CGIAR RESEARCH PROGRAM ON WATER, LAND AND ECOSYSTEMS

CGIAR | RESEARCH PROGRAM ON Water, Land and Ecosystems

LED BY: IWMI International Water Management Institute

TOWARDS SUSTAINABLE INTENSIFICATION: STORIES OF REAL-WORLD SCIENCE

RESEARCH HIGHLIGHTS PHASE 1

Farmer Rachael Njeri collects soils samples on her land in the Tana River watershed, Kenya.
Georgina Smith/CIAT

For WLE, sustainable intensification means more than minimizing agriculture's environmental footprint; it means making sure that agriculture benefits both the planet and its people, providing global populations with food and nutritional security, resilience and livelihoods.

LED BY: IWMI International Water Management Institute

IN PARTNERSHIP WITH: Bioversity International, CIFOR, CIAT, CIP International Potato Center, FAO, ICARDA, ICRISAT, IFPRI International Food Policy Research Institute, ILRI International Livestock Research Institute, RUAF Foundation, World Agroforestry Centre, WorldFish

New briefs on sustainable intensification

Achieving resilient food systems requires identifying incentives for sustainable farming, developing new policies and institutions, as well as working with diverse stakeholders to test and scale integrated solutions.

The program's findings so far are summarized in a new series of briefs, ***Towards sustainable intensification: Insights and solutions.***

The series aims to guide and support decision and policy makers, investors and others working to achieve sustainable intensification of agriculture. Each brief is focused on a topic of strategic relevance and provides analysis of and recommendations on how to place sustainability at the heart of agri-food systems.

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PHOTO: GEORGINA SMITH/CIAT

Curbing land degradation for livelihoods and climate change adaptation

Farmer Rachael Njeri lives in the middle of the Tana River Basin in central Kenya. She collects soil samples that are used to build up a bigger picture of how poor land management causes soil erosion, which in turn is clogging up the Tana River.

The Tana River is important because it supplies water to the majority of people in Nairobi, as well as to big businesses downstream, like Coca Cola. It is also used to generate most of the electricity used by Nairobi. Therefore, improved soil health upstream can have big benefits for those living downstream.

Best bets for soil restoration

Rachael is working with researchers of the International Center for Tropical Agriculture (CIAT). They are investigating how to improve the flow of water in the Tana River by advising on which agricultural management practices farmers can use to reduce soil erosion and even boost harvests.

For example, Rachael has started growing forage strips on her sloping land,

which prevent soil erosion and provide feed for her cattle. "When I planted the Napier grass, the water was trapped. Now more soils stay at the top of the farm," said Rachael. Capturing water and topsoil both boosts agricultural productivity locally and improves water quality downstream.

CIAT is implementing this work as part of its contribution the Tana-Nairobi Water Fund, coordinated by the Nature Conservancy. This is the first water fund for Africa, and it unites water users along the watershed, leveraging big businesses to finance protection measures carried out by users upstream – farmers like Rachel.

Aiming to make information about promising soil health restoration methods widely available, CIAT has published a Soils Best Bets compendium. It is a detailed guide to the various methods and practices, such as planting grasses on sloping land, which can be used to maintain, or increase, the organic matter and fertility of soils. The compendium also details how suitable each option is for different geographies and agro-ecologies.

Tools for tailoring and targeting soil restoration efforts

Acknowledging the benefits of healthy soils, many governments and non-governmental organizations are striving to combat land degradation, but one frequent challenge is a lack of data on existing soil conditions.

WLE researchers, including those from the World Agroforestry Centre (ICRAF) and the International Potato Center (CIP), have been developing a range of tools to overcome this issue.

ICRAF has helped set up Soil-Plant Spectral Diagnostic Labs in 10 African countries. They are collaborating with scientists in Ethiopia, Ghana, Nigeria and Tanzania to prepare soil health baselines as part of the Africa Soil Information Service (AfSIS), the most comprehensive soil sample database available for Africa, with over 28,000 sampling locations by the close of 2016.

Researchers of ICRAF have also contributed to the infrared and x-ray spectroscopy methodology used by AfSIS, which costs much less than conventional soil and plant analysis techniques. Similar technologies have been piloted by researchers of CIP, who have developed a portable device that uses laser-induced optical techniques, making it possible to measure, monitor and verify soil carbon levels in the field.

There is growing evidence that some donors and governments in Africa are using these tools to map soil fertility problems, target soil conservation efforts and measure soil carbon stocks. For example, the Ethiopian Soil

Information System (EthioSIS) has produced soil fertility atlases for all regions. They are being used to shape interventions in Ethiopia's second Growth and Transformation Plan (GTP II) Agricultural Transformation Agenda to improve fertilizer use efficiency.

Capturing carbon in soils for climate change mitigation

Finally, while soil health is a prerequisite for long-term, sustainable agricultural productivity, it can also contribute to climate change mitigation.

Recent analysis shows that agricultural lands could be turned into a carbon sink, absorbing between 0.9 and 1.85 gigatons of carbon per year – equal to about 6 to 13% of all human-induced carbon emissions – on the 16 million km2 of agricultural land globally.

To aid decision makers and investors to understand where investments in soil restoration could result in climate change mitigation benefits, researchers have developed a Soil Organic Carbon App. This app can help users calculate the capacity of a soil to store - or sequester - organic carbon.

Stemming soil and land degradation has the potential to improve agricultural productivity, food security and help in efforts to mitigate climate change, but success depends on selecting the right solutions for the context, providing incentives and removing institutional barriers.

Learn more about what WLE is doing to promote healthy soils for more productive agriculture.

PHOTO: PRASHANTH VISHWANATHAN/IWMI

Finding the right balance to sustainably manage groundwater

Policy makers and other decision makers across Africa and Asia are increasingly looking to groundwater to help address variability and ensure reliability of water resources. Knowing and understanding where and how to sustainably develop groundwater is key. Equally important is to identify where overexploitation is taking place. Practical tools for addressing overuse and mismanagement can help ensure that groundwater remains available for generations to come.

Innovative research by WLE is supporting the development of sustainable groundwater policies for increased social, environmental and economic outcomes. It is also supporting sustainability of urban aquifers via inter-sectoral water transfers. Additionally, WLE is enhancing community management of groundwater resources through experimental games.

For example, WLE has developed an interactive online tool that water managers can use to visualize and assess sustainable groundwater abstraction scenarios at various scales. The assessments are based on calculations of the contributions of surface and groundwater to environmental flows (i.e., the water flows required to sustain ecosystems).

This global environmental flow information will help inform some specific targets and measurements for the Sustainable Development Goals (SDGs).

In 2016, the International Water Management Institute (IWMI), which leads WLE, launched a global partnership, the Groundwater Solutions Initiative for Policy and Practice (GRIPP). The aim of this initiative is to embed sustainable groundwater practices at the heart of natural resource management towards achievement of the SDGs. The initiative is forging new partnerships, sharing solutions, scaling-up successes and helping to address knowledge gaps.

The groundwater opportunities and challenges in Africa may be different from those in Asia, but WLE has developed a range of solutions that fit the needs of policy and other decision makers in their specific regions and local contexts.

Scaling up sustainable groundwater use in Africa

IWMI, as part of WLE, has mapped the irrigation potential from renewable groundwater in Africa. Researchers have also developed transboundary aquifer maps for the continent, which identify renewable groundwater resources as those still available after human and environmental demands have been accounted for. In Africa, only 1% of cultivated land (approximately 2 million ha) is currently irrigated using groundwater, compared to around 14% (approximately 38 million ha) in Asia. Overall, groundwater resources in Africa are plentiful but unevenly distributed and underutilized. This abundance represents a huge untapped opportunity for Africa to improve food security and livelihoods through groundwater-supported irrigation.

Some African farmers have already begun to embrace groundwater irrigation. The WLE maps suggest that the area in Africa irrigated with groundwater could be sustainably expanded beyond the current 2 million ha to 40 million ha. The maps offer guidance to water managers and investors for sustainably scaling up use of groundwater for agricultural production.

However, this expansion of groundwater use in Africa needs to be done carefully and with a thorough understanding of each specific region's context and sustainable limitations. There is a lot of unexploited potential, for example, in the semi-arid Sahel and eastern regions from Ethiopia to Zimbabwe. In contrast, groundwater resources in parts of southern Africa and northern Africa have already been exploited beyond sustainable levels and, as a result, now need improved management options.

Reinvigorating the sustainability of groundwater resources in

Asia

In Asia, groundwater resources have been widely developed, and places such as western and southern India are now suffering from unsustainable overexploitation. To help address these challenges, WLE has developed a set of management tools and policy options. These foster an in-depth understanding of hydrogeological, institutional and stakeholder contexts. At the same time, they focus on potential incentives for reducing groundwater withdrawals that don't significantly impact farmer livelihoods.

WLE research and field-testing of technologies in the north Indian state of Uttar Pradesh have focused on identifying ways to harness floodwater in the monsoon season and use it to replenish groundwater resources for irrigation during the dry season. The Underground Taming of Floods for Irrigation (UTFI) initiative aims to tackle two challenges at once - annual flooding and groundwater overexploitation. UTFI is a collaboration between WLE and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). It uses floodwater to recharge groundwater aquifers in order to improve the sustainability of the resource.

Through this initiative, a pond in the village of Jiwai Jadid, 20 kilometers east of the town of Rampur in Uttar Pradesh, was renovated. The renovation allowed diverted floodwater to percolate through recharge wells, thereby replenishing aquifers and raising groundwater levels. In the dry season, this water can be re-accessed for irrigation.

Based on the results of this pilot, Rampur District has now included UTFI in its District Irrigation Plan and has set aside US$ 1.2 million from government funds for implementation. In the year ahead, similar trials are planned in Vietnam, Bangladesh and elsewhere in India.

Learn more about what WLE is doing to build farmer resilience through sustainable groundwater use and management.

PHOTO: PRASHANTH VISHWANATHAN/CCAFS

Improving farmer resilience to risk and disaster with satellites

In South Asia, over a billion people are dependent on agriculture for their livelihoods. Many of them are low-income farmers who are very vulnerable to climatic shocks such as floods and droughts. These events adversely affect farming activities, livelihoods and food security. As climate variability increases globally, there is a pressing need to find practical solutions to help these farmers become more resilient to climate shocks.

To address this growing challenge, WLE has been collaborating with a diverse range of private sector, government and research institution in India, and elsewhere in South Asia, to develop solutions for growing climate and water variability. These solutions already have real, positive impacts on farmers' lives. Insights gleaned from this work in India have also proved crucial in efforts to help the Sri Lankan government cope with severe flooding in 2016.

Using satellite technology to support crop insurance schemes

WLE has been using satellite imaging to support insurance companies to improve existing crop insurance products for smallholder farmers who live in areas with high probability of extreme weather events.

WLE, through the International Water Management Institute (IWMI), has delivered crop damage assessments to Bajaj Allianz, an insurance provider in Bihar, India. In 2016, Bajaj Allianz provided 349,074 farmers with flood insurance as part of Pradhan Mantri Fasal Bima Yojana (the Prime Minister's Crop Insurance Scheme), launched by Prime Minister Narendra Modi earlier in the year. In response to a major flood in August 2016, Bajaj Allianz asked the WLE and IWMI research team for help with estimating the total crop damage. Researchers used satellite images to quickly and precisely assess rice and maize losses in each administrative unit (at block level) across an area of 30,357 ha. With these estimates, Bajaj Allianz was able to cover farmers' losses with timely payouts of around USD 34 million.

With the goal of making crop insurance available to even more smallholders in the future, WLE and IWMI researchers also partnered with the CGIAR Research Program on Climate Change and Food Security (CCAFS) ; the Agriculture Insurance Company of India (AICI); Bajaj Allianz; Swiss Re, a Swiss reinsurance company; local government representatives; and farmers to develop a new insurance product.

The new product, called Index-Based Flood Insurance (IBFI), will identify flood thresholds based on an assessment of flood depth and duration, derived through modeling that uses remotely sensed data and flood modelling tools. Payout levels will then be estimated based on historical flood event data and related economic losses. It is expected that index-based insurance will help insurers to rapidly and accurately predict a farmer's yield loss after a flooding event, unlike traditional insurance which assesses losses on a case-by-case basis, which is time consuming and unsustainable. IBFI will promote payouts through bank transfers directly to farmers, to avoid additional losses through agents. In 2017, more than 200 farming households have enrolled in an IBFI pilot in Bihar.

Mapping for disaster prevention and relief

Satellite monitoring has also been the key to WLE's efforts to help governments and communities respond to flood and drought disasters, through innovative tools such as the South Asia Drought Monitoring System (SADMS) and rapid emergency response mapping. SADMS is a comprehensive, regional drought monitoring system that provides near real-time information on drought risks in easily understandable maps. The rapid response maps are used by the emergency operation center for relief operations and impact assessment. The maps pinpoint locations under stress and provide regional to district scale information about the drought and floods onset, progression and likely impact on agriculture.

SADMS was used by the Sri Lankan Disaster Management Center to inform their response to a serious drought in 2016. SADMS acts as an early warning

system allowing government departments, communities and others to take pre-emptive action to mitigate the negative impacts as a situation develops, rather than merely waiting to deal with the repercussions of a drought after it has occurred.

Earlier in 2017, the WLE team also prepared drought maps and statistics for the Rabi (dry) season for drought affected states in India. They then delivered these maps to key government officials as a drought situation was developing that could potentially affect millions of people. The WLE maps indicated that the states of Tamil Nadu, Andhra Pradesh and Karnataka faced severe agricultural drought but that the state of Rajasthan would be less affected, thereby enabling government responses to be more targeted.

By innovatively using cutting-edge technology and linking up with policy makers and businesses, WLE is helping to ensure that smallholder farmers - their livelihoods and food security - are buffered from the most severe impacts of climate variability.

Learn more about WLE's research on enhancing smallholders' livelihoods.

PHOTO: LIZ HUMPHREYS

A community-managed approach to improving agricultural productivity in the Ganges delta

Rural communities in Southern Bangladesh have been benefiting from a pilot project established to explore low-cost, community-based solutions to combat the effects of flooding, saline water intrusion and monsoon rains that destroy crops. WLE has been piloting new ways to collectively manage water in these areas to increase both agricultural and aquaculture productivity. The pilot, led by the International Rice Research Institute (IRRI), is exhibiting strong improvements in productivity, rural incomes and family nutrition.

WLE researchers worked in the polders of the coastal zone of Bangladesh. A polder is infrastructure that helps control tidal flooding, including embankments and sluice gates, that enables one or two crop seasons a year in hostile coastal environments. Over eight million people depend on the land within the polders for their food security and livelihoods. 139 of these polders were constructed in Bangladesh during the 1960s and '70s with the aim of boosting the productivity of over a million hectares of low-lying farmland.

Unfortunately, rural communities living in these areas of the Ganges delta experience much lower levels of agricultural productivity than elsewhere in the country, resulting in widespread poverty and food insecurity. They are also highly vulnerable to climate risk and variability.

Partnerships for increased productivity

Despite widespread assumptions that saline intrusion was to blame for low productivity on these farms, WLE research found that the main cause was poor drainage. In response, researchers in partnership with Blue Gold, a collaborative program between the Governments of the Netherlands and Bangladesh, pilot tested two strategies to improve agricultural productivity in four villages in a 30ha polder. Local communities, NGOs and local government were also deeply engaged in the research and pilot testing.

WLE examined the potential use of early maturing, high yielding rice varieties as a first crop, followed by a dry season of maize or sunflower crop, grown and harvested before the monsoon rains. The window between harvest of the first crop and arrival of the monsoon rains is short so second dry season crops had previously been at risk of getting destroyed by the arrival of rains before they were ready to harvest.

In addition, researchers looked at the impacts of revitalizing water infrastructure and its management. WLE pilot tested an improved community-managed drainage system that involved the repair of existing culverts (drainage pipes), digging new drainage channels and de-silting the original drainage system. Members of the community water management organization were trained and mentored to enable systematic sluice gate operation at low tide. The community-managed drainage system greatly reduced the risk of water logging in farmer's fields, brought about by frequent heavy rainfall taking place even before the monsoon.

Early results, unexpected wins and further action

The new, high-yielding rice varieties enabled a jump in yield from around 2-3 tonnes per hectare to 4-5.5 tonnes per hectare. The next step is to match this raised productivity with improvements in the agricultural marketing chain to make sure that returns can be maximised.

Augmenting rice production in the wet season by integrating aquaculture was also found to play an important role in diversifying and improving the incomes of polder communities. WLE research showed that collective fish culture, within a well-defined Water Management Unit, can produce significantly more fish than can be harvested from naturally occurring stock in the rice fields. Improved household nutrition and the profitability of this aquaculture for both women and men are already providing good

incentives, but some types of fish (such as carp) also feed on rice weeds. This reduces the need for, and cost of, regular weeding.

Indications from WLE research show that there could also be potential for other new income-generating activities connected to the three interventions examined in the pilot project. For example, women (whose ability to find employment and other livelihood generating activities is often restricted by traditional social norms in Bangladesh) and youth may find new employment possibilities through the adoption of rice transplanting machines or preparing rice mat nurseries. Equally, if dry season sunflower production is successfully expanded, this opens up avenues to produce and market sunflower oil.

Lessons from the success of these pilots in Bangladesh are now informing WLE work on improving the productivity of flood-based farming sites in Sudan and Ethiopia. Other similar opportunities to have an impact are also emerging in the Mekong Delta.

Learn more about WLE's research on enhancing smallholders' livelihoods.

PHOTO: JOSIANE NIKIEMA/IWMI

PROMOTING INNOVATIVE BUSINESS MODELS AND INSTITUTIONS

Green business models bring nutrients in waste back to the farm

Tema, a vibrant, bustling city on Ghana's coast, is one of West Africa's busiest ports with a flourishing fishing industry. But the city is struggling to deal with the challenge of waste, particularly human waste, generated by its burgeoning population. If not well managed, this waste can have significant health and environmental ramifications.

Nearby, Ghanaian farmers are working hard to squeeze every drop of growth potential out of their farmland to earn a living and feed the country. But pushing the land to deliver between five and ten harvests a year depletes soils of nutrients and organic matter, making current practices unsustainable and unproductive.

An innovative public-private partnership has been set up to address both of these challenges at once: between 2015-16, WLE, led by the International Water Management Institute (IWMI), supported the development of a purpose-built co-composting plant on the outskirts of the city.

The scheme has been set up in collaboration with the Tema Metropolitan Assembly (TMA), Jekora Ventures (a private waste management company)

and Training, Research and Networking for Development (TREND). Supporting partners include the Government of Ghana, Bill & Melinda Gates Foundation, the Department for International Development of the UK government and Grand Challenges Canada.

From unsafe waste to safe fertilizer

The co-composting plant is able to process 12,500 cubic meters of fecal sludge (equivalent to that generated by up to 100,000 people) and more than 700 metric tonnes of organic food waste a year. Combined, these will be used to produce up to 500 metric tonnes of Fortifer, a safe, nutrient-rich, organic fertilizer.

Fortifer was approved for use and commercial production by the Ghanaian Ministry of Food and Agriculture in 2016 and is now a registered trademark. It will be produced and sold in both powder and pellet form, and is eligible for government subsidies. Fortifer also meets the international safety standards for composts set by the World Health Organization (WHO).

Jekora Ventures is investing US$90,000 to set up, operate and maintain the plant and to commercialize Fortifer. The TMA provided the land for the recycling plant and the Ministry of Local Government and Rural Development, Ghana, have committed nearly US$156,000 capital investment in the plant, amounting to about 24 percent of the total, with the remainder coming from international donors. The initiative, informing policy and private enterprise with the potential to result in significant development impact, draws on over twelve years of research.

Additional economic and production benefits

The Fortifer production process not only offers a solution to the challenges of waste management and depleted soils, but also presents an opportunity for Ghanaians to reduce their reliance on imported fertilizers. The process supports local enterprise and creates jobs. Some of the revenue generated can be used to improve sanitation in nearby cities and urban areas, creating a positive feedback loop.

Concurrently, farmers will be able to access a soil enhancing compost fertilizer that is convenient to transport, effective and easy to apply. Field trials have confirmed that Fortifer improves the yields of vegetable crops, such as tomatoes, okra, pepper, cabbage and lettuce, as well as common grains, like rice and maize.

Business models to reuse resources from waste

Fortifer production is just one example of many business models developed

by IWMI and WLE, through applied research, with the aim of addressing the multiple challenges involved in recovering and reusing water, nutrients and energy from domestic and agro-industrial waste streams. These business models are detailed in a WLE report on fecal sludge management spanning the full sanitation value chain, which joins a wide range of publications on this topic.

Our view of waste is changing. In a rapidly urbanizing world, with significant pressure on resources, innovative solutions that draw value from garbage demonstrate what can be achieved through collaboration and action research. And it shows we can no longer afford to waste our waste.

Learn more about what WLE is doing to reuse nutrients from waste for healthier soils for productive and resilient agricultural landscapes.

PHOTO: PRASHANTH VISHWANATHAN/IWMI

Developing sustainable business models for solar-powered irrigation pumps

Making good use of surface and groundwater for irrigation in agricultural production has significant potential to build farmer resilience against food insecurity. Sustainable irrigation practices are known to raise agricultural productivity, improve rural incomes and help to ensure that farmers are better able to deal with the impacts of a changing and more erratic climate. But irrigation is a highly labor-demanding venture, and mechanization--such as using diesel pumps--add to the agricultural emission of greenhouse gasses.

As the world grapples with increasing climate variability, our dependence on irrigation is likely to intensify. Farmers in rural India, as in many other parts of the world, are becoming increasingly reliant irrigation with groundwater, so the need to use and manage this precious resource in a sustainable way has never been greater.

Incentivizing sustainable use

WLE is helping to scale up innovative solutions that help address overexploitation of groundwater in India and other countries by identifying

effective economic incentives to reduce groundwater withdrawals.

For example, the successful Solar Power as Remunerative Crop (SPaRC) business model was developed and piloted by the International Water Management Institute (IWMI) and supported by the Tata Trusts through the IWMI-Tata Water Policy Program. SPaRC monitors on-farm electricity generation, income, water efficiency and crop production.

Following the success of the initial pilot, WLE researchers brought together six small-scale vegetable farmers in Anand province to form the world's first solar irrigation cooperative - the Dhundi Solar Pump Irrigators' Cooperative Enterprise (SPICE). With financial support from IWMI, each farmer installed a solar irrigation pump that was connected to the state power grid. The six farmers collectively signed a 25-year power purchase agreement, which allows them to sell surplus energy to the grid at Rs 4.63 per kWh.

Researchers found the farmers were extremely responsive to incentives that improved their productivity and incomes. They began selling electricity to the grid in May 2016, and since then, the number of kWh being used to pump groundwater for irrigation has been significantly reduced while the percentage of electricity being sold to the grid has risen considerably.

Increased incomes, more efficient groundwater use, and greener energy

In five of the eight months since SPICE began, the portion of electricity sold was higher than the proportion of electricity used to pump groundwater. This not only means a good financial return for farmers, but also more efficient irrigation practices and less groundwater extraction.

In addition, since neither petrol nor diesel is being used to run these pumps, these solar pumps help reduce carbon emissions and play a role in reducing emissions from agriculture. Exchanging India's electric tube well pumps for solar ones could reduce carbon emissions by 4-5% per year. This striking example of a triple win provides farmers with choices and additional income, supplies the local electricity board with more power and contributes to the conservation of water resources.

These results of SPICE are compelling and the model, if further scaled up to other suitable areas in India, offers multiple potential benefits for farmers, the state and the environment. SPICE also provides the India government with another route to achieve its objective of 100GW of solar capacity by 2022. These lessons can now be used to inform similar initiatives elsewhere.

Business thinking for better irrigation

This initiative forms part of a wider focus of WLE and IWMI on incentivizing the adoption of solar pumps to improve the sustainability of the irrigation sector by developing a framework for business models that support it. Integrating more business-oriented thinking and market-driven mechanisms into irrigation investments to ensure that the right incentives are in place makes them more financially and socially attractive. Researchers have been working on developing sustainable business models for solar-powered irrigation pumps by analyzing a range of investment scenarios and incorporating diverse potential investor perspectives.

This approach can foster sustainable intensification of agriculture through solar pump irrigation, not just in India, but also in other parts of the world. In Africa, for example, groundwater irrigation for agricultural production has only just begun to be tapped, with only around 1% of cultivated land in Africa being irrigated using groundwater. IWMI researchers, with support from WLE, have developed a series of continental-scale maps of renewable groundwater resources in Africa, which account for both human and environmental demands. These maps suggest that the area irrigated with groundwater could be expanded by a factor of 20, from the current 2 million ha to 40 million ha.

WLE has also been supporting and collaborating with the International Centre for Integrated Mountain Development (ICIMOD) to explore sustainable financing options that would encourage smallholder farmers in Nepal to adopt solar irrigation pumps.

Rigorous business models and financing options such as these will help to ensure that groundwater irrigation development progresses sustainably while enabling agricultural intensification goals to be achieved.

Learn more about what WLE is doing to build farmer resilience through sustainable groundwater use.

PHOTO: DOUGLAS VARCHOL

Sustainable watershed management benefiting rural communities in India

Mr. Dmopi lives with his family in the northern Karanataka State in India. He used to work as a laborer for less than US$100 a month. But now, he has significantly increased his income by turning his hand to farming. This is thanks to an innovative public-private partnership (PPP) supported by WLE and the CGIAR Research Program on Dryland Systems through the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

The successful public-private partnership brought together one of Bangalore's leading steel plants, JSW Steel Ltd., state government, local NGOs and local farmers. The partnership engaged in a range of activities aimed at improving and restoring watershed management, fostering productive farming and thereby increasing yields and rural incomes.

Keeping agriculture healthy to ensure a future for business and communities

Rural livelihoods and food security in the area historically depended on family farm plots. After many years of poor water and soil management, yields had been low. Youth who saw little future in farming were migrating

to find work elsewhere.

The nearby JSW Steel plant, which provides jobs for many residents in over 40 local villages, decided they wanted to support local communities. The idea was to help them improve crop productivity and farming incomes by fostering improved land and water management. The company also recognized that stemming youth outmigration from the area would not only be beneficial for the community, but also help ensure a sufficient future supply of labor for the steel plant. The vision was for stronger, more sustainable land and water management to lead to stronger and more sustainable rural communities, helping to ensure stronger and more sustainable business – a win-win for all.

As detailed in a video about the initiative, four villages were initially chosen to participate in the PPP, which impacted around 5,000 farmers. Water surveys confirmed that groundwater in the area was suitable for use in agricultural crop irrigation. The partnership then implemented a variety of actions aimed at reducing rainfall runoff and increasing rainwater infiltration into the soil to recharge groundwater resources. In consultation and collaboration with local villagers, a number of water-harvesting structures were constructed. For example, check dams (small dams constructed across waterways to counteract erosion) and farm ponds were built. The check dams were found to recharge between 15-20 borehole wells, which could in turn be used by farmers to irrigate food and other cash crops. The farm ponds were also used to supplement irrigation, while simultaneously contributing to groundwater recharge.

Citizen science to improve resource management

Participating farmers were taught how to take quality field samples as part of a detailed soil survey. In total, over 3,000 soil samples were collected and analyzed.

Each participating farming family was also given a soil health card, in the local language, detailing current and desirable soil nutrient levels. The WLE team collaborated with these farmers in setting up demonstration sites to show what could be achieved. They wanted to encourage farmers to adapt or change their land and water management practices.

When farmers used this new knowledge, understanding and following recommendations about how to manage and improve their fields and use of water resources, the result was yield increases of around 20%. Yields grew from an average of 66 kg previously to around 84 kg. This impressive result encouraged more farmers to get involved and try the techniques on degraded land that had previously been considered virtually barren. Youth who have seen the results from the demonstration farm plots have also

been observed returning to agriculture in the area.

In Mr. Dmopi's case, he used the improved land and watershed management tools and practices to grow chilies as a cash crop. This year, his harvest is expected to generate about 300,000 Indian Rupees ($US4,400), a big leap from his US$100 a month income as a laborer.

Following the success of the initial pilot, JSR Steel Ltd., encouraged by the power of partnerships, has plans to expand the initiative to include over 100 villages in the area. This example clearly shows that PPPs, when based on principles of sustainability, can be successful in delivering mutual benefits for both the private sector and local communities. They have the potential to make significant, positive contributions to reducing poverty and migration away from rural areas. They also have potential to ensure the ongoing sustainability of private sector ventures, while helping to mitigate the impacts of climate change and variability.

Learn more about what WLE is doing to improve soil and land management.

PHOTO: PETTERIK WIGGERS/PANOS PICTURES UK

FACILITATING COMMUNITY-LED SCIENCE

Soil and water conservation measures for halting and reversing land degradation

In the highlands of northwest Ethiopia, farmers are simultaneously dealing with land degradation and vulnerability to climate change. These threats to their livelihoods and food security are inextricably linked, so it makes sense that they require holistic solutions that also help to ensure the sustainability of the ecosystems on which these farmers rely.

Land degradation in the Ethiopian highlands is predominantly evidenced by extensive soil erosion. While deforestation is often locally cited as the major cause, the picture is much more complex.

WLE, through the International Center for Agricultural Research in the Dry Areas (ICARDA) and the International Water Management Institute (IWMI), has been working to provide practical solutions focusing on soil and water conservation (SWC). SWC practices include soil fertility and crop management, soil erosion control measures and water harvesting, all good ways to address the challenges faced in the Amhara region of northwest Ethiopia.

Modelling land use change to prepare for climate variation

Through ICARDA, WLE has used hydrological and bio-economic models to assess the impact of climate and land use change on watershed management. As part of this work WLE has also been specifically exploring strategies to improve women's livelihoods as a way to simultaneously enhance equity and strengthen agricultural productivity. Like many farmers in Africa, these communities combine crop farming with livestock rearing and other income generating activities in a patchwork of efforts to meet their needs.

Farmers' perceptions about their vulnerability to climate variability were explored through participatory research processes. This gave WLE the opportunity to sound out farmer's willingness to adopt improved soil and water management options, some of which may have been new to them.

Remote sensing identified land use changes over time showing, for example, that between 1986 and 2007, around 30% of watershed forests were lost, much of them replaced with crops. Hydrological and bio-economic models, developed and calibrated using extensive datasets and combined with downscaled climate change scenarios, are being used to analyze system dynamics, productivity and constraints at the watershed scale. Findings from this research are included in a book, Mitigating Land Degradation and Improving Livelihoods.

Establishing exclosures to improve watershed rehabilitation

Also in the Amhara region of Ethiopia, WLE, through IWMI, has been exploring the impacts of exclosures in the Gomit watershed. Exclosures are plots of land that have been closed off to protect against interference from people and domestic animals, allowing a process of soil and vegetation rehabilitation. In the Gomit watershed, exclosures were identified and established in close collaboration with local communities and are managed by the Community Watershed Team together with the Regional Bureau of Agriculture, the District Agricultural and Rural Development Offices, and other district administrative bodies.

11 exclosures were established on communal grazing land, anywhere from 1 to 7 years ago. Community members and researchers have all noticed a regeneration of indigenous tree species, increased vegetation cover, reduced soil erosion and water channel sedimentation, increased fodder production and the rehabilitation of gullies. Additionally, exclosures offer further benefits that could lead to revenue generation from carbon trading.

WLE's work has resulted in a catalogue of management options examining exclosures for ecosystem restoration and economic benefits in Ethiopia. WLE has also produced guidance on sustaining the benefits of soil and water conservation in the highlands of Ethiopia and on expanding and

sustaining exclosure land management. These form parts of a set of identified methods for sustaining soil and water conservation in Ethiopia.

Data and tools to improve management of land and water

WLE also developed a tool that offers a participatory, user-friendly and gender-sensitive approach to evaluating land management options from the perspectives of farmers themselves; the Evaluating Land Management Options (ELMO) tool.

In collaboration with local communities, strengthening local capacity and facilitating collective action, WLE is making a significant contribution to addressing the challenges of land degradation and vulnerability to climate change faced by farmers in the Ethiopian Highlands. The tools and approaches developed by WLE researchers, as well as the exploration of a diverse range of land and water management options, have the potential to increase rural incomes and reduce food insecurity in tandem with enhancing environmental sustainability. Through these processes, WLE and others are learning valuable lessons that may also be usefully applied in other parts of Africa and beyond.

Learn more about what WLE is doing to promote better soil and water management for sustainable agriculture.

PHOTO: WARECOD

Community-led science and participatory videos for ecosystem service sustainability

Engaging rural communities in the research process is a common element in research for development. Taking this participation a step further can lead to important insights and interactions among all involved parties. WLE has been testing new approaches to community-led – or citizen – science and participatory video, challenging research teams and communities to explore new and effective ways of sharing knowledge and experience.

Participation brings behavior change in the Mekong Delta

In Vietnam, WLE has brought together citizen science and field observation in an innovative combination to monitor ecosystem services, co-design research questions and collect data. Partnering with local communities as well as NGOs, national research institutes, universities and government departments, the WLE team helped build awareness of effective land and water resource management. Residents from three villages affected by saltwater intrusion, periodic flooding, pollution of waterways, and lack of electricity have helped identify and guide the development of a range of future, local level, socio-economic development scenarios. These scenarios

help the communities to understand the impacts of individual and community activities and their own role in sustainably managing water resources.

Led by Vietnamese NGO, WARECOD, community members and WLE researchers selected what all felt was a practical, feasible development path to improve flood protection and increase water and electricity supply. The path they identified combines local knowledge and experience with international research expertise and is tailored to ensure the sustainability of ecosystem services, even when faced with climate variability.

WARECOD and the WLE team involved communities directly in the research and strategy development process using *Thaibaan* research, a participatory farmer-led (as opposed to scientist-led) research method, while taking particular care to ensure inclusivity through active participation of women and ethnic minorities. The *Thaibaan* approach, which was developed in Thailand, aims to enable local people to design and carry out natural resource research projects on issues important to their daily lives. The use of photovoice was encouraged by the WLE team to foster capacity building and learning exchange without the need for high levels of literacy.

Early results indicate that those involved in the community-led science activities now have a better understanding of, for example, how rubbish disposal and pesticide use today is likely to affect their future livelihoods. The farmers have also begun to adapt their livelihoods strategies in ways that improve their incomes while minimizing the impact of their activities on the environment.

Video production as a pathway to communication and capacity building

In Kenya and Ghana, WLE initiatives led by the International Center for Tropical Agriculture (CIAT) have used participatory video production as an approach to engage local communities, give diverse community members a voice, and to foster capacity building and knowledge exchange.

The WLE research team was keen to learn why the farmers make certain resource management choices, what their needs and challenges are, and what other factors impact their decision making.

Through the participatory video process, 19 farmers in North Alego, Kenya, produced a video that details their hopes and aspirations, as well as the challenges they face. The farmers also explain how important training and information exchange is for addressing these challenges and achieving their goals.

In the Upper East Region of Ghana, 11 members of farming communities from the villages of Damolgo and Sekoti expressed their views on local land management issues and recorded themselves on camera. Five women and six men learned how to shoot video footage, conduct on-camera interviews and edit the footage with guidance from the WLE research team, which included CIAT, the International Union for Conservation of Nature (IUCN), University for Development Studies (UDS) and the Association of Church-based Development NGOs. The result is a film the group called Ti Na Nyang - We Can in which members describe key aspects of farming important to them and their communities, including managing on and off-farm tree mulching, using manure and crop waste as fertilizer, the downsides of bush burning, and how and why they use stone bunds and contour planting. Through district level platforms and screenings, a total of five participatory videos presented the trade-offs involved in different sustainable land management options with a focus on ecosystem-based management.

These innovative participatory processes create opportunities for researchers to learn more about rural communities and the social, economic and environmental challenges they face. By engaging communities directly in the research process, WLE works to ensure that the research and its outputs are relevant to those communities, addressing their needs and concerns and helping to foster sustainable agricultural intensification within specific ecosystems.

Learn more about what WLE is doing to promote healthy soils for productive and resilient agricultural landscapes.

PHOTO: FARID TRAORÉ

FACILITATING COMMUNITY-LED SCIENCE

Role-playing games for better community resource management

The Bagré dam, the largest multi-purpose water infrastructure in Burkina Faso, lies on the White Volta River. It is crucial to hydropower and food production as well as to regulating water flows, which help to reduce downstream floods. Recently, agricultural investors have taken an interest in the areas around the dam in order to build large-scale irrigation schemes. The Government of Burkina Faso and the World Bank are encouraging this type of private investment because it has the potential to expand agricultural production and generate employment.

But what does it mean for local smallholder farmers?

Farmers, who have traditionally relied on rainfall to supply their water needs, are now being offered parcels of land within these new irrigation schemes in exchange for their farms. Although the irrigated parcels of land they are offered are considerably smaller (one irrigated hectare for every four rainfed), Bagrépole, the agency overseeing irrigation development in the area, predicts that irrigated agriculture will be four times more productive than purely rainfed farming.

This arrangement could potentially benefit both local farmers and agri-business investors but key questions need to be answered. What options are available for tailoring these irrigation investments so they are productive while also ensuring enhanced equity, promoting healthy ecosystems and minimizing any negative impacts? How can the needs and concerns of communities affected by large-scale development be heard and adequately taken into account? What is the right level of compensation? Will farmers' incomes be improved or reduced?

Simulating resource management through games

An experimental role-playing game - Bagrépoly - was developed as part of a WLE research project led by CIRAD to explore improved management of these common resources with all relevant stakeholders in the community. Bagrépôle staff, members of the Nakanbé Water Agency and researchers collectively developed Bagrépoly using participatory *companion modelling* principles, namely equity, transparency, adaptability and iteration.

The game was specifically designed to address the equity and environmental dynamics of large water infrastructure. It is applicable to Bagré dam but may also be usefully adapted to other agricultural water "hot-spots" in Africa and beyond. Among Bagré dam communities, the game was used as a way to engage all kinds of stakeholders. It allowed them to discuss issues such as the conditions under which farmers would accept changing the type of crops they produce.

Players express their views, listen to others, learn to adapt and to develop relations with actors they're not used to interacting with in a simulation that is close to reality. This helps inform real life situations and the decisions they face.

Games go global

Bagrépoly joins an increasing number of resource management games that have been developed in other parts of the world, including for groundwater in India and surface water in Colombia, as well as for sanitation in Tamil Nadu. These games can help create dialogue and awareness among diverse stakeholders, while many enable 'learning by doing' and the virtual exploration of possible outcomes, where decisions can be made with limited risk.

The common element in all of these games is that they highlight the importance of collective action and provide insights into what factors will affect whether or not relevant actors will cooperate with each other.

What more engaging ways can there be for building the capacity of decision

makers, from the local to the national level, to effectively manage these resources and promote equity among their multiple users than through games that help to simulate reality but in a 'safe' learning environment?

Learn more about what WLE is doing to promote sustainable groundwater use.

More information about this project:

- What does for today won't do for tomorrow!
- Managing water infrastructure and equitable land compensation schemes in irrigation projects for social and environmental benefits.
- Ideologies. Development models and irrigated land tenure: the bagré irrigation project in Burkina faso.

PHOTO: NANA KOFI ACQUAH/IWMI

FACILITATING COMMUNITY-LED SCIENCE

Working together to bridge the gender gap in agriculture

Women make essential contributions to agriculture and rural economies in all developing countries. Yet, women's productivity is often constrained by their access (or lack of access) to productive resources such as land, water, and capital. Their contribution is also often constrained by their lack of freedom to play a fully participatory role in decision making about these resources. When women lack access to resources, or are unable to equally participate in decisions about them, they are unable to make investments in agricultural production.

Considering the basic fact that women make up half the population, it can be argued that achieving sustainable intensification of agriculture at scale will depend on women having greater opportunities to contribute. Evidence indicates that reducing or eliminating the gender gap could lead to significant gains for society as a whole. This could be not only in the form of increased agricultural productivity, but also through improved household livelihoods.

WLE has been developing and trialing tools, manuals and other community-led and capacity building approaches with the aim of fostering this beneficial transformation. A very important insight emerging from WLE's research is that enhancing positive collaboration between men and women

will likely lead to better outcomes for everyone.

Improving gender equality for better irrigation management

WLE researchers have successfully developed and piloted the Gender in Irrigation Learning and Improvement Tool (GILIT) in Malawi and Uzbekistan. In Uzbekistan, the International Water Management Institute (IWMI) partnered with irrigation water user associations and Nazar Business and Technology to develop and pilot the GILIT tool on six large irrigation schemes. Similarly, in Malawi, IWMI partnered with the academics from the University of Malawi, the Agricultural Extension Service and smallholder farmers in the Kaziputa and Lufilya irrigation schemes, which have matrilineal and patrilineal inheritance systems, respectively.

The GILIT tool, which is intended to support local governments and other stakeholders in improving gender integration in irrigation scheme planning, identifies policies and operational procedures in formal irrigation schemes that need to be adjusted in order to promote gender equity. GILIT is based on a set of indicators that focus on three critical themes in gender and irrigation: access to resources, participation in decision making, and access to benefits. It also includes supporting discussion questions and an adaptable scoring system.

This is important because evidence suggests that the community-based approaches applied in water management projects do not necessarily lead to greater participation and empowerment of all the stakeholders involved. Commonly used approaches sometimes make the mistake of viewing the community as a single, homogenous entity in which all members generally share common interests and goals. In reality however, men and women (to give just one demographic example) have different needs and priorities when it comes to using and managing resources.

Measuring and facilitating rural women's empowerment

The Women's Empowerment in Agriculture Index (WEAI) is one useful tool for monitoring the level of women's empowerment and inclusion in the agricultural sector. It was developed by the International Food Policy Research Institute (IFPRI) and the International Livestock Research Institute (ILRI) through WLE.

Through WLE, researchers from IWMI have also been working to develop and pilot participatory gender training for community groups in 12 villages of Nepal and India. Working with around 60 field staff from 15 NGOs the WLE team piloted the training with 200 farmers. The techniques and approaches used are captured in the Manual for Critical Discussion on

Gender Norms, Roles and Relations.

Through carefully designed activities participants are encouraged to reflect on their own gender perceptions, critically discuss gender roles at home and in the community, and develop bargaining skills through role play. This work was carried out in collaboration with a variety of partners, including SAKHI (Bihar, India), the Centre for the Development of Human Initiatives (West Bengal, India) and iDE Nepal.

Tools for improved access for women in Africa

In West Africa, WLE through IWMI explored how effective a number of agricultural water management solutions have been in delivering multiple ecosystem services, maintaining environmental health and providing returns on investment. Researchers found that improving women's access to small reservoirs can improve household livelihoods. This can be achieved for example by investing in community-managed small reservoirs and by including women in the planning and management.

This work is a result of a partnership between WLE, IWMI, the Women in Agricultural Development Directorate of the Ghana Ministry of Food and Agriculture, the Kwame Nkrumah University Science and Technology, iDE Burkina Faso and the West African Science Service Center on Climate Change and Adapted Land Use (WASCAL).

WLE has also demonstrated a simple yet innovative socio-hydrological approach using participatory three-dimensional maps to identify gendered ecosystem services in Ethiopia.

In Burkina Faso and Niger, a WLE research team led by ILRI discovered that a number of opportunities exist to increase sustainable productivity, enhance equity, improve incomes and spread the benefits of fodder biomass production more widely. They explored biomass production and management from a gender perspective in communities at two sites in the semi-arid north of the Volta and Niger River basins (four villages in Yatenga province in northern Burkina Faso, and four villages in Fakara district in south-western Niger).

All of these efforts, designed to explore innovative approaches to overcome gender barriers in agriculture in various parts of the globe, are helping to shed light on the path towards achieving inclusive, equitable and sustainable agricultural intensification.

Learn more about WLE's research on enhancing smallholders' livelihoods.

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