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UPPER RIVER BASIN WATERSHEDS: SUSTAINABLE, EQUITABLE AND PROFITABLE INTERVENTIONS

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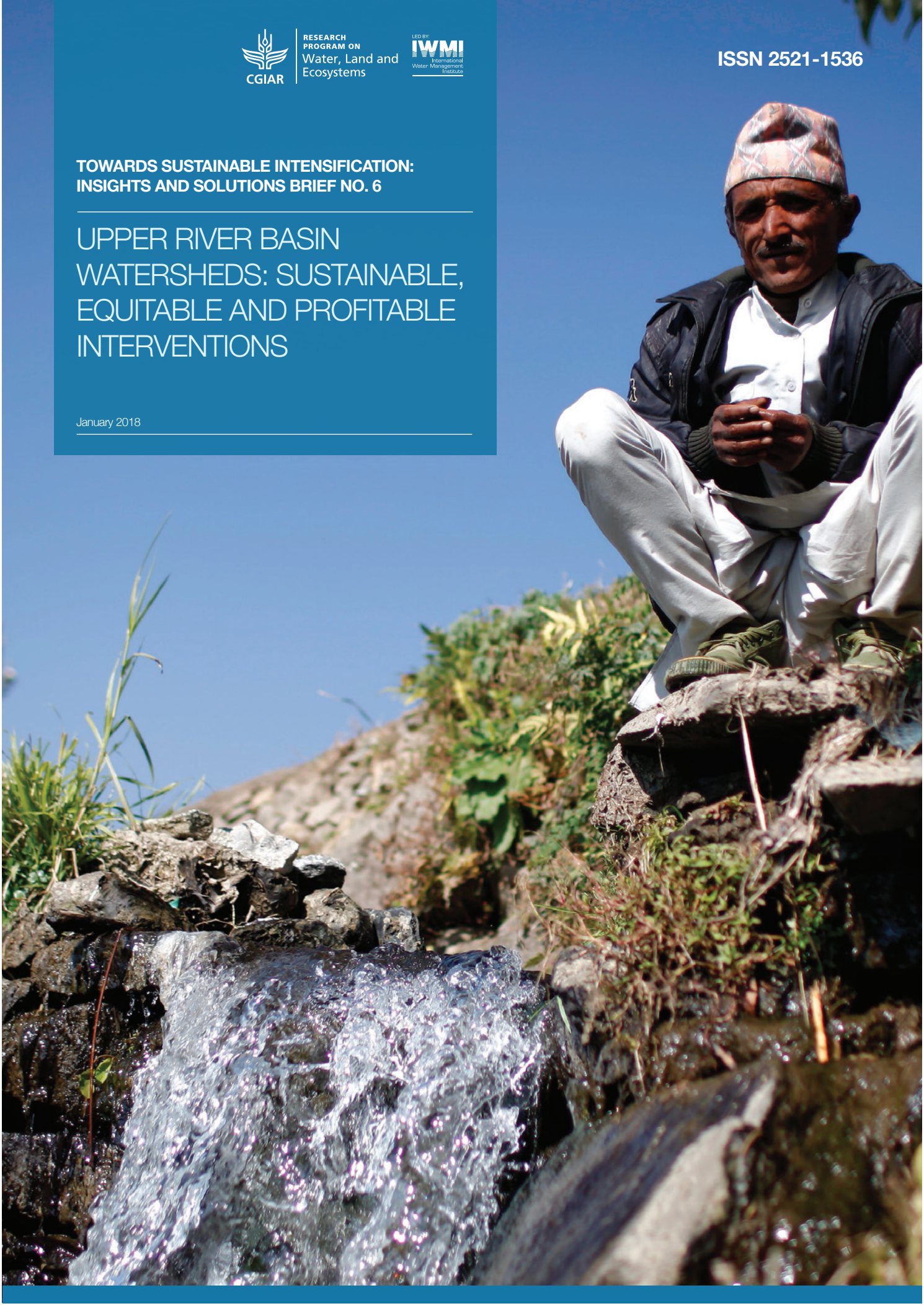

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SERIES INTRODUCTION

Raising global food production is essential to eradicate hunger and achieve food and nutrition security. But agriculture has become the world's single largest driver of environmental degradation, and it is pushing Earth beyond its natural boundaries. **Sustainably feeding future generations requires a fundamental shift in global agriculture.**

Since its inception in 2012, the CGIAR Research Program on Water, Land and Ecosystems (WLE) has developed scientific evidence and solutions for **sustainably intensifying agriculture**. For WLE, sustainable intensification means more than minimizing agriculture's environmental footprint; it means making sure that agriculture adds value to the environment, while it supplies global populations with sufficient food, nutrition and income.

More than 500 million smallholders worldwide stand to benefit from sustainable intensification of agriculture. Historic commitment to the UN Sustainable Development Goals (SDGs) and the Paris Climate Agreement further highlights the need for investing in sustainable and resilient agriculture.

But achieving sustainable, healthy food systems requires identifying **incentives** for sustainable farming. Likewise, it hinges on social and institutional innovations to **mitigate trade-offs and achieve synergies**, and **enable equitable access** to knowledge and resources. Not least, integrated solutions that work across sectors, disciplines and scales will be essential to realizing such a fundamental shift. Such innovations are what WLE has worked to develop. The Program's findings are summarized in this series of briefs, titled ***Towards sustainable intensification: Insights and solutions***.

Key Reading

Rockström, J.; Williams, J.; Daily, G.; Noble, A.; Matthews, N.; Gordon, L.; Wetterstrand, H.; DeClerck, F.; Shah, M.; Steduto, P.; de Fraiture, C.; Hatibu, N.; Unver, O.; Bird, J.; Sibanda, L.; Smith, J. 2017. Sustainable intensification of agriculture for human prosperity and global sustainability. *Ambio* 46(1): 4-17.

ABOUT THE WLE FOCAL REGION PROGRAM

From 2014 until the end of 2016, WLE implemented an innovative set of projects in response to a call for more demand-driven and locally led initiatives in support of agricultural intensification at a regional scale. Researchers partnered with local actors to co-design projects that used an ecosystem-based approach to influence investment and decision making in support of more equitable management of natural resources. In total, 33 projects were implemented in 18 countries with 175 partner organizations in four regions: The Ganges; the Greater Mekong; the Nile-East Africa; and the Volta-Niger.

This brief reports on research results from five projects from WLE's focal region portfolio, namely two in the Ganges region, two in the Mekong, and one in the Nile-East Africa region:

- Reviving springs and providing access to solar powered irrigation pumps through community-based water use planning, led by International Centre for Integrated Mountain Development (ICIMOD) in collaboration with Helvetas, Nepal; the Mountain Institute, India; Atom Solar; the Advanced Center for Water Resources Development and Management, Pune, India; the Government of Sikkim's Rural Management and Development Department (Dhara Vikas Programme); and independent consultants from George Washington University and Harvard University.
- The irrigation-hydropower nexus in the Ganges headwaters, led by the University of Arizona in collaboration with the People's Science Institute; ICIMOD; Kumaun University; and the Shaheed Bhagat Singh College at the University of Delhi.
- Implementing cross-sectoral negotiations to coordinate Nam Xong water resources, livelihoods, ecosystem services and agricultural intensification, led by the Mekong Region Futures Institute in collaboration with the Department of Water Resources, Ministry of Natural Resources and Environment, Lao PDR; the National Economic Research Institute, Lao PDR; and the Ministry of Planning and Investment, Lao PDR.
- Inclusive development paths for healthy Red River landscapes based on ecosystem services, led by Delft University of Technology in collaboration with the National Centre for Water Resources Planning and Investigation; the Institute of Water Resources Planning; Hanoi University of Natural Resources and Environment; the Water Resources University; GreenID; Viet Nam Netherlands Center for Water and Environment; UNESCO-IHE; FutureWater; and IWMI.
- Water, land, ecosystems and trade in staples, led by Kilimo Trust in collaboration with the International Food Policy Research Institute (IFPRI); Kenya Agricultural and Livestock Research Organization (KALRO); the Rwanda Agriculture Board; and the Environmental Management Unit of the Ministry of Agriculture, Tanzania.

DEFINITIONS

Citizen science: The collection and analysis of data relating to the natural world by members of the general public, typically as part of a collaborative project with professional scientists.

Ecosystems approach: A strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.

Run-of-the-river hydroelectric projects: Unlike other hydroelectric projects, which depend on reservoirs that flood large areas, run-of the-river systems divert water at a weir on the river. The water is then transported through a pipe or tunnel to another location at a lower elevation for power generation and subsequently returned to the river further downstream, or occasionally as permitted by topography and tunneling, released to an adjacent river.

Water-energy-food nexus: A phrase denoting that water security, energy security and food security are inextricably linked and that actions in any one area often have impacts in one or both of the others.

SUMMARY

The CGIAR Research Program on Water, Land and Ecosystems (WLE) has conducted innovative research in the upper watersheds of the Ganges, Mekong, Red and Nile river basins. WLE sought to identify how to improve people's livelihoods in ways that are equitable, profitable and sustainable, while also improving ecosystem services locally and downstream. The research specifically examined the impact of interventions spanning several sectors, including water, food, energy and trade. This brief presents results, insights and tools that can be adopted and applied elsewhere. Escaping from the confines of narrow sectoral investments and adopting an integrated, ecosystems-focused approach can lead to more sustainable, profitable and equitable use and development of upper watershed landscapes.

Recommendations

- Design infrastructure investments in upper watersheds in collaboration with local communities, based on an integrated ecosystem services and inter-sectoral 'nexus perspective'.
- Design and implement upper watershed interventions that prioritize benefitting upstream as well as downstream people.
- Provide training and support both to strengthen the institutional capacities of local communities to engage effectively with others in planning and managing infrastructure projects, and to encourage 'citizen science' in collaboration with external scientific expertise.
- Use trade and marketing policies to promote sustainable intensification of agriculture, other ecosystem services and food security.
- In upper watersheds where communities are highly dependent on springs for water, adapt and make use of participatory interdisciplinary methodologies to identify and implement actions to ensure they will remain productive.

INTRODUCTION

Large river basins are dynamic and complex systems. Investments and other interventions in the upper reaches of such basins naturally impact livelihoods and ecosystem services downstream.

First, investments in infrastructure are often made with too little attention to their potential impacts locally or elsewhere. For example, dams and mines in the upper portions or headwaters of river basins have profound consequences, both for downstream ecosystems and people, and for those displaced locally. A hydroelectric dam may provide low-cost energy to distant cities, while people in the vicinity of the dam have no access to electricity. The reservoir may also flood cultivated fields or forests and wetlands providing important ecological services, leaving local people with diminished livelihood opportunities. Even if they have received some cash reimbursement, there are often no opportunities to use it to establish a new business.

Second, inter-sectoral interactions introduce additional complexity. Energy policies affect water resource availability and food supply – hence the renewed attention to the 'water-energy-food nexus'. A third level of complexity concerns trade, and more generally, agricultural input and output pricing policies, which may provide disincentives to farm sustainably, but can also be designed to promote positive change. Failure to examine potential interventions systematically in a nexus perspective, the lack of attention to the potential use of trade policies to encourage sustainable use of ecosystem services, and the all too common practice of paying only lip service to local people's concerns often lead to drastically reduced benefits and even avoidable harm.

Based on a highly competitive process, WLE in 2013 selected and funded several innovative research projects led by a diverse set of institutions. Some of these projects are located in the upper watersheds of the Ganges, Mekong, Red, and Nile river basins. They have examined the impacts of upper watershed interventions and explored the potential to improve ecosystem services and livelihoods, both locally and downstream. The projects in the Ganges and Nile basins were completed by the end of 2016; those in Southeast Asia are continuing, but have already produced interesting results.

Bridging sectors can increase benefit sharing and foster inclusive, sustainable development

In large river basins, policy decisions are often made within single sectors, based on a specific agency's mandate and objectives. Integrating river management, agricultural productivity, ecosystem services, land use change and livelihood issues into cross-sectoral negotiations when designing development interventions is rare. Although single-sector objectives might be achieved, adverse and unforeseen social, ecological and economic consequences can emerge for other sectors. Failure to treat individual sectors as part of a coupled social and ecological system compromises the overall system performance.

WLE projects in the Ganges, Mekong and Red rivers have documented the damage done by interventions that do not pay adequate attention to local people and the ecosystem services on which they depend. However, the same studies have also demonstrated that effective involvement of local and external stakeholders, and building on local knowledge and experience, can result in win-win outcomes. Using such approaches can enhance rather than undermine local livelihoods and potentially achieve some degree of gender equity.

Hydroelectric-water-food nexus in the Ganges headwaters

As is true for other large rivers, the headwaters of the Ganges River offer tremendous potential for hydroelectric projects. Run-of-the-river hydroelectric projects (Fig. 1) are seen by many policy makers as less environmentally, socially and economically damaging than large reservoir-based hydroelectric projects. However, a detailed study of the impacts of three run-of-the-river hydroelectric projects in the Indian state of Uttarkhand on the Bhilangana tributary to the Ganges River demonstrated that these schemes also have significant, even devastating, local social and environmental impacts. But the study also identified strategies to use hydropower projects to safeguard, and possibly enhance, the livelihoods of women, youth and men and maintain critical ecosystem services (Buechler et al. 2016).

The project team, spearheaded by the People's Science Institute, facilitated a series of science–policy dialogues with decision makers, hydropower developers, community representatives, non-governmental organizations (NGOs) and allied researchers. In these fora, it was recognized that there are important benefits to run-of-the-river projects; however, there are also trade-offs: multiple stakeholders have divergent interests, and currently there is no effective institutional mechanism to support negotiations aimed at balancing these interests. Powerful urban interests prevail and reap most of the benefits. Local water-dependent livelihoods differentiated by gender include farming, fishing, livestock rearing and fodder collection. Construction of the infrastructure and expropriation of river water means rural villagers are often the losers. This has led to widespread protests and demands for more transparent and equitable compensation and benefit sharing. Since women are the primary farmers in this area, due to high rates of male and youth out-migration to cities, concerted initiatives are needed to include their concerns and ensure their participation as leaders.

The study found that there were mixed opinions regarding hydroelectric projects by various social groups in rural Uttarakhand; all, however, insisted on the importance of local control over power generation and water allocations, including decisions regarding irrigation and benefit sharing. The study concludes by advocating participatory governance and establishing clear legally enforceable guidelines and mechanisms for benefit sharing, pointing to the example of Nepal, which does mandate sharing benefits with the local communities (Box 1; Buechler et al. 2016; WLE 2017b).

FIG. 1. RUN-OF-THE-RIVER HYDROELECTRIC SCHEME

Source: Arica Beth Crootof, University of Arizona PhD student

BOX 1. THE HYDROPOWER-WATER-FOOD SECURITY NEXUS: THE ANDHIKHOLA CASE FROM NEPAL

The run-of-the-river Andhikhola Hydropower Project (AHP) is a multipurpose hydroelectric and irrigation project in western Nepal. It was designed to minimize trade-offs by providing electricity to local residents as the first priority, selling surplus electricity to the national grid and supplying water for a new irrigation scheme. Local benefits include a share of the profits that can be used to fund local development needs. AHP began operations in 1991 and was recently modernized and upgraded. It is managed by the Bhutwal Power Company (BPC) under the aegis of the United Mission to Nepal (UMN). Since 1995, the irrigation scheme has been operated by the local water users' association, which negotiated a formal water-sharing agreement with BPC. UMN had assisted the water users' association to allocate land and water rights equitably; the association is supported financially by both the users and BPC. Focus group discussions with local residents confirmed that the project has brought transformative benefits: farmers can now grow three major crops annually and, using a road constructed by the project, sell their produce in a nearby market town. This hydropower-water nexus case indicates how a nexus approach can result in benefits and reasonable trade-offs among water, energy and food. Well-designed multi-purpose run-of-the-river projects that focus on local benefits, like AHP, and explicitly account for farmer-managed irrigation, could be the best option for water, energy and food security.

Sources: Scott et al. 2016; Thapa et al. 2016.

Cross-sectoral negotiations on upper catchment development in the Mekong watershed

A recently completed WLE project, led by the Mekong Region Futures Institute, has demonstrated that intersectoral coordination framed by the water-energy-food nexus, combined with systems thinking, can lead to unexpected positive results. This project was being implemented in the Nam Xong catchment, a Mekong tributary in Lao PDR. The researchers gathered data from over 1,000 households on how they thought various development paths would affect their lives. They then used a simulation model to estimate the effects of various development scenarios in the Nam Xong region. The model links biophysical and socioeconomic dynamics, and considers spatial impacts, such as livelihood adaptations, deforestation, hydrological flows, water quality and human migration (Smajgl et al. 2016).

The results were shared with government decision makers from various sectors and levels. Contrary to the widely held assumption that expanding mining in the upper catchments would bring prosperity, the study showed that mines would contribute little to the local economy and could even generate less local income than current land and other resources do. Downstream, flood peaks would likely increase and generate more out-migration. Two issues emerged as being key to understanding development trade-offs: migration as well as the links between livelihoods and ecosystem services. These potential results of mining expansion were acknowledged by the participants, who proposed to place greater controls on the approval and monitoring of mining ventures and to develop strategies for improving land use planning processes and their enforcement.

Project data also showed that current tourism levels are having a negative effect on river health, oxygen levels specifically, due to untreated water, sewage and other waste from hotels and resorts. Given these and other findings, the participants resolved to develop actions that could regulate developments in not only mining, but also tourism and agriculture and thus protect the future of the communities in the area (Lao News Agency 2016).

This WLE project is thus facilitating a participatory process to coordinate development investments framed by the water-food-energy nexus and has laid a robust foundation for decisions that address gender-specific livelihood, ecological and economic trade-offs arising from proposed water and land development investments.

Participatory methodologies and tools to enhance water-related ecosystem services

The Nam Xong catchment project is an example of the use of participatory methodologies to bridge science and policy, and bridge gaps between competing sectors (Smajgl and Ward 2013). Two other WLE projects demonstrate the potential for combining formal science with citizen science following a participatory approach.

Inclusive development paths for healthy Red River landscapes based on ecosystem services

In the Red River Basin, another WLE project, led by Delft University of Technology, is demonstrating an approach to monitoring ecosystem services that combines the use of remote sensing, citizen science and on-the-ground observation (Figs. 2 and 3) (WLE 2017a). The project has been working for two years with decision makers, researchers and communities in the Red River Basin to increase the understanding of water resources and the threats they face, and to devise practical and sustainable ways of safeguarding ecosystem services. The partners include Vietnamese research institutions, universities, an NGO and government departments, supported by international expertise. Polluted waterways, lack of water for households and industry, flooding and saline intrusion are some of the issues addressed by the project.

Working with local communities, the project has helped identify a range of scenarios for future socioeconomic development at local level, and modeled how these scenarios would affect water resources, and how to preserve water resources and the services they provide. For example, the project worked with the residents of three villages to develop scenarios to address the impacts of industrial wastes flowing through their land, saltwater intrusion, periodic flooding and lack of electricity.

Researchers worked with community members to devise scenarios to improve flood protection and increase both water and electricity supply, while governing flows from upstream and downstream. The costs and associated risks of these scenarios were presented and discussed until the villagers selected a development path they agreed was feasible. Efforts to implement this course of action are currently being undertaken by the community, with government assistance.

Reviving springs in the mid-hills of Nepal

Springs are the main source of water for millions of people in the mid-hills of the Hindu Kush Himalayas (HKH). Both rural and urban communities depend on springs to meet their drinking, domestic and agricultural water needs. But springs are drying up, or their discharge is reducing, throughout the HKH, creating serious water stress. The exact extent and hydrogeology of this problem is not well understood. Springs are also part of complex socio-technical and informal governance systems with pronounced gender and equity dimensions. These systems are also not well understood, leading to inappropriate policies and interventions. Climate change and changes in land use and vegetation are widely implicated for drying of springs, but there is little systematic knowledge to effectively link climate change, vegetation change and spring discharge.

An innovative WLE project has developed and pilot-tested an eight-step participatory integrated methodology for reviving springs and for better management of springsheds (Fig. 4). The methodology combines advanced hydrology methods with community engagement – including citizen scientists, referred to as 'barefoot hydrologists' (Shrestha et al. 2016).[1]

Using this methodology, specific interventions such as spring recharge are designed and implemented.

FIG 2. CITIZEN-SCIENCE: MONITORING WATER WITH A SMART PHONE

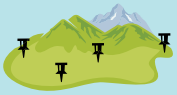
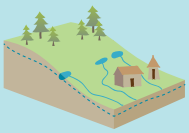
Source: WLE Greater Mekong

FIG 3. TESTING A GAME THAT GIVES QUALITATIVE VALUES OF ECOSYSTEM SERVICES WITH PEOPLE IN HANOI

Source: WLE Greater Mekong

[1] Maheshwari et al. (2014) report on a similar community-based approach using citizen science to recharge a groundwater aquifer in Rajasthan and Gujarat, India.

FIG 4: EIGHT-STEP METHOD FOR REVIVING SPRINGS AND FOR BETTER MANAGEMENT OF SPRINGSHEDS

STEPS	SUB-STEPS	LEADS TO	
I Comprehensive mapping of springs and springsheds	1.1: Collect background information of identified area 1.2: Reconnaissance survey 1.3: Map springs and collect data 1.4: Delineate springshed area	 Delineation of water tower	 Comprehensive map of springs
II Setting up a data monitoring system	2.1: Data collection (why, who, where, what, how) 2.2: Data storage and management 2.3: Data analysis (software development, app development) – Hydrograph/basic software 2.4: Share data with community	 Setting up of rain gauge station	 Hydrometeorological data in Excel
III Understanding social and governance aspects	3.1: Analyze existing institutions and systems of management using: questionnaire survey, focus group discussions, key informant interviews, and communication and dialogue with community and public policy makers	 Management of spring by the local community	 Questionnaire survey tool
IV Hydrogeological mapping	4.1: Obtain geological map of the area 4.2: Observe geology during transect walk: latitude, longitude, elevation, spring location, geological observations and measurements 4.3: Create a base map using Google Earth/Toposheet	 Excel format of hydrogeological data	 Google-based base map
V Creating a conceptual hydrogeological layout of springshed	5.1: Create a hydrogeological map based on the transect walk 5.2: Draft cross-sectional layout	 Geological map of spring and springshed	 Cross-sectional layout
VI Classifying spring types, identify mountain aquifer and recharge areas	6.1: Identify spring and aquifer types 6.2: Delineate recharge area	 Example of spring types	 Outline of recharge area
VII Developing springshed management protocols	7.1: Hydrogeological inventory for springsheds 7.2: Negotiable and non-negotiable land use and land cover change 7.3: Institutional mechanism 7.4: Conservation and intervention, measures of recharge and discharge area 7.5: Develop operational and maintenance guidelines	 Revival activities using voluntary labor	 Recharge structures
VIII Measuring the impact of spring revival	8.1: Impact study 8.2: Continuous monitoring	 Before	 After

Source: Shrestha et al. 2016

The final step is measuring the hydrological and social impacts of the interventions. Capacity development was a significant component of the project. A training-of-trainers module was developed and run during the project's early stages. Training barefoot hydrologists—citizen scientists—in two districts not only exposed community volunteers to the skills of mapping and measurement, but also catalyzed dialogues with the community, knowledge sharing and decisions on implementation of recharge measures. Finally, the eight-step methodology was shared with institutional partners through a training workshop on spring water management.

The study found there are no formal institutions to govern the use of spring water. Communities depend on informal rules and norms, for example first come–first served, and only those who contribute to spring cleaning can collect water. However, with growing scarcity these rules are no longer effective: a stronger legitimate local authority is needed to collectively restore the spring.

The institution leading this project, the International Centre for Integrated Mountain Development (ICIMOD), and its partners are expanding the use of the methodology. There are an estimated four to five million springs in the entire HKH region. An average of 10 to 100 households depend on each spring. Mapping, understanding and reviving them could have a tremendous impact on the livelihoods of the people in the mid-hills. This tool is applicable in a wide variety of settings beyond the HKH region.

Regional trade in staples can support food security and ecosystem services

The potential for trade policies to affect the sustainability of ecosystem services is a neglected topic. An innovative WLE project, headed by Kilimo Trust, addressed this gap in the East African Community (EAC), whose members are in the upper watersheds of the Nile. The project investigated how policies, investments and practices in the EAC countries can prioritize trade-based approaches to achieve (i) resilient food and nutrition security; (ii) sustained provision of ecosystem services; and (iii) equitable access to ecosystem benefits.

The project mapped selected agroecologies based on their suitability for cultivating three staple crops (maize, beans and rice), and estimated the mismatch between the mapped suitability and actual use for production of these crops. A high level of mismatch was found, which is a result of cultural preferences, national policies and weaknesses in regional trade. The study concluded that more sustainable, productive and profitable agriculture and other ecosystem services can be achieved through the effective use of agroecological comparative advantages; but achieving this would require major changes in national and regional trade policies (WLE 2016).

The study also recommended assigning a monetary value to the full range of ecosystem services in national and regional policies, for example, by using taxes to provide incentives for ecologically desirable products; adopting policies to promote the participation of women and youth in trade; and emphasizing measures to support equitable access to land and other productive resources. These measures would boost profitability for cultivators while reducing costs of food for consumers, improve regional food security, enhance gender equity and contribute to long-term sustainability of natural resources (WLE 2016).

CONCLUSIONS

Large-scale investments in upper watersheds, such as hydroelectric dams and mines, are nearly always made without fully considering the impacts on local communities and ecosystem services. Even run-of-the-river hydroelectric projects can have significant, negative local impacts. The total cost of such disruptions to local ecosystem services and livelihoods may even exceed the value of the downstream benefits.

A major insight emerging from these studies is the critical importance of examining upper watershed investments from integrated ecosystem services and inter-sectoral perspectives, such as the water-energy-food security nexus. A second major insight is that effectively involving local communities from the beginning in planning such projects, and designing them to prioritize benefiting local communities over downstream interests, is not only feasible but likely to lead to greater benefits overall, and will reduce protests and resistance that can delay investments and raise their costs.

Attempts to mobilize and involve communities in development projects often run up against the weakness of local institutions, the inherent inequities

built into local institutional arrangements, and a high degree of skepticism regarding advice from outsiders. These issues emerged in the work on reviving springs in the mid-hills of the Himalayas; the studies of run-of-the-river hydroelectric projects; and the study of potential impacts of mining, rubber plantations and tourism in upper watersheds of the Mekong River. Unfortunately, there is no easy panacea to address these problems. However, the projects demonstrated that facilitating collaboration among communities, local NGOs, research institutions and government agencies can make a large difference. Providing training to local community members in basic science and on how to measure and monitor resources such as water flows can help overcome skepticism and empower communities to take more responsibility for managing local resources.

Another important insight is the potentially critical role of policies regarding regional trade and marketing. The project implemented in the EAC countries demonstrated the connections between sustainable intensification of agriculture, other ecosystem services, food security and trade. We recommend adoption of a policy reform package to leverage trade policies to achieve two goals: (1) encourage profitable and sustainable intensification of agriculture; and (2) promote more equitable access to land and trade opportunities for women and youth.

The studies described here demonstrate that escaping from the confines of narrow sectoral investments—thinking out of the box; using systems analytical approaches; combining advanced modern science with citizen science; following an integrated ecosystems approach; and encouraging local communities' active participation—can lead to more sustainable, profitable and equitable use of upper watershed landscapes.

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RESEARCH PROGRAM ON
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About the Towards Sustainable Intensification: Insights and Solutions Briefs

WLE's series of Towards Sustainable Intensification: Insights and Solutions Briefs synthesizes the research findings and solutions generated during the program's first phase, which was composed of more than 140 projects across 48 countries in Africa, Asia and Latin America. Each brief is focused on a topic of strategic relevance to sustainable intensification of agriculture and provides analysis of and recommendations on how to place sustainability at the heart of agri-food systems. The series aims to guide and support decision and policy makers, investors, and others working to achieve poverty alleviation and livelihood improvements through sustainable intensification of agriculture.

CGIAR Research Program on Water, Land and Ecosystems

The CGIAR Research Program on Water, Land and Ecosystems (WLE) combines the resources of 11 CGIAR centers, the Food and Agriculture Organization of the United Nations (FAO), the RUAF Foundation, and numerous national, regional and international partners to provide an integrated approach to natural resource management research. WLE promotes a new approach to sustainable intensification in which a healthy functioning ecosystem is seen as a prerequisite to agricultural development, resilience of food systems and human well-being. This program is led by the International Water Management Institute (IWMI) and is supported by CGIAR, a global research partnership for a food-secure future.

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