

WATERSHED MOMENTS

A PHOTOGRAPHIC ANTHOLOGY CELEBRATING 30 YEARS OF RESEARCH FOR A WATER-SECURE WORLD (1985–2015 AND BEYOND)







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1985-2015 AND BEYOND

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Writer and Editorial Consultant: Carolyn Fry Copy Editor: Mahen Chandrasoma Designer: Jim Smith Design Ltd Printer: Gunaratne Offset Printers

PICTURE CREDITS

IWMI / IIMI 4; 6; 30 (top); 38 (top); 77; 85 (right)

IWMI photographers

Felix Antonio: 85 (top left)
Hamish John Appleby: 1; 10; 20; 21 (right); 23; 31; 80 (left); 81; 90; 94 (top left); 96
Akiça Bahri: 85 (bottom left)
David Brazier: 65 (left); 66; 68; 69;
Karen Conniff: 21 (left)
Desalegne Tadesse: 72
Apollo Habtamu: 75; 77 (left)
Chu Thai Hoanh: 40 (top); 41
Jim Holmes: 39; 48; 50; 52 (right)
Ikuru Kawajima: 56 (top)
Sharad Maharjan: 93 (right); 94 (bottom left)
Matthew McCartney: 46
Steve McCurrach: 13
François Molle: 78
Josiane Nikiema: 87
Neil Palmer: 29; 37 (bottom); 54; 56 (bottom); 57; 58; 59; 61; 93 (left); 94 (top right)
Daniel Prudek: 37 (top)
Joe Ronzio: 86
Faseeh Shams: 34; 35
Prashanth Vishwanathan: 24; 30 (bottom)
Petterik Wiggers: 76
Graeme Williams: 62; 70; 71

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Panos

Abbie Trayler-Smith: 15

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FOREWORD

I am delighted to introduce this photographic collection as we move from celebrating the 30th anniversary of the International Water Management Institute (IWMI) to preparing for the challenges of the years ahead.

The year 2015 may have marked our third decade, but it has also been described as the most important year for human development in a quarter century. The United Nations (UN) adopted the far-reaching Sustainable Development Goals (SDGS), which will influence development policy and investment for decades to come. We also saw a major agreement in Paris for a binding global treaty on climate change. Delivering on these new commitments will be an immense challenge, and, with our partners, we fully expect to play our part as a globally recognized leader in water management science and solutions.

Behind the images presented here lies an interdisciplinary approach to understanding issues, assessing options for change across sectors, and proposing solutions to benefit society and the environment that supports it. Such solutions may have their roots in cutting-edge technology, institutional reform or policy dialogue. Only together can these approaches make a real difference to those suffering from water insecurity.

So you will see photographs here of solar-powered water pumps, laser land levelling, water monitoring systems that are accessible by mobile phone, and the use of satellite imagery for real-time flood and drought management. All of these technologies are revolutionizing the way water is managed and how we undertake our solutions-orientated research. However, you will also see images of farmers with few resources, striving to gain better access to water and achieve the resilience needed to lift themselves out of poverty. Sometimes all that may be holding them back are poorly targeted subsidies or a lack of access to markets. Our research seeks to uncover these barriers and to influence change.

IWMI has always argued that a combination of technological, institutional, social and political dimensions is needed to deliver sustainable growth. Add the immense power of remote sensing and 'big data' approaches to resource management and raising public awareness of key issues, and I feel confident that we are on the verge of something significant: a chance to deliver on the spgs, and an ambitious development approach that embraces the need for growth while nurturing the natural systems upon which we all depend.

That to me is the difference that IWMI brings. We embrace complexity and actively reach out to partners at all levels. Our approach has brought success stories that have been scaled up, but that is not sufficient. Looking back over the past 30 years, it is clear that we need to continuously adapt to new challenges as they emerge. We are ready and excited at the prospect of identifying creative and innovative evidence-based solutions that bring about change. I know that the scientists, communicators, managers and many other staff at IWMI are totally committed to realizing our great vision: to create a water-secure world for all. I dedicate this book to them.

JEREMY BIRD DIRECTOR GENERAL, IWMI



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FROM IRRIGATION ENGINEERS TO CHAMPIONS OF WISE WATER USE

IWMI's current headquarters in Colombo, Sri Lanka (top left). A Memorandum of Agreement to form the Institute (then IIMI) was signed in 1983 (top right), and it began operating 2 years later in Digana Village, near Kandy, Sri Lanka (bottom right). In its early years, IIMI built relationships and set up projects in several countries (bottom left). Set up to improve irrigation, the International Water Management Institute (IWMI) has grown into a center of excellence on sustainably managing water across scales from field to river basin, to support livelihoods, food security and ecosystems.

Thirty years ago, IWMI began life with four staff amid the lush central highlands of Sri Lanka. Then called the International Irrigation Management Institute (IIMI), the organization was founded primarily to improve the below-par performance of irrigation schemes that had fuelled Asia's Green Revolution in the 1960s and 1970s. Over time, as environmental concerns emerged, populations increased and urbanization gathered pace, experts realized that irrigation challenges would be better addressed as part of wider water resources management. Building on IIMI's foundations, and with the field of water management continuing to evolve, IWMI today provides scientifically backed methods and technologies that enable people to sustainably manage water and land resources in ways that provide plentiful food, support livelihoods and maintain healthy ecosystems. The need for an organization dedicated to conducting research on water use within agriculture emerged in the late 1960s. At this time, a proposal put forward to the Bellagio Group of international donors and experts stressed the importance of water management for agricultural development. The Ford Foundation and the Rockefeller Foundation later recommended setting up a center to undertake research into irrigation technologies, the economics of water management and policy issues. In 1971, the Consultative Group on International Agricultural Research (CGIAR – a consortium of countries, regional and international organizations, and private foundations) was founded to breed better staple food crops. At meetings of its Technical Advisory Committee, water-related issues repeatedly surfaced. The need for a center concerned with irrigation management was becoming more pressing.

However, more than a decade would pass before the center came to fruition. By the early 1980s, CGIAR was already funding 13 centers; for this reason, it was reluctant to directly support a new water management organization. Instead, the Ford Foundation

IIMI's first home, near Kandy, had been built to house the engineers who constructed Sri Lanka's tallest dam, Victoria, seen here.

set up IIMI, with the World Bank acting as custodian of funds raised by CGIAR'S IIMI Support Group. Sri Lanka succeeded against competition from India, Pakistan and the Philippines to host the new center. Initially, IIMI was located at Digana village, east of Kandy. Built to house engineers constructing the Victoria Dam, the village had become vacant as building work on this large hydropower and irrigation project drew to a close. Once an Act of Parliament formally establishing IIMI had passed into law in 1985, the organization got down to business.

IIMI soon set up projects in its host nation as well as in Bangladesh, India, Indonesia, Morocco, Nepal, Nigeria, Pakistan, the Philippines and Sudan. In 1990, as Sri Lanka wrestled with internal violence, IIMI relocated to temporary accommodation in the country's capital city of Colombo. The following year, the Institute was able to move into its current purpose-built building in the city, within the leafy suburb of Battaramulla, close to Sri Lanka's Parliament. Provided as part of the hosting agreement with the Government of Sri Lanka, the building had been constructed with loans provided by the governments of Canada and Switzerland. As IIMI settled into its new home, it also formally joined CGIAR, following the Consortium's decision to expand, restructure and adopt new research directions.

In its early years, IIMI investigated several challenges: how Asia's rice-based irrigation systems might better support farmers wishing to grow higher-value crops in the dry season; the growing dependence on groundwater for irrigation in India and Pakistan; the influence of gender on irrigation in Nepal, Sri Lanka and Bangladesh; and the threat to agriculture from saline soils in Pakistan. The Institute's work went beyond studying engineering and hydrological aspects of irrigation to pioneering new management approaches. While exploring how irrigation systems were managed, it consistently identified weaknesses within institutions and frequently encountered positive results when water users were involved. IIMI's efforts to demonstrate the value of 'participatory irrigation management' led to this concept becoming the guiding principle for governments and major lending agencies for many years.

A CHANGING WORLD

By the end of IIMI's first decade, it was evident that irrigation could no longer be viewed in isolation from other demands on water. Environmental damage, such as the shrinking of Central Asia's Aral Sea through excessive use of the rivers that fed it, starkly demonstrated the need for a new approach. In the first edition of its flagship Research Report series in 1996, entitled *The new era of water resources management: From "dry" to "wet" water savings*, IIMI urged water managers and researchers to view irrigation within a river basin context, and to consider the needs







Assessing the impacts of rapidly expanding tube well irrigation, where farmers pump groundwater as they require it, remains a focus for IWMI. of non-agricultural users and the environment. Within 2 years, IIMI had become IWMI, reflecting this shift in focus. IWMI's broadened remit enabled its scientists to investigate new concepts, such as 'open' and 'closed' basins, water accounting, multiple-use water systems, basin institutions and environmental flows. It began working across a wider area, conducting research as far afield as Latin America, Turkey and North Africa.

Emerging technologies, such as geographic information systems (GIS) and remote sensing from satellites, made taking a wider view of water resources and their use easier, although 'ground-truthing' (gathering reference data) was costly and it could be difficult to access remote or politically hostile locations. Nonetheless, IWMI's scientists could now gather data from all parts of the world at a relatively low cost. In 1999, IWMI's 105th Research Report published the first irrigated area map of the world, which showed that more irrigation was taking place than had been thought. Subsequent projects engaged the technology to study changes in wetlands, analyze river basins in Asia and Africa, assess the rapid expansion of tube-well irrigation, and identify areas affected by floods and droughts. When the tsunami struck IWMI's host nation in 2004, its staff used remote sensing to help the government direct aid to the most-affected areas.

Being able to measure water resources at farm, national and global levels revealed the extent to which the world was already

suffering from water scarcity. In 2006, IWMI published its findings on the state of the world's water resources, gathered in consultation with 1,000 experts, in its *Comprehensive Assessment of Water Management in Agriculture*. It highlighted that a quarter of the world's people were living in areas of physical water scarcity (where water resources were insufficient to meet their needs) and a billion people were suffering from economic water scarcity (where insufficient investment meant they had difficulty accessing the water resources available to them). With agriculture responsible for 70% of water use, the report shone a spotlight on a huge challenge: how to feed the world's rising population with already scarce water resources, while facing increasing pressure from climate change. The assessment became the touchstone for future work on water scarcity.

IWMI is researching wastewater use as one means to help overcome water scarcity. The need to feed growing populations amid competing demands for water from industry and homes had led increasing numbers of urban and peri-urban farmers to use wastewater for irrigation; today, around 20 million hectares (Mha) of land are irrigated informally with untreated or partially treated wastewater. IWMI's extensive work in this field helped to convince people, including the World Health Organization (WHO), that wastewater is a valuable resource that should be carefully used, not spurned. With many of the countries in which this practice is widespread unable to afford the cost of treating wastewater, finding simple, low-cost techniques and management practices that prevent crops from becoming contaminated remains a priority.

UNCERTAIN TIMES

Climate change is forecast to make life increasingly difficult for urban and rural farmers alike. In the coming years, the observed rise in the frequency of floods and droughts will intensify, adversely affecting agricultural production. In many places, the effects of climate change are already being felt keenly; scientists have recorded that the northern part of Myanmar's Dry Zone has received less rainfall in June in recent decades, for example. Improving the productivity of water (the gains made from a quantified volume of the resource), creating more facilities to store water, and integrating the management of surface water and groundwater resources will be vital to overcome the effects of climatic shifts. Much of IWMI's current work is concerned with improving people's access to water and promoting its sustainable use, be that through formal irrigation schemes, small ponds to store water during dry periods or incentive frameworks that help farmers to pump groundwater without over-exploiting it.

The desire to improve water productivity has underpinned much of IWMI's research over the past 20 years. As its scientists have honed our understanding of the issue, the strengths and Sophisticated technologies, such as this pivot-irrigation system with cattle and pasture in South Africa, may represent a model for the future for some regions. However, there is no one-size-fits-all solution to effective water management.

limitations of this approach have emerged. The Institute's early efforts involved designing a water accounting framework to identify where water was being used and reused; initially, it simply wanted to find ways to achieve more 'crop per drop'. Now, IWMI also recognizes the value of measuring the development benefits gained per drop, such as reducing poverty and improving health. Meanwhile, the newly emerged concepts of the water footprint and water stewardship seek to encourage agricultural and other businesses to measure the volumes of water they use and pollute, and to take action to manage water sustainably as a shared, public resource. Recent IWMI research has revealed that good water management has the potential to alleviate poverty, maintain healthy ecosystems and become an engine for economic growth.

Over the years, many of the staff, postdoctoral fellows and interns who have worked at IWMI have gone on to hold highly influential positions around the world. Also, both individual scientists and IWMI projects have received accolades, including the International Water Association's Water and Development Award for Research, the International Water Resources Association's Crystal Drop Award, the Norman Borlaug Award for Field Research and Application, and the 'Water for Life' UN-Water Best Practices Award. In 2012, IWMI, as a whole, was awarded the Stockholm Water Prize, the world's most prestigious water honor, by the Stockholm International Water Institute. The awarding



Although irrigation remains a central focus of IWMI's work, it now has a much broader remit than when it was founded. For example, it seeks to ensure that women and men have equal access to water management infrastructure.

committee cited IWMI's contribution to developing new policies and investments in agriculture, stating that these had facilitated more productive use of water, as well as enhancing food security, economic development and environmental health around the world.

Going forward, IWMI's expertise has potential to help attain the United Nations (UN) Sustainable Development Goals (SDGS). Five of these 17 goals feature water, oceans and marine resources within 20 separate targets. One of the Goal 6 targets covering clean water and sanitation strives to 'substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity, and substantially reduce the number of people suffering from water scarcity' by 2030. IWMI's two decades of research on water productivity can underpin efforts to achieve this goal.

One of the Goal 5 targets for achieving gender equality is to 'undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources ...'. IWMI's ongoing gender research has shown that agricultural productivity improves when men and women have equal access to water management technologies and innovations. IWMI worked in Zimbabwe to address the challenges facing women farmers in the Limpopo River Basin, who have taken over farming as men have migrated to urban areas to seek employment or died from HIV and AIDS. Understanding the competing demands on women's time was important. An initiative that freed women from the chore of collecting firewood, for example, enabled them to attend training sessions.

Water management has become much more complex since IIMI set out to revitalize Asia's irrigation 30 years ago. Precious water resources must now be managed in a way that sustains interconnected natural ecosystems, guarantees community equity and considers competing uses, which calls for interdisciplinary approaches and cross-sectoral partnerships. IWMI's current setup reflects this need; not only does the Institute now lead the CGIAR Research Program on Water, Land and Ecosystems (WLE – a coalition of CGIAR centers and the Food and Agriculture Organization of the United Nations [FAO]), it also has partnerships with many governments, nongovernmental organizations (NGOS), research institutes and private-sector organizations around the globe. Ensuring the world has sufficient water, and that everyone, whether rural or urban, rich or poor, male or female, can access it in a sustainable way that helps them live healthy, fulfilling lives is one of the most challenging tasks facing humanity. With more than 300 expert staff in 14 offices across Asia and Africa, many motivated collaborators, state-ofthe-art technology and three decades of invaluable experience, IWMI is ready and willing to take on this challenge.







BUILDING ON THE WATER WISDOM OF ANCIENT KINGS

Irrigation systems built in Sri Lanka as far back as 2,300 years ago were among the most complex systems of the ancient world. IWMI strives to continue and build on its host nation's legacy of excellence in water management. Irrigation has a long history in Sri Lanka. The challenge, given today's far larger population, is to manage the nation's water in a way that reflects modern-day farming and increasing competition for resources.

The location of IWMI's headquarters in Sri Lanka is particularly appropriate given the country's long history of water management. As far back as 2,300 years ago, Sri Lankan kings built complex networks of reservoirs and canals to store and distribute water for agriculture. Building on these historic foundations, IWMI works to improve water management for farmers within Sri Lanka's current social and economic context, and to provide science-based forecasts to inform policies for making the nation resilient to climate change.

As an island, Sri Lanka has highly variable climatic zones. It often suffers from too much or too little water, with droughts and floods occurring regularly. Between 2000 and 2013, 25 floods affected the lives and livelihoods of more than five million people. In 2014, when unusually heavy monsoon rains brought floods, landslides and high winds to seven districts, IWMI used its flood-mapping tools to indicate where flooding was taking place to assist relief efforts. It later hosted workshops on using weathermonitoring technologies as part of a capacity-building program.

GOING IT ALONE

Sri Lanka's climatic variability means it is not always easy for farmers to access water when they need it. Mirroring a trend across South Asia, more and more smallholders have dug wells on their land and installed cheap pumps to extract water on demand. IWMI is monitoring the proliferation of wells to identify whether groundwater is being over-exploited. In one area, within Jaffna District, researchers found the number of wells had increased by 37% between 2003 and 2009, despite the area used for agriculture expanding by only 6%. Ongoing work aims to uncover the consequences of this rapid rise in the number of wells.

In other locations, farmers have switched to pumping groundwater to supplement unreliable surface irrigation infrastructure. In one part of the Mahaweli River irrigation scheme, so many farmers were found to have dug wells that IWMI scientists realized it would be more effective to use the irrigation canals to recharge groundwater than to use them as the primary delivery mechanism for which they were designed. Its researchers installed flow-monitoring technology so that operators could access flow data online, and release water into the canals as required. When farmers realized water would be available in their wells 'on demand', they began investing in sprinkler technology and cultivating higher-value vegetable crops. Their increased incomes demonstrated that good water management can be an engine for economic growth.

A SOLID FOUNDATION

Effective water management depends on having good data on which to base decisions. IWMI has helped to improve people's access to water data by launching the Sri Lanka Water Resources Information System. Showcasing more than 700 water-related scientific papers, it provides maps and data on water availability, quality and use. An important tool on the site is the 'environmental flow calculator', which highlights how much river water is needed to keep ecosystems healthy. The Mahaweli Authority of Sri Lanka, which is responsible for maintaining and rehabilitating Sri Lanka's irrigation network within the Mahaweli River Basin, used the tool to prepare its water 'Master Plan'. IWMI is also assisting Sri Lanka's authorities to safely reuse sewage, while helping its farmers to improve their yields. Only a very small proportion of Sri Lankans are connected to modern sewerage systems; the remainder make use of facilities such as septic tanks or latrines. Dumping waste in the sea or on land had threatened to jeopardize Sri Lanka's efforts towards meeting the sdg on sanitation. IWMI is working with the government and local councils to find ways of reclaiming and reusing the nutrient-rich waste, for example, by making fertilizer pellets that are safe for farmers to use to grow crops.

Sri Lanka's tropical climate enables it to grow a wide range of crops, from rice to tea (right). However, it often suffers from too much or too little water (far right). IWMI works with the government to help it plan for droughts and floods.







Improving water management for Sri Lankan farmers enables them to grow a wider range of crops. IWMI's work has shown that having a well and a pump (opposite page), access to well-managed canals (below left) or sprinkler technology (below) can contribute greatly to boosting incomes and livelihoods.





An important aspect of effective water management is balancing the needs of different users. In Sri Lanka, fishers (left and below left) and foragers (such as this man [right] who is gathering Nymphaea nouchali, Sri Lanka's national flower, to sell at Buddhist temples) also rely on water for their livelihoods.







FROM BALANCING GROUNDWATER USE TO MANAGING SACRED RIVERS

Farm workers Sukhdev Vishwakarma and his daughter Meenu extract water using a solar-powered pump in Yamunanagar District, Haryana State, north India. Solar energy provides a cheap way to pump groundwater but must be carefully managed to avoid depleting resources. India is confronting the challenge of over-exploited groundwater, and working to allocate river water resources fairly to people and ecosystems.

IWMI'S work in India dates back to 2000, when it entered into a 12-year policy research and capacity-building partnership with the Sir Ratan Tata Trust (SRTT). The IWMI-Tata Water Policy Research Program (ITP), in which IWMI and SRTT were equal co-partners, set out to promote practical research with the potential to have substantial impacts. During the course of the partnership, ITP invested USD 5.2 million to develop participants' skills, produce research, foster collaboration and disseminate results. The work directly influenced policy decisions involving some USD 2,500 million of public investments, and the knock-on impacts of the program are continuing to spread. In particular, ITP brought groundwater to the fore in water policy discussions with India.

With 14% of the nation's gross domestic product (GDP) coming from agriculture and allied sectors, managing the use of groundwater for irrigation is a pressing issue. Large-scale

irrigation systems installed in the 1960s are no longer favored by smallholder farmers, who seek more flexible ways to water their crops. As in Sri Lanka, they have installed tube wells and small pumps, so that they can extract water when needed. While this has helped to boost agricultural production, electricity subsidies for agriculture and increasing water use by urban industries has depleted groundwater supplies in some areas. Today, 61% of India's irrigation comes from groundwater, but 29% of the country's groundwater assessment blocks are classified as being in a semi-critical, critical or over-exploited state.

In the western state of Gujarat, electricity subsidies that encouraged excessive groundwater irrigation led to farmers using electricity designated for homes and schools, the state electricity utility going bankrupt, groundwater resources becoming depleted, and the agricultural economy declining. IWMI worked to find a way to resolve the situation, recommending that agricultural electricity feeder lines be separated from nonagricultural lines and that electricity be rationed to farmers. After the state government adopted these recommendations,





A complex permit system for tube-well pumps affected agricultural output from small-scale farmers in West Bengal.

Gujarat recorded a growth of nearly 10% from agriculture within 7 years, the highest rate in India. The project has since become a model for other states facing similar problems.

PLENTIFUL SUPPLIES GO UNUSED

It is vital to consider the local context when planning for groundwater use. In West Bengal, farmers need to grow two or three crops a year to feed the state's 91 million people. However, concerns about possible over-exploitation of groundwater led the government to introduce a permit system in 2005 for anyone wishing to install a tube-well pump. Although this was fine for large users, many smallholders were driven by the complexity of the application process to hire expensive pumping equipment instead. Agricultural output declined as a result.

These small-scale farmers had never been sufficiently large water consumers to threaten West Bengal's relatively abundant and annually replenished groundwater resources. However, they ended up being the unintended victims of the government legislation. To improve their lot and invigorate agricultural production, IWMI recommended scrapping the permit scheme and charging a fixed fee to connect tube-well pumps below a certain size to the electricity grid. Following the state government's adoption of these recommendations, demand for electric pumps rose from 170,000 to 250,000 in 2012. Impact assessments are under way to find ways to strengthen farmer incentives and optimize water productivity. Findings so far show that the change has led to an increase in the cropped area, but has also led to unexpected behavior, such as farmers switching to crops that consume more water. Other action may be needed to ensure water use remains sustainable; the study demonstrates the complexities involved in introducing new policies.

OVERCOMING FLOODS AND DROUGHTS

IWMI is currently researching a completely new way to increase the amount of groundwater available to farmers, while minimizing the impacts of floods at the same time. The process, referred to as *Underground Taming of Floods for Irrigation* (UTFI), involves increasing the volume of water that infiltrates into underground aquifers during the wet season and extracting it for irrigating crops during the dry season. A study of Thailand's Chao Phraya River Basin has indicated that 270,000 additional hectares of land could be irrigated, and that 25% of monsoon runoff could be stored underground in aquifers. This could potentially save billions of dollars in prevented damage from floods and droughts.

UTFI has not yet been implemented at a large scale, but IWMI scientists are currently examining its potential use in the Ganges River Basin. It would require farmers to allow their land to be flooded in exchange for financial compensation; additional work is needed to explore whether this would be culturally acceptable.

KEEPING THE GANGES FLOWING

The Ganges River flows from the western Himalayas across India to the Bay of Bengal in Bangladesh. The river provides water for an array of needs, from irrigating agriculture to supporting wildlife and facilitating religious ceremonies. IWMI was involved in determining the environmental flows of the Ganges to ascertain the quantity, quality and timing of water flows required to sustain its ecosystems.

The research team assessed 88,000 km² of terrain over an 800 km stretch of the river. Drawing on studies by various experts, they recommended having sufficient flow depth to ensure that habitats remain connected; floods are maintained to redistribute nutrients relied on by wildlife, such as snow trout; and bathing rites can be completed, at least in non-drought years. Cultural requirements ended up dominating the water allocation, highlighting the need to consider religious and social water needs when calculating environmental flows. Scientists take a sample to measure water quality in a river. With rivers in India often relied on for bathing and conducting religious rites, pollution is a major concern. IWMI has been involved with calculating 'environmental flows' - the water required to sustain a waterway's ecosystems and support human needs - for the Ganges River.











A farm worker (left) adjusts a sprinkler used to irrigate crops in Alwar, Rajasthan. IWMI works to help farmers access groundwater in a sustainable way.

In Jiwai Jadid, Uttar Pradesh, scientists analyze water collected in a pond created under the UTFI scheme (below left). Brick structures in the pond allow water collected in the rainy season to flow swiftly below ground, for use by farmers during the dry season.

Using drip irrigation is an efficient way to water crops, avoiding wastage (opposite page).





ASIAN COUNTRIES FACE MULTIPLE WATER ISSUES

IWMI has worked in Pakistan for many years, focusing, for example, on overcoming salinity and finding ways to distribute water equitably. Revitalizing underperforming irrigation schemes, making the most of hydropower and keeping ecosystems healthy are priorities for Pakistan, Nepal and Bangladesh.

The Indus River rises on the Tibetan Plateau before flowing 3,000 km through the Indian-administered state of Jammu and Kashmir, and then across Pakistan. It empties into the Arabian Sea close to Karachi. Within Pakistan, the river is vital for food production, with the Indus Basin Irrigation System (IBIS) supporting a quarter of the nation's GDP through agriculture. However, land fragmentation and the increasing trend for farmers to grow cash crops are putting pressure on water resources. With the country's population forecast to increase by 47% from the level of 2012 to 300 million by 2030, the situation is set to become critical in the future.

IWMI has a long history of working in Pakistan. The country has the largest, contiguous artificial irrigation canal system in the world, but its performance has deteriorated over time. In many places, inappropriate irrigation has led to soils having high concentrations of salt, making it unsuitable for farming. IWMI scientists identified that saline soils were affecting one-eighth of the 16 Mha being irrigated in the Indus River Basin. After examining the factors affecting this trend, they concluded that the region could mitigate the negative effects of this 'salinization' by improving how irrigation systems are managed, changing how smallholders manage their own irrigation at farm level, and by managing groundwater and surface water conjunctively.

Other IWMI research has revealed that improvements to irrigation systems tend to disproportionately favor wealthier farmers. Its experts are now working to identify the institutions and technologies needed to sustainably improve crop yields while distributing water fairly. This includes piloting automated watermeasuring systems to aid canal managers. The *Revitalizing irrigation in Pakistan* project installed a data-gathering system on canals in the province of Punjab. The first of its kind in the country, it sampled canal water levels every minute and recorded the data every 10 minutes. This data was used to update government agencies and farmer institutions on distribution and equity issues.




A Pakistani farmer uses laser levelling (opposite page), where the land surface is smoothed by + or - 2 cm from its average elevation. This can help make water use more efficient and achieve higher crop yields.

Pakistan has the largest contiguous artificial irrigation canal system in the world (above).

Having reliable data is vital for effective water management (above).



TRANSFORMING NEPALESE LIVELIHOODS

IWMI's early research in Nepal helped to establish long-running, community-based irrigation management schemes in several regions. When its scientists returned to one site, Dhap Village, after 25 years, they found a thriving and prosperous community. Before the project, 250 households had relied on a single spout of water to provide their needs and it had taken each household half a day to collect one bucket of water. IWMI's work to develop a farmer-managed irrigation system provided the village with a steady and continuous flow of water. This substantially increased agricultural production and enhanced livelihoods. Today, IWMI scientists are studying the link between a lack of access to water for poor farmers and the annual out-migration of rural men looking for work during the dry season.

Nepal has plentiful rivers and mountainous terrain, making it ideal for developing hydropower. However, experts estimate that less than 1% of its hydropower potential has so far been exploited. Developing this resource could address the country's chronic power shortages, as well as providing the opportunity to sell

> Terraces of rice paddy fields in Nepal (opposite page and above right). IWMI's work here has demonstrated that improving water management can enhance livelihoods (right).





IWMI's research on managing river basins holistically is helping Nepal to balance the needs of farmers (left, below left and opposite page) with other water users.

electricity to high-demand centers in India. However, developing river basins in a manner that meets the needs of hydropower, irrigation, tourism, wildlife and culture – as well as considering the specific needs of women, who are increasingly running farms while men migrate to seek employment in cities – is a challenge. IWMI helped to pioneer holistic river basin management, and is currently providing advice and data to Nepal's policymakers and investors. The Institute is also helping to improve access to national water data, drawing on its expertise in remote sensing.

HELPING BANGLADESHI FARMERS TAKE CONTROL

IWMI has many years' experience of working in Bangladesh. One early project involved assessing the trend in privatization of minor irrigation and making recommendations to drive further development of the sector. Researchers found that the best ways to help farmers benefit from minor irrigation was to make credit available to them, provide technical information to help smallholders care for their equipment and prolong its life, promote local manufacturing of hardware and spare parts, provide mechanical training, supply information on the capacity of aquifers, and phase out poorly performing deep tube wells in favor of shallow wells.

More recently, IWMI has been working to help fishers and farmers in Bangladesh to sustainably manage the ecosystems





on which they depend. One project carried out under WLE involved analyzing the ways in which Bangladesh's '*beels*' (inland lakes) are used and managed. The many thousands of *beels* on the Ganges-Brahmaputra floodplain support 8 million livelihoods and contribute to almost 30% of the country's fish production. With the floodplains under pressure from pollution, overfishing and infrastructure development, the project identified ways to manage the *beels* more effectively. These included using larger fish to restock water bodies at the start of the season, reintroducing small native fish to encourage biodiversity, and regulating the volumes of fish taken and the fishing methods used. Taking such action has helped to enhance the health of the *beels*' ecosystems.

Discussing cultivation techniques with farmers in Kulna, Bangladesh (above left). In this region, where there are many inland lakes, or *beels*, the water needs of farmers and fishers (left) must be carefully balanced.

Beels on the Ganges-Brahmaputra floodplain (opposite page) support millions of livelihoods and are an important contributor to Bangladesh's fish production.





PROMOTING DEVELOPMENT WITHOUT LEAVING POOR FARMERS BEHIND

Rapid economic development across Southeast Asia is fuelling the need for dams to create hydroelectric power. IWMI works to try and ensure the benefits and disadvantages of installing dams and power plants are shared across society. Southeast Asia's water management issues range from keeping pace with rapid urbanization to installing hydropower plants, and overcoming droughts and floods.

The Mekong River flows almost 5,000 km from the Tibetan Plateau through three Chinese provinces and then on to Myanmar, Lao PDR, Thailand, Cambodia and Vietnam, passing through seven geographical regions. The Tibetan Plateau, Three Rivers Area and Lancang River Basin form the Upper Mekong Basin, while the Northern Highlands, Khorat Plateau, Tonle Sap Basin and Mekong Delta jointly comprise the Lower Mekong Basin.

The countries through which the Mekong flows are at different stages of development, with Thailand and China the most advanced, Vietnam having made significant advances in recent years and the others less developed but progressing rapidly. The trend is for agriculture to shift from traditional subsistence to modern, climate-smart farming. Small-scale producers remain important across the region. With droughts and floods occuring regularly, efficient water use is key to future food security. The region's rapid economic development is increasing the demand for energy to power industry; light, cool and heat houses; mechanize agriculture; and expand transportation infrastructure. There is great potential to develop hydropower in the Mekong River Basin, but ensuring that the monetary, social and environmental costs of schemes are not borne by one section of society is a challenge. IWMI is undertaking research into the social consequences of infrastructure development and the institutions that govern it. This has resulted in hydropower companies financing new livelihood opportunities for communities displaced by dam development. Meanwhile, IWMI's hydrological expertise has helped shed light on how new dams may affect the flow of rivers used by other countries.

HELPING DAM-AFFECTED COMMUNITIES

In 2003, construction of the Yali Falls Hydropower Dam in Vietnam resulted in a major upheaval for farmers. More than 1,000 farming households and nearly 2,000 ha of land were lost. Farmers adapted by farming the 'drawdown area', the land

FREQUENCY OF FLOODS ACROSS THE MEKONG DELTA BETWEEN 2007 AND 2011

Stilt houses beside the Mekong River in Vietnam, where flooding is an ever-present threat.











A smallholder lifts water from a hole dug in a riverbed in Myanmar's Dry Zone (opposite page). IWMI scientists who investigated water management across the region found that great potential exists for farmers to make better use of groundwater.

revealed when levels in the dam's reservoir dropped in the dry season. The relatively short period of land exposure (7 to 8 months) and the risk of flooding at the end of the growing season made this a very high-risk occupation. An IWMI-led research project carried out under the CGIAR Challenge Program on Water and Food (CPWF) helped improve agricultural production by introducing a variety of cassava well suited to the reservoir's hydrologic behavior, local climate conditions and farmers' preferences. During a trial planting, 36 households cultivated 20 ha of this cassava. The yield was estimated to be 60–89% higher and the net income 100% higher than that gained from the variety of cassava most commonly grown in the drawdown area.

INVESTIGATING MYANMAR'S WATER USE

A third of Myanmar's population lives in the central droughtprone Dry Zone. With the nation developing at an unprecedented rate, decision makers need robust scientific data on which to base decisions around future agricultural development and food production. The Livelihoods and Food Security Trust Fund (LIFT) requested that IWMI rapidly review access to and management of water in the Dry Zone. Over 6 months, IWMI and several partner organizations assessed physical water resources, surveyed communities' use of water, and examined institutional arrangements related to water management practices. Researchers found that: managing water variability is key to improving livelihoods in the Dry Zone; there is plentiful water stored in rivers and reservoirs, but access to this resource is limited; formal irrigation is underperforming; and there is potential for farmers to make better use of groundwater. IWMI's recommendations are providing a baseline for many development partners, guiding their planning for interventions within the Dry Zone.





A mother carries her baby, along with pipes for irrigating her garden, in Phonhong District, Vientiane, Lao PDR (opposite page). As climate change affects water variability, IWMI is seeking ways to help smallholders to manage water resources better. The Mekong Delta supports livelihoods for more than 17 million people (above left and above).





Families prepare fish from community ponds in Lao PDR (opposite page).

Many people rely on fishing and aquaculture for their livelihoods in Vietnam (above and above left).





Rice farming is another important livelihood in Vietnam (above left and above). IWMI has worked in the country to resolve conflicts between fishers and rice farmers over access to water resources.

Mobile phone technology provides one way for farmers to obtain accurate weather forecasts, so they can plan when best to plant and harvest their rice crops (opposite page).





OVERCOMING THE PROBLEMS OF A UNITED PAST

The nations of Central Asia have faced major water management challenges in recent decades. The Aral Sea (opposite page) shrank extensively due to overextraction of water from the rivers feeding it. Grounded in the past, Central Asia's nations seek ways to stimulate economic growth, overcome environmental degradation and rejuvenate out-of-date irrigation infrastructure.

Issues underlying agricultural water management in Central Asia today are rooted in the past. The region's fertile lands had long been successfully irrigated, but a plan to turn land straddling the major Amu Darya and Syr Darya rivers into a highly productive cotton belt (initiated in the 1960s by the Soviet Union) resulted in excessive extraction of water. The volume of water in the Aral Sea diminished by two-thirds, resulting in the loss of its fishing industry, salt deposits on farmland, climatic change leading to shorter growing seasons, biodiversity loss and the lowering of the local water table.

In 1991, when the Soviet Union collapsed, the ongoing consequences of this environmental disaster, along with the vast irrigation infrastructure responsible for causing it, were inherited by the new independent republics of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. Since then, they have struggled to cope with the extreme environmental degradation, while trying to make aging and high-cost irrigation infrastructure (which was designed for use by one nation to water a small selection of crops) cater to the needs of many small-scale farmers, growing a variety of different crops, across five national territories.

PROMOTING FAIR WATER SHARES

IWMI has a long heritage of working to resolve water management issues in Central Asia. For 10 years, the focus of the Institute's work in the region was the Fergana Valley, where it implemented Integrated Water Resources Management (IWRM). It helped establish an institutional framework that has improved water delivery across 430,000 ha of irrigated land, increasing both agricultural productivity and farmers' incomes. Using knowledge gained during this work, IWMI now promotes transboundary water cooperation across Central Asia. For example, where no institutional framework exists for farmers



using water from small transboundary tributaries, IWMI nurtures 'bottom-up' cooperation, building on existing and past agreements on property rights, water sharing, basin linkages and compensation mechanisms.

In the early 1990s, many donors initiated projects to improve water management in the new republics by instigating Water Users' Associations (WUAS). Today, IWMI is working to identify which of the numerous approaches taken in establishing these WUAS have been most effective, and to promote modern approaches to water management. Analyzing hundreds of project reports, surveys, evaluation studies, journal articles and datasets has enabled IWMI scientists to pilot new, more effective structures for WUAS, and to advise governments on the rules, enforcement procedures, capacities and mechanisms most likely to achieve sustainable and efficient water use.

Central Asia's lack of water management specialists threatened to hamper its plans to implement Integrated Water Resources Management (IWRM), a participatory practice involving users, planners and policymakers. IWMI helped to introduce studies on IWRM to university curricula. Here, students at Kyrgyz National Agrarian University try out the tools of the water manager's trade (top left).

This canal has run dry, leaving the soil affected by salinity (left). Salinity occurs when salts present in the soil are dissolved during irrigation and become concentrated on the land surface when water evaporates.

A man opens a sluice gate to divert water to an adjoining field (opposite page).





UNDERSTANDING WOMEN'S ROLES

In Tajikistan, women are increasingly managing farms and community water resources, while men migrate to seek employment elsewhere. This trend began in the Soviet era, and has been exacerbated by the slow pace of subsequent land reforms, high unemployment rates and the increasing cultivation of diverse cash crops alongside cotton. Faced with food insecurity in the absence of men, women have turned to running kitchen gardens and seeking day work as farm laborers. Having studied the 'feminization' of agriculture in Tajikistan in detail, IWMI has highlighted the importance of integrating women into existing agricultural policies and mechanisms.

Women are becoming increasingly involved with agriculture in Central Asia. IWMI aims to help female farmers (left) become integrated into existing agricultural policies and mechanisms, which are often designed for men.

Much of Central Asia's irrigation infrastructure (opposite page) dates back to pre-independence days when Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan were part of the Soviet Union. IWMI has worked extensively to improve transboundary cooperation across these nations' boundaries, and to ensure that water is shared equitably.



RISING SOIL SALINITY IN SYR DARYA PROVINCE FROM 2000-2003 (LEFT) AND 2008-2011 (RIGHT)

Trying to make ageing irrigation infrastructure suit today's farmers' needs is an ongoing challenge in Central Asia (opposite page).







BALANCING THE NEEDS OF PEOPLE AND THE ENVIRONMENT

A man lays pipes for accessing water for cultivation. There is great potential for more farmers in southern Africa to make use of groundwater resources. Southern African countries prone to extreme drought could benefit from using groundwater more productively, planning water developments for multiple uses and managing their wetlands sustainably.

The southern African region comprises the countries of Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe. The largest eastward-flowing river systems draining the region are the Limpopo and the Zambezi. Both these rivers flow into the Indian Ocean, the Limpopo rising in Botswana and South Africa, and the Zambezi farther north in Zambia. Southern Africa's climates, ranging from arid to semi-arid and temperate to tropical, are highly seasonal. This seasonality regulates water flows and places strong constraints on agriculture. The region suffers from an unequal distribution of resources, particularly water. With rainfed farming providing livelihoods for more than 70% of southern Africa's population, water availability and accessibility are critical issues. Southern Africa has some of the most productive farms in the world, many using state-of-the-art irrigation equipment backed by advanced computer modelling to indicate water availability. However, the majority of smallholders in the region are subsistence farmers, who struggle to cope with increasingly unpredictable rainfall. IWMI looks at how improved policies and more sustainable practices could better address this inequity. Using more groundwater could provide an answer. While many people rely on groundwater for domestic water supplies, an estimated 75 Mha could be irrigated sustainably with groundwater in sub-Saharan Africa. Yet, only between 0.4 and 1.2 Mha are developed. So, there is potential for farmers to tap into this resource without exceeding sustainable levels of extraction.

INHIBITING CIRCUMSTANCES

IWMI scientists undertook an in-depth investigation to identify why not many farmers in southern Africa are presently using groundwater to boost their smallholder enterprises. They found that farmers had insufficient access to funds to dig wells and buy pumps, as well as suffering from labor shortages. Moreover, a lack of policies designed to catalyze change meant that smallholders were not motivated to improve their situation. IWMI hopes its research will help irrigation planners to address the situation and bring farmer-driven irrigation developments to fruition in the future.

One problem faced by rural communities is that authorities' planning for water provision does not always match the myriad ways in which people use the resource. For example, village pumps designed and located for domestic use are also used to water kitchen gardens and livestock. Canal systems built to irrigate adjacent fields are used to supply water for drinking and washing clothes. This situation frequently arises because the responsibility for water provision is split between different government departments. A more efficient and integrated approach known as Multiple-use Water Services (MUS) takes into account poor people's varied water needs as a starting point for development. However, although MUS has been implemented on a small scale in at least 22 countries in Asia, Africa and Latin America, it has yet to be widely adopted due to institutional silos.

ENGAGING MULTIPLE USERS

IWMI investigated why MUS had not been embraced on a larger scale and presented its findings in the book *Scaling up multiple*

use water services: Accountability in the water sector. It was identified that designing cost-effective, multipurpose water infrastructure could have a positive impact on people's livelihoods and health, and that ensuring communities were involved from the outset could help overcome resistance to MUS. For example, South Africa's Community Work Programme, which reached almost 100,000 beneficiaries, included many water-related initiatives – from cleaning rivers and irrigation canals to providing drinking water and sanitation facilities to homes and organizations, and supporting 45,000 kitchen gardens. Its commitment to generating multiple benefits from multipurpose infrastructure, and its approach to managing conjunctive water resources clearly contributed to its success.

NURTURING ECOSYSTEMS

Wetlands are natural ecosystems that provide a multitude of services to people living nearby. However, keeping wetlands in good health requires a balance between extracting water to support livelihoods and maintaining sufficient water volumes for the wetlands themselves to function. The *Wetlands and Poverty Reduction Project*, on which IWMI worked in partnership with Wetlands International, aimed to find ways to achieve such a balance. One case study in Malawi and Zambia showed that *dambos* (grassy depressions where water seeps to the surface)



MUS is an approach that designs water provision taking into account many uses, from meeting domestic needs (below left) to supporting ecosystems (below).





could help reduce hunger, if managed sustainably. Prior to the project, *dambos* at six project sites were degraded and people had died from starvation. By the end of the two-year project, many more people had access to sufficient water to grow their own vegetables. They had better nutrition and were able to sell surplus produce at the market to earn an extra income.

Managing water sustainably can benefit farmers and the environment alike (left and opposite page).







Many farmers presently struggle to raise funds to pay for digging wells and pumping equipment (above). This explains why so few farmers currently use groundwater, relying instead on rainfall and surface water supplies. This maize grower in Zimbabwe (opposite page) has benefited from having access to irrigation.




Using modern irrigation infrastructure (opposite page) has helped some of southern Africa's farmers to become highly productive. This Zimbabwean farmer (right) proudly displays her cabbage harvest.





MAKING THE MOST OF SCARCE WATER TO IMPROVE LIVELIHOODS

IWMI is working in Ethiopia to help farmers make the most of limited water resources. Under the Institute's guidance, this smallholder is experimenting with new methods of planting crops. Faced with a limited and shared water resource, countries in North and East Africa are gathering data, developing hydropower infrastructure and improving water storage facilities.

IWMI's work in North and East Africa is focused around the Nile River Basin, which drains 10% of the African continent. The river itself flows north more than 6,500 km, across 11 countries, from its farthest source within the Kagera River Basin (spanning Burundi, Rwanda, Tanzania and Uganda) to its delta in Egypt. While there is some cross-border cooperation regarding water management, the intense pressure on water resources inevitably causes some tensions in the region. IWMI primarily focuses on Egypt and Ethiopia. At different stages of economic development, these nations are both densely populated, but suffer from contrasting constraints to water and land resources.

Outdated policies and low levels of investment in water infrastructure have contributed to making Ethiopia one of the world's most food-insecure nations. The livelihoods of many people who depend on rainfed agriculture are becoming more precarious, in line with increasingly unpredictable rainfall patterns. A particular problem is insufficient water in the dry season. Therefore, IWMI is researching ways to make better use of the available resource. Improving rainwater harvesting and installing farm ponds are solutions, along with increasing groundwater use. Groundwater utilization in Ethiopia is presently relatively low and estimates indicate that the resource may be extensive.

A PATH TO PROGRESS

In 2015, the Ministry of Agriculture and the Ethiopian Agricultural Transformation Agency outlined plans for agricultural development that could contribute to achieving the government's vision for Ethiopia to become a middle-income country by 2025. The report *Realizing the potential of household irrigation in Ethiopia: Vision, systemic challenges, and prioritized interventions* identified "27 independent systemic interventions to increase the adoption and effectiveness of household irrigation technologies, and build a vibrant and self-sustaining household irrigation sector." In his foreword, Sileshi Getahun, State Minister, Ministry of Agriculture, cited the influence of IWMI's work: "IWMI has made significant contributions to research on irrigation in Ethiopia ... Indeed, various studies made by IWMI were used as baselines during the development of this sector strategy."

One of the difficulties in shaping new water management strategies in Ethiopia is that data on water is scarce. This makes it difficult to identify the kinds of interventions that will be most helpful to farmers. To help overcome this issue, IWMI engaged the help of local communities to monitor water within three watersheds of the Blue Nile River Basin. Inhabitants helped to plan, install and manage monitoring networks, and were involved in manually collecting data on a daily basis. The project helped to forge bonds between communities and researchers, and enabled people to understand their local hydrological regimes better. This gave them a useful insight into the likely impacts of different rainwater management strategies.

MAKING SCARCE WATER GO AROUND

Egypt faces the difficult challenge of providing water to high numbers of people using limited resources. Although it has many large-scale public irrigation systems, these cannot always supply farmers with sufficient water when they need it to secure their crops. Because most surface water resources have already been diverted or are polluted, farmers facing shortages have turned to pumping water from drains and groundwater to meet their water needs. They have often ended up using saline or polluted water.

Egypt's Ministry of Water Resources and Irrigation has worked to reduce individual pumping by installing collective pump stations that distribute water taken from secondary canals. Many of these schemes have faced difficulties, ranging from stolen pumps to uneven water pressure. IW MI investigated why projects had worked in some areas but failed in others, and identified a gap between formal institutions and actual practices on the ground. Understanding why farmers adopted, modified or rejected the new systems should help the Ministry to tailor investments to farmers' needs better in the future.

> IWMI helps farmers to improve their agricultural outputs with new technologies, such as this wetting front detector.







In Ethiopia, effective water management is hampered by a lack of reliable data, so IWMI is working to help rectify this problem. Here, an IWMI scientist collects data from a weather station (opposite page). The station records groundwater level, rainfall and temperature. IWMI also works with the country's Innovation Lab for Small-Scale Irrigation (ILSSI) project, which aims to increase the efficiency of water use through small-scale irrigation. In this image, water isotopes are being analyzed (above left). In Oromia, women participate in a project to map the landscape by gender (above).



Farmers connect individual pumps to the piped network in Egypt. The government is trying to reduce individual pumping of water, so it can manage scarce resources better (left). With very little rainfall, the Nile River is Egypt's primary source of water (opposite page).







Farmers enjoy a joke while harvesting lettuce (above left).

The Aswan Dam Hydroelectric Plant (above). The Nile River must be shared by the 11 nations it passes through, providing water for agriculture, energy, industry and domestic uses.

Growing crops in poly tunnels using sprinkler irrigation reduces evaporation (opposite page), increasing the water-use efficiency.





MEETING THE NEEDS OF URBAN FARMERS AND DAM-AFFECTED COMMUNITIES

Farmer and plumber David Dotsey experiments with his drip irrigation system in Ghana. Introducing new water management methods can help smallholders to increase their incomes. The water management priorities of West African nations range from reusing wastewater to building new dams.

The Economic Community of West African States (ECOWAS) comprises the countries of Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. IWMI collaborates with partners across these countries to help deliver the ECOWAS Agricultural Policy. It also supports the West Africa Agricultural Productivity Program's goal of achieving 3% annual growth in sustainable agricultural productivity.

This target is ambitious, as many farmers do not have access to formal irrigation infrastructure. Although smallholders across sub-Saharan Africa have started taking irrigation into their own hands by installing small water storage and pumping facilities, this trend has been slow to catch on. IWMI's 3-year Agwater Solutions project, conducted with local, regional and international partners, sought to support this trend and make smallholder farming an engine for economic growth. The project identified context-relevant methods for managing water for agriculture, along with strategies aimed at encouraging wide-scale adoption of those methods by entrepreneurial farmers.

WASTE NOT, WANT NOT

Although the majority of sub-Saharan Africa's poor smallholders still live in rural areas, an increasing number of farmers are now growing food in peri-urban areas to meet the demand from towns. In West Africa, the population living in urban areas increased from 4% in 1920 to 45% in 2011. With high demands for water for industrial and domestic uses, farmers inevitably resort to using wastewater for irrigation. While this presents consumers with a potential risk of contamination by pathogens, wastewater is rich in nutrients and organic compounds that could benefit farmers. Over the past 12 years, IWMI has undertaken considerable research with partners in Ghana on how wastewater can be safely used in peri-urban agriculture. A dedicated Resource Recovery and Reuse program is exploring ways of profitably converting fecal sludge into pelletized fertilizer in cities, including



the process by which human wastewater is converted into fertilizer pellets.

Many farmers have to rely on wastewater for irrigation, which has the potential to contaminate food if not used safely (opposite page). IWMI researchers work to find ways to turn waste into a nutrient-rich resource.

Accra, Tamale and Tema. The hope is that this approach could be emulated in other cities across West Africa and the wider developing world.

POWER TO THE PEOPLE

IWMI also works in Ghana to improve the livelihoods of farmers affected by dam building. Built in 1965, the Akosombo Dam created the largest artificial lake in the world: the Volta Lake. Its shoreline stretches for 5,500 km and, when full, it contains 150 billion cubic meters of water. The reservoir generates 80% of the nation's power and provides water for irrigation. However, constructing the dam displaced many people and its operation, together with that of Ghana's smaller Kpong and Bui dams, continues to compromise the livelihoods of communities living downstream.

In 2006, IWMI led the establishment of the Ghana Dams Dialogue (GDD), a 60-member platform aimed at bringing

together dam-affected communities, hydropower authorities and government ministries to improve communications between them and reduce the social impacts of dam-building projects. After 5 years, GDD reached maturity with a Ghanaian team taking full ownership of it. It is now viewed as a model for promoting multi-stakeholder dialogue and sharing lessons learned on dam development, globally. Today, IWMI researchers are assessing how changes to the way dams operate could enhance environmental flows in the Lower Volta and improve the health of ecosystems.







Drip irrigation (opposite page) is a relatively safe way to apply wastewater to crops, as contact between the plants and wastewater is minimized.

'Fortifer' pellets, made from human waste, undergoing testing (above left). A man measures the height of a plant to compare its growth using the pellets as opposed to using other fertilization methods (above).



The Volta River in Ghana (left). The Akosombo Dam (opposite page) was constructed on the river in the 1960s. It now provides energy for almost all of Ghana and half of Togo. IWMI helped to establish the Ghana Dams Dialogue to improve communication between the parties involved and to share knowledge; it is now hailed as a model for dam diplomacy.







HARNESSING TECHNOLOGY TO ACHIEVE OUR VISION

Access to irrigation is key to improving livelihoods of smallholder farmers in the future. Going forward, IWMI will use its knowledge to identify appropriate approaches and technologies for specific contexts. When IWMI began life as IIMI, water was considered a bountiful resource. The Institute's primary aim was to enhance the performance of existing irrigation infrastructure by improving how it was managed. The hope was that addressing governance issues, which were causing water to be distributed inequitably, would contribute to reducing food shortages. However, the Institute's global investigations during its early years helped to reveal that water was far from abundant; a message underpinned by the World Water Commission of 2000. A decade and a half on, and increasing water scarcity – driven by global population rise, expanding economic activities and climate change – has elevated IWMI's main focus to a global concern. How can we grow sufficient, affordable and locally available food to feed everyone, with less water, and manage the increasing competition for water resources from industry and cities?

Water scarcity will undoubtedly be a major challenge for humanity as we seek to answer this question in the coming decades. Human development has already strained water resources, causing problems for the agriculture sector. In developed regions of the world, such as the USA and Europe, water withdrawn by the energy and industrial sectors is already greater than that extracted for agriculture. If emerging economies follow the same trend, agriculture will increasingly be competing with other sectors for resources, with demand having already exceeded supply in some cases. Moreover, climate change is exacerbating the problem.

INFORMATION BROKER

In recent years, the analysis of water resources at global scale has gone as far as it can; scientists know only too well where the problems lie. However, large gaps exist in our ability to assess the synergies and trade-offs among portfolios of potential solutions at local and regional scales. These knowledge gaps need to be filled by stepping up data-gathering efforts and improving decision support through careful analysis of that data. This is where IWMI's focus will be, going forward. The Institute has already developed a realistic picture of the water balances for the regions in which it works, understands options available for overcoming water scarcity, and recognizes the approaches and technologies that are most effective within different contexts. Using this intelligence will enable IWMI, working with its partners, to become an information broker between local and global scales.

'Options analysis' involves identifying the best ways to use water more productively within a specific context. It is a complex issue, within which uncertainties remain; if you use water more efficiently on a farm, it does not necessarily mean you are using water in the most productive way for the river basin as a whole. For example, you might be using the exact volume of water that your crops evapotranspire, which saves energy by pumping only the groundwater you need. However, there is no water left to recharge the aquifers or provide return flows for water users downstream, which can be beneficial processes. Choosing optimal water management options involves weighing up the benefits and trade-offs against each other at the appropriate scale.

IWMI has the opportunity to make a difference in this regard by developing local data resources and information systems. Currently, there is no good database of water uses detailing where particular uses take place, the quality of water needed for those uses, and the times at which water is needed. These are all extremely important components of basic water accounting that are needed to manage water resources effectively, yet the data does not exist for many parts of the world. Therefore, generating core information and understanding current trends is highpriority work, which will benefit planning agencies, decision makers and global monitors alike.

IWMI is already responding to this need through its work on water productivity. For example, together with partners, it has developed the *Water Accounting Plus* (wA+) framework, which integrates data on hydrological processes, land uses, managed water flows and the services resulting from water consumption in river basins. It uses available global information, and remote sensing and local data. However, a lack of local-level data, or access to it, currently limits its accuracy. Often, even where national data exists, it is located within different agencies or ministries and has never been combined in the country. The wA+ approach aims to address these constraints.

GUIDING GOVERNANCE

Another role for IWMI for the future is to help nations identify innovative policy and institutional responses to the water scarcity challenge. The Institute has already built a track record in this area through its research theme on *Governance, gender and poverty*. Although problems are seemingly well known, and solutions are available, the complexity of social, institutional and political contexts requires different approaches from place to place. Finding and adapting solutions for everyone, which Technology, including drone imaging (opposite page left) and geographic information systems (opposite page right), will be central to IWMI's future research.





Overcoming the challenges of water scarcity and climate change to feed the world's future populations will motivate IWMI's research in the coming decades. embrace incentives to change behavior, is mostly a matter of good governance. This will therefore continue to be an important focus for the Institute.

IWMI's other research themes, reflecting the increasingly broad and interconnected scope of agricultural water management are: *Ecosystem services*; *Sustainable agricultural water management*; *Resource recovery, water quality and health*; and *Water availability, risk and resilience*. Each of the themes assesses different aspects of the water cycle. The newly introduced *Water futures* theme cuts across all of the others to develop scenarios that can help planners and managers make more informed and effective decisions.

Increasingly, water is managed across sectors, including agriculture, energy and industry. This calls for multi-sectoral work, which is where efforts to develop water information systems and decision-support tools will be invaluable. There are so many different organizations and institutions managing and controlling water today; robust information systems have the potential to bring together multiple stakeholders and help them to understand the system aspects of water management. The hope is that they will help different sectors to work together synergistically to improve water productivity and achieve equitable allocations of the resource, while also making progress towards meeting development aims. IWMI is committed to working more closely across sectors and with the other CGIAR Research Programs in the future. It already has a history of effective collaboration with many of the centers; for example it has worked with the International Food Policy Research Institute (IFPRI) on policy aspects of agricultural water management related to food production. Going forward, IWMI will continue with this kind of research, as well as working closely with agri-food system research programs to ensure sustainability is built into initiatives aimed at intensifying agriculture.

OVERARCHING GOALS

An over-riding ambition of development organizations, including the CGIAR centers, is to contribute to meeting the SDGS. As a pioneer of taking an integrated approach to water resources management, IWMI has essentially been working towards achieving such goals for much of its 30-year history. In its next three decades, the Institute will develop the solid information systems required to enable water resources to be managed holistically. Also, by focusing on the opportunities that modern technology and 'big data' offer, IWMI will help farmers tap directly into the Institute's scientific knowledge, so they can respond intelligently to the challenges that water scarcity and climate change bring in the decades to come.





Set up to improve irrigation, the International Water Management Institute (IWMI) has grown into a center of excellence on sustainably managing water across scales from field to river basin, to support livelihoods, food security and ecosystems. This photographic collection celebrates the 30th anniversary of the Institute, as we prepare for the challenges of the years ahead.



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