Australia's National
Science Agency

Stories of change

Scientists working together for a stronger water future in South Asia

Published by

CSIRO Land and Water, Black Mountain Science and Innovation Park, Clunies Ross St, ACTON Australian Capital Territory, Canberra

Citation

Wahid S, Cuddy SM, Ahmad MD, Mainuddin M, Almeida AC, Brandon C, Jade L (2022) Stories of change: Scientists working together for a stronger water future in South Asia. CSIRO Land and Water, Australia.

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CSIRO acknowledges the Traditional Owners of the land, sea and waters, of the area that we live and work on across Australia. We acknowledge their continuing connection to their culture and pay our respects to their Elders past and present.

We extend the same acknowledgement to the peoples and cultures of all the countries in which we work and are made welcome, and especially to our collaborators and partners in Afghanistan, Bangladesh, India, Nepal and Pakistan who made the stories told in this Storybook possible.

Front cover: Bagmati River, Nepal.
Photo credit: Tanya Doody, CSIRO

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Acknowledgements

It has been a great privilege to be on this journey with our colleagues and partners in Afghanistan, Bangladesh, India, Nepal and Pakistan. We hope that through telling some of our stories we convey our achievements and cement the enduring relationships that we have with our friends in South Asia.

We are grateful to the Australian Government Department of Foreign Affairs and Trade (DFAT) for co-funding the research. The Sustainable Development Investment Portfolio was initiated by AusAID, the then Australian aid agency, which was merged into DFAT in 2013. The Sustainable Development Investment Portfolio was innovative, based on partnerships and development and impact pathways, and evaluated against outcomes. It was a great honour to be selected as one of the partners and to have had the opportunity to work within such a framing.

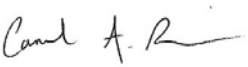
Foreword

This booklet contains stories of people and places that benefitted from CSIRO's Sustainable Development Investment Portfolio (SDIP) projects in South Asia. These projects worked on improving water security in Afghanistan, Bangladesh, India, Nepal and Pakistan and encouraged sustained, positive change in water management practices and policies. Drawing on global experience, scientists from Australia and South Asia gathered evidence, researched key developmental challenges, and filled important knowledge and capacity gaps.

The stories range from building a nation's water information system to uncovering the science and economics of groundwater use. Gender was a key focus for our projects, because women and girls are particularly vulnerable to water scarcity.
In many instances, they are an untapped resource in making water management more sustainable and equitable.
By telling these stories, we celebrate international research collaboration as a vehicle for countries to work together towards a sustainable future.

We hope the stories in this booklet will deepen our understanding of what drives change and where future research for development could focus, and inspire our readers to continue to advance water management in South Asia.

Jane Coram
Director Land and Water | CSIRO



Carmel Pollino
Research Director Water Security Program
Land and Water | CSIRO

Kamala River valley in the Koshi Basin, Nepal. Photo credit: Tanya Doody, CSIRO

Snapshot

CSIRO-DFAT Sustainable Development Investment Portfolio

5
countries' researchers worked with CSIRO (India, Pakistan, Bangladesh, Nepal and Afghanistan)

117
researchers from CSIRO and partner organisations worked in the projects
(28 women, 89 men)

29
institutes from South Asia collaborated with CSIRO

579
professionals trained
(177 women, 402 men)

1,337
participated in workshops and policy forums
(386 women, 951 men)

52
graduate research projects supported
(28 by women, 24 by men)

38 Journal articles

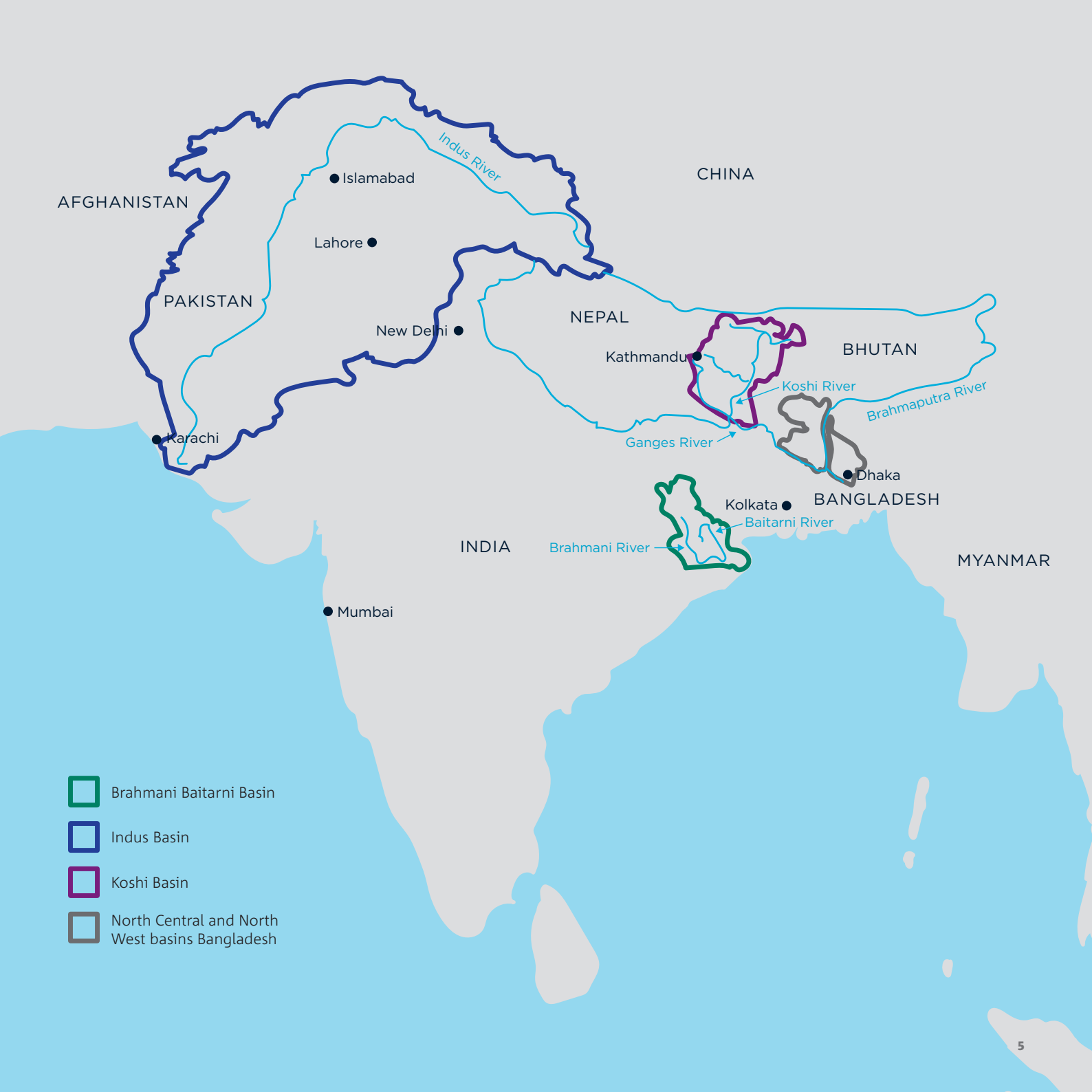
58 Technical reports

27 Fact sheets

20
new knowledge products with a gender lens, of these 10 directly address knowledge gaps on gender and include sex-disaggregated data

Research focus

- Integrated assessment of water-agriculture-livelihoods interactions
- Social inclusion and gender equity in water management
- Climate change impact on water
- Transparent, trusted, and timely water information access


AFGHANISTAN
PAKISTAN
Islamabad
Lahore
Indus River
New Delhi
Karachi
CHINA
NEPAL
Kathmandu
BHUTAN
Koshi River
Brahmaputra River
Ganges River
Dhaka
BANGLADESH
Kolkata
Baitarni River
Brahmani River
INDIA
MYANMAR
Mumbai
Brahmani Baitarni Basin
Indus Basin
Koshi Basin
North Central and North West basins Bangladesh

Kamala River headwater in the dry season.
Photo credit: Tanya Doody, CSIRO

Introduction

The development and management of water resources is one of the most pressing and complex challenges facing the world today. Population and economic growth are putting increasing pressure on water resources, affecting food and energy security. Climate change further complicates water issues. The United Nations recognises these issues in several Sustainable Development Goals (SDGs) and has designated 2018–2028 as the International Decade for Action: Water for Sustainable Development.

The complexity, intensity and urgency of global water challenges require global solutions and pooling of resources. Fortunately, water research capacity around the world has grown impressively over the past few decades, creating a solid foundation for scientists from different institutions and countries to work together towards common research goals. Even so, there are still many unknowns and competing interests on how to solve complex problems and deal with uncertainty in water resource management.

Recognising the importance of collaborative research in water resource management, CSIRO works with Australian and international partners to develop breakthrough science and management innovations to drive change in the water sector. The Australian Government's Sustainable Development Investment Portfolio (SDIP) in South Asia was one such collaborative program. Through this initiative, CSIRO worked to improve water management in South Asia, with a special focus on the most vulnerable populations including women and girls. The results are remarkable. They provide evidence to support how water resources can be managed sustainably and equitably, and help strengthen institutional infrastructure and data collection and analysis to inform effective water management.

The benefits to science have been significant. The collaborations brought together new combinations of perspectives, backgrounds and experiences; and inspired new ideas and innovation that led to advances in science and technology. They fostered mutual understanding and respect and developed strong scientific networks. CSIRO scientists adapted to working with colleagues in countries with very different cultures and water management policies and practices. They developed the skills to more explicitly integrate gender and social inclusion into their work. Together, the meaningful engagements have developed trusted relationships with research partners and universities of the fastest-growing region of the world, and improved water research capability in South Asia and Australia. This project highlights that scientific collaboration is creating opportunities for countries to work together towards a more sustainable future.

Despite the growing involvement of women in farm activities, rural women get recognition for their household activities, but not for their agricultural activities

Rahman et al. (2020)

Women are taking on more responsibilities in accessing and using water in Bangladesh. Photo credit: Lingkon Serao, Shutterstock

Including women in making decisions about water

A project in Bangladesh contributes to inclusive water management

Climate change is making life more difficult for many people living in rural Bangladesh. It is increasing risks to farming incomes, which is forcing many male farmers to migrate to cities in search of other opportunities. As a result, women are taking on more responsibilities in accessing and using water, especially in poor and marginalised households.

However, women are often left out of local water decisions. In light of the changing climate and demographics, it is more important than ever to ensure equitable access to water in rural areas. This has multiple gains for the whole community, for both men and women, rich and poor.

CSIRO and its partners in Bangladesh sought to understand factors that made women's inclusion in water decisions more likely. They found that women's education and membership in non-government organisations are the two most important factors – that is, men tend to include women in water decisions when women are educated and actively engaged in non-governmental organisation initiatives within their community. Decisions that men and women make together tend to lead to better outcomes for the entire community.

> Local government and non-governmental authorities should interact with rural communities including women and involve them in decision-making processes for boosting agricultural production and abating the impacts of climate change, and ultimately ensuring food security of the country
>
> Al-Amin et al. (2019)

Professor Hasneen Jahan interviewing a woman as part of the project to better understand inclusive water management. Photo credit: Md Wakilur Rahman

So, how can women be potential agents for inclusive water decision-making?

First, women need to be recognised as farmers by communities, governments and the broader society. About half of all women in Bangladesh are engaged in agriculture. Their contribution to agriculture must be duly valued and farming must not be seen as a men-only activity. The traditional view that women lack knowledge of irrigation should change and more and more women should be brought into decisions about the allocation and use of water. Targeted training and agricultural extension input for women will help their meaningful participation in water decision-making.

Second, women must be supported to take on leadership roles in farming organisations currently dominated by men. This will allow women to explain why and how water decisions can differently affect their gender. Information and training about water-saving technologies, specifically targeting women, can help to improve the efficiency of water use across the sector. Agricultural research on women farmers will be key to enhancing productivity.

Third, our surveys found that men and women also think and act differently in adapting to climate change. These differences must be recognised so that women can play a more significant role in their communities adapting to a changing climate. For example, in areas affected by water scarcity in north-west Bangladesh, women do not recognise decreasing rainfall trends as much as men. But when they do, women are more likely to change their farming practices in response compared to men of the same age.

CSIRO and its partners presented the research findings to Bangladeshi decision-makers and encouraged women's full economic and political participation in rural Bangladesh.

Despite women taking on more responsibilities in accessing and using water, they are often left out of local water decisions. Photo credit: Lingkon Serao, Shutterstock

PROJECT (2016–2020)

Sustaining groundwater irrigation for food security in the north-west region of Bangladesh

Partners: Water Resources Planning Organization, Barind Multipurpose Development Authority, Bangladesh Agricultural Research Institute, Bangladesh Agricultural University, Institute of Water Modelling

Further reading: 1. An Empirical Investigation of Men's Views of Women's Contribution to Farming in Northwest Bangladesh. 2020

2. An intra-household analysis of farmers' perceptions of and adaptation to climate change impacts: empirical evidence from drought prone zones of Bangladesh. 2019

Full references are on page 41.

CSIRO and its partners in Bangladesh sought to understand factors that made women's inclusion in water decisions more likely. Photo credit: Talukdar David, Shutterstock

Understanding groundwater decline

Research helps Bangladesh sustainably manage groundwater resources

Bangladesh suffered a chronic food shortage in the 1970s. Since then, successive governments targeted food self-sufficiency as their key strategic development goal. They reformed water and land management, and promoted minor irrigation systems to make watering crops cheap and possible during the dry months of the year (November to May). Farmers, particularly in the north-west region, benefitted from the expanded irrigation. They grew more crops a year (up to 4 crops in some areas). This region supplies Bangladesh with 35% of all dry-season rice and 60% of wheat and maize, helping to achieve food security for about 1658 million people.

> The north-west region is of greatest concern over falling groundwater levels... affecting access to water for drinking and irrigation
>
> Mohammed Mainuddin, CSIRO Project Leader

Pumping groundwater to irrigate rice fields. Photo credit: Mohammed Mainuddin, CSIRO

In the past, farmers used both surface water and some groundwater to irrigate farmland. Things started to change 3 decades ago, as pumps capable of accessing lower groundwater for irrigation became cheaper and more widely available. Farmers started to pump more groundwater than they had previously to irrigate in the dry season.

Unfortunately, in many parts of the region, pumping during the dry season led to the groundwater table temporarily dropping beyond the reach of drinking-water hand-pumps. Newspapers ran more and more reports of people running out of drinking water in the dry season.

In some areas of Bangladesh, pumping of groundwater has led to the groundwater level temporarily dropping beyond the reach of drinking-water hand-pumps. Photo credit: HM Shahidul Islam, Shutterstock

Generally, the groundwater levels recovered in the next wet season. But in a few parts of the region, particularly in the elevated area of the Barind Tract, groundwater levels declined permanently.

Many people thought that pumping for irrigation, particularly for Boro rice, reduced groundwater levels. Policymakers responded by proposing restrictions to groundwater use for irrigation.

However, blanket restricting groundwater use for irrigation on its own may not recover groundwater levels.

For example, blanket or default restrictions do not recognise that in some areas, groundwater levels recover in the next wet season. This means there is less reason to restrict its use for irrigation.

There may be also other factors reducing groundwater that have been overlooked.

Policies restricting groundwater use may also have unintended consequences including on food security. Alternative surface-water supplies for irrigation are not available everywhere. For example, there is a shortage of surface water for irrigation in the Teesta river area, and the problem is worsening.

CSIRO led a project to better understand the causes of north-west Bangladesh's declining groundwater levels. Researchers used hydrological modelling to test the widely held belief that pumping for irrigation was only to blame. They captured long-term changes of water use by crops by utilising remote sensing and crop survey data. They used modelling to combine this data with analyses of rainfall, evapotranspiration (the combined process of water surface evaporation, soil moisture evaporation and crop water use) and groundwater levels.

Women harvesting rice in Bangladesh.
Photo credit: fotomatik, Pixabay

The team found that several factors were linked to declining groundwater levels. These included reduced rainfall, changes in rainfall characteristics, reduction in recharge areas, reduced ponding in the wet season and reduced percolation due to large areas of soil puddled for rice cultivation.

Such variety of contributing factors highlights the need for a multi-pronged approach to addressing the root causes of groundwater decline. A single policy or management change like restricting groundwater use for irrigation will not be enough to reverse the diminishing resource.

Research leaders met with key decision-makers, including the Bangladeshi Minister of Agriculture, to brief them on the findings of this research.

As more leaders come to understand the factors that contribute to groundwater decline and how groundwater levels can be recovered, evidence-based policies can be developed and implemented to help ensure the long-term sustainability of Bangladesh's groundwater resource.

Rice fields in Bangladesh. Photo credit: Mohammed Mainuddin, CSIRO

PROJECT (2016–2020)

Sustaining groundwater irrigation for food security in the north-west region of Bangladesh

Partners: Water Resources Planning Organization, Barind Multipurpose Development Authority, Bangladesh Agricultural Research Institute, Bangladesh Agricultural University, Institute of Water Modelling

Further reading: 3. Rainfall-induced recharge-dynamics of heavily exploited aquifers – A case study in the North-West region of Bangladesh. 2021

4. Water usage trends under intensive groundwater-irrigated agricultural development in a changing climate – Evidence from Bangladesh. 2021

5. Water Table Trend – A Sustainability Status of Groundwater Development in North-West Bangladesh. 2019

6. Groundwater use and rapid irrigation expansion in a changing climate: Hydrological drivers in one of the world's food bowls. 2020

Full references are on page 41.

Deepening understanding of river basin management

Building models to explore water resource management options in north-east India

Sixty percent of Indians depend on agriculture for food security and livelihoods. The sector is intrinsically linked to water resources, but these are under increasing pressure. We see proof of this pressure in variable rainfall (including droughts and floods), poor water quality, and insufficient irrigation to achieve potential crop yields.

Growing populations and climate change are increasing pressure on water resources – however, investment in infrastructure and improved irrigation practices can help to address this challenge.

For example, in the Brahmani Baitarni Basin, in north-east India, rural communities lack access to reliable water and food sources. Throughout the Basin, agriculture is critical to the food security and socioeconomic development of its people.

CSIRO researchers worked with government and water managers in India to identify key future challenges and opportunities for water – its use, planning and management – in the Brahmani Baitarni Basin.

A modelling approach, developed in Australia and adapted for India, helped researchers understand the current available water resource, and explore potential investments in water management with a view to improve agricultural production and livelihoods in the Basin.

Irrigated agriculture is a large and growing contributor to the Indian agricultural economy and improving irrigation water delivery is a critical need. For example, in the upper part of the Brahmani Basin, research shows farmers could grow more rice for their families and to sell if they could access more supplementary irrigation. Other constraints include low yielding crop varieties, a lack of nutrients and farming practices.

CSIRO researchers used a river system model to deepen understanding of the Brahmani Sub-Basin. River systems models are analytical tools that help people explore interactions between the river system, environmental forces, human water use and infrastructure, under current and likely future conditions.

Groundwater well in India. Photo credit: Carmel Pollino, CSIRO

Sufficient and clean water resources are vital for supporting people and their livelihoods and the environment.

Pollino et al. (2016)

Rice crops being maintained by a farmer in a tribal village in the State of Jharkhand, India. Photo credit: Carmel Pollino, CSIRO

This tool can provide information to improve the management of water resources for agriculture, industry, energy, critical human needs and the environment.

Researchers evaluated scenarios with different levels of investment development in the Sub-Basin, for irrigation, hydropower and domestic water use. Using a scenario analysis approach also helped researchers to evaluate the potential impacts of climate change.

By using a river system model and scenario analysis, CSIRO researchers and partners created a case study to demonstrate evidence-based basin planning, that leverages local data for modelling.

The CSIRO and the Government of India established a partnership to build capacity in the Government of India to sustainably manage their water resources. An early outcome was that the government and local water managers developed a river system model for the Baitarni Sub-Basin as the companion to the Brahmani Sub-Basin. This allowed for more holistic management of the Brahmani-Baitarni Basin.

Though the focus of the engagement was on building technical expertise, it demonstrated the power of collaboration and the benefits that developing and using models bring to the processes of basin planning and water resources management.

PROJECT (2013–2016)

Modelling for river basin planning: a demonstration in the Brahmani Basin, India

Partners: Government of India, State Governments of Jharkhand, Odisha and Chhattisgarh, Barma Water Resources, eWater, FlowMatters

Further reading: 7. Modelling for river basin planning: a demonstration in the Brahmani Basin, India. 2016

8. Portrait of a river basin. 2016

Full references are on page 41.

Foundation for tomorrow

A roadmap to build a nation's water information system paves the way for investment in Afghanistan

In a country recovering from war, how do you make fair decisions about water? You need accurate, up-to-date and reliable data.

In a country where water supply is variable, how do you ensure that supply is steady, reliable and maintained? You need a good understanding of water availability and how to manage it, and the infrastructure needed for storage and delivery.

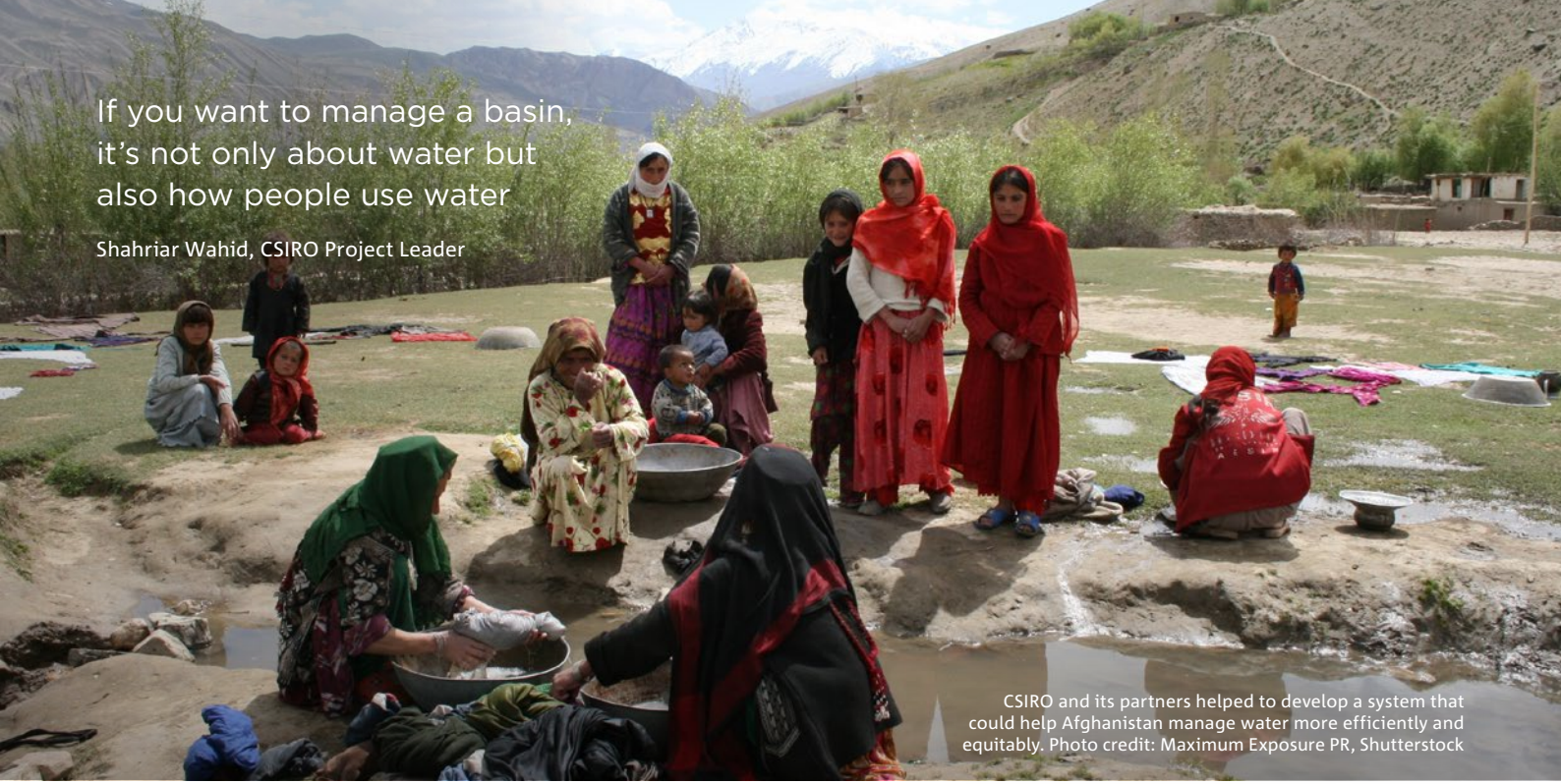
Afghanistan has faced constant and unrelenting pressures on water supply and management. Decades of conflict, prolonged drought, climate change, increasing population, urbanisation, deterioration of water infrastructure and periods of missing water data have all contributed.

Water managers can be more confident in their decision-making when they have access to high-quality, timely information and data. CSIRO and the Australian Bureau of Meteorology worked with the former Afghanistan Government up to 2021, to co-develop a roadmap for building a reliable, accessible water information system that would provide such information and data.

Afghanistan has faced constant and unrelenting pressures on water supply and management.
Photo credit: timsimages.uk, Shutterstock

I am excited by what has been achieved in this co-designed road mapping exercise. Through the process, we have learnt from the Australian experience what challenges and opportunities face us and strengthened our capability to develop the Afghanistan national water information system (ANWIS)

Khan Mohammad Takal, Minister of Energy and Water, February 2020



CSIRO and its partners helped to develop a system that could help Afghanistan manage water more efficiently and equitably. Photo credit: Maximum Exposure PR, Shutterstock

The roadmap outlines components needed for the Afghanistan National Water Information System, when and how they can be developed, and necessary governance mechanisms to ensure the information system's sustainability. It offers different pathways and notes potential risks and opportunities associated with each.

CSIRO and the Australian Bureau of Meteorology drew from lessons learnt during the development of the Australian Water Resources Information System, which is now a mature product trusted by the Australian public. The Afghanistan Government assessed the institutional and staff capability of Afghanistan.

This roadmap has unlocked investment to develop the Afghanistan National Water Information System and promote nation-wide integrated water resources management. Australia's Department of Foreign Affairs and Trade invested to develop foundational components of the Afghanistan National Water Information System while the World Bank and Japanese Government designed two companion projects to support its development.

The project terminated and all communications ceased from August 2021 when the Taliban declared an interim government in Afghanistan.

PROJECT (2018–2021)

Strengthening Water Resources Management in Afghanistan

Partners: International Centre for Integrated Mountain Development, Government of Afghanistan

Further reading: 9. National Water Information System development: a roadmap for Afghanistan. 2020

Full references are on page 41.

Basin planning aims to equitably share water to meet the needs of users.
Photo credit: Tanya Doody, CSIRO

Transforming water management

A newly federated Nepal develops a people-centric water management strategy in the Kamala Basin

Farmers in the Kamala River Basin, in south-east Nepal, produce their crops in the face of many challenges including drought, floods, landslides and riverbank erosion. Currently, 70% of the population relies on agriculture, and the problems of too much water in the wet season and not enough in the dry season seriously affect their livelihoods. Water also supports biodiversity.

To address the water management challenges in river basins such as the Kamala, the 2020 federal national water resources policy embraced basin planning. Basin planning aims to equitably share water to meet the needs of users, and to create future opportunities and sustainable livelihoods. It mitigates the negative impacts of climate variability, establishes water-sharing arrangements, and promotes engagement and decisions from different stakeholders. The Government of Nepal has committed to reforming the water sector, including through sustainable basin planning, and it wanted to bring in additional expertise to help.

Women spend a lot of their time collecting drinking water for their families. Photo credit: Tanya Doody, CSIRO

If people from middle and lower level demand [access] to drinking water there may be a situation of dispute

Dr Namita Yadav, Deputy Mayor, Siraha Municipality, Siraha

Basin planning aims to create future opportunities and sustainable livelihoods. Photo credit: Tanya Doody, CSIRO

Knowing how much, when and where water is available is the first step toward basin planning. A team at CSIRO worked with the Government of Nepal, local partners and local communities to understand local issues and demands in the Kamala River Basin. Their findings were captured in the report *State of the Kamala River Basin, Nepal*. This report provided up-to-date knowledge about water resources and trends for the Kamala River Basin. It included current water availability and livelihood knowledge.

The basin planning project strengthened existing capabilities among water users through local, provincial and central government agencies, non-government organisations and informal networks. The project enabled them to effectively engage in the strategic planning process. Meetings and workshops explored plausible, inclusive water management scenarios and alternatives, all of which were guided by Nepal's water policy and incorporated good practices from Australia.

A scenario planning approach helped these stakeholders understand the Kamala River Basin and its management in different ways, and influenced their decision-making process.

At the beginning of the project, the stakeholders shared their aspirations and values and these helped the project explore alternatives for future development which incorporated water supply and demand and methods of agriculture production in different parts of the Basin. A wide range of current water users was involved in defining the goals, objectives and performance indicators of the water management strategies. This engagement helped them to feel greater ownership of the strategies, which is key to the strategies being implemented and sustained.

The *Kamala River Basin Water Resources Strategy* developed and applied a river system hydrological model to estimate water availability and demand across the Kamala River Basin throughout the year. It identified strategies and scenarios for managing water. The *Strategy* sets priorities for investment actions and the governance needed to achieve the desired outcomes. It includes stakeholders' preferred development scenarios and implementation options and includes 3 goals:

- **Goal 1:** Sustainable management of the Chure and its natural resources for livelihood support and reduced vulnerability to water-induced disasters.
- **Goal 2:** Improved availability, use and allocation of water resources for livelihood generation, wellbeing and economic growth.
- **Goal 3:** Increased agricultural development through the application of science for local economic prosperity and livelihood security. The *Strategy* sharpens the focus of efforts to produce basin plans, outlining the pathways, activities, timing and mechanisms for implementing agreed development and management actions.

> As water is scarce, Chure has been degraded. Farmers do not have access to sufficient water in the dry season
>
> Kari Yadav, District Chairperson, Dhanusha National Federation of Irrigation Water Users Association

Nepal's national water policy proposes the development of basin plans. This project showed how a strategy and practices required for basin planning could be developed in Nepal. It has influenced the implementation of basin planning across Nepal. The Kamala River Basin example showed the benefits of involving stakeholders from the 3 tiers of government. These benefits include democracy and social inclusion, state restructuring, planning and practice, representation of small agricultural landholders and more even distribution of water resources. The responsible Government of Nepal agency, the Water and Energy Commission Secretariat, has increased its knowledge and ability in basin planning during this initiative and beyond. The time and effort put into building trust in this process have paid dividends. At all levels of government, there is a greater understanding of basin planning with practical actions.

Various users of water benefit from river basin planning in Nepal. Photo credit: Tanya Doody, CSIRO

PROJECT (2016–2021)

Kamala River Basin Initiative

Partners: Water and Energy Commission Secretariat Nepal, and contribution from Jalsrot Vikhas Sanstha, Policy Entrepreneurs Incorporated

Further reading: 10. Water Resources Development Strategy for the Kamala River Basin, Nepal. 2021

11. State of the Water Resources in the Kamala Basin, Nepal. 2020

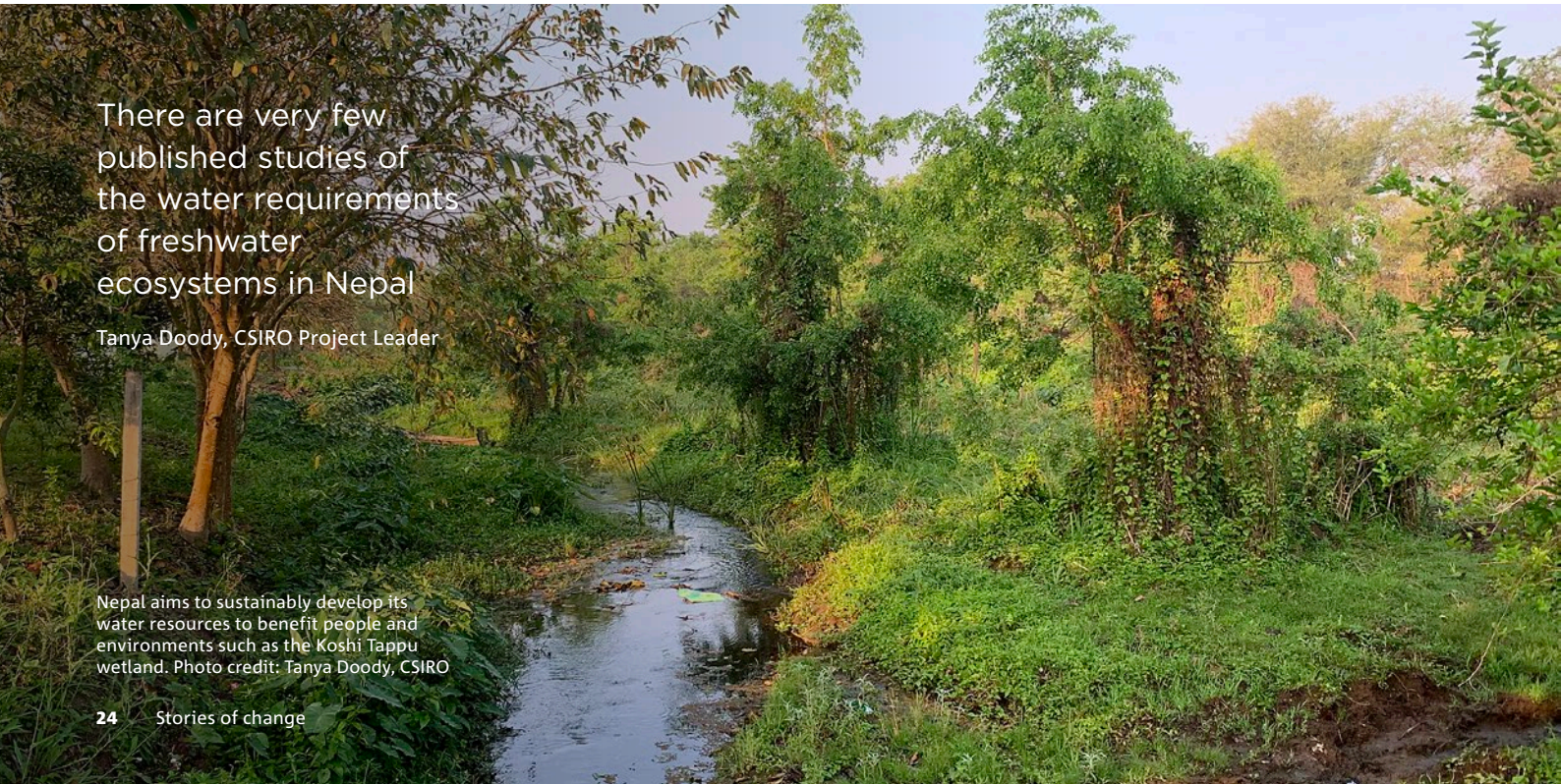
Full references are on page 41.

Linking river flow and ecology

A research project in Nepal leads the way to uncover how river flow impacts aquatic life

Nepal is a biodiversity hotspot of the world and changes induced by climate change and people can put these plants and animals at risk.

In water management, often limited consideration is given to the water requirements of biodiversity, including species such as the Ganga dolphin, Asiatic wild buffalo, endemic crocodiles and hundreds of bird species. Within the country, the installation and operation of hydropower plants are growing to meet the increased energy needs of the Nepali people, as is irrigation to support agricultural food production and bolster economic development. As a result, rivers are being modified, leading to significant ecological degradation. Nepal is now on a water reform journey, and it is a pivotal opportunity to protect the environment and maintain the provision of freshwater, including for women and children.



There are very few published studies of the water requirements of freshwater ecosystems in Nepal

Tanya Doody, CSIRO Project Leader

Nepal aims to sustainably develop its water resources to benefit people and environments such as the Koshi Tappu wetland. Photo credit: Tanya Doody, CSIRO

People must understand the relationship between changing river flows and ecology. Nepali scientists have a deep understanding of how water moving through rivers and wetlands supports wildlife – that is, the river flow-ecology relationships. CSIRO, the International Centre for Integrated Mountain Development and local partner organisations worked to document this knowledge. Together, they collated quantitative and qualitative flow-ecology relationships. The quantitative data revealed specific thresholds to flow change that, once exceeded, will cause a change (generally a decline) in native species populations. Qualitative data from observations help to inform sustainable management of Koshi Basin water resources.

As well as linking flow metrics with changes in species populations, the researchers also investigated how these factors relate to livelihoods. With university support, students devised and carried out household surveys to ask locals what the river means to them and their lives. Rivers provide both an essential source of protein and employment (such as fishing, basket weaving).

To increase the likelihood that such work continues, the project partners worked with university partners in Nepal to train researchers and university students in the research project development and data collection techniques. The partnerships established as part of this collaborative project endure and bring significant benefits for everyone involved, including shared resources and funds as well as an expanded, youthful and skilled base of researchers.

A key component of the CSIRO-led project in Nepal was building capacity in aquatic ecology. Photo credit: Tanya Doody, CSIRO

As an education tool, the flow-ecology report provided an improved understanding of aquatic ecosystems and their relationship to river flows at 2 Nepalese universities. This aids to build future capacity in aquatic ecology, particularly related to environmental flows and their importance.

Nepal aims to sustainably develop its water resources, and this requires a solid policy platform, community engagement and a comprehensive understanding of available water resources. This collaborative research and capacity-building work supports this ambition.

PROJECT (2015–2020)

River flow and ecology in Nepal

Partners: Himalayan Nature, Nepal; International Centre for Integrated Mountain Development; Bird Conservation, Nepal; Tribhuvan University, Nepal; Kathmandu University, Nepal; Zoological Society of London, Nepal.

Further reading: 12. Connecting flow and ecology in Nepal: Current state of knowledge for the Koshi Basin. 2016

Full references are on page 41.

Recognising women in agriculture

New research provides insights into women's issues in Pakistan's agricultural sector

Women make up a significant proportion of the agricultural labour force in Pakistan but their contribution is not properly acknowledged or rewarded. Sixty per cent of women's rural labour is unpaid (compared to 17% for men[1]). This includes time spent caring for family members and homes, as well as agricultural activities on family farms and in related businesses. Women participate in all stages of agriculture from sowing to post-harvest activities in crops, and management of livestock. Despite this, women have less access to assets, finance, services, training and other opportunities compared to men.

This study provides important data and insights to help understand the differences in men's and women's labour composition in Pakistan's agriculture. Photo credit: ACIAR

Considerable literature exists on gender inequality and the status of rural women. However, there are knowledge gaps. For example, which factors drive women's participation in the agricultural labour market in Pakistan? And how are women and men involved in wheat and rice production in the Pakistani province of Punjab?

This reflects that gender research is relatively new to organisations working in Pakistan's agricultural sector.

> It is well-known that women's contribution to agricultural production is significant, but studies on women's labour in agricultural activities in Pakistan are limited
>
> Muhammad Asif Kamran,
> University of Agriculture Faisalabad

1 Zaidi Y., Farooq S. et al. 2018. Rural Women in Pakistan – Status Report 2018 UN Women Pakistan.

Despite their contribution to agriculture in Pakistan, women are often not allowed to make decisions about a farm's operation. Photo credit: A M Syed, Shutterstock

Researchers from CSIRO and the University of Agriculture Faisalabad sought to quantify women's contribution to agriculture, and investigate the drivers of differences between men's and women's labour in the sector.
Photo credit: A M Syed, Shutterstock

Researchers from the University of Agriculture Faisalabad and CSIRO built their understanding of how to conceptualise and implement gender research. Together they tackled questions such as 'What are the gender-labour relations in cropping and livestock activities?'. To answer this question, researchers were taught gender-sensitive data collection methods and took those skills into the field. Women enumerators conducted surveys of rural women, which is religiously and socially appropriate and made the interviewees feel more comfortable. Insights from these surveys demonstrate the value of gender-based studies.

Along with quantifying women's contribution, researchers investigated the drivers of differences between men's and women's labour in the agricultural sector. For example, increased use of mechanisation and migration of men from rural to urban areas raise a phenomenon termed the 'feminisation of agriculture' which refers to the increasing participation of women in agricultural activities. However, women are often not allowed to make decisions about a farm's operation. The study also found that women mainly do manual harvesting of wheat, rice nursery transplantation and harvesting, and livestock management. The farm size, household size, family type and a woman's level of education affect whether she is paid or not for her labour.

Mechanisation is changing farming practices. While mechanisation can boost productivity, it affects men and women differently. Traditionally men are expected and trained to operate machinery, and this is reinforced by government agricultural machinery training centres dominated by men. This has disadvantaged women, as their labour is now limited to relatively harder manual tasks that are considered less valuable.

This study provides important data and insights to help understand the differences in men's and women's labour composition in Pakistan's agriculture. Its findings can help inform the development of policies aimed at protecting and ensuring rights for women engaged in agricultural activities, including providing opportunities for training so they can participate more fully in the labour force and seize economic opportunities.

Women make up a significant proportion of the agricultural labour force in Pakistan but their contribution is not properly acknowledged or rewarded. Photo credit: Lynda Disher, Shutterstock

PROJECT (2018–2019)

Scale and Drivers of Female Agricultural Labor: Evidence from Pakistan

Partners: University of Agriculture Faisalabad

Further reading: 13. Profitability analysis and extent of female labour participation in mung bean production in Punjab, Pakistan. 2022

14. Extent and impact of female labour participation in canola production in Southern Punjab Province of Pakistan. 2022

15. Scale and Drivers of Female Agricultural Labor: Evidence from Pakistan. 2020

16. Raising the role of gender in agricultural research in Pakistan. 2019

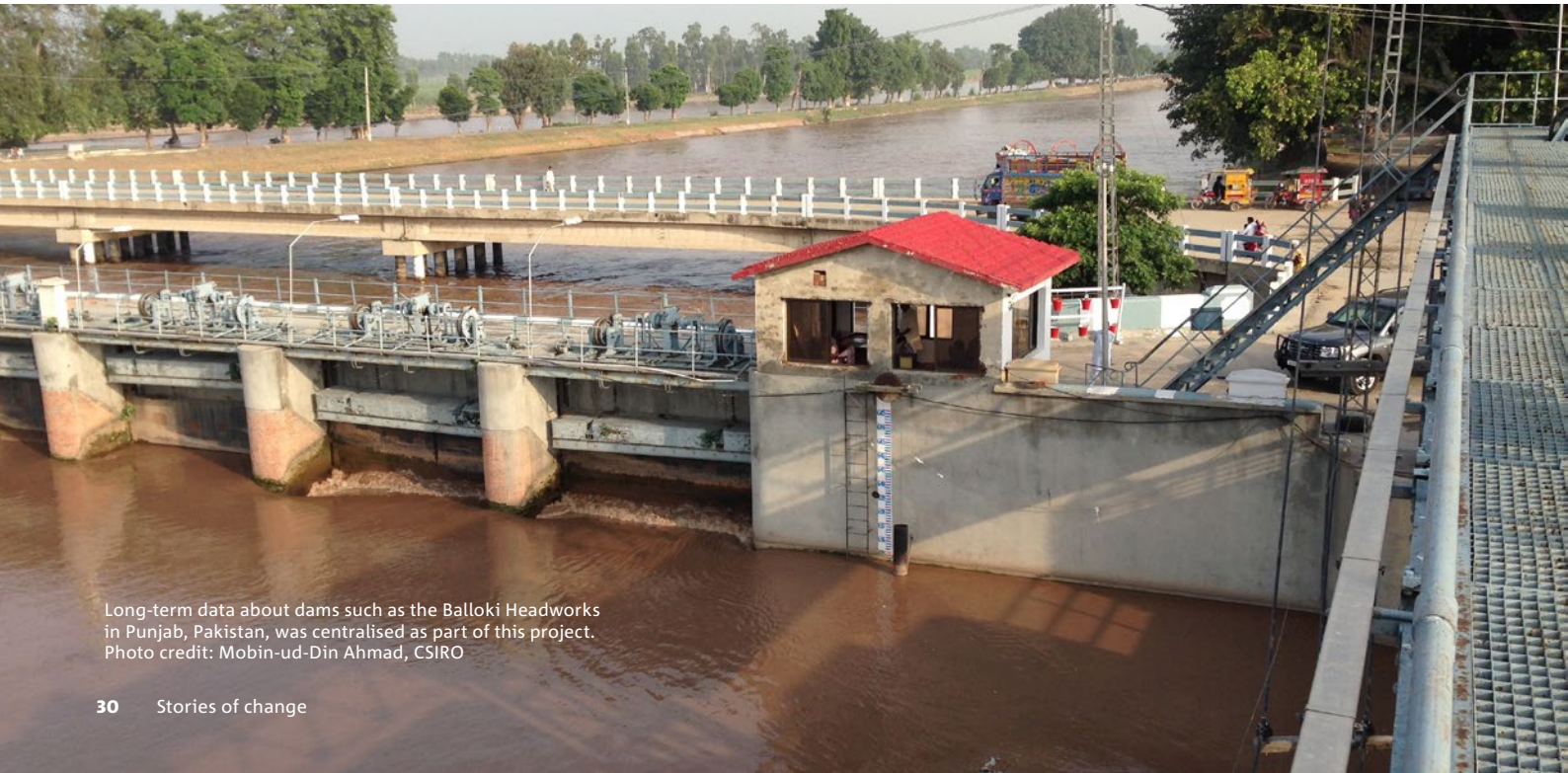
Full references are on page 41.

Modernising water data management

Accurate, accessible data informs decision-making in Pakistan

All countries are looking for ways to improve how they measure and manage water. A key requirement for this is having access to timely and accurate water data. Where floods and droughts are part of the pattern of life, as is the case in Pakistan, having such data readily available can save lives. This is because it allows water managers to quickly forecast flooding levels and activate plans including evacuations. Water managers also need access to long-term climatic and hydrological data so they can proactively manage the water resource through the cycles of drought and water abundance.

The Water and Power Development Authority is the lead federal water agency in Pakistan. It is responsible for planning, designing and executing major water resource development projects. It also manages Pakistan's long-term water data.



Long-term data about dams such as the Balloki Headworks in Punjab, Pakistan, was centralised as part of this project. Photo credit: Mobin-ud-Din Ahmad, CSIRO

The national information base shall be improved by developing a national planning database...

National Water Policy 2018, Ministry of Water Resources, Government of Pakistan

A modern, centralised water information system improves information to help water managers get water to where it is needed most. Photo credit: Katja Tsvetkova, Shutterstock

Centralising data and making it accessible would improve asset management and support evidence and data-driven decision making. It would also support the vision, outlined in Pakistan's *National Water Policy (2018)*, to modernise water-sector information systems.

CSIRO, water managers and other project partners worked together to introduce a modern software system developed to manage such historical data. Engaging government officials in the rollout of the system, including seeking and addressing their feedback, has fostered their understanding of and trust in it. This underpins their confidence in the analyses the system provides. The system, called Hydstra, is used by water managers around the globe. For Pakistan's Water and Power Development Authority, it is providing valuable evidence for decisions on water management, storage and use.

Evidence is emerging of the impact of this project. In the first year the Authority used Hydstra, its Surface Water Hydrology Project team showed increased confidence and expertise in processing flow datasets. Researchers compared the modelling of discharges – that is, the volumetric flow rate of water at a site – from the old water information system and the Hydstra system. They found the Hydstra system was more accurate, with the discharges modelled with it being closer to those measured, compared to the old system. The project team used Hydstra to produce real-time discharge assessments for critical hydropower locations such as the Neelum-Jhelum Hydropower Plant. Staff from Pakistan's Hydrology and Research Directorate were trained to use Hydstra to analyse discharge data, which will help them predict and manage water use in the future.

Hydstra helped the Authority's Surface Water Hydrology Project team enter a backlog of water data, including annual discharge reports and climate data. Pakistan's federal government requested additional guidance on how to further develop its in-house capacity to manage Hydstra. This signals its commitment to continuing to upgrade the water information management system.

A modern, centralised water information system provides the knowledge, data and evidence to support decisions including when resources are constrained, such as in drought. This means the best available information is being used to make allocation and distribution decisions to help get water to where it is needed most.

PROJECT (2017–2020)

Building knowledge and capacity to support integrated water resources management in Pakistan

Partners: KISTERS, Water and Power Development Authority – Surface Water Hydrology Project, Glacier Monitoring and Research Centre

Further reading: 17. Hydstra User Manual for analysis of discharge data. 2018

18. Hydstra User Manual for analysis of climate data. 2019

19. Water Information Management in WAPDA: Development pathways. 2022

Full references are on page 41.

Canal irrigation system in Punjab, Pakistan.
Photo credit: Mobin-ud-Din Ahmad, CSIRO

Bringing transparency and consistency

Research delivering tools that support sub-regional water cooperation in Pakistan

In a water-stressed country, understanding how much water is available and how to allocate it fairly are urgent needs.

Pakistan's growing population places increasing pressure on water resources. Rapid urbanisation, degradation of water environments, depletion of groundwater, deterioration of water quality, changing cropping patterns and growing competition for water all contribute, as does the threat of climate change. The Indus River System, which supports the world's largest contiguous irrigation system, is not immune to these pressures.

Pakistan's Inter-provincial Water Apportionment Accord (WAA), signed into effect in 1991, describes broad water-sharing principles among Pakistan's provinces. It does not prescribe how these principles are to be implemented. The Indus River System Authority, in consultation with the Water and Power Development Authority and provincial irrigation departments, decide how much water can be drawn from the river in each province. How the water is allocated is a detailed, complex process that had been understood in full by just a few key individuals. This lack of clarity has resulted in confusion and contestation between provinces, particularly during dry periods.

Through several years of transparent engagement, SDIP project partners shared information about water allocation processes and techniques. This enabled CSIRO and partners to develop a prototype digital tool, called the WAA Tool. Working with key federal and provincial government agencies, the team improved the management of hydrological datasets and developed tools for assessing water availability and demand, sharing and delivery. The prototype WAA Tool replicates pre-seasonal allocation processes done by key river operators. It makes the rules determining these allocations clear to all stakeholders.

Pakistani partners first tested the Tool against manual calculations for the Rabi (grow in winter, harvest in spring) cropping season of 2019–20. Success in this first trial saw more key federal and provincial water managers learn about and start to use the WAA Tool.

> Sindh Chief Minister Syed Murad Ali Shah has said that a river system model of the Indus Basin in Pakistan for modelling the 1991 Water Apportionment Accord would be useful for exploring different interpretations of provincial sharing arrangements as well as understanding the potential impacts of climate change and dam sedimentation on Sindh's water security
>
> Business Recorde, March 20, 2019

We endorse adopting the Accord tool for water distribution during the Kharif cropping season, April to September 2020

Ministry of Water Resources

Water allocations for the 2020 Kharif (grow during monsoon, harvest in autumn) cropping season, were determined more efficiently using the WAA Tool. Improved reservoir and irrigation system operations allowed more equitable supplies to be distributed among provinces and an additional 987 gigalitres were identified for distribution to the Sindh and Punjab provinces.

In 2020 the Ministry of Water Resources endorsed the WAA Tool for use in water distribution across Pakistan's provinces.

Thanks to the WAA Tool, more people now understand the water-sharing process in the Indus River System. It allows for more efficient, consistent and transparent water resource management. It can also help water managers assess the potential impacts of climate change and dam sedimentation on water security and plan for the future.

Collaborating with partners and stakeholders to develop the WAA Tool has improved respect and trust between different jurisdictions' water managers, which also supports more equitable and efficient water sharing.

Thanks to the digital tool introduced with support from CSIRO, more people now understand the water-sharing process in the Indus River System in Pakistan. Photo credit: Mobin-ud-Din Ahmad, CSIRO

PROJECT (2019–2020)

Development of a tool to support the consistent and transparent implementation of Water Apportionment Accord

Partners: Australian High Commission to Pakistan, Ministry of Water Resources, Indus River System Authority, Water and Power Development Authority, Punjab Irrigation Department, Sindh Irrigation Department, Khyber Pakhtunkhwa Irrigation Department, Balochistan Irrigation Department

Further reading: 20. Bringing transparency and consistency to Pakistan's seasonal water planning decisions: 1991 inter-provincial Water Apportionment Accord (WAA) Tool User Guide and Reference Manual. 2022

Full references are on page 41.

When there is a robust and trusted tool for showing how much water is available, a transparent water allocation process is possible

Dr Mobin-ud-Din Ahmad, CSIRO Project Leader

CSIRO and its partners developed a tool to help make water allocations more transparent and consistent. Photo credit: SkycopterFilms Archives, Shutterstock

Mainstreaming gender in water modelling

New perspective has the potential to improve water decisions

Water management is a complex task and models are used to support decision-making. Models allow planners, managers and users to understand how much water is available, used and needed, when and where, and how to best develop and manage the resource. For example, how may climate change reduce the consumptive pool? Or, how may a new dam in the headwater change water availability in a downstream household?

Women play a role in water management and are affected by it, but water managers and modellers rarely include gender factors in water models. Including gender factors in water modelling could reduce the risk of decision-making models entrenching social disadvantage for women and increase the likelihood that the outputs are relevant and helpful to a greater diversity of people.

CSIRO researchers asked water managers and modellers 'Would considering gender in the modelling process yield different and better outcomes for the men and women affected by water management decisions and policies?'.

The researchers used the three key steps in the Australian best practice *Guidelines for Water Management Modelling* to develop a range of examples to show how gender factors can be integrated into water modelling.

In Pakistan, we found that models built to bring water to the irrigated fields did not consider that the canal water is also used by women for washing. The village women are interested in irrigation but they want to make sure that they get enough good-quality water throughout the year for washing. If the water model is set up without including washing points, the information is never available nor considered in the modelling or its outputs.

CSIRO and its research partners found that models built to bring water to the irrigated fields did not consider that the canal water is also used by women for washing. Photo credit: Auro Almeida, CSIRO

Women play a central part in the provision, management and safeguarding of water

Dublin Principle 3 Integrated Water Resource Management

Women play a role in water management and are affected by it, but water managers and modellers rarely include gender factors in water models. Photo credit: Muhammad Usman Ghani, IWMI

Again, in Pakistan, we found that given the choice, men and women would pick different crops to plant, because they consider different factors. Women may prioritise the distance between the field and their home and the timing and duration of watering as they may need to fit farming in with household and child-rearing duties. These factors have not been reported by male farmers. Including water usage information provided by women provides a mechanism to explore and reveal gendered assumptions knowingly, or unknowingly, embedded into the model and the modelling process.

While exploring the sustainability of groundwater use in Bangladesh, our modelling identified that groundwater is generally replenished in most years despite increasing extraction and a changing climate. In those years when the groundwater table fell below the usual level, people do not pump so much water that the well water drops below the pumps' suction head. This could suggest to modellers that groundwater use is sustainable for irrigation. But in this instance, modellers might overlook the use of groundwater for household chores in some parts of the aquifer. If the groundwater table falls below 6 m, it is very difficult for women to retrieve water without a pump. This realisation changed the way we framed our groundwater modelling approach to address equity questions and highlight the knowledge, values and choices that may otherwise be overlooked.

PROJECT (2019–2020)

Inclusive modelling

Partners: CSIRO strategic project

Further reading: 21. Mainstreaming gender into water management modelling processes. 2020

Full references are on page 41.

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2 BOM – (Australian) Bureau of Meteorology; ICIMOD – International Centre for Integrated Mountain Development.

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4 CEEW – Council for Energy, Environment and Water; CWC – Central Water Commission (Government of India); JWRD – (Government of) Jharkhand Water Resources Department.

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