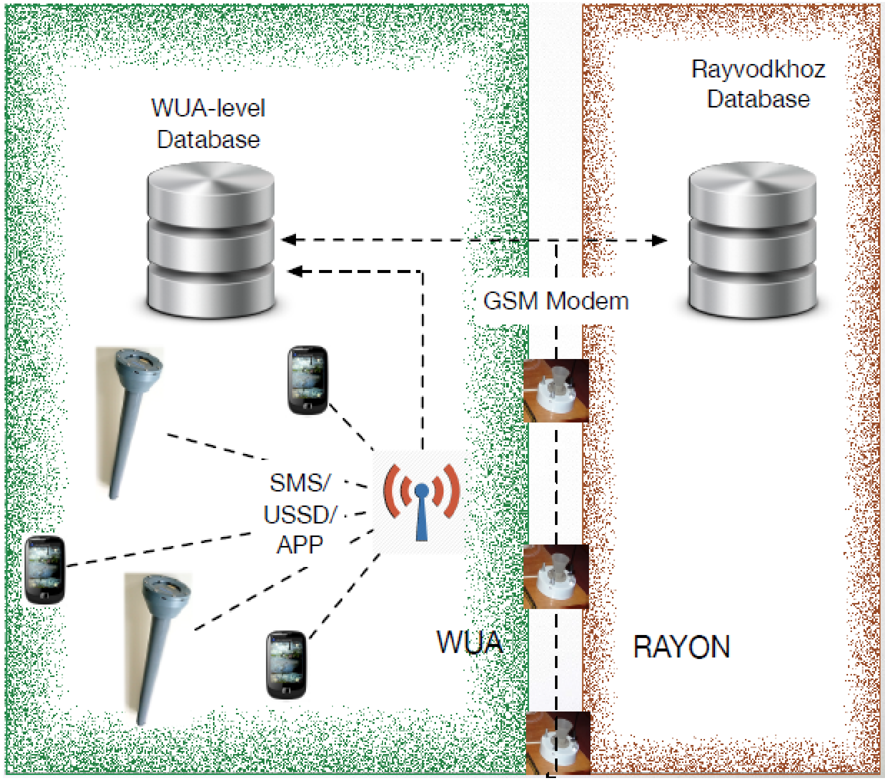
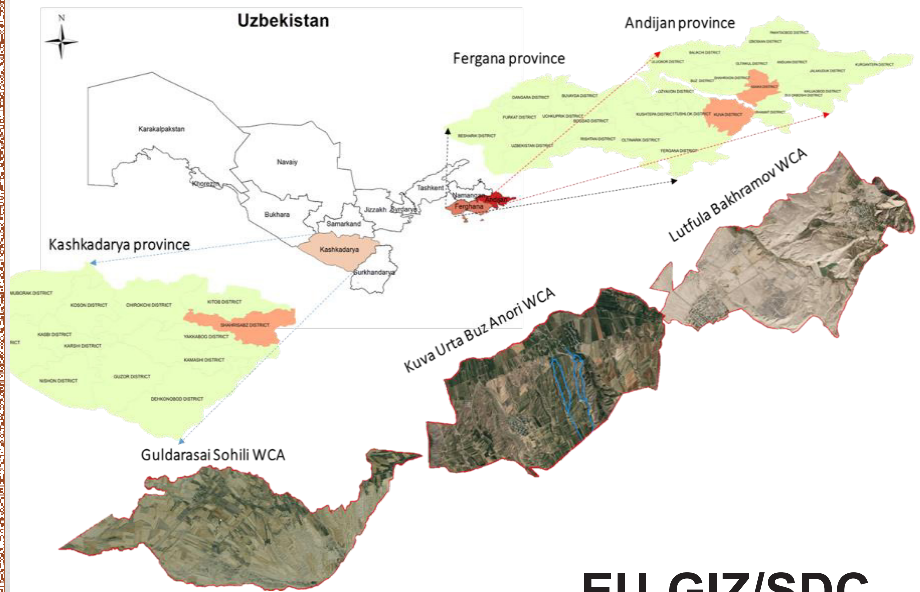
WATER ACCOUNTING AT WCA LEVEL
EXAMPLE OF ACTUAL IMPACT TO IMPROVE ON-FARM WATER ACCOUNTING AND INTRODUCTION INCENTIVES FOR WATER SAVINGS



LOCAL SOLUTION TO APPLY TECH



EU-GIZ/SDC

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A water-secure world

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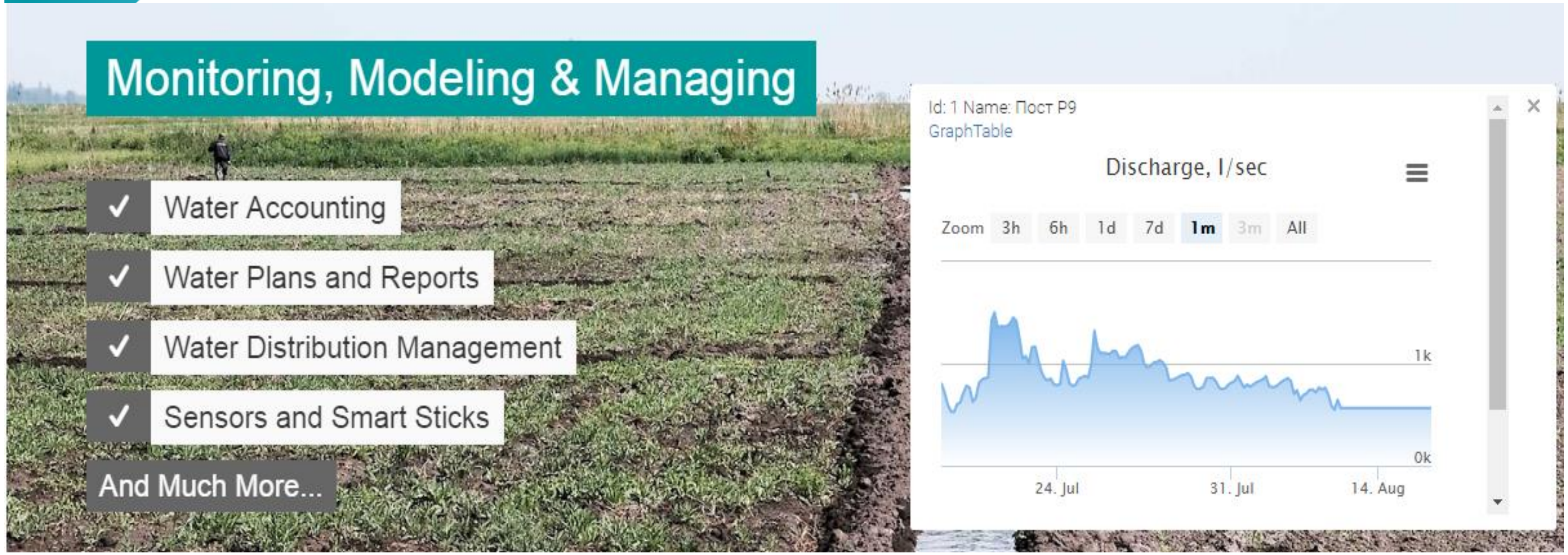
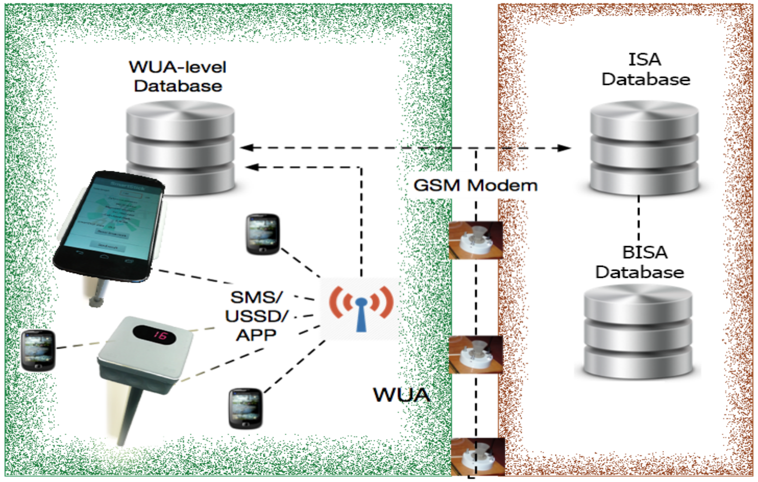
Water & financial accounting





- two part-tariff
- Water monitoring
- Lowest hierarchy of WIS

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Decrease of electricity consumption in selected pump scheme

	2018	2019	2020
Electricity consumption by pump stations in the balance of Kuva Urta Buz Anori, Ag Cluster (former WUA) KwT	66,106	60,648	55,641

In average, yearly electricity saving was around 15- 16%

Equity of water distribution in WCA Kuva Buz Anori, 2019

Name of canal	Average water availability along the canal,%	Water availabilty in the tail of canal, %	Equity of water distribution, %
May	60.8	62.8	103
Anor	106,7	86,8	81
Tolipov	77,4	73,2	95
Xasanov	100,1	77,5	77
Shodi	80,5	72,0	89

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Head Water Intake – Big Karshi Main Canal

Off-Farm irrigation canal (2-order canal)

Smart Water Smarsticks

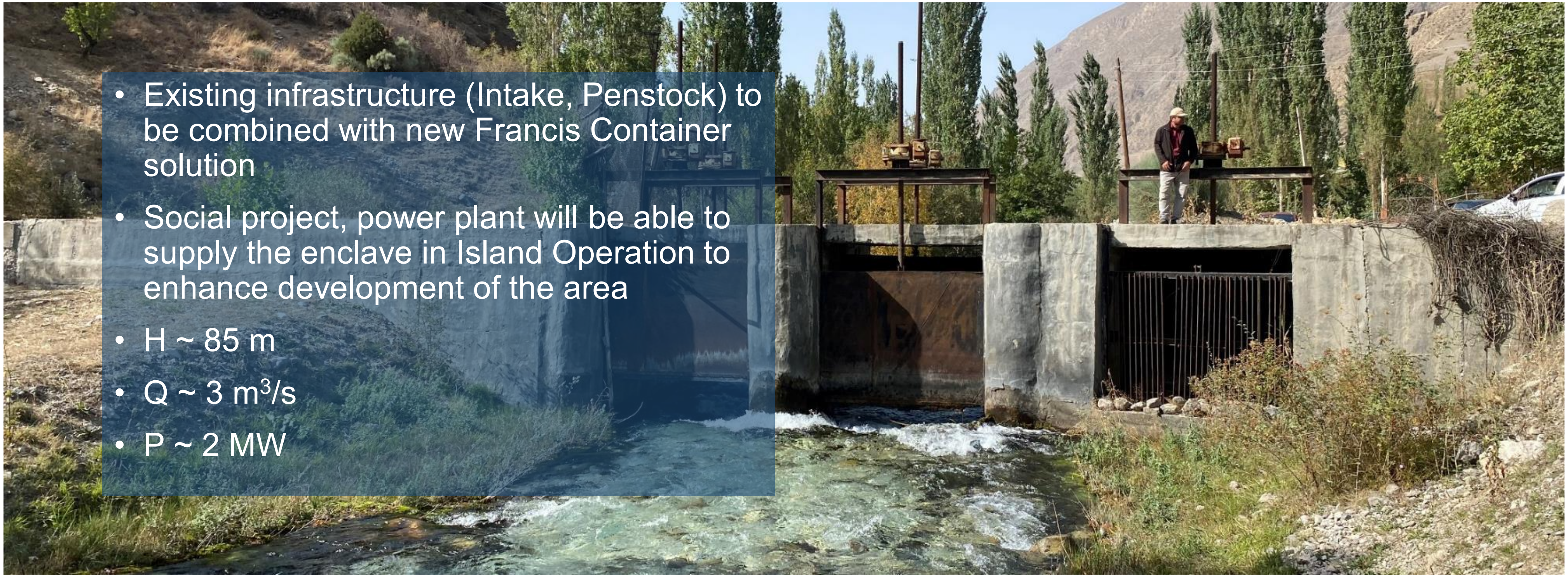
Demo Site – At-Bashi, Kyrgyzstan

- Existing Dam for Irrigation Diversion in need of refurbishment
- 3 gates, suitable for downstream integration of 2 Shaft Power Modules
- H ~ 7 - 8 m
- Q ~ 18 m^3/s
- P ~ 1.2 MW

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101022905.

← Contents

Demo Site – Shakimardan, Uzbekistan



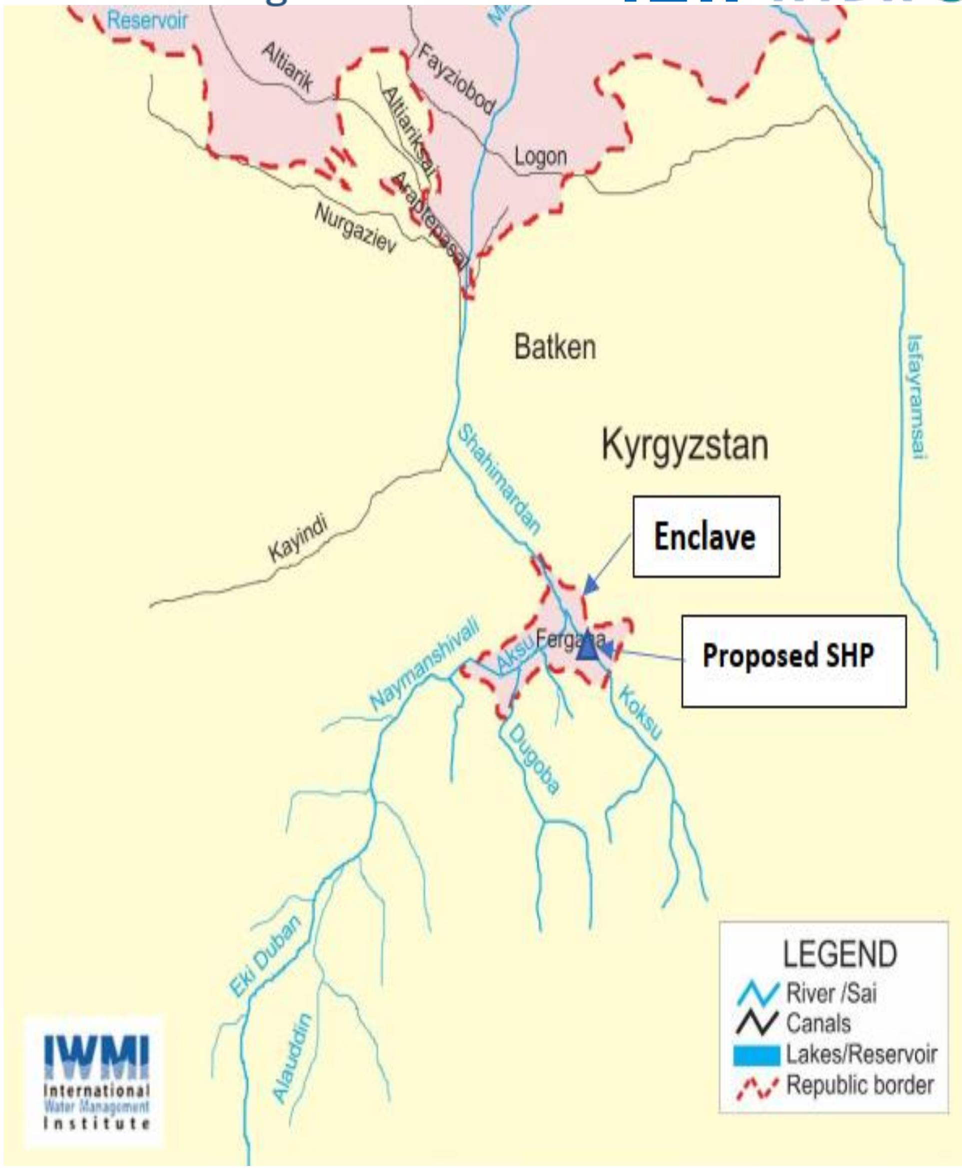
- Existing infrastructure (Intake, Penstock) to be combined with new Francis Container solution
- Social project, power plant will be able to supply the enclave in Island Operation to enhance development of the area
- H ~ 85 m
- Q ~ 3 m^3/s
- P ~ 2 MW

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101022905.

← Contents

WP2 objectives:

- ❑Quantifying benefits and trade-offs out of SHP



The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101022905.

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Analysis of the overall benefits and trade-offs from SHP

- The proposed SHPP will operate as a run-of-river project with no storage component.
- In this mode of operation, there will be no impact on the amount and timing of water availability for downstream users.
- According to the impact analysis (model) of climate change, the flow of the Koksu River will not change significantly during the life of the project (40 years).
- .Thus, there are no direct trade-offs associated with the relationship of WEP associated with the installation of SHP under current and future river flow conditions.
- The proposed SHP is expected to generate 11.5 GWh of hydroelectric power annually with an economic cost of US$0.57 million (TUM, 2022).
- The enclave, with a population of about 6,500, currently consumes 9 GWh of electricity per year.

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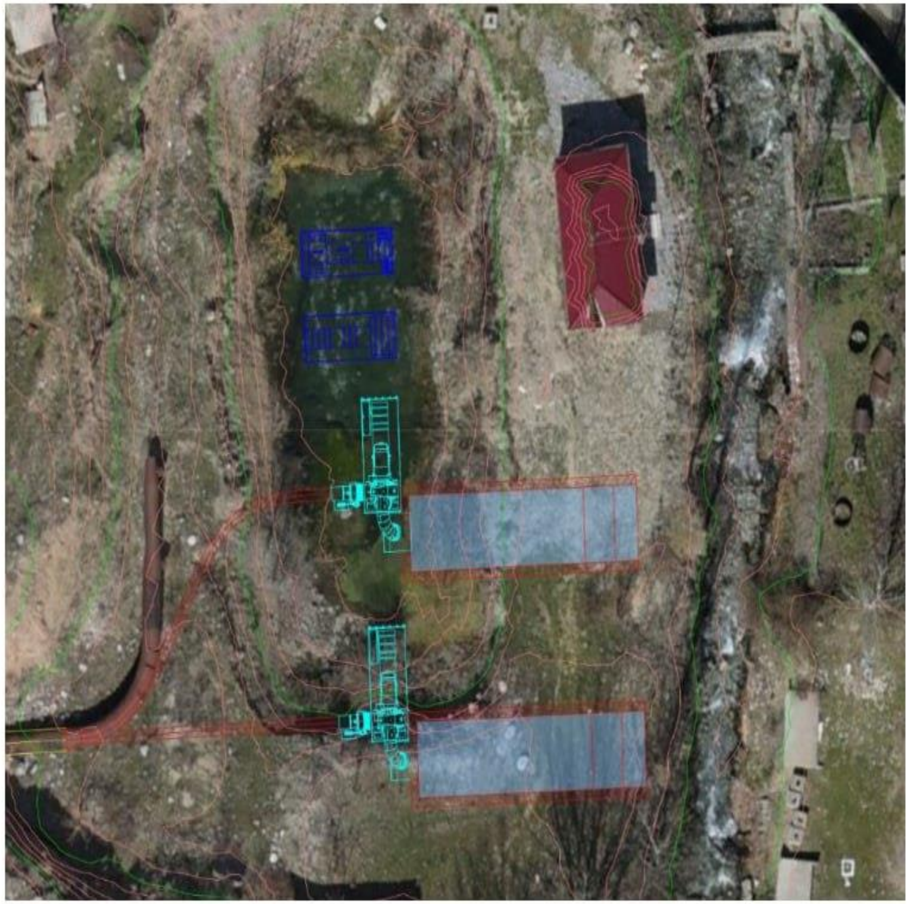
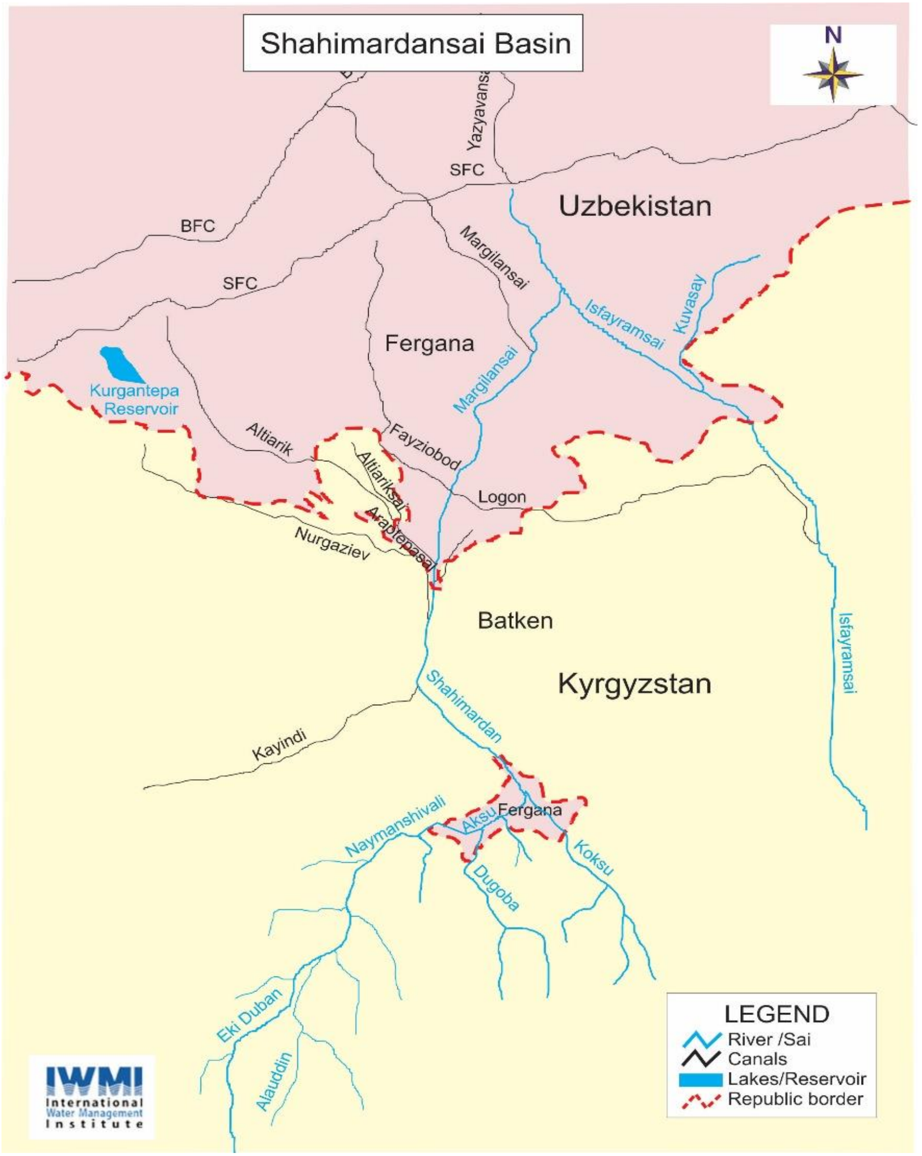
- Существующая инфраструктура (забор, водовод) будет объединена с новым решением Francis Container.



The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101022905.

Analysis of the overall benefits and trade-offs from SHP



In the Shakhimardan enclave, according to the MFY, 350 hectares of land are irrigated from ditches.

With the generation of additional electricity, residents indicated the possibility of irrigating additional land using pumps

Reliable power supply can also help support regional tourism, down significantly since 2005

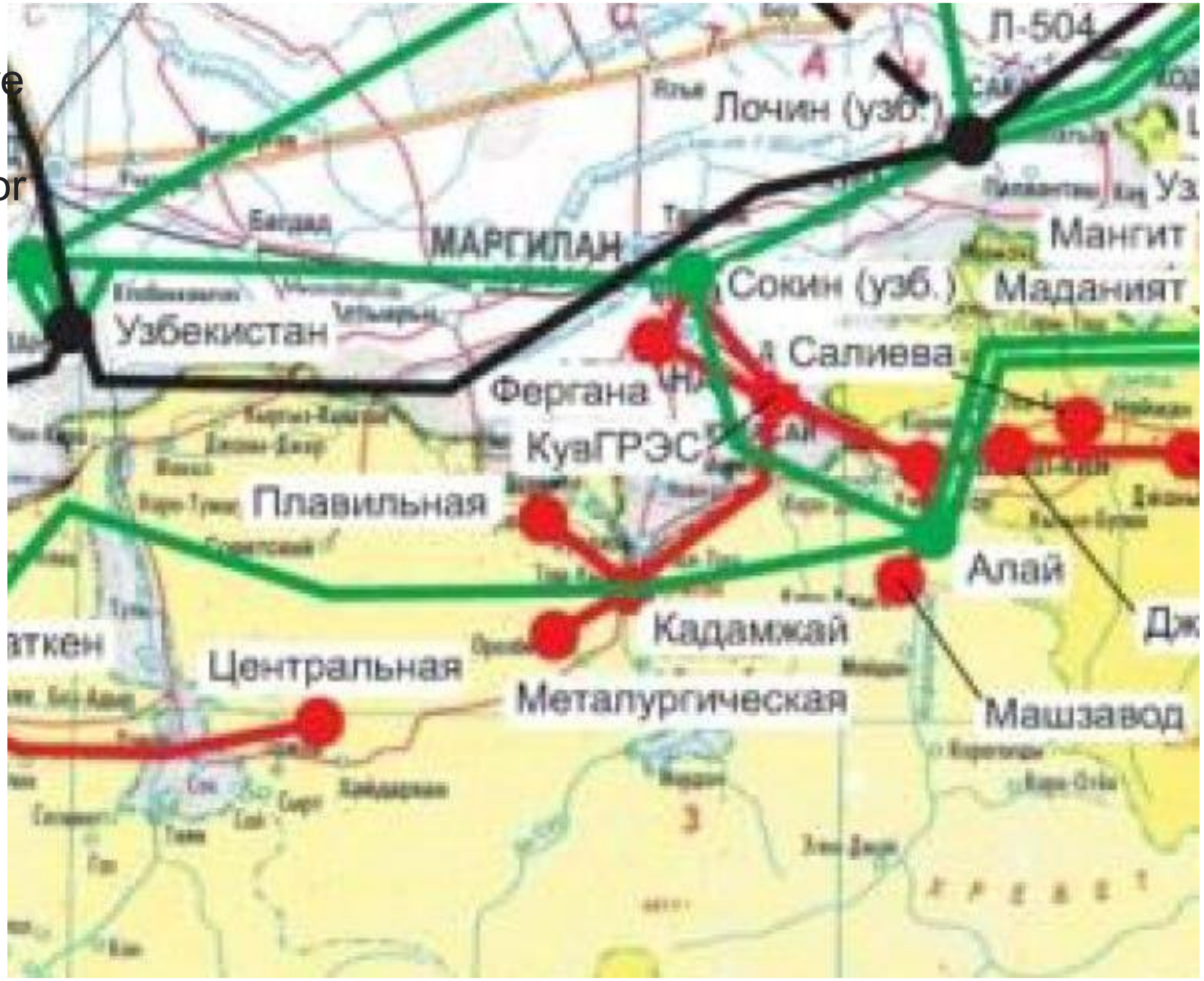
Additional electricity - will significantly reduce the use of coal, the production of carbon dioxide, as well as improve the living conditions of the family

Reduces tree production in the enclave

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101022905.

Partnership of Energy specialists

The villages of Kara-Shoro and Dugoba, as well as the cable car, are located in the upper part above the Shakhimardan enclave. Electricity for Kara-Shoro and Dugoba (120 households) is supplied through the Shakhimardan substation.



The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101022905.

← Contents

Why WEFE nexus important in the Aral Sea Basin?

- ✓ The lack of systems approaches in the past resulted serious environmental degradation and social consequences in the region – Aral Sea disaster;
- ✓ WEFE nexus helps to identify and manage trade-offs and to build synergies, allowing for more integrated and cost-effective planning and decision making in Transboundary water management;
- ✓ WEFE nexus is critical to rural livelihoods, food security & economies, and systems are strongly interconnected;
- ✓ Although Aral Sea Basin Countries share transboundary water resources there is missing regional strategy and each country developed it's own strategy, which is directed more water abstraction rather than sustainable use.
- ✓ WEFE nexus scenarios are critical for the Aral Sea region to develop coherent policies at national and regional level.

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THANK YOU VERY MUCH!

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Water-Energy-Food-Environment nexus in transboundary rivers of Central Asia

Zafar Gafurov

Innovative water solutions for sustainable development

Food · Climate · Growth

CGIAR

Water Resources of the Aral Sea Basin

The total mean annual flow of all rivers in the Aral Sea Basin is estimated as about 116 km3.

This amount comprises the flow of the Amudarya at **79.4 km3/year** and the Syrdarya at **36.6 km3/year**.

Source: http://www.cawater-info.net/aral/water_e.htm

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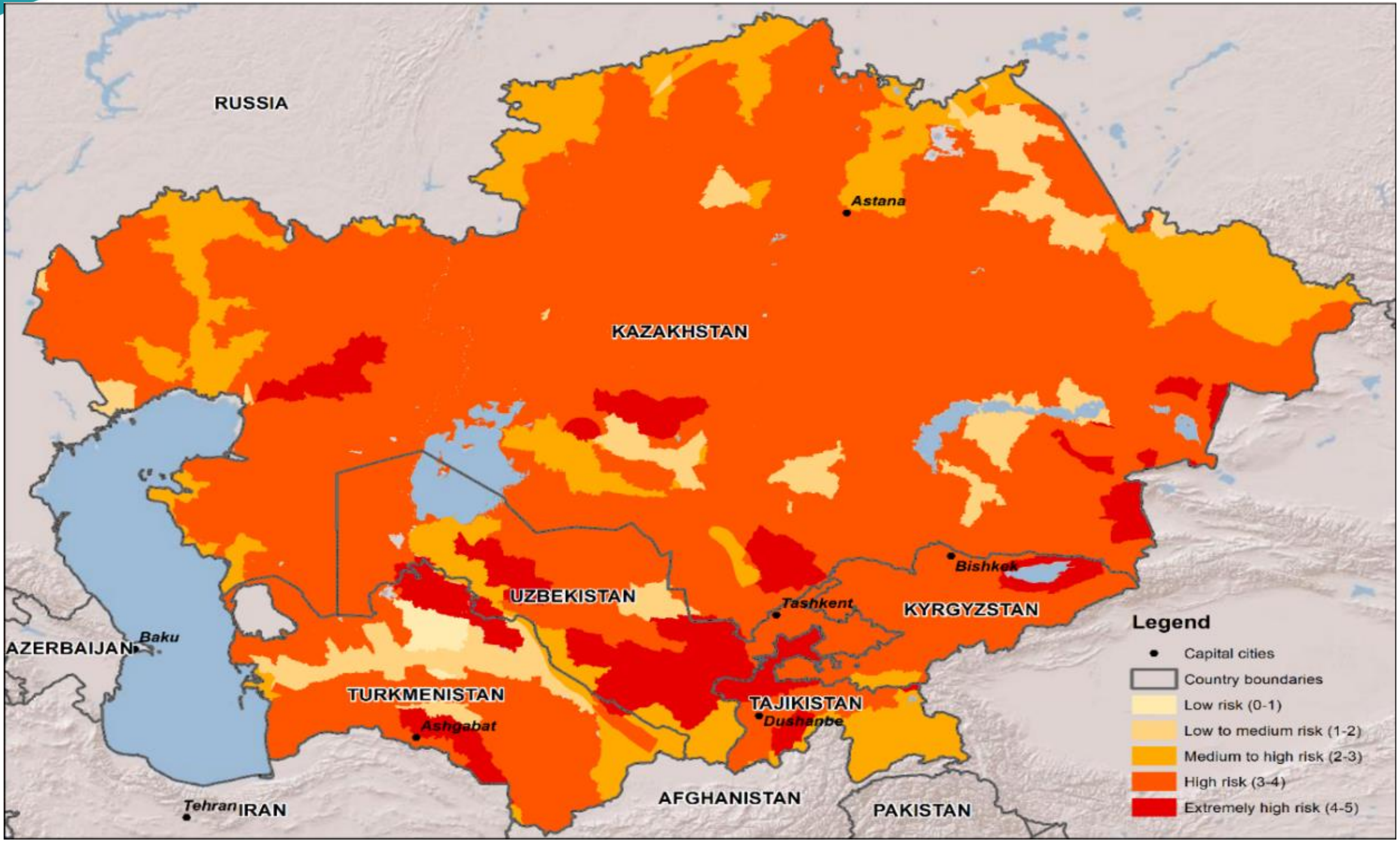
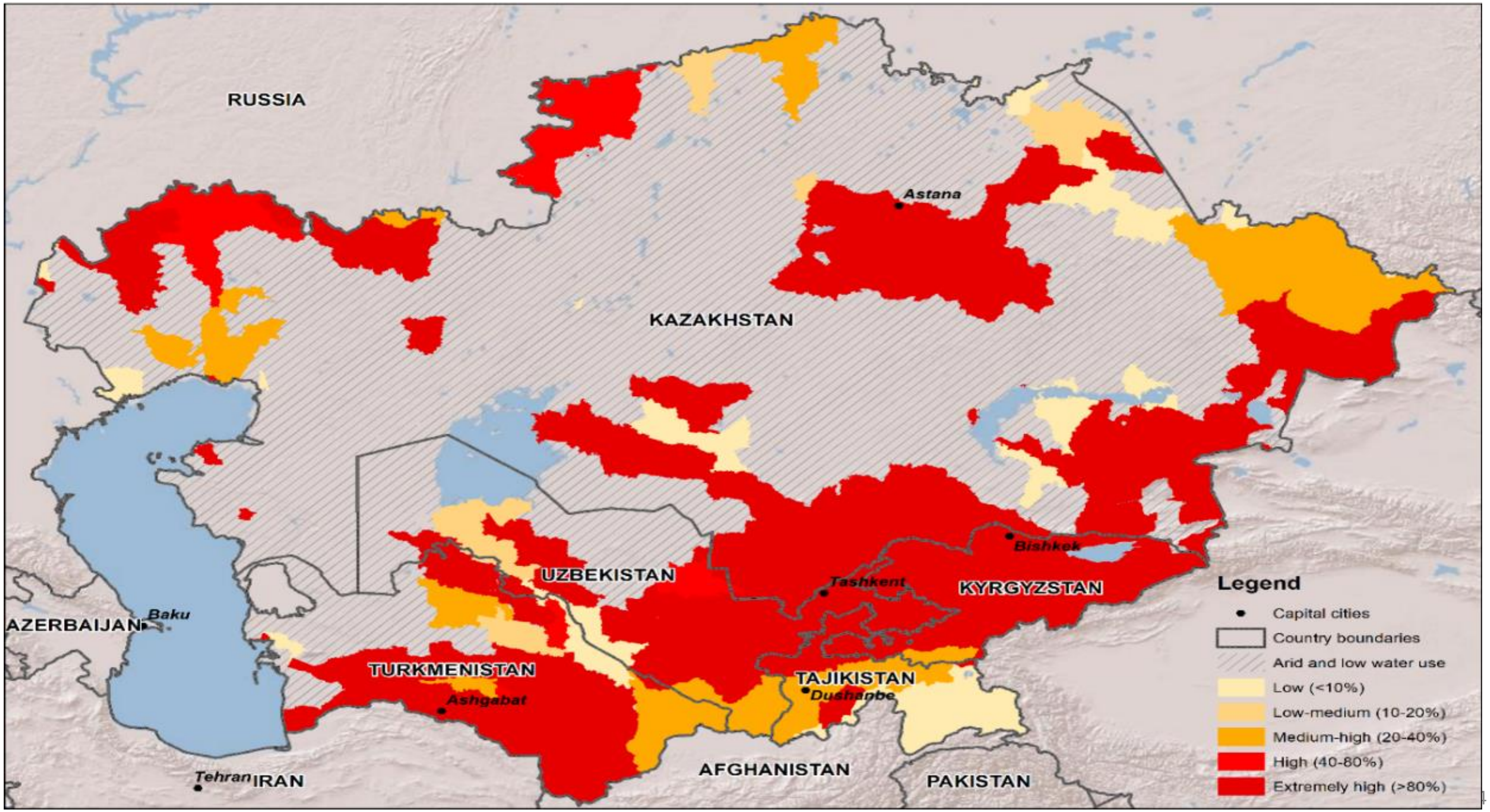
2

Current Water Risk Levels in Central Asian countries (Source: WRI)



3

Projected change in water stress levels in Central Asian countries by 2030 (Source: WRI)



← Contents

Competition for water is increasing in different sectors

Climate change Impact

Why WEFE nexus concept important in transboundary river management context?

- ✓ The perfect storm of competition between water-energy-food as they interact with environment and the climate is perfectly illustrate Aral Sea Basin case;

- ✓ The lack of systems approaches in the past resulted serious environmental degradation and social consequences in the region – Aral Sea disaster;

- ✓ WEF nexus helps to identify and manage trade-offs and to build synergies, allowing for more integrated and cost-effective planning and decision making in Transboundary water management

- ✓ In Central Asia, however, the nexus between water-energy-food has not received adequate attention, with few studies that have been conducted falling short of quantifying nexus tradeoffs and benefits at a practical, small scale (Djumaboev et al. 2019)

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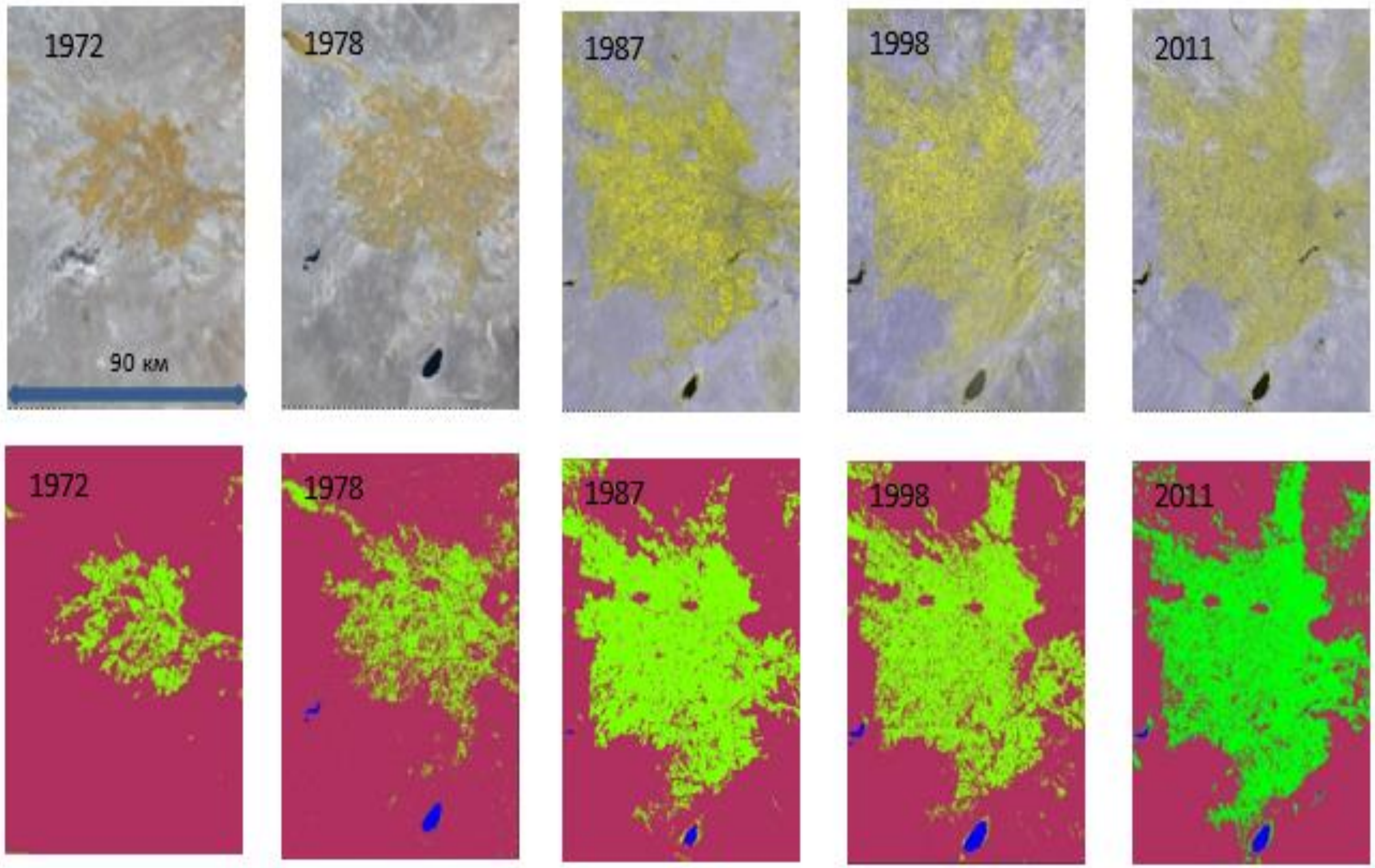
Expansion of Irrigated area in Karshi steppe

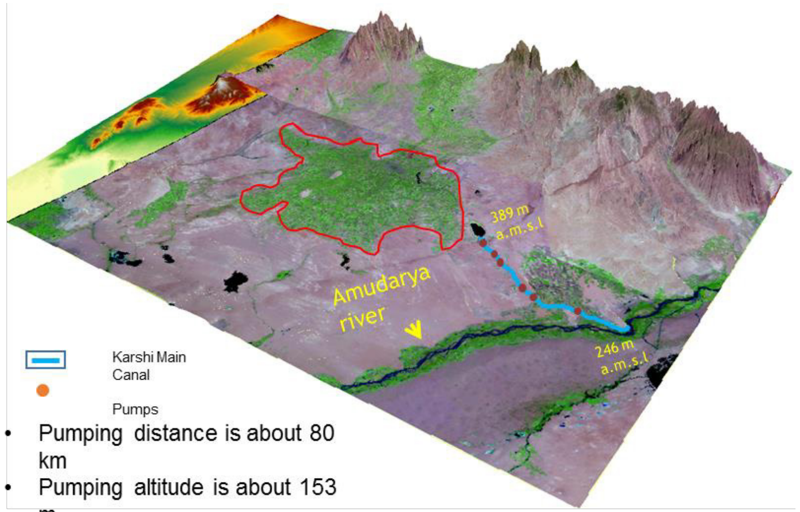


Estimated by IWMI

7

Water Resources Management Challenges in Central Asia

- ✓ Population growth along with emerging climate change has resulted in rising demand for **water**, **energy**, and **food** production;
- ✓ According to climate scenarios, Amu Darya river flow might be reduced 15% and Syr Darya 10% by 2050;
- ✓ Farmers use conventional irrigation practices that lead to excess drainage water runoff;
- ✓ Inefficient irrigation practices have led to water losses and caused excessive consumption of energy by outdated pumps.



- Pumping distance is about 80 km
- Pumping altitude is about 153 m
- Irrigated area is about 335,000 ha

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Return flow back to water bodies from lift irrigation scheme

Source: Avezmuradov (2018)

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Application of WEF nexus in the lift irrigated areas of Amu Darya

Project objectives:

- ✓ Create a spatial data base for estimating the sub-basin water and energy use efficiency using a combination of archival data collection, field data collection, and RS/GIS methods;
- ✓ Document best practices of farmers on water and land management implemented in in the region;
- ✓ Assess the potential impact of improvements in the water use efficiency and energy use intensity through development of different scenarios;
- ✓ Prepare key recommendations for policy makers to improve existing water and energy management strategies on water use in transboundary rivers.

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Water and Energy use in Karshi steppe of Amu Darya River Basin

Crop	Total pumped area, ha	Irrigation application, mm		Total water use, MCM		Total water saving, MCM	Electricity consumption, GWh		Total energy saving, GWh	GHG emissions, Kton		CO_2 reduction, Kton of GHGs
		Current	Improved irrigation practices	Current	Improved irrigation practices		Current	Improved irrigation practices		Current	Improved irrigation practices	
Wheat	102600	1011	587	1037	602	**435**	468	272	**196**	219	127	**92**
Cotton	119681	765	648	916	776	**140**	413	350	**63**	194	164	**30**
Total	222281	N/A	N/A	1953	1378	**575**	880	621	**259**	413	291	**122**

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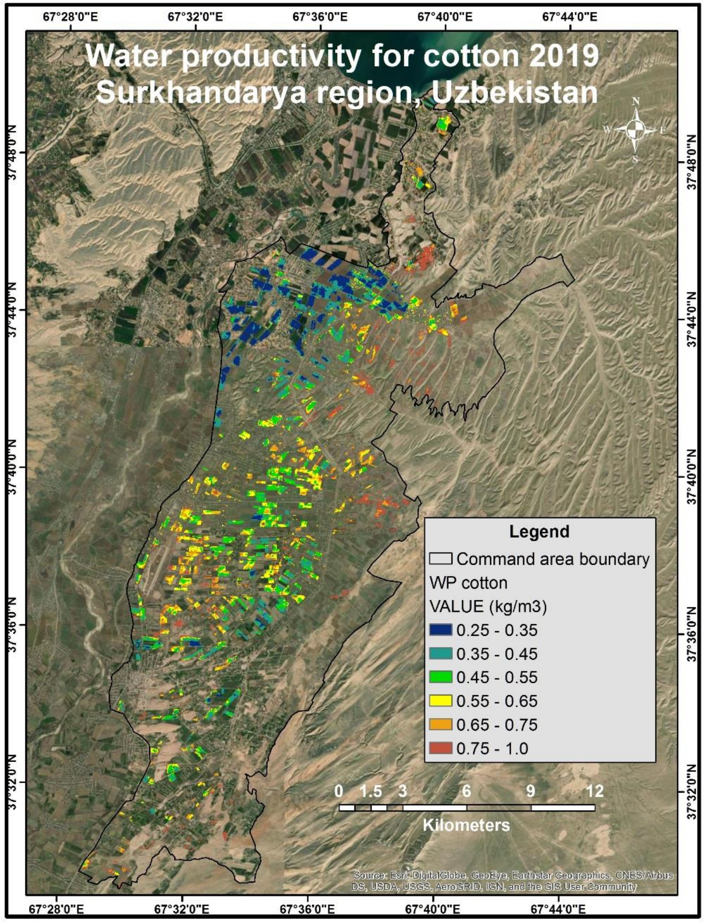
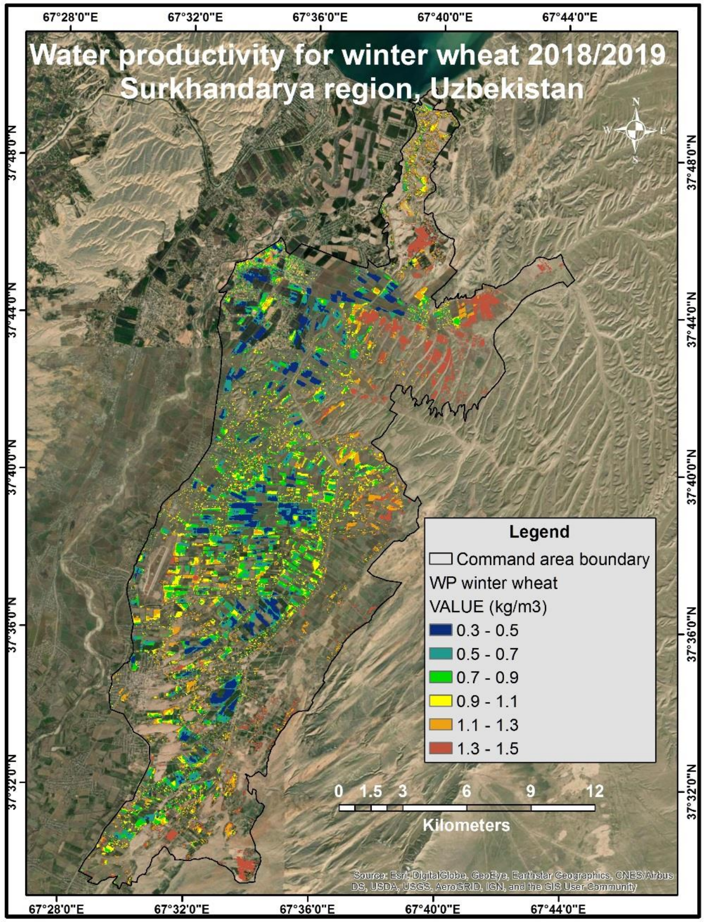
Water productivity, Uzbekistan





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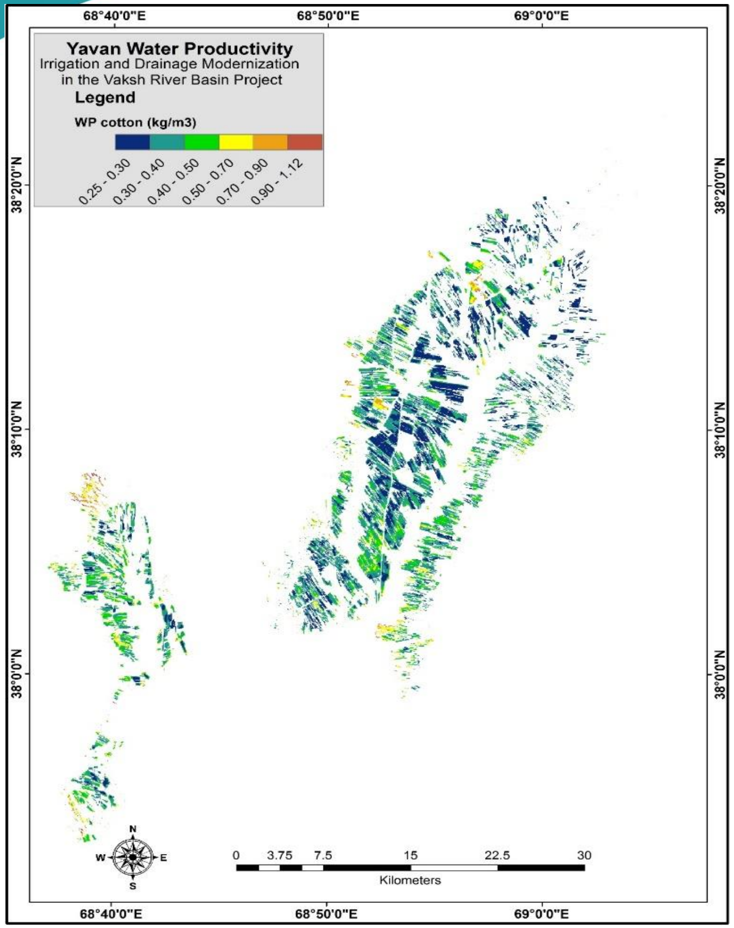
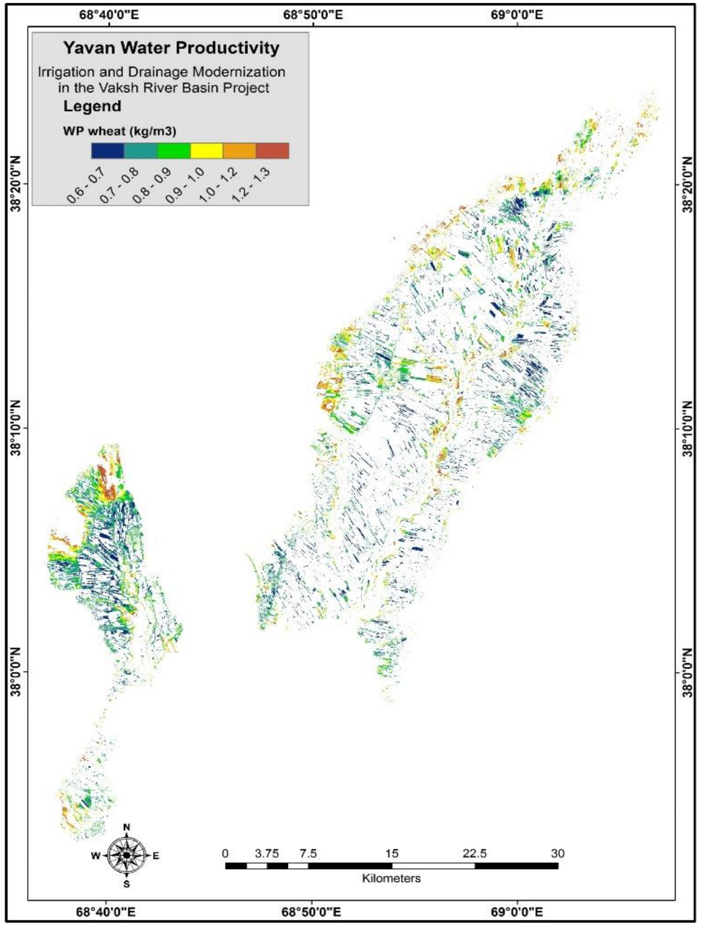
Water productivity, Tajikistan





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Project outcomes highlighted in social media

- ✓ A researcher journey to conserve water in Uzbekistan. https://usaidcentralasia.exposure.co/a-researchers-journey-to-conserve-water-in-uzbekistan?source=share-USAIDCentralAsia

- ✓ Research shifts policy from energy subsidy to water savings in Uzbekistan's irrigated heartland. https://wle.cgiar.org/news/research-shifts-policy-energy-subsidy-water-savings-uzbekistans-irrigated-heartland

- ✓ WEF Nexus, Water Productivity and Water Accounting. https://events.development.asia/learning-events/wef-nexus-water-productivity-and-water-accounting

- ✓ The Vital Resource: Water Management in Central Asia. https://www.caspianpolicy.org/the-vital-resource-water-management-in-central-asia/

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Conclusions and Policy recommendations

- ✓ Current government policies on energy subsidy in the lift irrigated areas do not support water and energy savings. Therefore, if the government shifts subsidies from energy to water-saving technologies, it will reduce water and energy consumption in agricultural sector and mitigate competition for water and energy use at national and transboundary level;

- ✓ In addition, basin wide water productivity will be improved, return flow and CO2 emissions will be reduced and hence, the environment is protected;

- ✓ There is a need to introduce platforms to discuss the WEF nexus related issues in order to improve inter-sectoral cooperation, existing policies, strategies on transboundary water management in the Aral Sea Basin.

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Policy Uptake in Uzbekistan

- The results demonstrated multi-benefits of promoting new irrigation technologies in lift irrigated areas that were communicated to stakeholders from the presidential administration and the Ministries of Water Resources and Economy in Uzbekistan;

- The government has adopted a strategy to expand drip irrigation areas by up to 253,381 ha during 2019-2022, which will cover farmers' ~50% of drip irrigation installation costs and exempt them from land tax for five years;

- Our key recommendations helped government officials in Uzbekistan to expand the program target on water saving technologies including drip irrigation, sprinkler irrigation and laser levelling up to 450,000 ha in 2021. This program came into effect on December 11, 2020 through a Presidential resolution;

- The project interventions have led to the improvement of water use efficiency in transboundary rivers in Central Asia.

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Management Institute
Thank you for your attention
Contact details:
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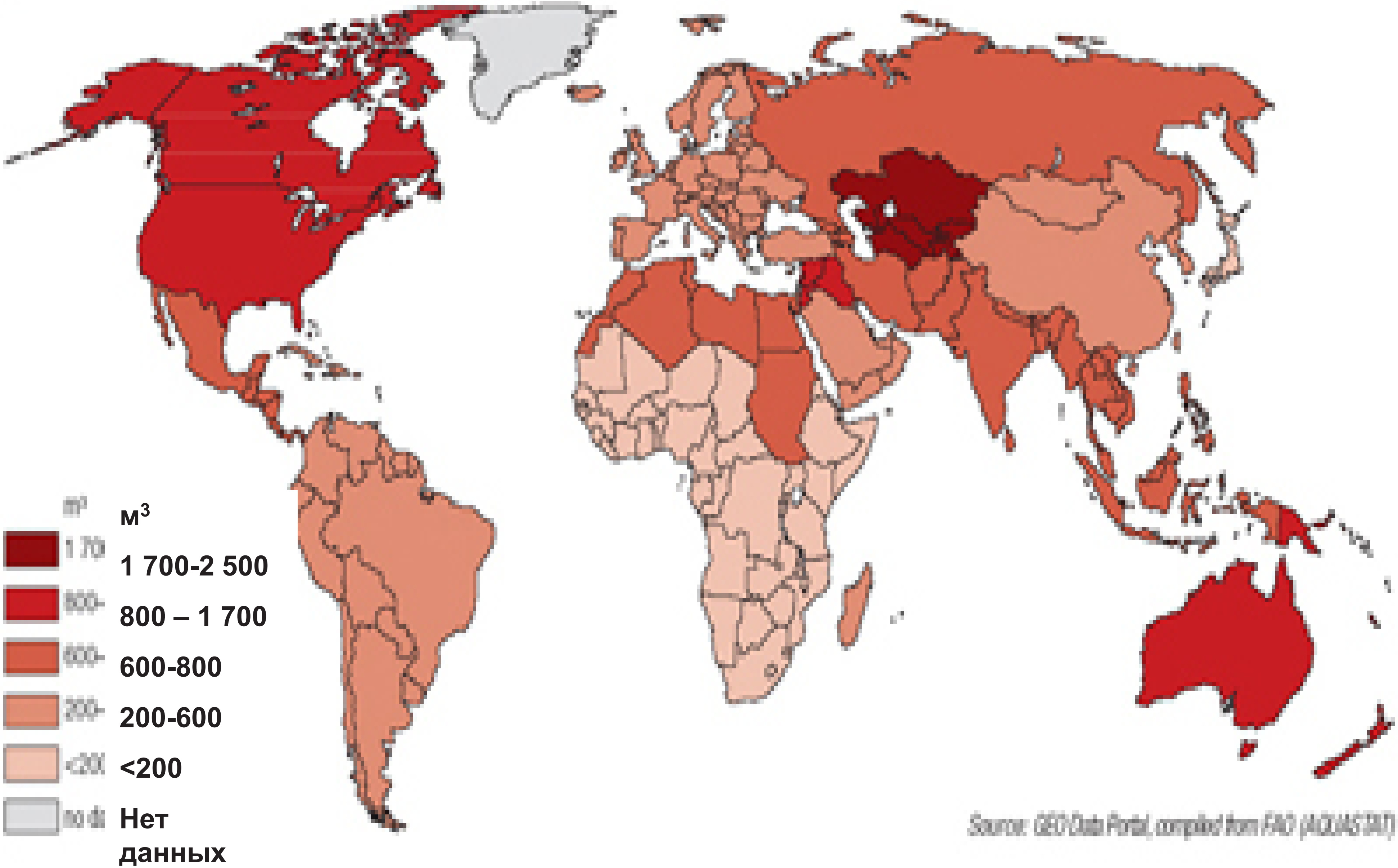
Apartment 120, Tashkent 100000, Uzbekistan
Tel: +99871-2370445
Innovative water solutions for sustainable development
Food · Climate · Growth

PULATOV Yarash Ergashevich - Head of the Department of the Institute of water problems, hydropower and ecology of the National Academy of Sciences of Tajikistan, Chairman of the Water Partnership of Tajikistan, Member of the Russian Academy of Sciences, Honored Worker of Science and Technology of the RAE, Doctor of Agricultural Sciences, Professor

WEF AND ECOSYSTEMS NEXUS IN SYRDARYA RIVER BASIN

(August 25, 2023, Tashkent)

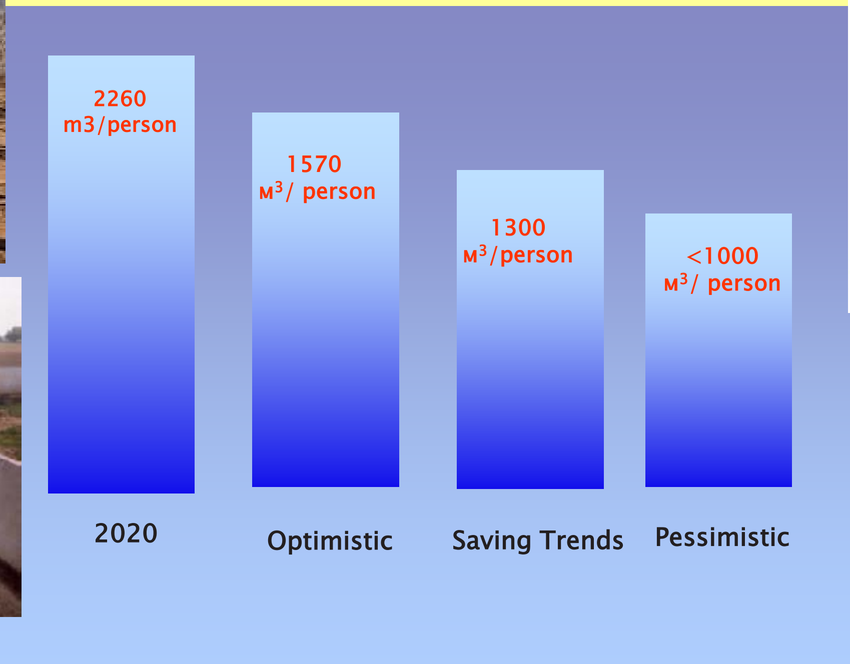
Water consumption per capita (m3) by region in 2020

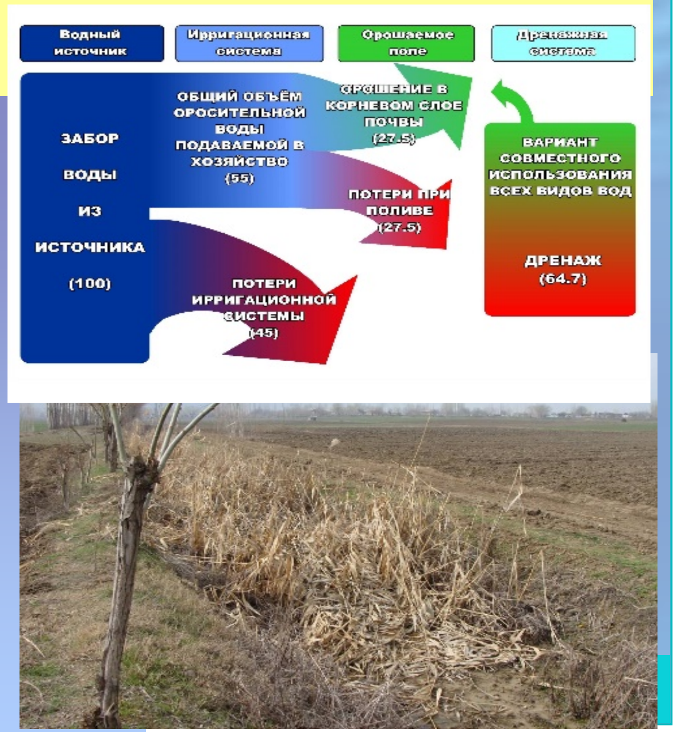


What awaits us in 2030-2050 ???

Expected deficit:

- ❖ Climate change -1.5-3 km3;
- ❖ Demogr. population growth -2.5% - 3 km3;);
- ❖ Urbanization -1-1.5 km3;
- ❖ Deterioration of infrastructure (up to 60%) and losses - 50%;
- ❖ Socio-economic progress in three countries - 2.5 km3;
- ❖ Reduction of glaciers and degradation - 1% annually;
- ❖ Increasing water withdrawal (Afghanistan) (Amu Darya basin);
- ❖ **TOTAL for an average year - 8-11 km3**





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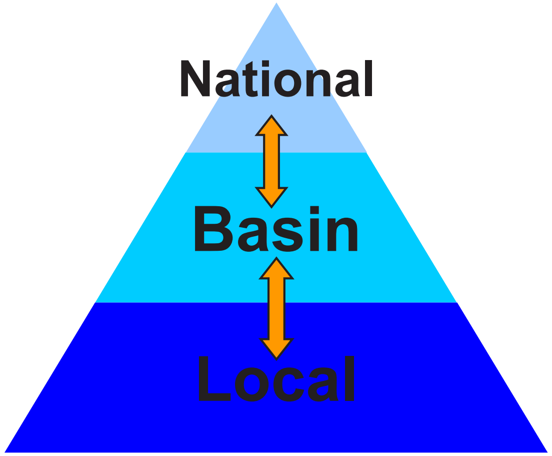
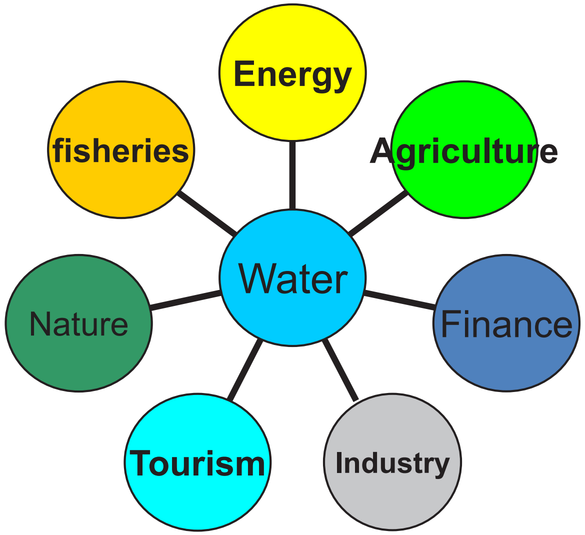
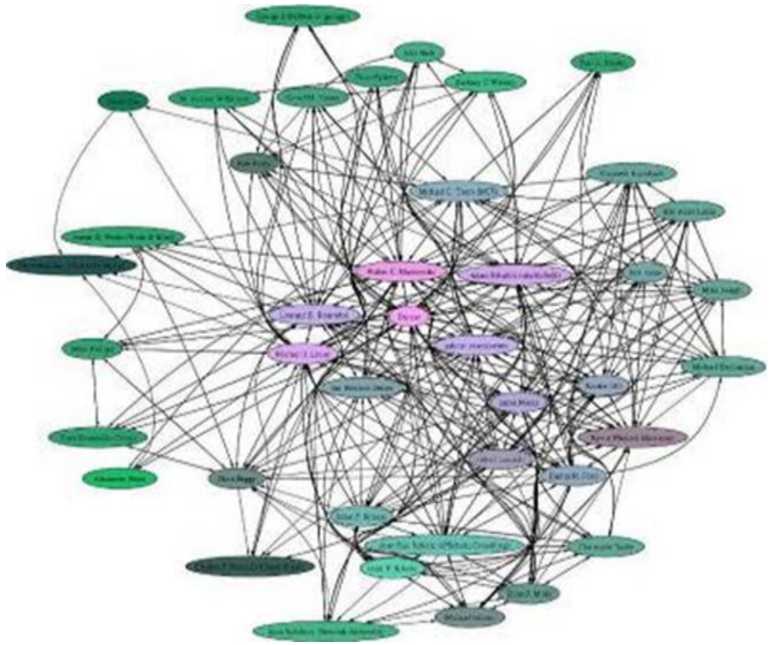
Basis for integration







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WATER SAVING IS A PRIORITY

- Water saving and RWR - a national priority (strategies, concepts, programs);
- Objectives of the International Decade for Action "Water for Sustainable Development, 2018-2028". (Resolution of the UN General Assembly of December 21, 2016);
- "Paris Agreement" (21st session of the Conference of the Parties to the United Nations Framework Convention on CC, December 12, 2015) - V and RWR as adaptation measures to COI;
- SDGs (17 goals and 169 indicators) adopted by all UN Member States in 2015. SDG-2: "Zero hunger, ensure food security, improve nutrition and promote sustainable agricultural development." SDG-6: “Ensure availability and REWR and sanitation for all”;
- Water saving, RWRM and careful attitude to water resources are the main principles of IWRM;
- “The program of reform of the water sector of Tajikistan for the period 2016-2025”, (approved by the Resolution of the GoT of December 30, 2015, No. 791;
- Giving importance to water in the framework of water activities: March 22 - International Water Day; “A drop of water is a grain of gold”, “Water is the basis of life” and others.

CURRENT CHALLENGES AND PRIORITIES:

- Lack of constructive intersectoral cooperation and coordination;
- Lack of incentives to conserve water, especially in the agricultural sector;
- Imperfect legislation, normative legal acts for the implementation of the Water Code of the Republic of Tajikistan and other adopted water laws have not been developed;
- Inadequate compliance with ecosystem protection requirements;
- Imperfection of supply and demand management mechanisms;
- The existence of intersectoral contradictions (irrigation and hydropower, ecology and economics, management and leadership, etc.);
- Lack of optimal models for the management, use and protection of water resources based on an integrated approach;
- Outdated water consumption norms and water allocation criteria, lack of national water quality standards;
- Provision of the rural population with drinking water supply and sewerage systems is very unsatisfactory (low). The existing drinking water supply and sewerage infrastructure is significantly worn out;

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CURRENT CHALLENGES AND PRIORITIES:

- Problems of ensuring the needs of ecosystems in water;
- Problems of natural disasters: droughts, mudflows, floods, floods, floods, soil erosion;
- Insufficiency of financing of the water sector and imperfection of the economic mechanism of water use;
- The need to take measures to ensure the country's water and energy security;
- Ensuring food security, reducing poverty, switching to intensive methods of agricultural development;
- The need to develop optimal regimes for irrigating crops and conducting hydromodule zoning of the irrigated territory of the republic in the context of climate change;
- The need to develop and implement innovative water-saving and soil-protective technologies;
- The need to rehabilitate the fixed assets of the water sector infrastructure;

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WATER USE

- **<u>Water intake -17…20%</u>** of the water resources formed on the territory of Tajikistan. For the period **1985-2022**. water withdrawal amounted to **8.0…14.5 km3**/year.
- **<u>Agricultural irrigation sector</u>** - provides **80%** of agricultural production and **uses 8.0-10.0 km3/year or 90%** of the total water withdrawal;
- **<u>Sector of domestic and drinking water supply and sanitation</u>** - **400** million m3/year, including **103-105 million** m3 used by the population of Tajikistan (**5.0%**).
- **<u>Hydropower sector.</u>** The annual electricity generation **is 16-17 billion kWh**. hours and for this, an average of **30-35 km3** of water passes through the hydro turbines of the HPP;
- **<u>Industry sector. Water consumption</u>** - **240-300 million m3** or its share in the structure of water consumption is **2-3%.**
- **<u>Sector - fisheries</u>** - **90-100 million m3** of water, their share in the structure of water consumption is **0.8-1.5%;**
- ***Sector - recreation*** on the waters. - **162** natural water monuments, more than **200** minerals are registered. springs, **18** mud and salt lakes;
- **<u>The sector is the environment</u>**. - There is no account.




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WATER USE


БАССЕЙНЫ РЕК И ОРОСИТЕЛЬНЫЕ СИСТЕМЫ ТАДЖИКИСТАНА
Условные обозначения
Бассейны и подбассейны рек:
Сырдарья
Зарафшан
Кофарнихон
Каратаг
Вахш
Пяндж
Оросительные системы:
1 Аштская
2 Матчинская
3 Исфаринская
4 Ходжабакирганская
5 Самгарская
6 Зафарабад-Кизилинская
7 Каттасайская (Басманда-Даганасайская)
8 Зерафшанская
9 Гиссарская
10 Верхне-Кафернинганская
11 Нижне-Кафернинганская
12 Верхне-Вахшская
13 Дангаринская
14 Явано-Обикиикская
15 Вахшская
16 Пянджская
17 Фархор-Чубекская
18 Кызылсу-Яхсуйская (Кулябская)
19 Верхне-Пянджская
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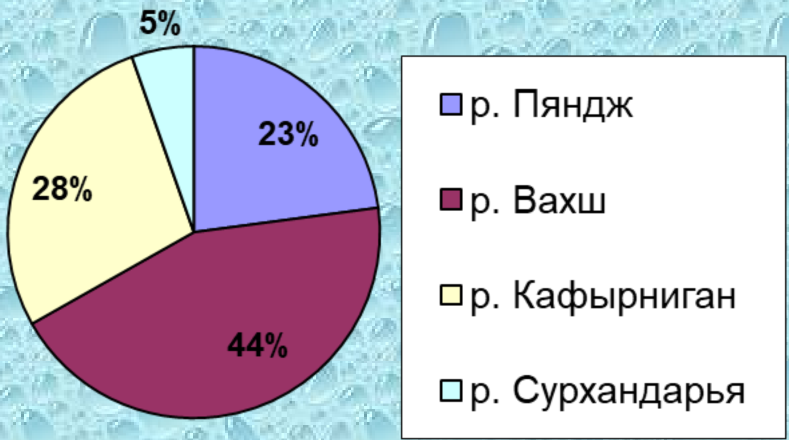
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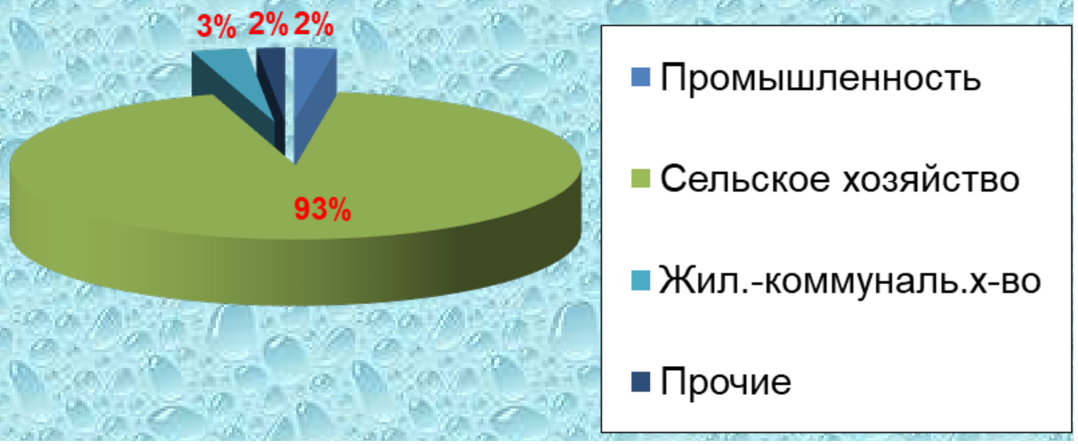
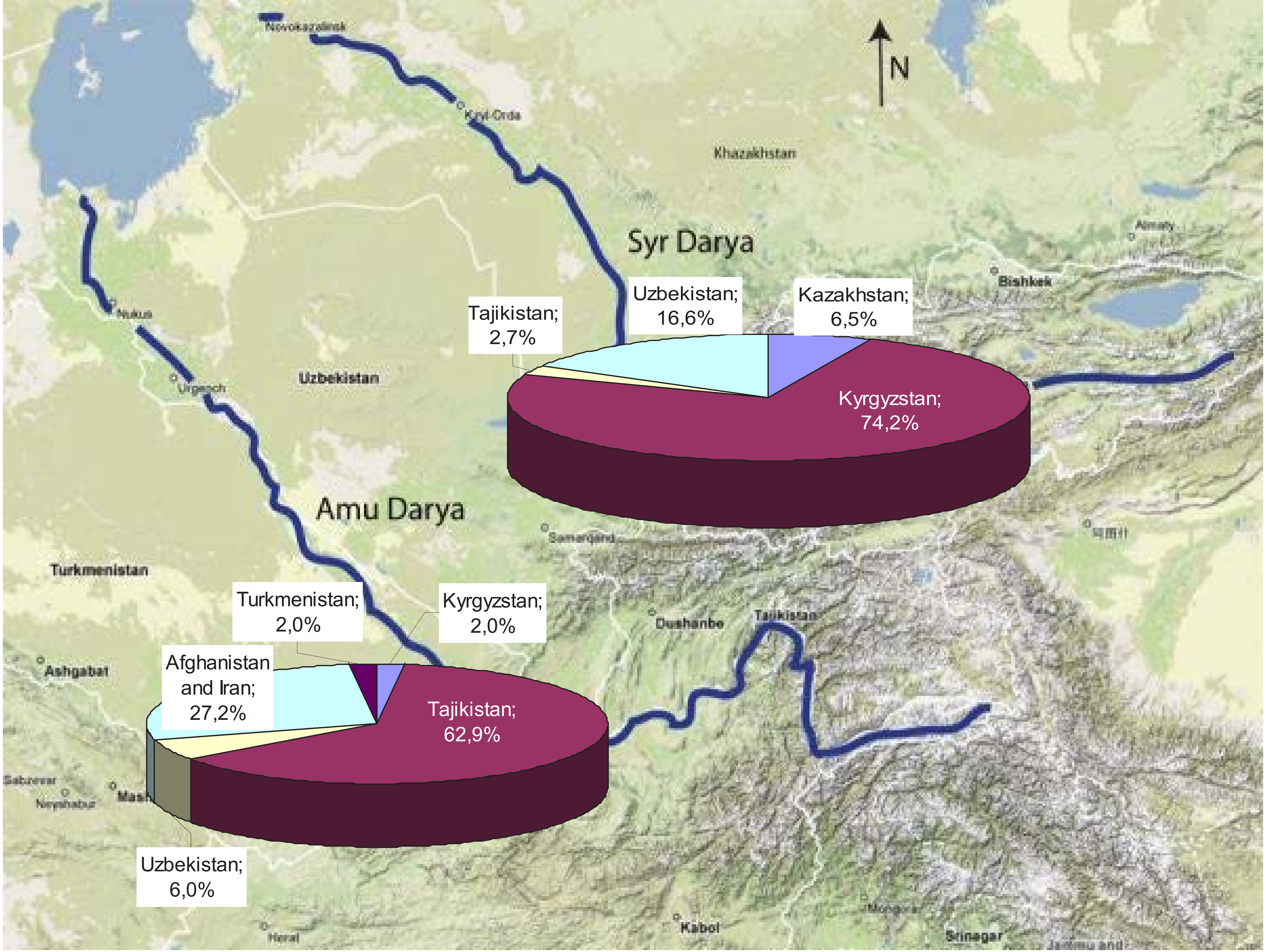
44%
р. Пяндж
р. Вахш
р. Кафырниган
р. Сурхандарья


3%
2%
2%
93%
Промышленность
Сельское хозяйство
Жил.-коммуналь.х-во
Прочие

Basin of the Syrdarya River


N
Novokazalinsk
Kzyl-Orda
Khazakhstan
Syr Darya
Almaty
Bishkek
Uzbekistan; 16,6%
Kazakhstan; 6,5%
Tajikistan; 2,7%
Kyrgyzstan; 74,2%
Nukus
Urgench
Uzbekistan
Amu Darya
Samarqand
Turkmenistan
Turkmenistan; 2,0%
Kyrgyzstan; 2,0%
Dushanbe
Tajikistan
Ashgabat
Afghanistan and Iran; 27,2%
Tajikistan; 62,9%
Sabzevar
Neyshabur
Uzbekistan; 6,0%
Herat
Kabol
Srinagar

Dependence of riparian countries on the resources of the Syrdarya river basin (all data in % of country data)

Relationship indicators	Kazakhstan	Kyrgyzstan	Tajikistan	Uzbekistan
Share of territory in the basin	12,7	55,3	11,0	13,5
Share of population in the basin	20,0	56,6	28,6	51,4
Share of surface water in the basin*	13,3	24,1	6,7	36,5
Share of agricultural land in the basin	61,66	44,64	38,85	51,14
Share of hydropower generated in the basin	3,34	98,56	3,09	87,62
Share of thermal energy produced in the basin	9,03	0,00	0,00	87,14

Main indicators of the basin

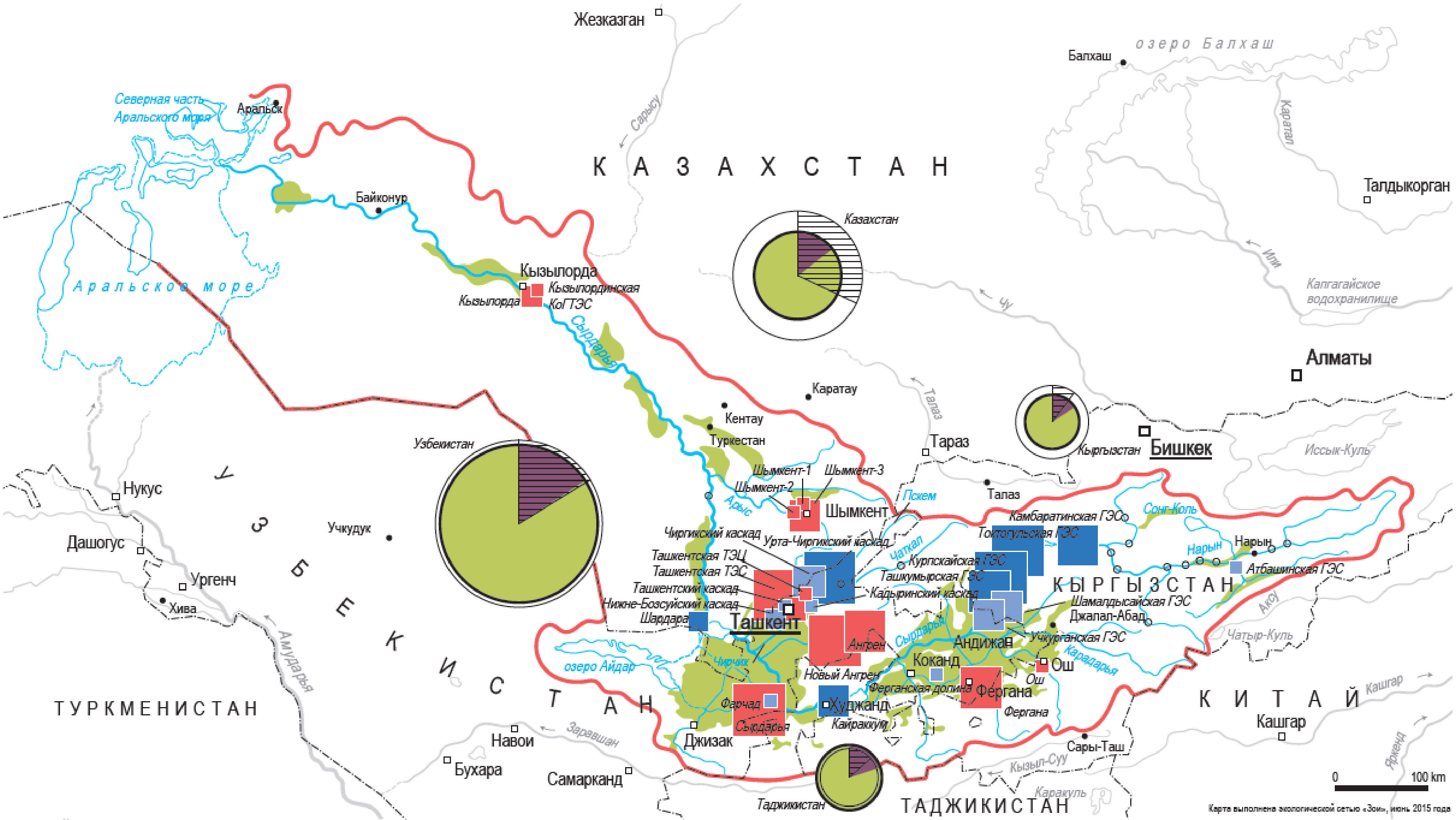
БАССЕЙН СЫРДАРЬИ

Протяженность реки 3,019 км

Площадь речного бассейна 410,000 км²

	КЫРГЫЗСТАН	ТАДЖИКИСТАН	УЗБЕКИСТАН	КАЗАХСТАН
ВНУТРЕННИЕ ВОЗОБНОВЛЯЕМЫЕ ВОДНЫЕ РЕСУРСЫ На национальном уровне, млн. м³/год	48,930	21,910	48,870	108,400
Бассейн Сырдарьи	28,500	2,000	12,000	5,400
ВОДОЗАБОР	8,000 million m³ (2006)	11,500 (2006)	56,000 (2005)	21,100 (2010)
Сельское хозяйство	93 %	91 %	90 %	66 %
Промышленность	4 %	3 %	3 %	30 %
Жилищно-коммунальное хозяйство	3 %	6 %	7 %	4 %
Бассейн Сырдарьи	2,700 (2013)	3,900	22,700	6,900
УСТАНОВЛЕННАЯ ЭЛЕКТРИЧЕСКАЯ ГЕНЕРИРУЮЩАЯ МОЩНОСТЬ	3.8 млн. кВт	5.1 млн. кВт	12.6 млн. кВт	17.8 млн. кВт
ГЭС	3.0 (79 %)	4.7 (92 %)	1.7 (14 %)	2.3 (13 %)
Ископаемое топливо	0.8 (21 %)	0.4 (8 %)	10.8 (86 %)	15.6 (87 %)
СЕЛЬСКОХОЗЯЙСТВЕННЫЕ ЗЕМЛИ	105,900 км² (2012)	48,750 км²	266,900 км²	2,079,800 км²
из которых пригодны к орошению	21 %	32 %	18 %	2 %

Поверхностный, подземный и возвратный сток, 1999



БАССЕЙН СЫРДАРЬИ

Электроэнергетические объекты

- Тепловая электростанция (уголь/нефтепродукты/газ)
- Гидроэлектростанция с водохранилищем
- Русловая гидроэлектростанция
- Планируемые гидроэлектростанции

Установленная мощность (МВт)

- > 500 МВт
- 250 - 500 МВт
- 100 - 250 МВт
- 50 - 100 МВт
- < 50 МВт

Водозабор

2013: Сельское хозяйство; Коммунальное снабжение

1984: Сельское хозяйство; Коммунальное снабжение

20 000 млн. м³

10 000

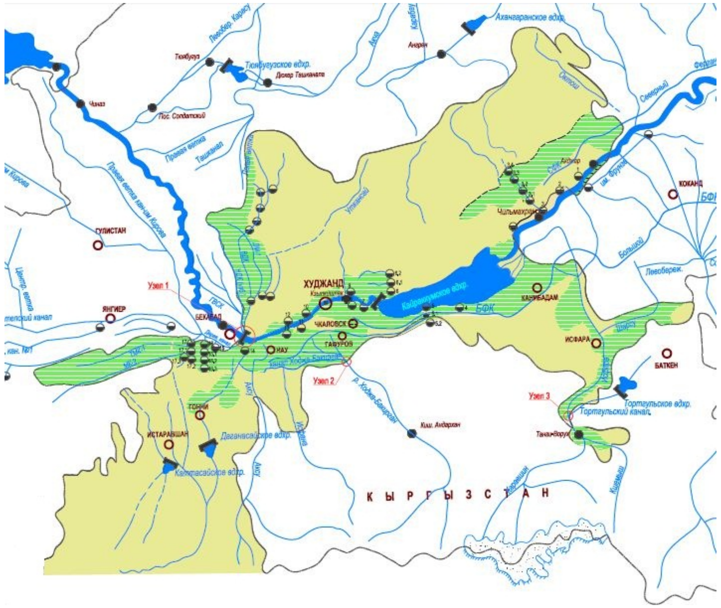
5 000

2 500

Орошаемые площади

Источники: Central Asia Regional Economic Cooperation: Power Sector Regional Master Plan, Asian Development Bank (ADB), 2012 (http://www.adb.org/sites/default/files/project-document/74195/43549-012-reg-tacr-01.pdf); Global Map of Irrigation Areas, University Bonn, FAO (http://www.fao.org/nr/water/aquastat/irrigationmap/index10.stm); Схема комплексного использования и охраны водных ресурсов бассейна реки Сырдарьи, утвержденная Протоколом № 413 (29 февраля 1984 года) Научно-технического совета Министерства водного хозяйства СССР; База данных CAWATER-info, НИЦ МКВК, 2013 год. Данные, полученные от национальных водохозяйственных органов и агрегированные по областям бассейна реки Сырдарьи.

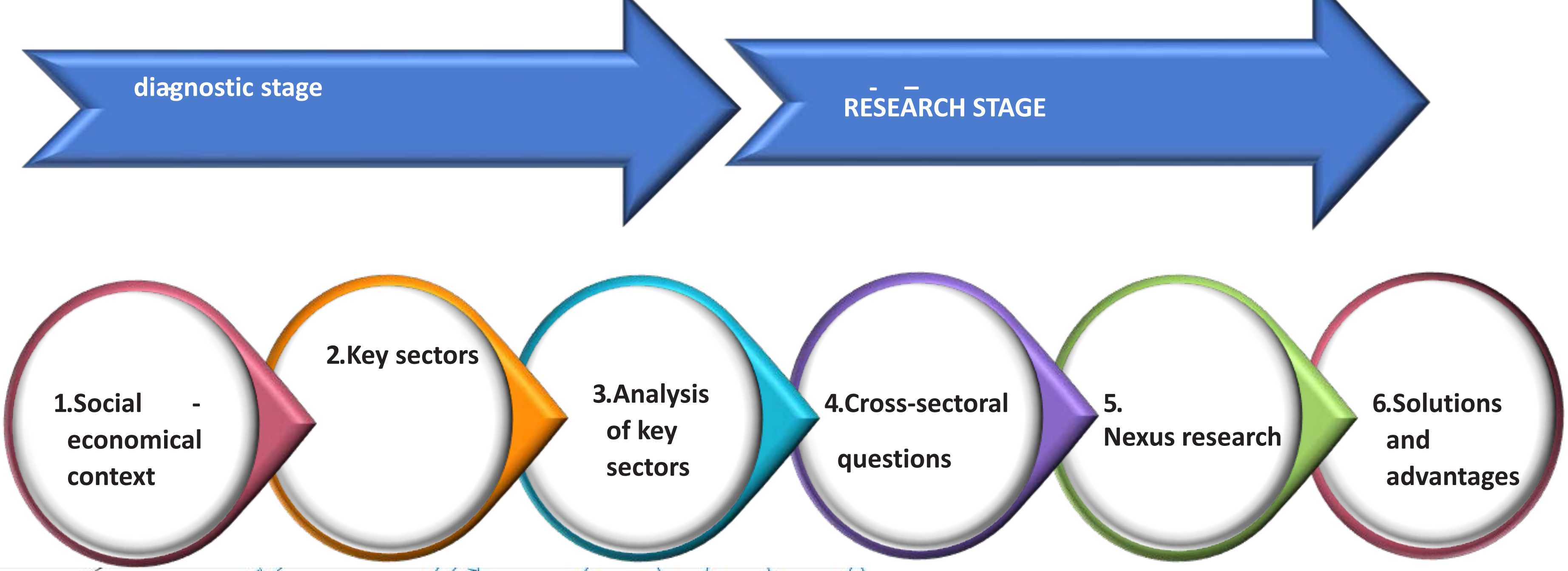
Tajik part of the river basin. Syrdarya: GENERAL INFORMATION

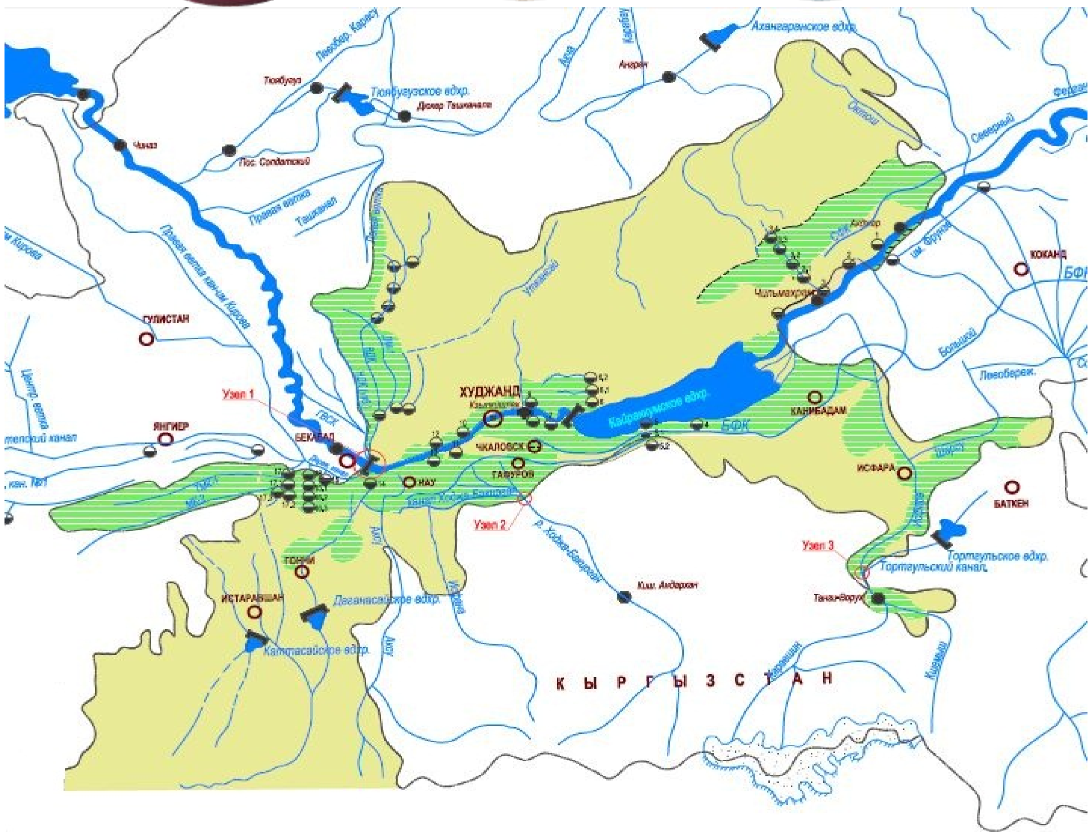


Legal basis for water allocation in the basin R. Syrdarya
1984 Protocol No. 413 of the meeting of the Scientific and Technical Council of the Ministry of Water Resources of the USSR agreed by all coastal republics of the river basin. Syr Darya
1992 Agreement between the Governments of the countries of Central Asia "On cooperation in the field of joint management of the use and protection of water resources of interstate sources" (Almaty, February 18, 1992)
1995 Nukus Declaration of Central Asian States and International Organizations

Indicators	Quantity
Catchment area:	12,67 ths. m2
river length, Taj. Part:	105 km.
Irrigated lands:	About 259 thousand hectares
The average long-term runoff is formed in Tajikistan:	1.1 billion m3
Major tributaries, Taj. Part:	R. Isfara, Khodjabakirgan, Isfana, Aksu
Water intake limit: a) from the trunk R. Naryn-Syrdarya b) from underground and return waters	1.81 km3, 1.2 km3,
Population:	2.0 million people
economic Meaning:	Water supply, Hydropower, Irrigation, Recreation

← Contents





- ЕЭК UN «NEXUS» (2014-2015гг.);
- GWP: «Water, climate and development» (WACDEP) (2013-2015гг.);
- "National Consultations on the Post-2015 Development Agenda" within the framework of UN-WATER" (2014); and the Fourth National Communication of the Republic of Tajikistan on the UN Framework Convention on Climate Change (2014, 2022);
- NEXUS-Zerafshan (2018-2022).

Tajik part of the river basin. Syrdarya: GENERAL INFORMATION

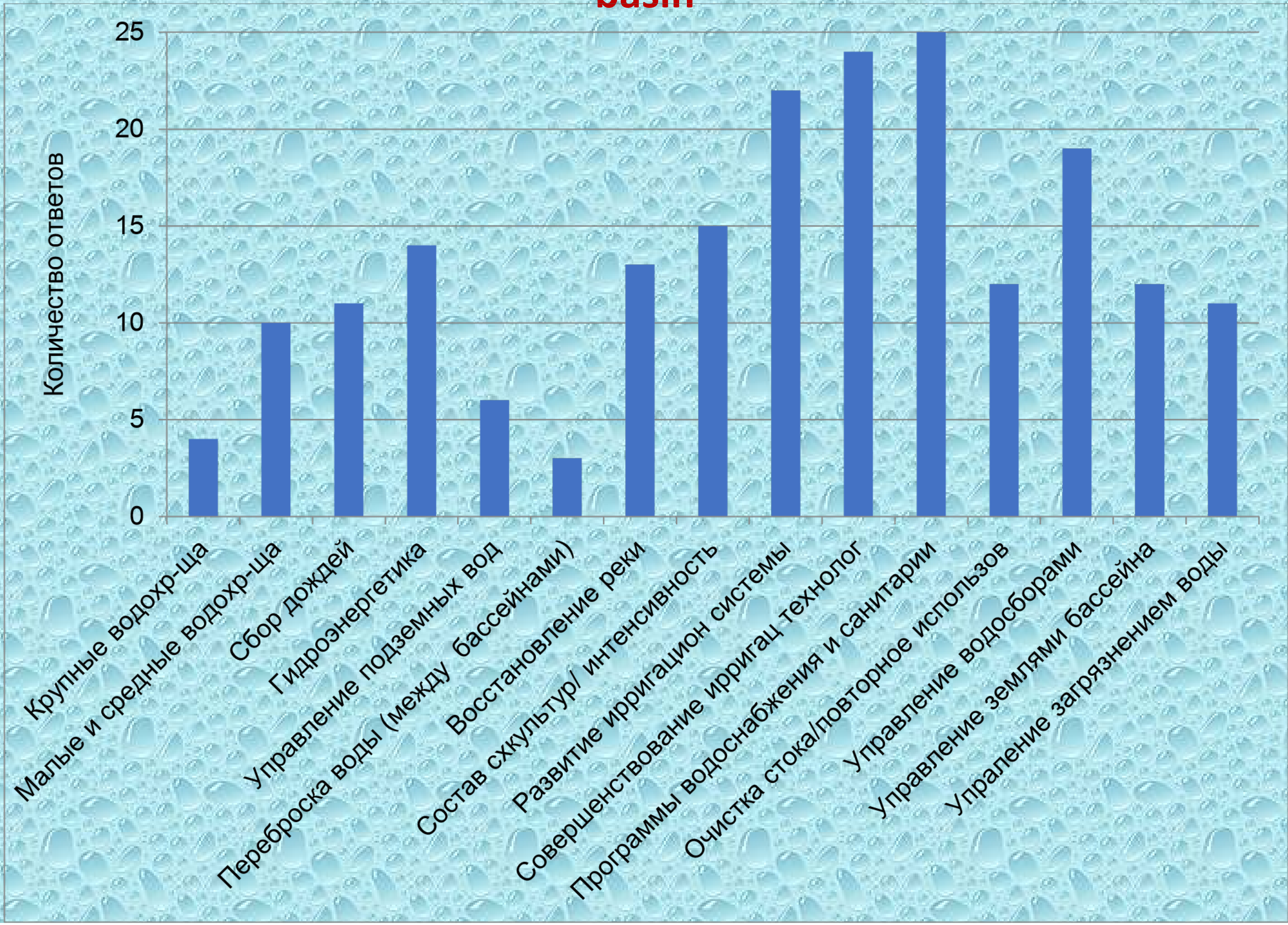
Water use by different sectors	
Drinking water supply and sanitation	2-3%
Industry	3%
Fisheries	1%
Irrigation	89-93
hydropower	Not a consumer

On the territory of the river basin. The Syrdarya is located in the Sughd region of the Republic of Tajikistan, which includes 14 districts (of which 11 are located in the Syrdarya river basin) and 8 cities.

Name of the unit of administrative-territorial division		
Aini district (bass river Zeravshan)	Aini district (bass river Zeravshan)	Gorno-Matchinsky district (bass river Zeravshan)
Asht region	Zafarabad region	Penjikent region (bass river Zeravshan)
Gafurovsky district	Istarafshansky district	Spitamensky district
Ganchinsky district	Isfara region	Shahristan region
Mastchinsky district	Kanibadam district	

← Contents

Stakeholder proposals for solving the main water issues in the basin



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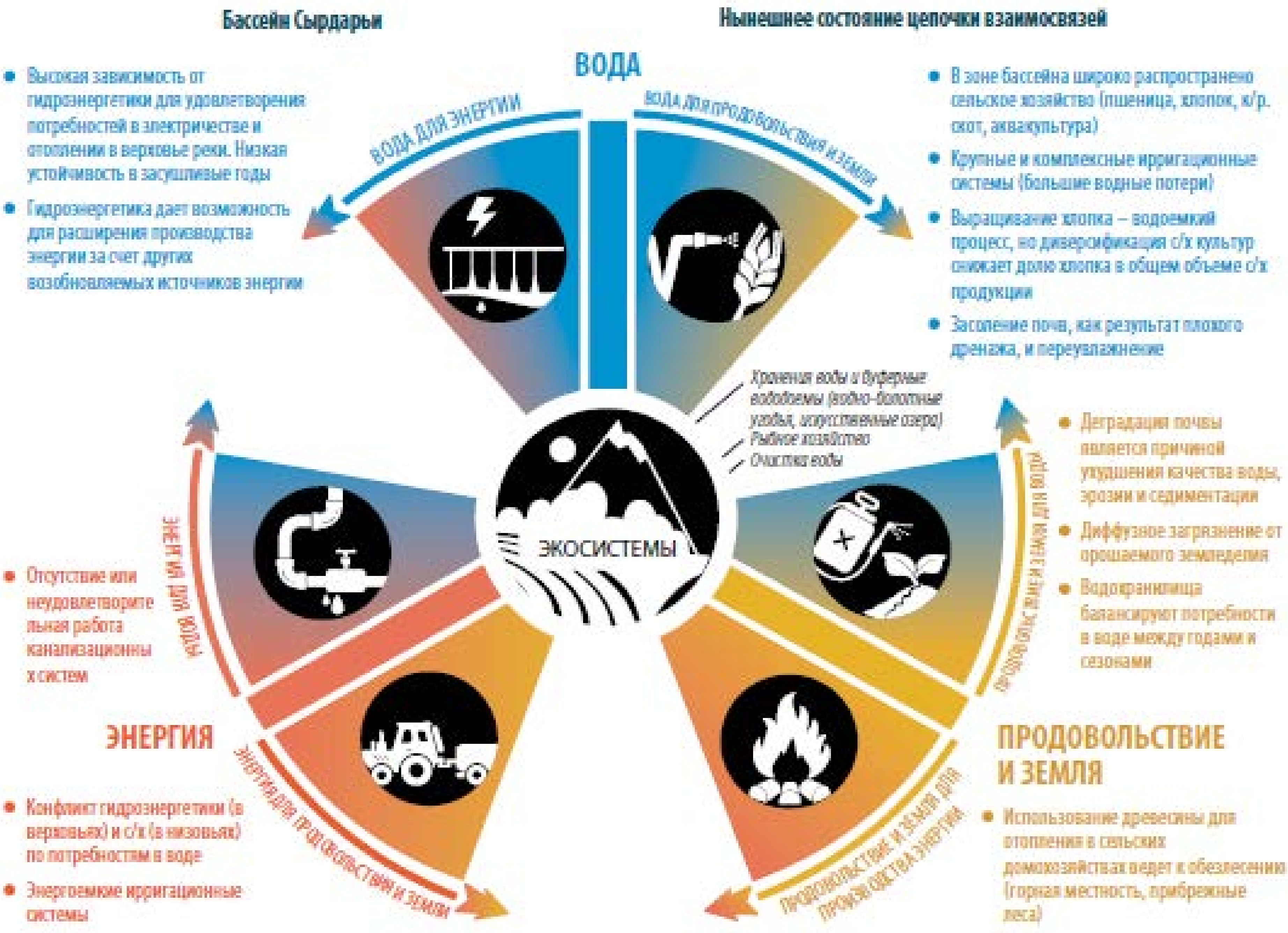
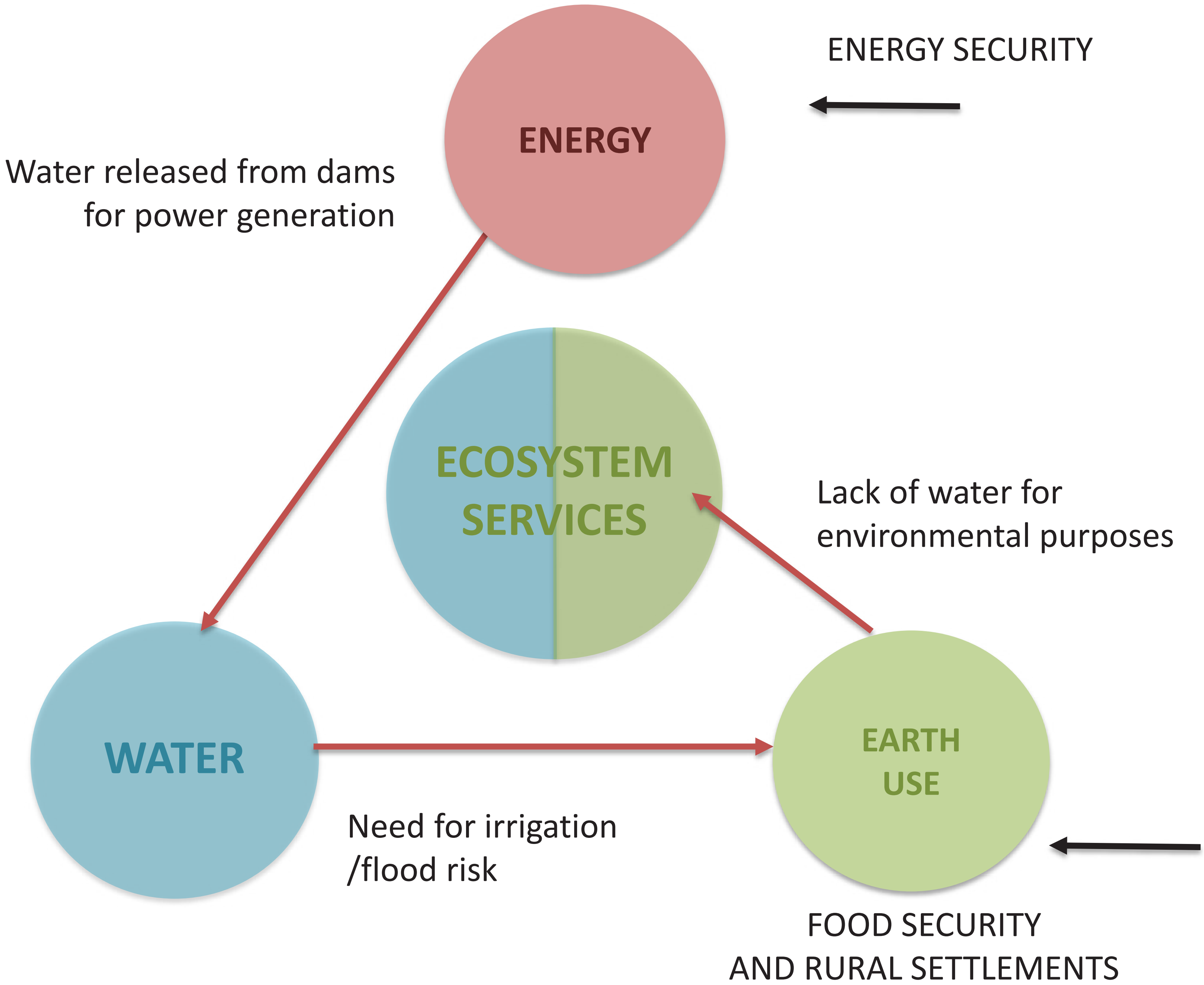
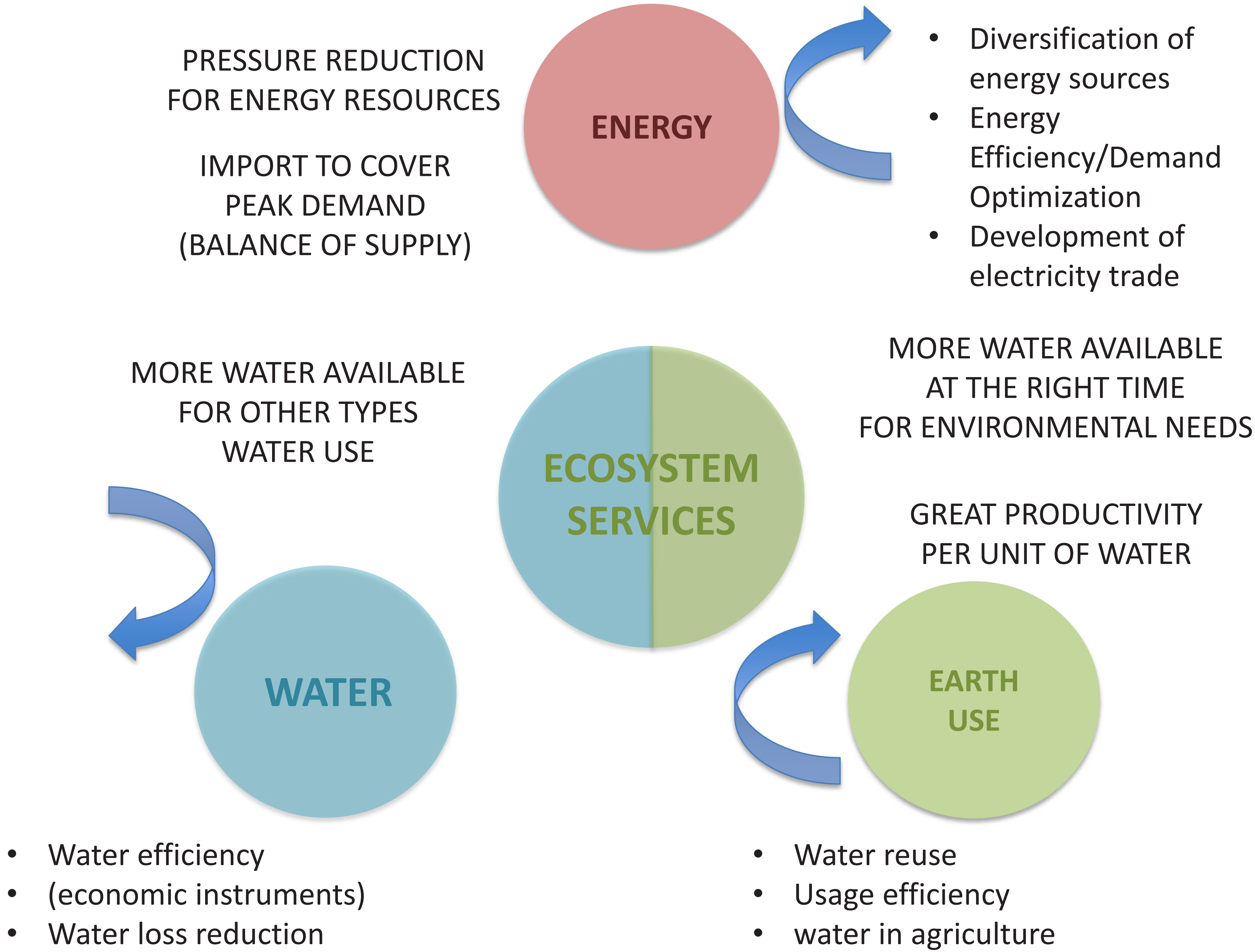

Бассейн Сырдарьи
Нынешнее состояние цепочки взаимосвязей
ВОДА
Вода для энергии
Вода для продовольствия и земли
Высокая зависимость от гидроэнергетики для удовлетворения потребностей в электричестве и отоплении в верховье реки. Низкая устойчивость в засушливые годы
Гидроэнергетика дает возможность для расширения производства энергии за счет других возобновляемых источников энергии
В зоне бассейна широко распространено сельское хозяйство (пшеница, хлопок, к/р. скот, аквакультура)
Крупные и комплексные ирригационные системы (большие водные потери)
Выращивание хлопка – водоемкий процесс, но диверсификация с/х культур снижает долю хлопка в общем объеме с/х продукции
Засоление почв, как результат плохого дренажа, и переувлажнение
Хранения воды и буферные водоёмы (водно-болотные угодья, искусственные озера)
Рыбное хозяйство
Очистка воды
ЭКОСИСТЕМЫ
Продовольствие и земля для воды
Деградация почвы является причиной ухудшения качества воды, эрозии и седиментации
Диффузное загрязнение от орошаемого земледелия
Водохранилища балансируют потребности в воде между годами и сезонами
Энергия для воды
Отсутствие или неудовлетворительная работа канализационных систем
ЭНЕРГИЯ
Энергия для продовольствия и земли
Конфликт гидроэнергетики (в верховьях) и с/х (в низовьях) по потребностям в воде
Энергоемкие ирригационные системы
ПРОДОВОЛЬСТВИЕ И ЗЕМЛЯ
Продовольствие и земля для производства энергии
Использование древесины для отопления в сельских домохозяйствах ведет к обезлесению (горная местность, прибрежные леса)

Examples. ASSESSMENT OPPORTUNITIES FOR RAIN COUNTRIES

- Reducing M by using WT by 30%, leading to a decrease in the load on pumping stations and a decrease in electricity consumption by 15%, an increase in crop yields by 20%, and a decrease in water loss by up to 50%. This leads to an improvement in the ecological and reclamation state of irrigated lands. The saved water will allow the development of new irrigated lands.
- Reducing investment in the reconstruction of hydroelectric power stations and irrigation systems.
- The transition to green technology, renewable energy sources (wind, solar, etc.) will reduce the conflict between irrigation and hydropower.
- Reducing dependence on hydropower will increase resilience to water scarcity in dry years;
- Energy efficiency measures reduce the need for further investment in energy production;
- Increasing the share of renewable resources will provide rural residents with access to electricity. Use of small hydropower plants and wind energy;
- Economic instruments (tariff diversification, subsidies, tax payments)
- Demand management: incentives to reduce the use of electricity for heating - support for the use of alternative energy sources, insulation - efficiency standards for buildings
- Opportunities for capacity building: Improving water use efficiency.
- Improving the agricultural sector: diversification of crops and the use of crops with less water consumption, organic farming and improved, more efficient irrigation technologies


ENERGY SECURITY
ENERGY
Water released from dams
for power generation
ECOSYSTEM
SERVICES
Lack of water for
environmental purposes
WATER
EARTH
USE
Need for irrigation
/flood risk
FOOD SECURITY
AND RURAL SETTLEMENTS

← Contents


PRESSURE REDUCTION
FOR ENERGY RESOURCES
IMPORT TO COVER
PEAK DEMAND
(BALANCE OF SUPPLY)
ENERGY
• Diversification of energy sources
• Energy Efficiency/Demand Optimization
• Development of electricity trade
MORE WATER AVAILABLE
FOR OTHER TYPES
WATER USE
ECOSYSTEM
SERVICES
MORE WATER AVAILABLE
AT THE RIGHT TIME
FOR ENVIRONMENTAL NEEDS
GREAT PRODUCTIVITY
PER UNIT OF WATER
WATER
EARTH
USE
• Water efficiency
• (economic instruments)
• Water loss reduction
• Water reuse
• Usage efficiency
• water in agriculture

MAIN RESULTS:

- The current situation of management, use and protection of water resources of the BRS was assessed;
- The legal, institutional, economic and environmental foundations of WRM have been analyzed. Identified the main sectors of the economy, and related organizations involved in water resources management. A horizontal and vertical hierarchy has been established, as well as cross-sectoral aspects of WRM in the BRS.
- A recommendation on water-saving innovative irrigation technologies has been developed;
- A review on the formation of water resources (hydrology) of the Syrdarya River has been compiled. Assessed the state of water use and land use in the BRS;
- A database on hydrology, hydropower, agriculture and climatology has been created for the BRS;
- Created maps and diagrams with the characteristics of the BRS;
- The hydrography is described, the characteristics of the water resources of the interstate river Syrzarya and its tributaries are given;
- The indicators of agro-climatic zoning of the territory of Northern Tajikistan have been specified, moisture coefficients have been identified, the moisture supply of crops has been assessed; The BKP of the territory was identified and indicators of water quality were determined;
- The optimal mode of irrigation of agricultural crops has been established. The required amount of water resources for the agricultural sector as the main water consumer in the water sector has been established.

CONCLUSION

- The policy of rational use of water resources as the main water strategy should be adopted by all countries at the national and regional levels in order to overcome the impending water deficit (2035-2040) in the region.
- As the Central Asian countries develop and their sovereignties are strengthened, a number of positions are revealed that require the improvement of existing Agreements and the adoption of new ones. The international legal status of interstate water bodies is not defined. The adoption of a general procedure for the distribution of water resources in Central Asia has not yet progressed.
- On water and energy issues, it is necessary to develop a new agreement, taking into account compensation mechanisms for water storage services, the operation and maintenance of the reservoir, as well as the conditions for the exchange of electricity during the scarce winter period.
- The cardinal resolution of the conflict between irrigation and hydropower is not to limit the activity of one of these areas or subjugate one of the other, but to develop a new use scheme that takes into account the satisfaction of the needs of all water users. For hydropower, this is an increase in the production of cheap and environmentally friendly energy. For irrigation, this is an increase in the depth of long-term flow regulation and the availability of already developed lands, as well as the possibility of developing new ones.

CONCLUSION

- The main principle of IWRM: equal rights of all water users (E, I, E, P, RH, Kommunal.V). Priority - human needs for drinking and sanitation.
- To optimize the WRM system, it is necessary to: switch to the basin method; accelerating the creation of WUAs; water demand management; tariff differentiation; develop various forms of private, collective and joint-stock water use on the basis of market water management activities.
- Interstate water relations are based so far on the water distribution between the CARs that took place during the Soviet period on the basis of the feasibility studies inherent in that time. In the current conditions, it is necessary to revise the issues of CIWRA, conclude new agreements, especially on IP, improve the structure of IFAS and its institutions;
- Develop a draft Strategy for capacity building in the water sector in the Syrdarya River Basin;
- Introduction and application of efficient irrigation methods and modern water-saving technologies, review existing irrigation regimes and water consumption rates;
- Rehabilitation of water management infrastructures and strengthening of the material and technical base of the water sector;
- It is necessary to develop a direct action law on payment for water, similar to the law on payment for land, which will have a positive impact on increasing the level of collection of fees for water resources and water supply services to consumers.

"If you have an apple and I have an apple, and we exchange these apples, then you and I will have an apple each. And if you have an idea and I have an idea and we exchange these ideas, then each will have two ideas."

Bernard *Shaw*

THANKS FOR YOUR ATTENTION!

Elevator pitch

Social uptake of the sustainable water management practices: possible underlying processes of farmers' decision making

Shakhnoza, Abulkosimova
Master of Science student

Humboldt University of Berlin
Uzbekistan

2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- **Research problem:** Demographic growth and dietary changes are estimated to put pressure on future food security while being affected by limited freshwater resources. Alternative sustainable water management practices may result in sufficient food production that may meet the estimated future food security while minimizing its detrimental environmental impacts
- **Existing knowledge gap:** Despite wide recognition of human behaviors both as a major cause of sustainable problems and major potential leverage for their solution, formal models of resource use either neglect human behaviors or are based on oversimplified and narrow assumptions
- **Expectations from the Summer School:** Knowledge gain

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Research objective and methods

- **Research aims** to build a conceptual model of potential key processes and conditions possibly underlying farmers' decisions making to adopt sustainable water management practices globally.
- **Methods:** scoping literature review; conceptual model by using UML (Unified Modeling Language) diagrams
- **Methods familiar with?** QGIS; R programming language; MAXQDA (qualitative data analysis)

The Impact of Tourism on Water Scarcity in South East Asia

Hannah Ackerman (with Klesti Huta and Jamina Akoua Kouablan Klein)
Masters Student INRM

Humboldt-Universität zu Berlin
USA

2nd International Summer School 2023

21 August 2023

Research **problem** and knowledge **gap**

- **Research problem:** The rapid growth of tourism in South East Asia has raised concerns about sustainability and resilience of ecosystems and local communities. Understanding the complex dynamics between tourism development and natural resource management is essential for formulating effective policies and strategies to achieve SDGs.

- **Knowledge Gap**: Groundwater is a renewable resource that requires proper management, different indexes for measuring water scarcity but not specifically groundwater. Very difficult to get widespread data and also to evaluate socio-cultural impacts.

- **Expectations:** I anticipate acquiring more knowledge regarding advanced methodologies for research, engaging in interdisciplinary collaboration, gaining practical insights from field exposure, and fostering cultural and knowledge exchange.

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Research objective and methods

- *What is the relation between tourism and the exploitation of groundwater reserves in Southeast Asian countries?*
- Our research was conducted remotely using qualitative data from case studies that provided insights into the socio-cultural, economic and environmental dimensions of water management, and we generated a QCA analysis that enabled the identification of the causal configurations that lead to sustainable water management outcomes.
- **QCA**, Atlas.ti, DPSIE, FoPIA, **GIS, econometrics**

JUSTIFICATION METHODS OF SURFACE WATER MANAGEMENT IN THE ASA RIVER BASIN IN THE CASE OF AGRICULTURAL SERVICES

Balzhan Amanbayeva
PhD, Senior Researcher

Kazakh Scientific Research Institute of Water Economy
Kazakhstan, Taraz

2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- The President of the Republic of Kazakhstan to the people of Kazakhstan on September 1, 2020 it is possible to create a competitive economy without developing agriculture noted that it is not. "There are times when 40% of the water goes to the field. Water without it Our country, which is suffering from shortages, cannot allow this. Of this industry to ensure regulation and introduce modern technologies and innovation it is necessary to develop measures of economic stimulation".
- • 60-70% of water resources used in Kazakhstan are used for irrigation and the Minister of Ecology and Geology that he will suffer a lot of losses during irrigation water that saves 30% of water by reducing planting of water-intensive crops proposed to introduce saving technologies. Irrigated crops in the face of global climate change and water scarcity adaptation of agriculture is an urgent problem.
- Expectation from the summer school to expand knowledge and exchange of experience in the field of agriculture and solve problems together

Research objective and methods

- To the water resources of the Asa river basin in the case of existing, expected water shortages methods of effective management of water resources by conducting comprehensive water management research determine the parameters and use advanced technologies of various irrigation methods as a result, obtaining a higher yield from agricultural crops.
- Study of the water management situation of the Asa river basin;
- • Use and existing management methods of river water resources in agriculture analysis;
- • study of the state of water management of water resources;
- • study of surface water management methods in agricultural conditions;
- • study of resource-saving technologies for efficient use of water resources;
- • parameters of surface water management methods in the context of agricultural activity determine and substantiate from a scientific and practical point of view.

"Development of science-based technology of rain irrigation of vegetable crops"

Munisa Burkhonova
PhD student

"TASHKENT INSTITUTE OF IRRIGATION AND AGRICULTURAL MECHANISM ENGINEERS"NATIONAL RESEARCH UNIVERSITY

Nationality: Uzbek

2nd International Summer School 2023

21 August 2023

Research problem and Aim of the research work:

--Research problem: The development, improvement and implementation of conomical irrigation methods for planting vegetable crops in the conditions of water scarcity.

--Aim of the research work: Planting carrot with the use of rain irrigation system

The main goal is to develop the irrigation regime, and to develop scientifically based suggestions and recommendations for growing carrots.

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Expectations from the Summer School:

- learn new methods of modern irrigation and agricultural technologies
- share my ideas
- share practical use of the knowledge
- connect with the lecturers
- work with the grops
- get individualized feedback on the projects
- learn more about the final results of other groups
- get experience about practical teaching

«Diagnostics and forecast of atmospheric phenomena on the territory of Uzbekistan”

Gulchekhra, Eshmuratova
PhD student

HYDROMETEOROLOGICAL RESEARCH INSTITUTE
Uzbekistan

2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- Atmospheric drought is exacerbated by observed global and regional climate changes, manifested in a positive trend in air temperature, increased evaporation, periodically leading to dryness.
- Atmospheric drought refers to dangerous meteorological phenomena, insufficiently explored, the consequence of which is significant damage to ecosystems, affecting water resources, agricultural production, the environment and the economy.
- Acquisition of new skills and exchange of experience

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Research objective and methods

- The objective of the dissertation is to develop an automated technology for the diagnosis and forecast of atmospheric drought with monthly, seasonal advance and for the growing season, which allows performing operational forecasts of atmospheric drought in real time.
- We use methods of mathematical statistics, methods of spectral analysis, expansion of the empirical in terms of a set of significant orthogonal functions (EOF) : correlation, regression, spectral, wavelet and causal analysis of functions.
- Remote sensing and GIS methods.

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Using fuzzy cognitive maps to promote nature-based solutions for water quality improvement in developing country communities

Kalina Fonseca [1,2]

***PhD** Student.*

[1]Centre for International Development and Environmental Research, Justus Liebig University Giessen, Germany.

[2]Water Resources Management Group, Technical University of Cotopaxi (UTC), Ecuador.

2nd International Summer School 2023

21 August 2023

Contact: kalina.fonseca@zeu.uni-giessen.de

Research problem and knowledge gap

- **Short introduction for explaining your research problem**

The simple nature of the Fuzzy Cognitive Maps provides a novel, inclusive, and locally adapted framework to understand how water quality could be improved using NbS,[1] guiding the future water management.

- **What is an existing knowledge gap in your discipline**

Several NbS[1] projects face sustainability issues due to insufficient community engagement and multisectoral planning, limited funds and technical support.

- **What are your expectations from the Summer School?**

Understand and apply scientific and practical methods that interconnect (WEFE) for sustainable use in agricultural communities in developing countries.

Fig 1. NbS- Artificial Floating Islands (AFIs)

Research objective and methods

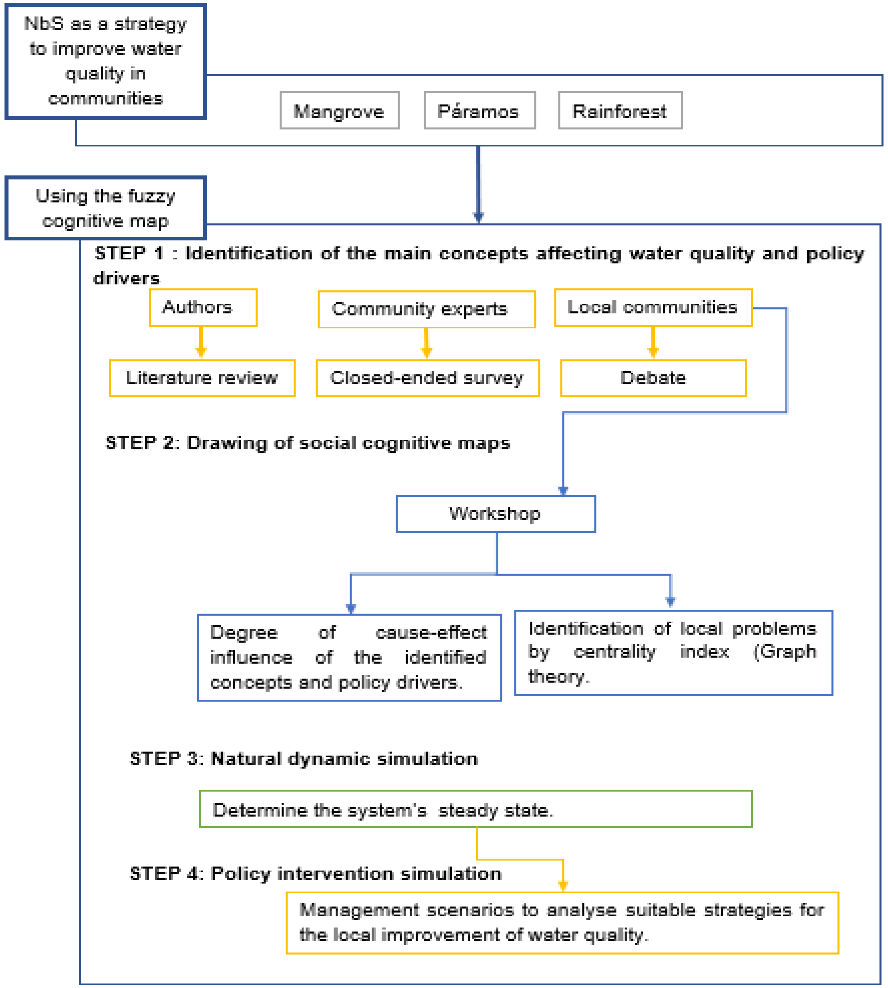
- **What is your research aim (or your research question)?**

To develop a decision-making framework that identifies the principal causes of water quality deterioration at the community level and explores the implementation of NbS together with policy interventions to improve water quality.

- **What additional methods you are familiar with?**

- Water Quality Indices, Remote Sensing Analysis (LULC) and interpolation methods

What are the methods you apply in your research?



Irrigation scheduling using CropWat in the Bukhara region

Nodirjon Gadaev
Post-Doc/Associate Professor

„TIIAME" National Research university
Uzbekistan

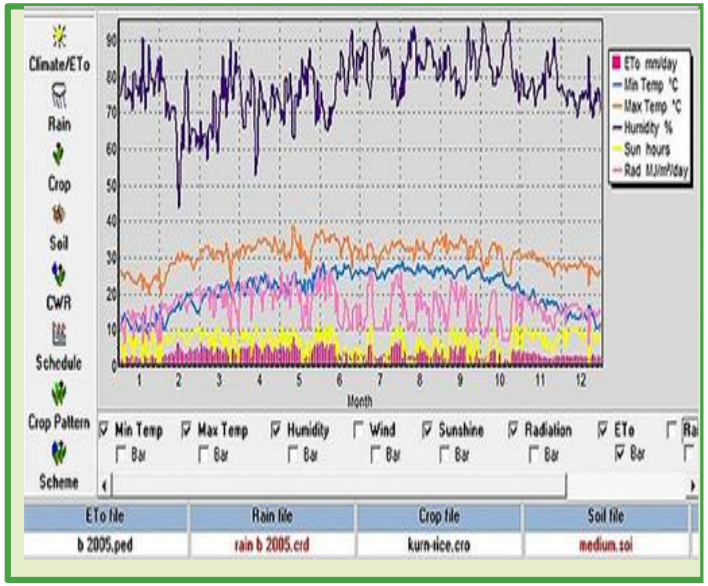
2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

Short introduction and research problem

- Irrigation is essential for agricultural production in the Bukhara region, Uzbekistan. However, water resources are limited and climate change is putting further pressure on water availability. The existing irrigation scheduling methods in the Bukhara region are not very efficient. They often rely on empirical rules that are not based on sound scientific principles.



Existing knowledge gap:

- There is a lack of knowledge about the most effective irrigation scheduling methods for the Bukhara region. The climate is changing, and the water requirements of crops are also changing. Therefore, it is important to develop new irrigation scheduling methods that are adapted to the changing climate.

Expectations from the summer school:

- I expect the summer school to help me to fill the knowledge gap in my discipline. I will learn about the latest advances in irrigation scheduling methods, and I will have the opportunity to network with other researchers working in this area. I am also looking forward to learning about the sustainability assessment of the water-energy-food-environment nexus for irrigated agriculture.

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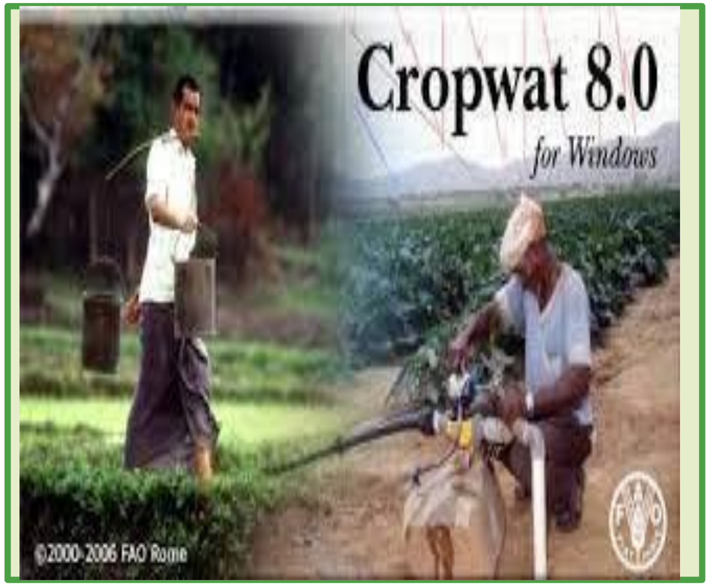
Research objective and methods

- ## Research aim:

The aim of my research is to develop an efficient irrigation scheduling method for the Bukhara region that is based on the CropWat model. CropWat is a water balance model that can be used to simulate the water requirements of crops.



Methods:

The methods I will apply in my research include:

Literature review

Data collection

CropWat modeling

Statistical analysis

Additional methods:

I am also familiar with the following methods:

Remote sensing
Ground-based measurements
Experimental field studies

Development of green economy curricula for higher educational institutions in Kyrgyzstan

Gulnaz Jalilova (Dr.nat.techn.)

Agriculture and Finance Consultants (AFC)
Kyrgyz National Agrarian University after named K.I. Skryabin
Kyrgyz State University after named I. Arabaev

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Research problem and knowledge gap

•**Research problem -** The lack of understanding of climate-smart agricultural practices in the field of land and water management in Kyrgyzstan in the framework of green economy development (strategy).

• **Exiting knowledge gap -** Despite the significance of understanding the of green economy concept, there is still limited applied knowledge.

•**Expectation from the Summer School –**, I am enthusiastic about acquiring insights into the current challenges in WEFCA in irrigated agriculture and utilizing practical tools to tackle these issues, particularly concerning sustainable water management.

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Research objective and methods

- **Research objective** - - Collect applied knowledge, local practice and new methodologies related to the green economy, and develop modules for students.

- **Research questions**:

1. What are the current sustainable land and water management employed in neighboring countries?

2. What are solving issues towards these challenges?

- **Methods:** Desk review, interview, group discussion, meetings.

- **Methods familiar with:** Socio-economic data analysis, SPSS, Multi Criteria Decision Making Analysis…

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Topic: Improving the technology of cleaning closed horizontal drainage in the irrigation zone

PhD student Kannazarova Zulfiya

“Tashkent Institute of Irrigation and Agricultural Mechanization Engineers” NRU

Uzbekistan

2nd International Summer School 2023

21 August 2023

Topic name	Keywords	Study area	Authors
Drainage (drain cleaning machine)	Drainage, irrigation (agriculture), water conservation, soil water, drainage water, ameliorative of land	Syrdarya	Kannazarova Z Muratov A

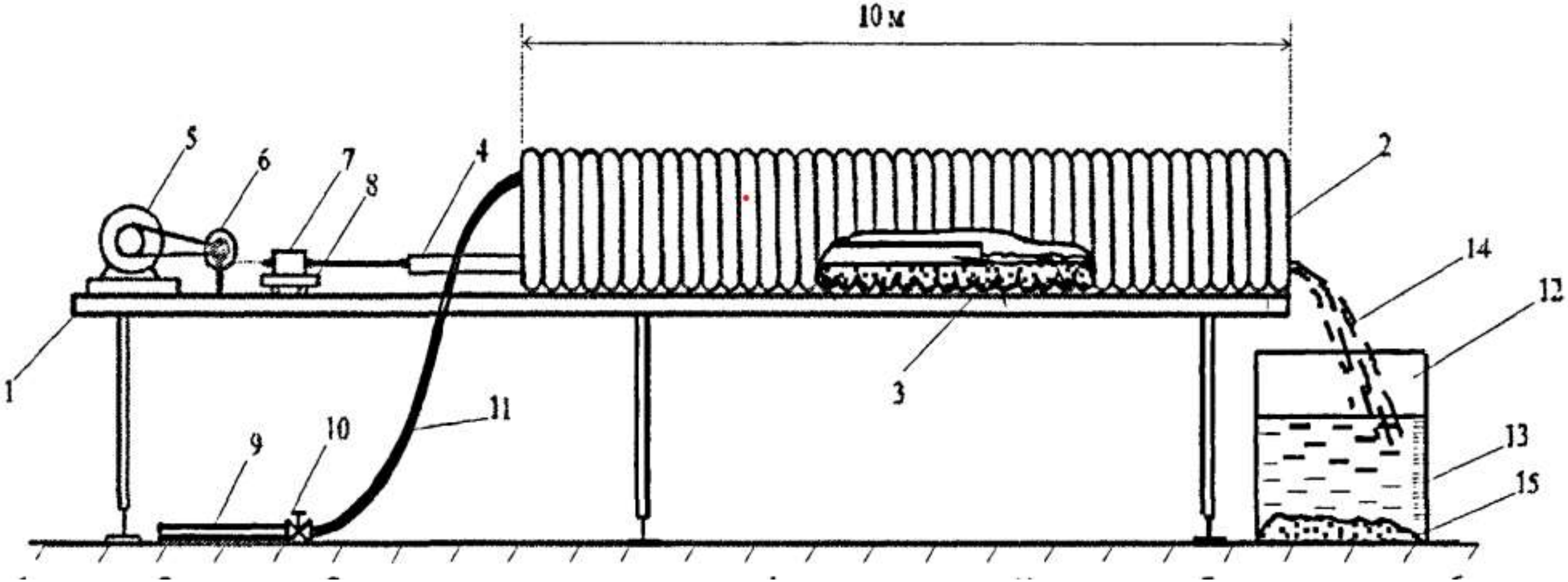
-total 36,9 thousand km

-about 14.6 thousand km (39.5%) require immediate and subsequent periodic flushing

-3.9 thousand km are in poor condition

- **Drainage washing machine -PDT-200**
- **Water-Energy-Food-Environment Nexus**

We are developing a special laboratory device to study an improved technology for cleaning drainage pipes



1-table, 2-drains, 3-silt deposits, 4-test hose, 5-el. motor, 6-drum, 7-tension link, 8-trolley, 9-water pipeline, 10-faucet, I-water conduit, 12-drainage tank, 13-dimensional scale, 14-drain, 15-removed mech. particles

- **Pipeline cleaning device-pipe head**

Review of understanding how NEXUS is perceived in Central Asia and whether water-food-energy-ecosystem approach can strengthen intersectoral cooperation

Aigerim Karibay
water resources specialist

2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- **Research Problem –** the lack of understanding how NEXUS works is also defined in CA, since such an approach is especially important in the face of growing global problems, such as climate change, population growth and lack of resources, which require a more integrated and sustainable development.

- **Existing knowledge gap –** despite the importance of understanding and implementing NEXUS as key relevant in the context of sustainable development, as it aims to balance the needs of human societies with the ecological needs of the natural systems on which they rely but in CA case NEXUS remains and only in the discussed circles.

- **Expectations from the Summer School –** gain knowledge and learn relevant methodologies for gathering scientific data and information concerning on the topic.

Research objective and methods

- **Research question** – it is seems to examines of definition of NEXUS in Central Asia and how water-food-energy- ecosystem approach can strengthen intersectoral cooperation

- **Research questions**: 1) What the difference of NEXUS from IWRM?

2) NEXUS approach in Central Asia with examples and how it works ?
3) Can the water-food-energy ecosystem approach in practice strengthen intersectoral cooperation?

- **Methods used** – qualitative and quantitative methods

- **Methods familiar with:** literature review, component analysis, survey, interview with experts

Evaluation of the effect of drip irrigation of cotton on the reclamation regime of irrigated lands in the Aral Sea region

Akhrorkhon Khamidov
PhD student at TIIAME-NRU, Uzbekistan

2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- **Research aim-** Study of existing problems related to the efficiency of water use in the selected pilot areas of the Aral Sea region and impact of climate change on the reclamation condition of irrigated lands;
- **Existing knowledge gap:** Limited scientific research on the selection of local varieties for cultivation with drip irrigation
- **Expectation from the Summer School:** sharing experiences and knowledge with like-minded individuals, join a platform for a future collaborations and networking.

Research objective and methods

- **Research objective:** Developing optimal drip irrigation method and technical elements in the care of cotton in the irrigated lands of the Aral Sea region.
- **Research questions:** 1) What are the key problems related to the efficiency of water use in the selected pilot areas of the Aral Sea region? 2) What existing methods are used to study the impact of climate change on the reclamation condition of irrigated lands? 3) How effective is drip irrigation of cotton in dry, water-deficient, salinity-prone soils?
- **Methods:** During the experimental work, all experiments, laboratory and phenological observations will be carried out. Both qualitative and quantitative methods will be used.
- **Methods familiar with:** Linear and logistic regression analysis

Determination of water requirement using soil moisture index base Evapotranspiration (ET) under climate change (Karakalpakstan, Uzbekistan)

Sardor, Khamidov
PhD student, Consultant

Research Institute of Environment and Nature Conservation Technologies
IWMI Central Asia office
Uzbekistan

2nd International Summer School 2023

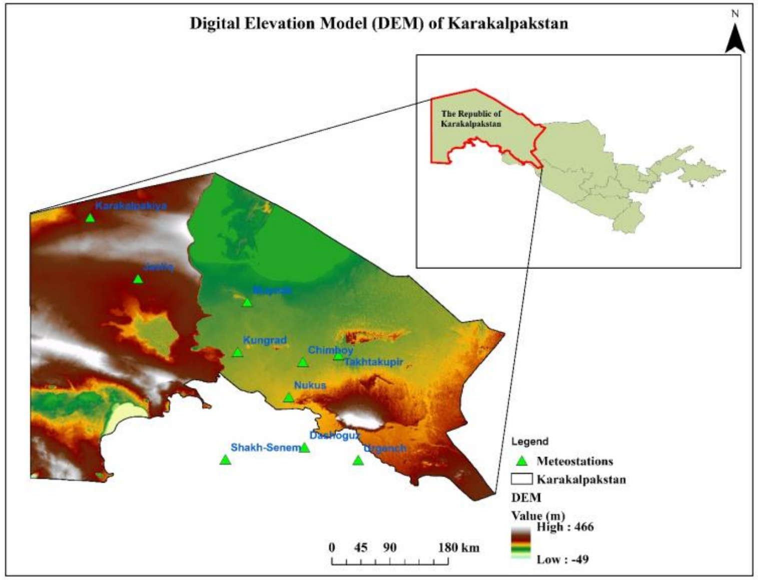
21 August 2023

Research problem and knowledge gap

- **Research problem:** Penman-Monteith method suggested by FAO requires many parameters (solar radiation, air temperature, wind speed and humidity) to calculate ET and obtaining these parameters are time-consuming.

- **Knowledge gap:** Since obtaining climate and weather parameters is a challenge for researchers, they use alternative methods/equations to calculate ET. Those methods give different results and their accuracies differ from area to area. Thus, there is no unique method or equation (with the least climate/weather parameters) with the highest accuracy for a specific area/continent/country etc.

- **Expectations from the Summer School:** Sharing knowledge with participants.



Research objective and methods

- Research aim (or research question)?

- To determine crop water requirement using soil moisture index-base Evapotranspiration (ET) under climate change. Hargreaves-Samani method (only air temperature is required) will be used to estimate reference ET and regression coefficients between soil moisture index (SMI) and ET by Hargreaves-Samani.

- What are the methods you apply in your research?

- **Mann-Kendall** trend test and **Sen's slope estimator** for trend analysis of climate parameters;
- **Soil Moisture Index (based on LST and NDVI)** by using RS and GIS tools;
- Correlation and regression analysis;

- Additional methods you are familiar with?

NDWI, NDVI, SAVI – to identify surface water area, vegetation areas, etc. from satellite images;

Analytical Hierarchy Process (AHP) – to identify potential groundwater areas based on GIS tool;

Regression analysis – to differentiate the contribution of anthropogenic and climate change on the total vegetation change;

etc.

Modern salinity leaching technology of agricultural land reclamation
(A case study from Bukhara region, Uzbekistan)

Kamol Khamraev
PhD in Agricultural Sciences, Associate Professor (Post-Doc Fellow)
Bukhara Institute of Natural Resources Management of the National Research University of "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers"
Uzbekistan

2nd International Summer School 2023

21 August 2023

Research problems:

- Water scarcity;
- Soil salinity in irrigated fields;
- High Mineralisation in irrigated and drainage water;
- Low yields from irrigated lands.

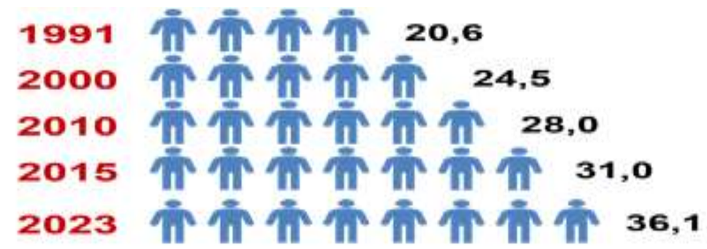
Existing knowledge gap:

- Bilogical analysis hasn't done yet;
- SperSal compound in irrigation and Biosolvent biological composition has never used in soil salinity leaching process before

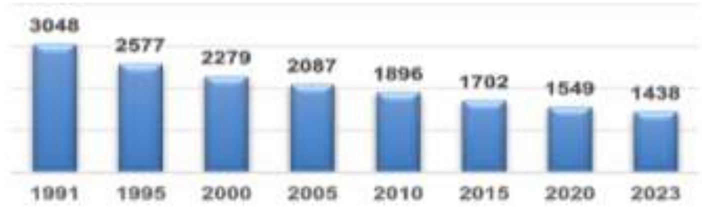
Expectations from the Summer School:

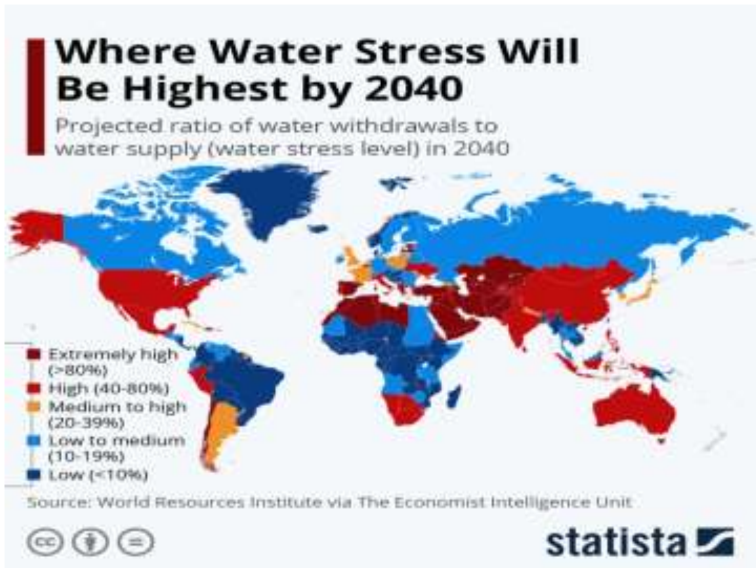
- Knowledge gain (learn new methods in research)
- Improve research design

Population of Uzbekistan (million)



Water supply per capita (cbm/year)





Our research objective is two-fold:

- using SperSal biological compound in irrigation of cotton to conserve water, to improve a watersaving technology for leaching of saline soils in vegetation period and obtain high yield from irrigated farming fields;
- carrying out Biosolvent compound in soil salinity leaching process to improve leaching technology with creating optimal water-salt balance in Agricultural fields.

Methods used in our research:

- Field experiments and laboratory analysis

Knowledge about other methods:

- Qualitative comparative analysis (QCA), systematic reviews (Web of Science and Scopus analysis, as well as Endnote), text analysis using Atlas.ti qualitative data analysis tool

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Agriculture and Food Security Issues in Pamir Region of GBAO Tajikistan

Aziz Ali, Khan
Research Fellow (Ph.D student)
Mountain Societies Research Institute (MSRI) University of Central Asia (UCA) Khorog, Tajikistan
Pakistani

2nd International Summer School 2023

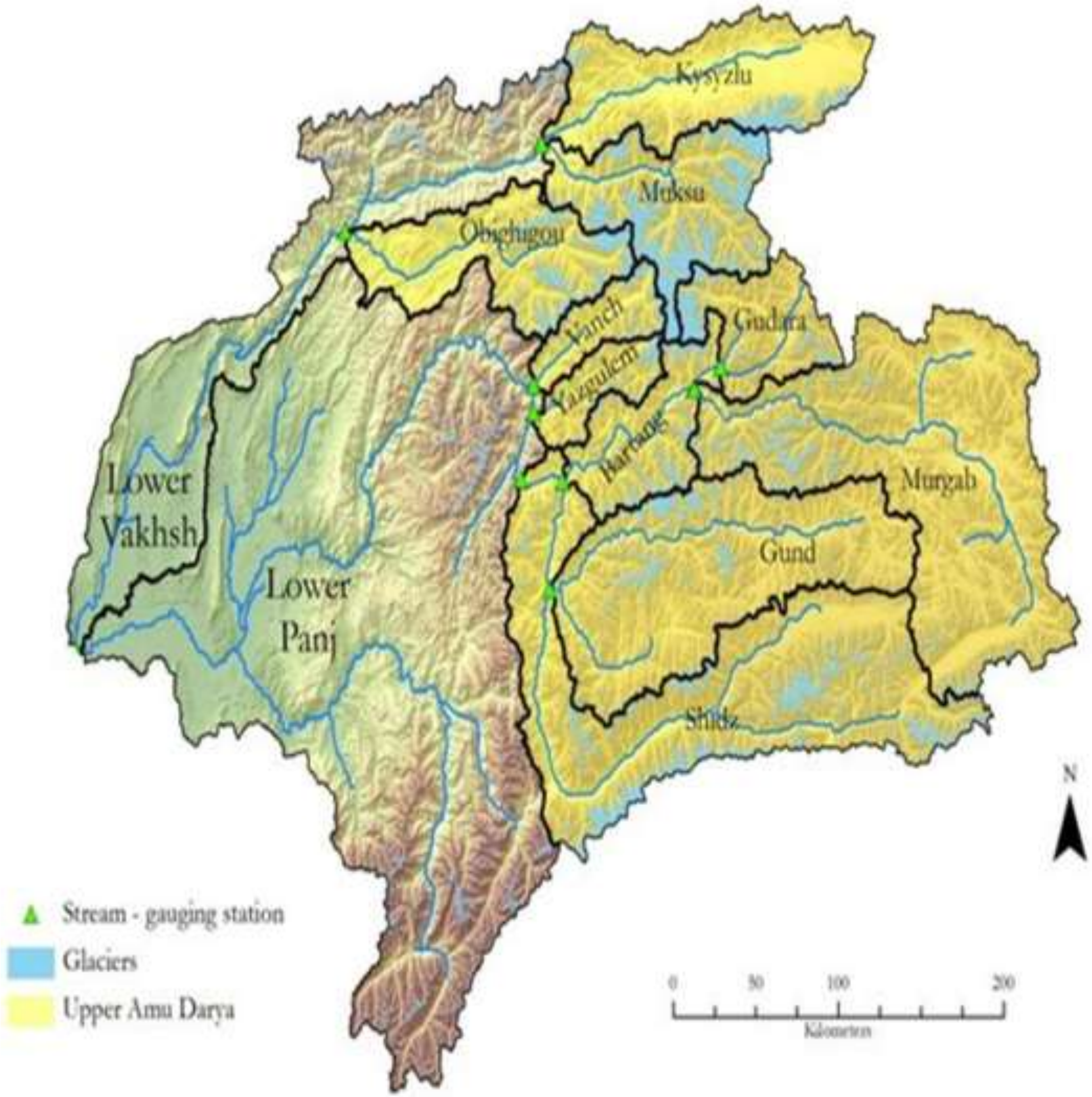
21 August 2023

Research problem and knowledge gap

- Total estimated grain production 2020 was 1.3 MT; Tajikistan imports 1.5 MT (60%) grains and flour from Russian and Kazakhistan.
- Potato production is 0.916 MT and import requirement is 0.204 MT.
- 20% of ↓5 Chilern are stunted (WB Recent study); 8%↓5 childern are underweight (UNICEF 2017) GDP Per capita $1070;
- 2019 remittances sent from Russia was $2.6 billion (28% of GDP); 5th of Tajik Pop (1.6M) entered Russia 2021.
- Negative impacts of Covid 19 and Ukraine war on economy
- My expectation to learn new techniques and process to collect acurate scientific data and information on FS and efficient utilization of NRs including water resources to increase per unit area food production.

The focus and aim of our research study is on the Pamir Range (Roof of the world or Water towers)

Pamir headwaters are critical to livelihoods of poor mountain communities in Tajikistan & Afghanistan and to downstream water users in the Amu Darya drylands



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Research objective and methods

- Our research aims to fill the knowledge gap on mountain food production system, identify major constraints and develop policy recommendations
- Our research methodology includes collecting available ancillary data, application of remote sensing and GIS technologies to assess past and present status of NRs and trends besides, field observations, surveys, focus group discussions.
- We have team of professionals with diverse tech backgrounds (NRs mgt; Hydrologists, Environmentalists, Social Scientists, GIS & RS Specialists).

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Satellite-based cotton yield estimation using panel data regression: A case study of Uzbekistan

Shovkat, Khodjaev
PhD student

Leibniz Institute of Agricultural Development in Transition Economies (IAMO)

2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- Satellite-based yield estimation is crucial for spotting potential deficits in crop at an early stage.
- No standard methods for estimating cotton yields using satellite technologies due to low biomass-yield ratio.
- Improving knowledge the Water–energy–food nexus

Research objective

- Comparison of multiple vegetation indices anchored in Sentinel-2 satellite imageries with farm-level panel data.
- Determine a suitable vegetation index for cotton yield estimation

Methods

- Obtain cloud-free Sentinel-2 satellite images based on the algorithm Google Earth Engine platform
- Crop classification based on a combination of both cotton phenology data and Sentinel-2 images with Google Earth Engine platform
- Panel data regression to evaluate the predictive ability of various vegetation indices

International Water Management Institute

“TASHKENT INSTITUTE OF IRRIGATION AND AGRICULTURAL MECHANIZATION ENGINEERS” NRU

2nd International Summer School 2023 “Sustainability assessment of the water–energy–food-environment nexus for irrigated agriculture: Interdisciplinary approaches for Central Asia (WEFCA)”

Kodirov Sobir M. senior teacher at “TIIAME” NRU

Background and research project

- Working at the department of hydrology and hydrogeology, “TIIAME” NRU
- Educational background: National University of Uzbekistan, Leibniz University, Germany, (exchange Program), Cadiz University, WACOMA Program
- Research: assessment of main hydrological features of The Chatkal River in the context of global climate change

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Ripple Effects of Water-Saving Technologies

Community-Driven Expansion of Adoption in Uzbekistan

Anton Liutin
PhD student in Aggricultural and Applied Economics

University of Wisconsin–Madison
Russian

2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- **Explanation of research problem**: In Uzbekistan, farmers are adopting water-saving technologies. Yet, it's unclear how these benefits extend beyond just the farmers to the broader community.
- **Knowledge gap**: While we understand the community's role in tech adoption, but how farmers value these technologies for the benefit of the community remains unknown
- **Expectations from the Summer School:** Enhance my WEFE nexus perspective, collaborate with diverse scholars, and foster deep connections with Central Asia experts

Research objective and methods

- **Research Objective:** Estimate the spillover effect of water-saving technologies and understand how farmers value water conservation for others
- **Methods:** Behavioral experiments (RCTs with behavioral games) and rural surveys
- **Additional Methods:** Econometrics, Machine Learning (ML), and GIS data analysis.

Mineral ground waters of South Kazakhstan

Rakhima Malau
PhD student

Satbayev university, Almaty, Kazakhstan

2nd International Summer School 2023

21 August 2023

Exploration and exploitation of mineral deposits are currently underway in more than 70 countries worldwide, with industrial use mastered in 60 countries. The effectiveness of mineral water utilization is also evidenced by the level of investment in this industry by leading nations. For instance, over a span of 20 years, 30 countries each invested $20 million in geothermal energy development. Additionally, 12 countries allocated more than $200 million each, and 5 countries spent over $1 billion each (USA - $7.5 billion; Japan - $5.3 billion; Italy - $2.4 billion; Iceland - $1.2 billion; Philippines - $1.1 billion). Moreover, financing from private sources increased by 160%, while public sources showed a 43% increase. This trend underlines the cost-effectiveness of utilizing thermal mineral waters.

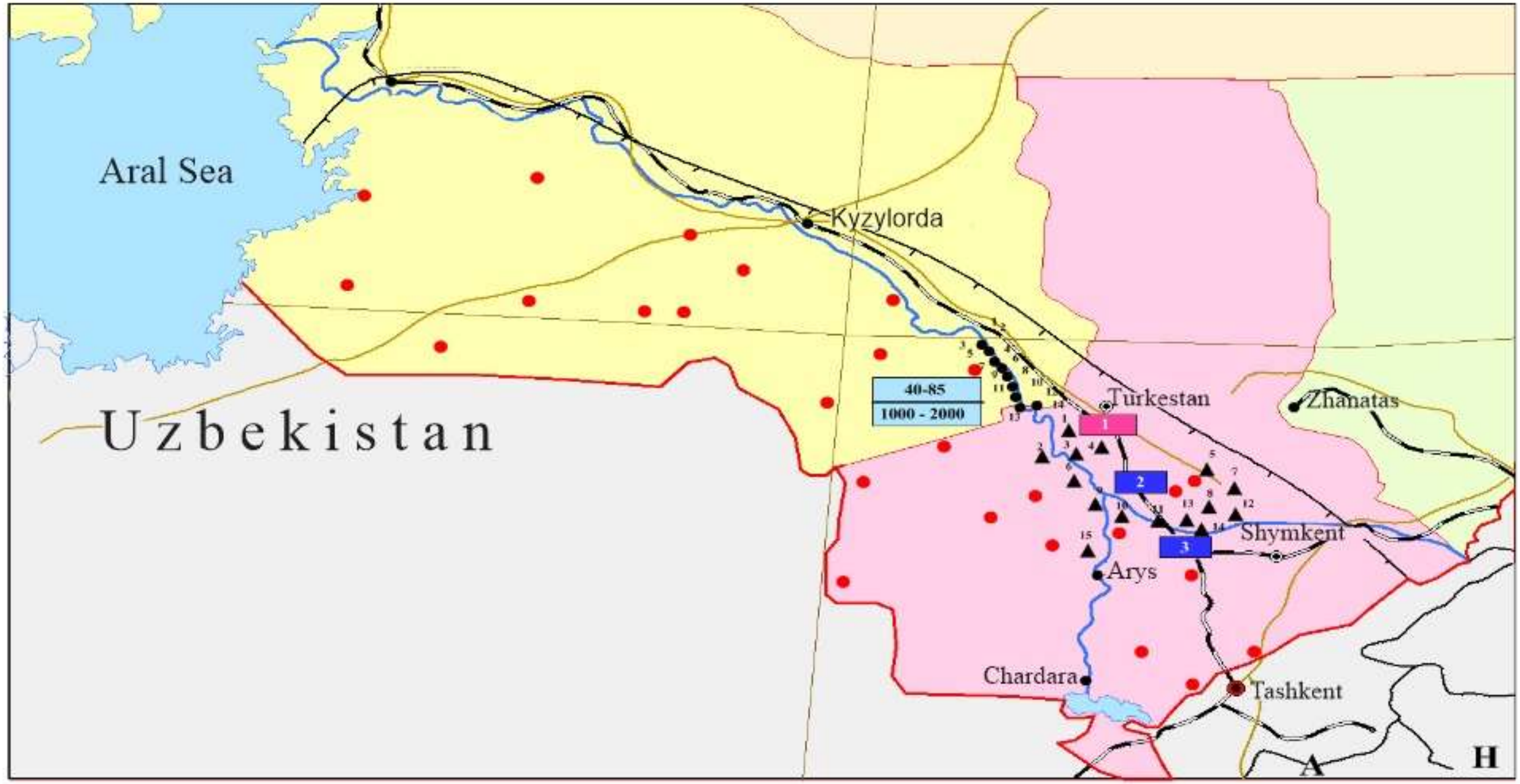
Research Problem and Knowledge Gap:

- Limited financing for hydrogeological works to replenish the resource base of mineral waters.
- Absence of investment proposals for organizing mineral groundwater extraction.

Expectations from the Summer School:

I anticipate gaining insights into alternative methods and approaches for utilizing mineral groundwater, as well as discovering novel strategies for locating mineral groundwater deposits.

Object of research: South - Kazakhstan region



Object of research: mineral ground waters of South Kazakhstan

The purpose of the research: assessment of resources, reserves and use of mineral underground waters in Kazakhstan

Research methods:

- drawing up maps and sections of the water conductivity of promising aquifers of artesian basins;
- classification of medicinal waters according to the conditions of occurrence;
- hydrogeological stratification of mineral waters according to distribution conditions;
- determination of methods for calculating regional resources and reserves of mineral groundwater in South Kazakhstan.

Development of Drought-Tolerant Varieties of Soft Wheat in the Central Asia Region

A little about myself…

Boburjon Najodov

- PhD Student at the Department of Genetics, Breeding, and Seed Production Institute of Agrobiotechnology, Russian State Agrarian University - Moscow Timiryazev Agricultural Academy

- **Junior Research Associate at the World-class Scientific Center "Agrotechnology for the Future«**

Moscow, Russia

2nd International Summer School 2023

Research Problem and Knowledge Gap

Research problem: Addressing the Need for Improved Drought Resistance in Soft Wheat Varieties in the Central Asia Region, including Tajikistan, Kazakhstan, Uzbekistan, and Kyrgyzstan.

•**Short introduction for explaining your research problem:** In the Central Asia Region, where changing climate patterns are posing unprecedented challenges to agriculture, the need for drought-tolerant crop varieties is paramount. My research focuses on developing soft wheat varieties that can withstand the rigors of drought, ensuring food security and agricultural sustainability in this vital region."

•**What is an existing knowledge gap in your discipline:** An existing knowledge gap in my discipline is the precise understanding of the complex genetic mechanisms that confer comprehensive drought tolerance in soft wheat varieties. While we have made strides in identifying individual stress-responsive genes, we lack a holistic understanding of their interactions and how they contribute to overall drought resilience.

•**What are your expectations from the Summer School:** My expectations from the Summer School are to gain a comprehensive understanding of interdisciplinary approaches in addressing water-energy-food-environment nexus challenges specific to irrigated agriculture in Central Asia. I look forward to acquiring new methodologies, collaborating with experts, and broadening my perspective to develop effective and sustainable solutions for the complex issues in this region.

Research objektive and Methods

• **What is your research aim (or your research question):** My research aim is to enhance the drought tolerance of soft wheat varieties through the identification and incorporation of key genetic traits. This involves understanding the genetic mechanisms underlying drought tolerance and applying this knowledge to develop wheat varieties that can thrive in water-limited environments, ultimately contributing to more resilient and sustainable agricultural practices.

• **What are the methods you apply in your research:** I employ a combination of phenotyping and genotyping techniques in my research. Phenotyping involves assessing various physiological and morphological traits of wheat plants under drought conditions, helping to identify stress-responsive characteristics. Genotyping involves the use of molecular markers to analyze the genetic makeup of wheat lines, aiding in the identification of genes associated with drought tolerance. These methods allow me to comprehensively understand the genetic basis of drought tolerance in wheat and contribute to the development of stress-resilient crop varieties.

•**What additional methods you are familiar with:** In addition to phenotyping and genotyping techniques, I am also familiar with statistical analysis and data interpretation. This proficiency enables me to effectively analyze the large datasets generated by phenotyping and genotyping experiments, helping to uncover meaningful patterns and relationships. Furthermore, I have experience with bioinformatics tools, which aid in the identification of candidate genes and pathways related to drought tolerance. Additionally, I possess knowledge in various agronomical traits relevant to crop performance and stress response, providing a holistic approach to my research.

Drought tolerance is a plant's ability to survive and produce reasonable yields under limited water availability

THANK YOU FOR YOUR ATTENTION

boburnajodovgmail.com

Boburjon Najodov

Boburjon Najodov

Boburjon Najodov

EVALUATION OF CLIMATE CHANGE IMPACT ON CROP YIELD IN TASHKENT PROVINCE

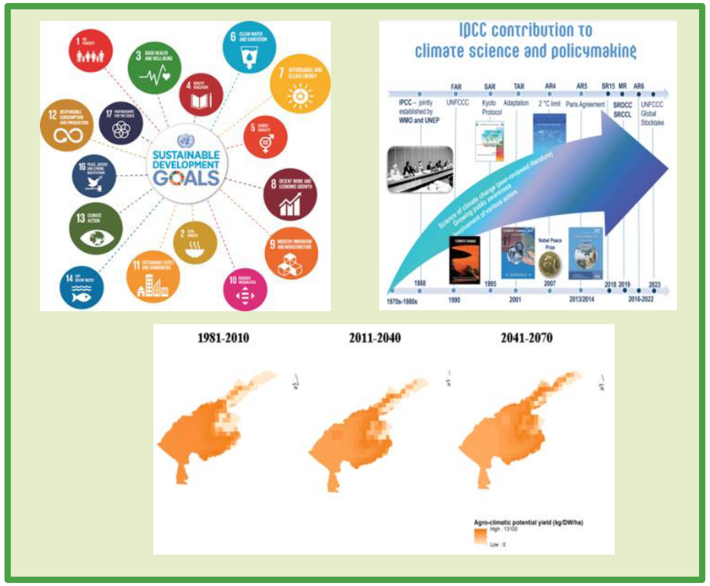
Makhliyo, Nasirova
PhD student
“Tashkent Institute of Irrigation and Agricultural Mechanization Engineers” NATIONAL RESEARCH UNIVERSITY
Uzbekistan

2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- **Short introduction for explaining your research problem**
- Changing climate variables requires assessing the current management of local crop production.
- **What is an existing knowledge gap in your discipline**
- 1) Temperature trend is changing significantly in the region. 2) Precipitation trend shows moderate change. 3) Irrigation water requirements do not increase under climate change. 4) Rising temperature cause increasing in grain yield.
- **What are your expectations from the Summer School?**
- To study methods of Sustainability Assessment of the Water–Energy–Food-Environment Nexus for Irrigated Agriculture for my future research.



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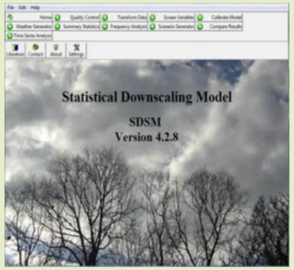
Research objective and methods

- **What is your research aim (or your research question)?**
- Study the impact of climate change on crop yield in Tashkent province.
- **What are the methods you apply in your research?**
- Spatial interpolation, bias correction, regression analyses and crop modeling
- **What additional methods you are familiar with?**
- Dynamical and statistical downscaling



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Water planning and valuation of ecosystem services in river basins of Kazakhstan

Ardak Nassir
PhD student

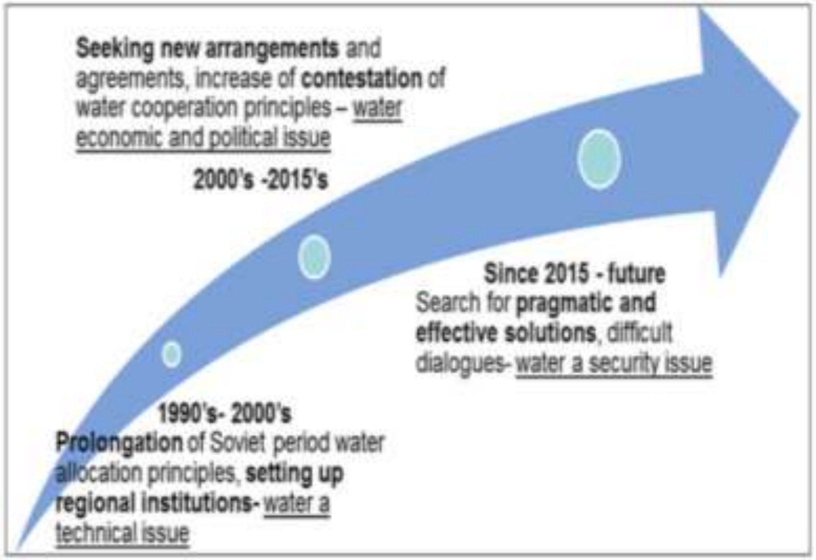
Nazarbayev University
Kazakhstan

2nd International Summer School 2023

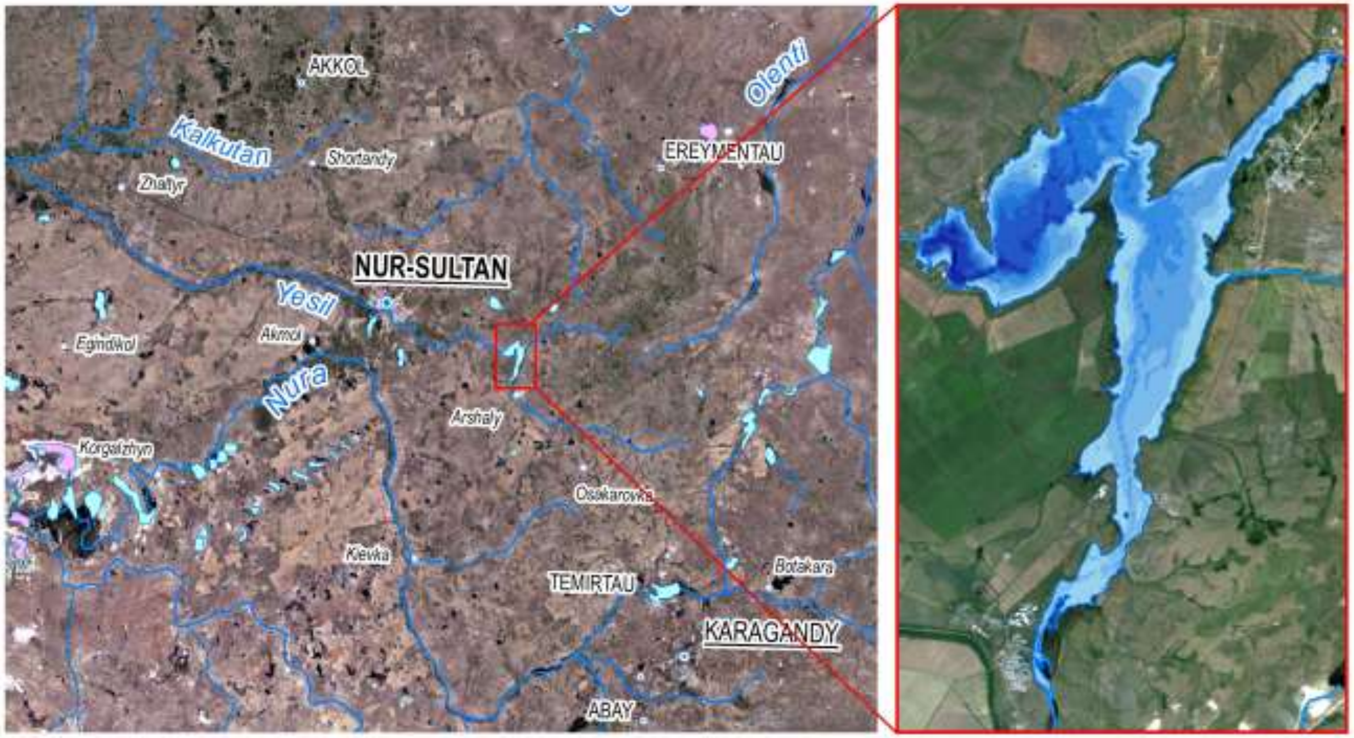
21 August 2023

Research problem and knowledge gap

- Environmental degradation (ignorance of ecosystem services (ES) in water planning); limited implementation of integrated water resource management in Kazakhstan.
- This study reveals a knowledge gap in Central Asia regarding the utilization of ecosystem services valuation methods (ecosystem-based approach for enhancing water resource management).
- Expect to to acquire advanced knowledge and skills in assessing the sustainability of WEFE relationships, including ecosystem services, water use efficiency, human health, and economic viability et al.



Source: Rakhmatullaev et al., 2017


AKKOL
Kalkutan
Shortandy
Zhaltyr
EREYMENTAU
Olenti
NUR-SULTAN
Yesil
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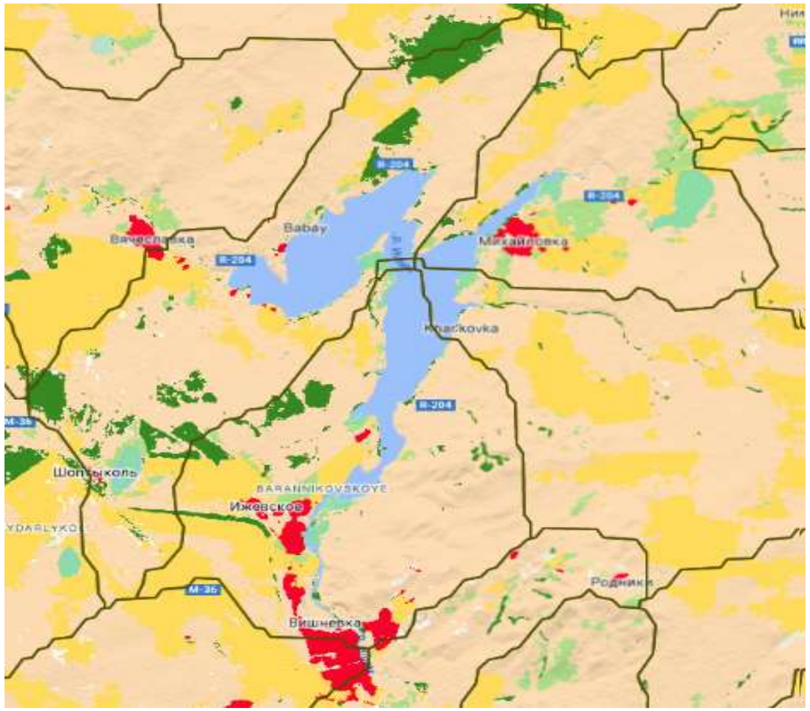
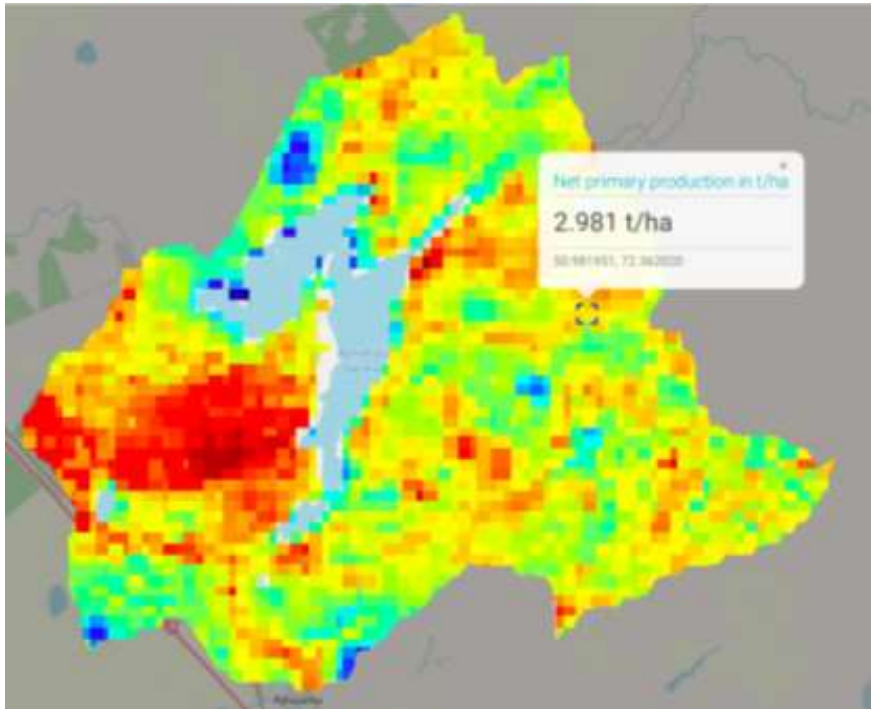
Osakarovka
Kievka
TEMIRTAU
Botakara
KARAGANDY
ABAY


R-204
Babay
Вячеславка
Михайловка
BARANNIKOVSKOYE
Ижевское
M-36
Родники
Вишневка


Net primary production in t/ha
2.981 t/ha

Research objective and methods

- This study is going to explore how to improve the water planning through valuation of ecosystem services in river basin systems of Kazakhstan.
- **Methodology:** SEEA-EA framework (System of Environmental and Economic Accounting-Ecosystem Accounting)
- **Analysis tools**: ARIES, InVEST

Source: IDEEA Group, Farrell et al., 2021

IMPROVING IRRIGATION TECHNOLOGIES FOR VEGETABLE CROPS IN THE REPUBLIC OF TAJIKISTAN (ON THE EXAMPLE OF THE KAFARNIHON RIVER BASIN)

Nazar Nurzoda
Post-Doc

Tajik Academy of Agricultural Sciences (TAAS)
Tajikistan

2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- Short introduction for explaining your research problem

One of the main directions for ensuring food security is the development of vegetable growing in the Republic of Tajikistan. At present, the area of irrigated land in the republic for growing vegetables is 55,323 hectares, including about 10,000 hectares in the Hissor natural and economic zone and 20,723 hectares in the Vakhsh natural and economic zone, which is extremely small for the growing demand of the population of Tajikistan for these products.

The list of food products and their quantity in the consumer basket of each state depends on the agro-climatic features, the provision of the industry with modern equipment and technology, and the culture of food consumption. In connection with climate change, the study, justification, and improvement of technologies for irrigating vegetable crops in the Republic of Tajikistan in order to ensure the food security of the state, the effective use of arable irrigated lands of public and farms and household plots is particular relevance.

Research problem and knowledge gap

- What is an existing knowledge gap in your discipline

Under these conditions, complex problems arise in the distribution of water and its shortage among new farms, problems with the use of equipment and fertilizers due to their lack and unsuitability for small areas. All this will lead to a decrease in the yield of vegetable crops, and low indicators of the use of the potential of natural and technical resources.

Proper and efficient organization of irrigation technologies for vegetable crops, including irrigation technology, increasing the efficiency of the use of irrigation water in the conditions of cultivation of vegetable crops in the field and greenhouses in various forms, management is becoming an urgent problem, which our developments are aimed at solving.

Research problem and knowledge gap

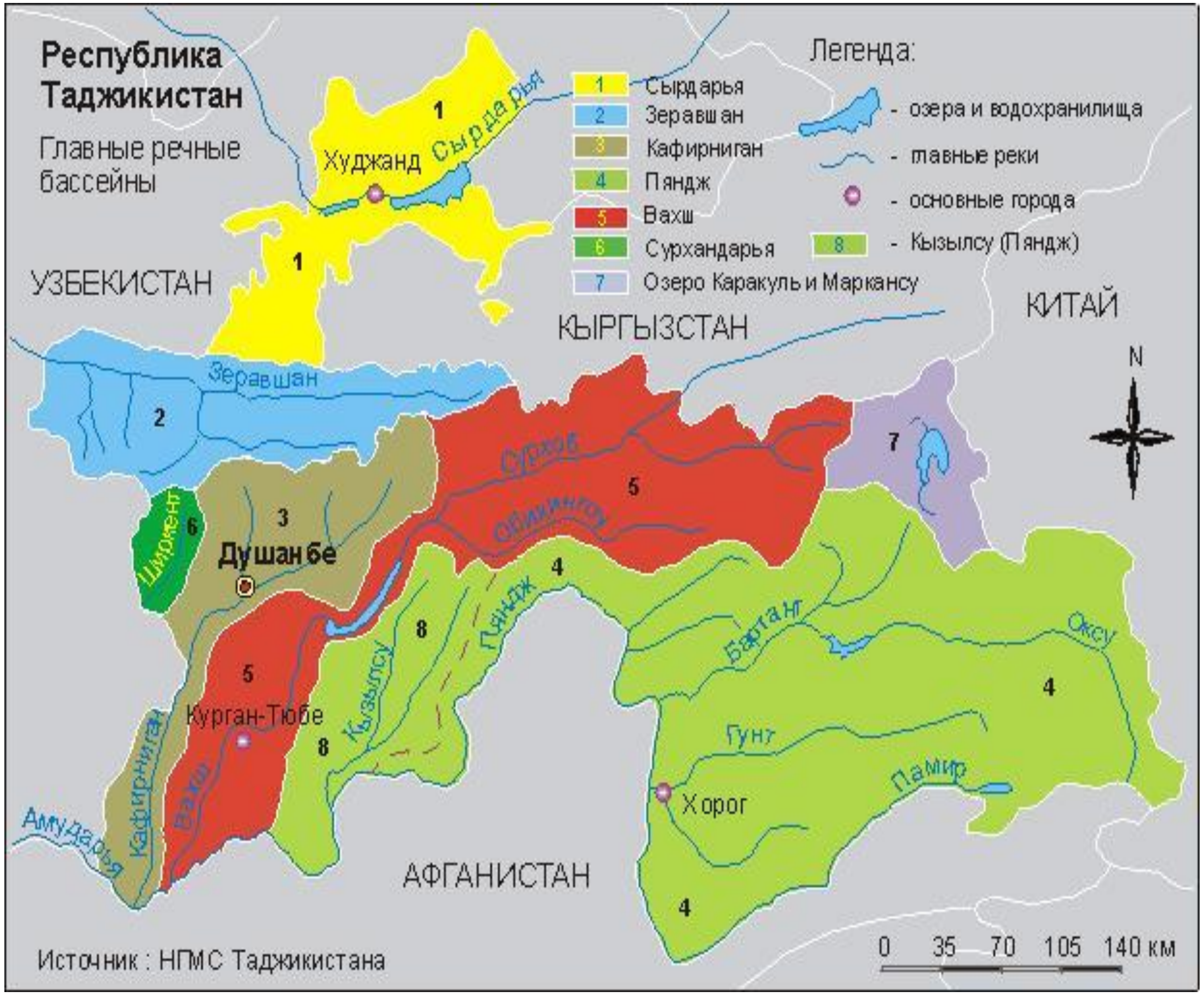
- What are your expectations from the Summer School?

This course would allow me to acquire successful training, meet other Ph.D. and Post-doc students, and provide an enjoyable experience. The program gives me the chance of being in a right atmosphere and learning much from professors, become acquainted with the culture of our neighbor, and so on. It is my pleasure after finishing the Summer School and then share my experiences, ideas, knowledge, and contribute to the public sector, especially in the field of education and culture.

Research objective and methods

- What is your research aim (or your research question)?

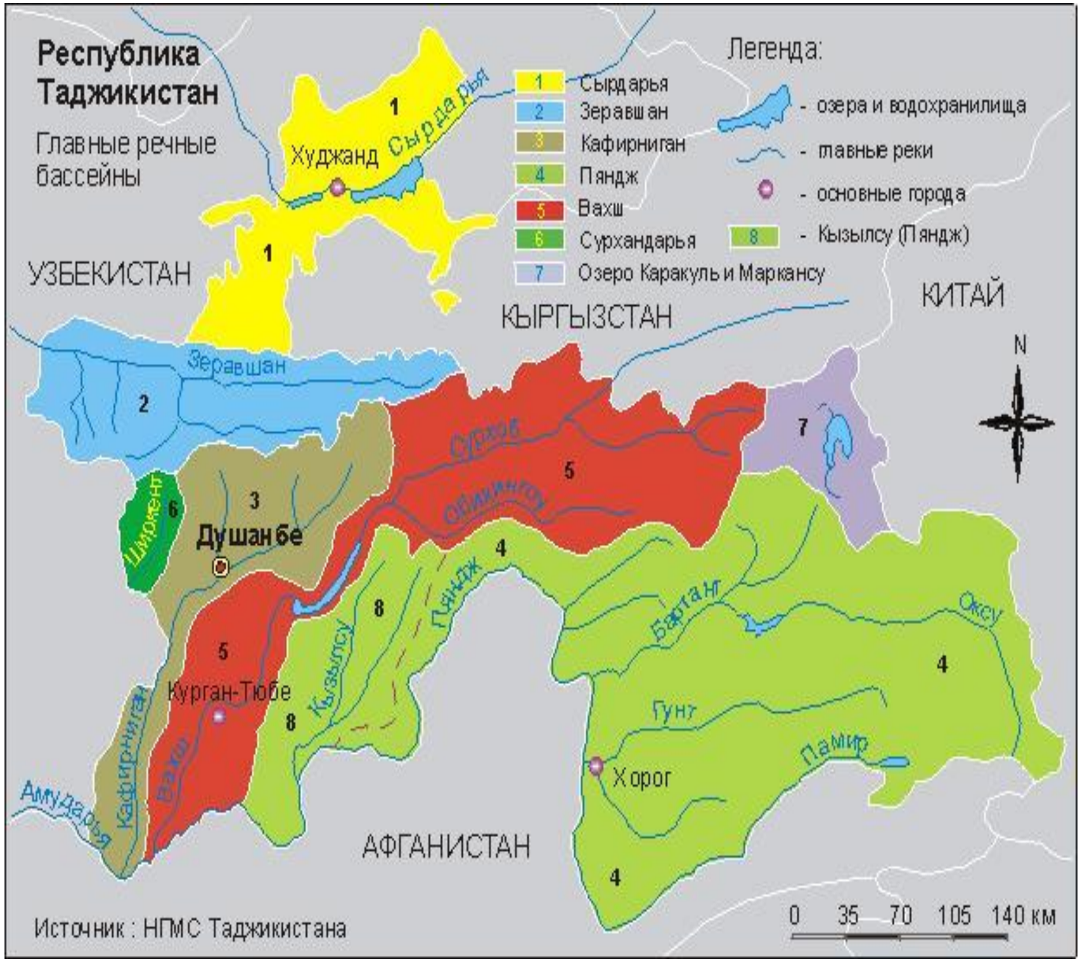
The purpose of my research is to develop theoretical and practical principles for improving the technologies for irrigating vegetable crops for various forms of farms in the conditions of Tajikistan, on the example of the Kofarnihon river basin, which provides a significant increase in the efficiency of the use of water, land and material resources and ensures the country's food security for vegetable crops.



Research objective and methods

- What are the methods you apply in your research?

For the first time for the conditions of the Kofarnihon river basin in Tajikistan, the development and improvement of the technology of irrigation of vegetable crops will be carried out, to substantiate the technological parameters of irrigation, taking into account the automation of irrigation processes in conjunction with their agrotechnical care, ensuring water conservation, soil protection and environmental safety of crops, the efficiency of the use of water, land and labor resources, as well as obtaining high and quality products on the territory of various forms of farms.




Thank You
For Your
Attention

Разработка почвенно-информационной системы на примере Нарынской области

Development of a soil information system in the Naryn region

Tinatin Oljobaeva
PhD student at the Naryn University, Kyrgyzstan

Kyrgyzstan

2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- **Research problem –** Повышение и сохранение плодородности почвы сельскохозяйственных земель. Нет единого государственного органа, осуществляющего координацию научной, инновационной и практической деятельности по сохранению и повышению плодородия почв, мониторинг за качественным состоянием почв, разработкой программ мероприятий по охране и восстановлению почв, контроль за соблюдением законодательства в области охраны почв.
Increasing soil fertility of agricultural lands. There is no single state body that coordinates scientific, innovative and practical activities to preserve and improve soil fertility, monitor the quality of soils, develop programs of measures for the protection and restoration of soils, monitor compliance with legislation in the field of soil protection.
- **Exiting knowledge gap -** Практическое обучение землепользователей сбору и использованию данных, а также органическому ведению сельского хозяйства.
Practical training for land users on data collection and use, as well as organic farming.
- **Expectation from the Summer School** – Ожидание от летней школы - сбор научных данных в научных исследованиях и знакомство с работами, проводимыми в других странах.
The expectation from the summer school is the collection of scientific data in scientific research and familiarity with the work carried out in other countries.

Research objective and methods

- **Research objective** – Оценка плодородности сельскохозяйственных почв, путем полевых исследований и лабораторных анализов почв. Сбор данных о землепользователей Нарынской области. Цифровизация и составление базы данных землепользователей Нарынской области. Разработка почвенной карты Нарынской области
- Assessing the fertility of agricultural soils, through field studies and laboratory soil analyses. Collection of data on land users in the Naryn region. Digitalization and compilation of a database of land users in the Naryn region.Development of a soil map of the Naryn region

- **Research questions**: 1) Отбор проб почвы и агрохимический анализ. Soil sampling and agrochemical analysis 2) Повышение знаний фермеров в области сельского хозяйства. Increasing the knowledge of farmers in the field of agriculture.

- **Methods:** С помощью агрохимических исследований. Through agrochemical research.

Climate Change Related Agriculture and Irrigation Water Challenges in a Small, Snow-Fed Mountain Basin in Pamir, Tajikistan: Case Study from Porshinev

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Tajik

2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- **Research problem –** changes in climatic variables posed by Climate Change significantly deteriorated local agriculture
- **Existing knowledge gap –** global Climate Models do not suit well local climate – uncertainties in inter-annual and seasonal shifts
- **Expectations from the Summer School –** knowledge gain and share

Research objective and methods

- **Research question –** how does Climate Change (CC) affect local agriculture and hydrology? – What are the adaptation methods used by the local farmers to overcome CC

- **Methods used** - Mann Kendell test and Sen's Slope Estimator - trend detection and magnitude, structured interviews

Methods familiar with? Data analyses – classification, regression, clustering: remote sensing, and GIS methods (SVM, Supervised Classification, etc.)

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Pastoral Practices, Economics, Institutions of Sustainable Pasture Management in Pamir Region of Tajikistan

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Monitoring and Evaluation Specialist at Caritas Switzerland

Tajik

2nd International Summer School 2023

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Research problem and knowledge gap

•**Research problem -** The lack of understanding about the key determinants of the adoption of sustainable land management practices of pastures in Tajikistan limits the effectiveness of implementing sustainable practices in the agricultural sector overall.

• **Exiting knowledge gap -** Despite the significance of understanding the key determinants of adopting sustainable land management practices in the agricultural sector, there is a lack of research specifically focusing on Tajikistan context.

•**Expectation from the Summer School –** learn and share relevant methodologies and strategies for gathering precise scientific data and information concerning sustainability assessment.

Research objective and methods

- **Research objective** - this study seeks to examines the causes, and methods of promoting sustainable management of pastures with possible positive feedback on improved livelihoods of the rural poor who depend on these resources .

- **Research questions**: 1) What are the current sustainable land management (SLM) practices employed in pastures in Pamir region of Tajikistan? 2) What are the main barriers or challenges preventing the adoption of SLM practices in Tajikistan's agricultural sector 3) What are the potential economic incentives, subsidies, or support mechanisms that could facilitate the transition to SLM practices in Tajikistan's pastures?

- **Methods:** Both qualitative and quantitative methods will be used

- **Methods familiar with:** Principle Component Analysis, Logistic regression..

Characteristics of atmospheric droughts and their future projections in Northern Kazakhstan

Laura Ryssaliyeva
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Al Farabi Kazakh National University
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2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- Short introduction for explaining your research problem

The analysis of unfavorable agrometeorological phenomena that caused significant or complete destruction of agricultural crops on the territory of Kazakhstan showed that atmospheric and soil drought account for about 80%, heavy rain and hail – 14%, frost – 2%, waterlogging of the soil – 2%, severe frosts and strong winds-1% each.

- What is an existing knowledge gap in your discipline

- no single developed index and indicator for determining drought;

- In addition to studying drought indices, the investigation of subregional drought behavior is important. This is because in most studies focused on drought in Central Asia, little attention has been given to the characteristics of drought at a subregional scale.

- Understanding the structure and attributes of drought, such as duration and intensity, is crucial for reducing vulnerability to drought and developing drought adaptation strategies.

- The issue lies in the unavailability of statistical agriculture data.

- What are your expectations from the Summer School?

My expectations for participating in this program include the opportunity to exchange experiences and knowledge with experts and participants from different countries, as well as collaborate on a common task. I hope to actively engage in interactive discussions, working groups, and practical sessions that will help me develop analytical thinking skills and address the challenges related to the impact of climate change on agricultural systems.

Research objective and methods

- What is your research aim (or your research question)?

To study the spatial-temporal distribution of atmospheric droughts and their characteristics in Northern Kazakhstan, as well as to analyze their future projections in the studied region

- What are the methods you apply in your research?

-Mann-Kendal trend test (enables the identification of statistically significant changes in the data)
-Sen's slope estimator (This robust nonparametric method, provides an effective approach for estimating the magnitude and direction of trends in various disciplines, including climatology, hydrology, and environmental studies.)
-Standardized precipitation index (SPI) (used for monitoring drought based solely on precipitation)
-Standardized precipitation evapotranspiration index (SPEI) (used to represent the probability of differences between precipitation and evapotranspiration over a specific time period)
-Selyaninov's Hydrothermal coefficient (HTC) (characterizes the moisture level of a territory)

- What additional methods you are familiar with?

-Run Theory
-China Z-index
-Meteorological drought index based on fuzzy logic:

Social aspect as interdisciplinary approach – basic level in agricualtural and water management

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PhD, economic sciences
Academy of sciences, Turrkmenistan

2nd International Summer School 20

Research problem and knowledge gap

- A **row** of **different aspects** can be determined and fixed in water and agricultural management: technical, economical, **eco**logical, biological, juridical, science and innovation, **eco**logical education, ecological culture, **eco**logical children's culture, **eco**logical behaviour

- Some of the **SDGs** must be **included** into **educational programmes** where could considered and discussed water sanitation and rational water usage issues. It is recommended to force into application a class as a **discipline like Water** rules, **Water** recommendations,**Water**culture,**Water**education, **Water t**hinking behaviour

- **Children's journal** ""Rational usage of drinking water: about ecological culture from the child's age in Water Magazine for kids and Children

- **My expectation are to analise more deeply the connection between social and technical aspects of sustainbale development's system and prove its influence on the rational usage water in agticulture and social life through eco-thinking**

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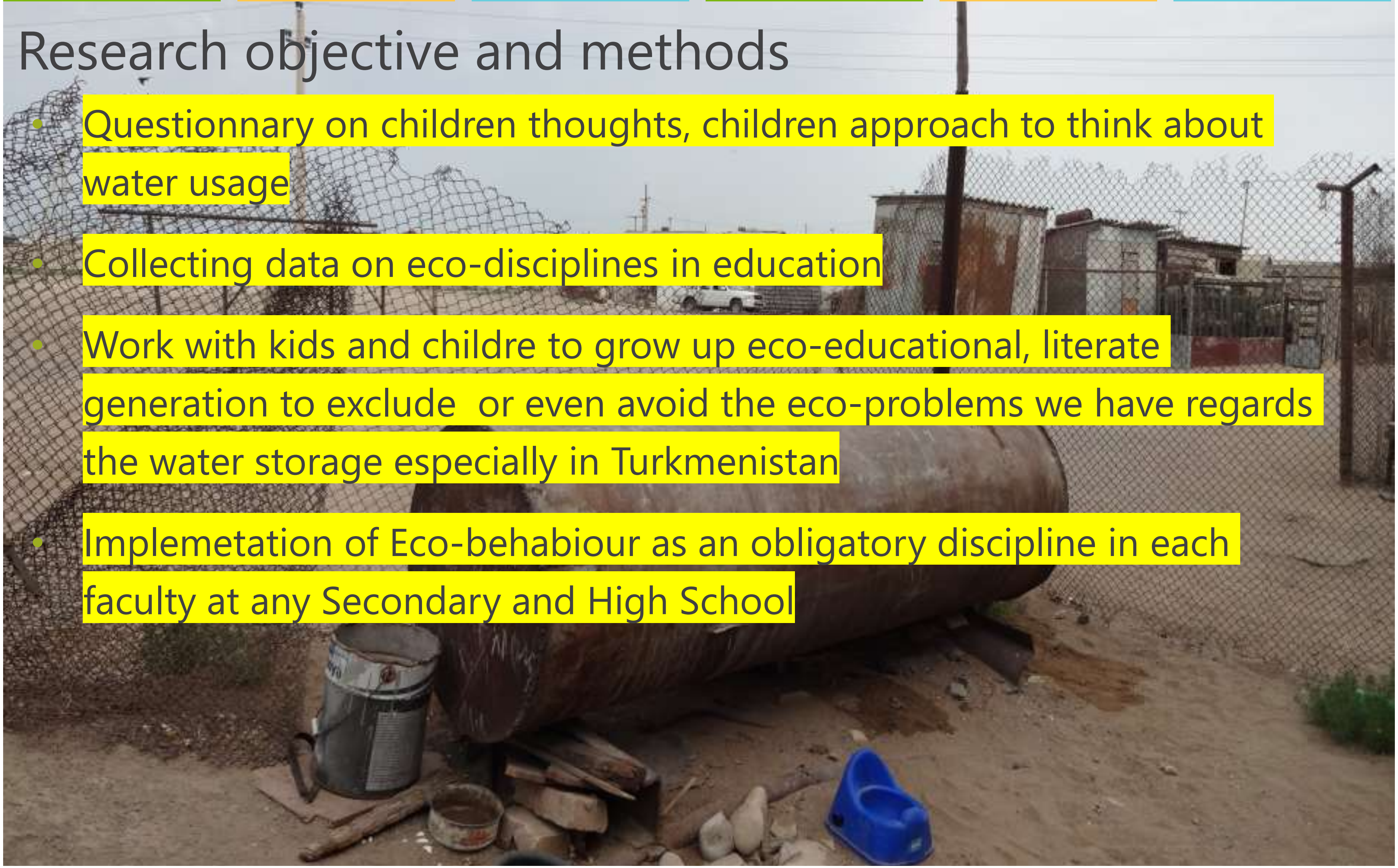
The focus and aim of our research study – to make unconscious eco-behavior level with its components as essential in agricultural and water management

This concrete approach is the required term for learning agricultural issues, connected with water security in arid zones of Central Asia.

The implementation of the strategy of under-conscious thinking of the rational drinking usage and other spheres is necessary



Research objective and methods

- Questionnary on children thoughts, children approach to think about water usage
- Collecting data on eco-disciplines in education
- Work with kids and childre to grow up eco-educational, literate generation to exclude or even avoid the eco-problems we have regards the water storage especially in Turkmenistan
- Implemetation of Eco-behabiour as an obligatory discipline in each faculty at any Secondary and High School

Possibilities of circular economy (CE) implementation in Uzbekistan

How far can the country go?

Anastasia Salnikova
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School of Business and Management

2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- **Short introduction for explaining your research problem**

(political will - ☑, investments - ☑, interest/conserns from international organisations - ☑)

- **What is an existing knowledge gap in your discipline**

(tools, methods and approaches to address the smooth transition to CE at local level - ☒)

- **What are your expectations from the Summer School?**

(Get inspiration! Bring together Water–Energy–Food-Environment dimensions)

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Research objective and methods

- **What is your research aim (or your research question)?**

Is transition to CE ever possible in Central Asia?

Which issues need to be addressed?

- **What are the methods you apply in your research?**

LCA (EcoInvent database), policy analysis, detection of social preferences and patterns (non-parametric statistics)

- **What additional methods you are familiar with?**

(hope to learn more during Summer School ☺

Improving the technology of drip irrigation for cotton plants (in the conditions of sandy clay soil of Jizzakh region)

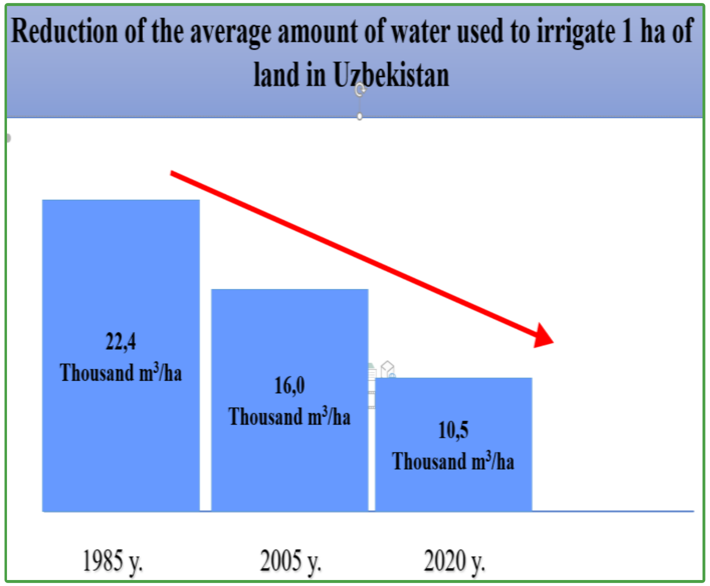
Jamshid Shukurullayev PhD student
TIIAME NRU Bukhara Institute of Natural Resources Management

2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- Cultivation of food products in the situation of global climate change and sharp reduction of water resources
- Changes in the value of water consumption in Uzbekistan over the years
- Mastering new knowledge of perfect use of water resources



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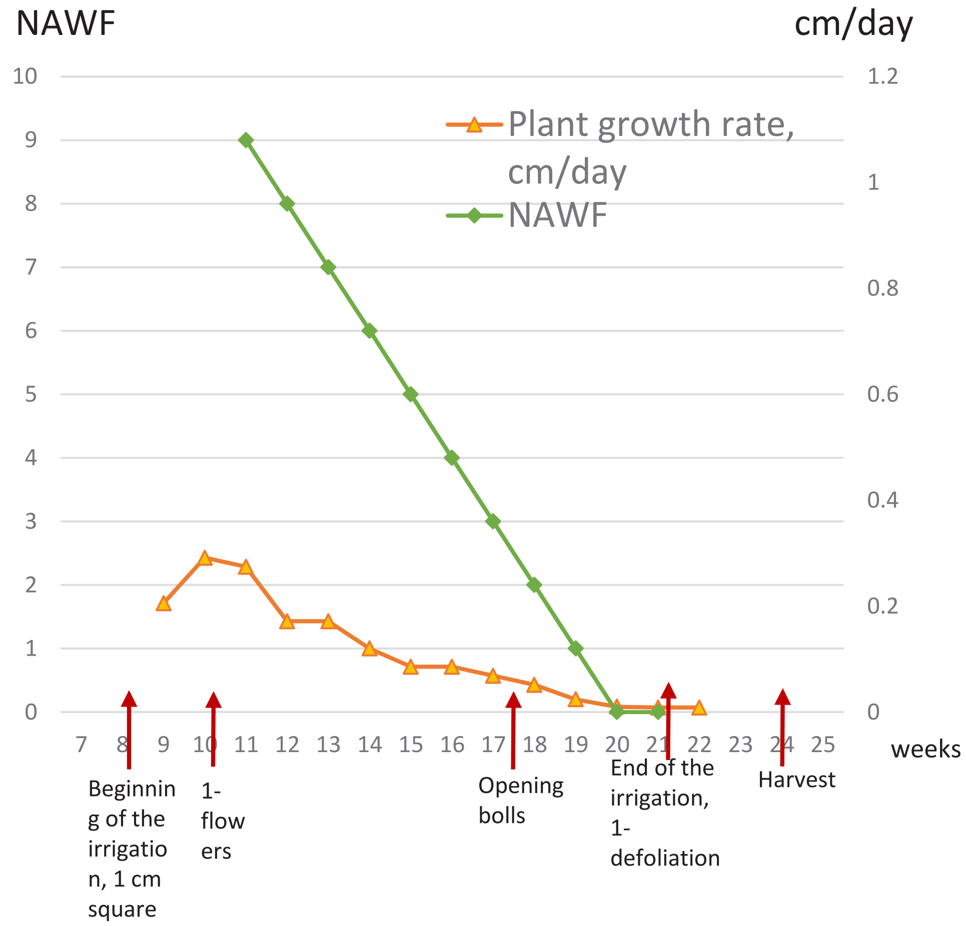
Research objective and methods

- The purpose of the research:
  - to calculate the optimal option of the water standard in drip irrigation;
  - to achieve maximum productivity.
- Complete soil analysis, irrigation , moisture monitoring, phenological observations and yield control.

Growth rate and NAWF



Plant growth height and number of nodes

Thanks for you attention

HYDROMODULAR ZONING OF IRRIGATED LANDS OF SOUTHERN KARAKALPAKSTAN AND THE OPTIMAL MODE OF COTTON IRRIGATION

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2nd International Summer School 2023

21 August 2023

Research problem and knowledge gap

- **Research problem -** hydromodular zoning of irrigated lands in the conditions of climate change and water shortage in the southern regions of the Republic of Karakalpakstan using modern GIS technology creation of electronic maps of the hydromodular region research and develop a scientifically justified regime for irrigating cotton in the main hydromodular area

- **Existing knowledge gap-** earlier, none of the scientists determined the indicators of climate change in the southern zone of the Republic of Karakalpakstan, and the areas of irrigated lands were not determined by hydromodular regions.

- **Expectations from the Summer School-**getting more knowledge and its application in scientific activities

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Research objective and methods

- Creation of an electronic map of hydromodular zoning of irrigated lands in the context of administrative districts, determination of a scientifically justified irrigation regime for cotton in a widespread main hydromodular region and its impact on growth, as well as development and productivity of cotton.
- Homogeneity test and T-test


Welcome to Uzbekistan
Willkommen in Usbekistan
Добро пожаловать в Узбекистан
Өзбекстанға қош келдіңіз
Өзбекстанга кош келиңиз
Хуш омадед ба Узбекистон
Özbegistana hoş geldiňiz
Ўзбекистонга хуш келибсиз

2nd Summer School WEFECA 2023