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TOWARDS SUSTAINABLE INTENSIFICATION: INSIGHTS AND SOLUTIONS BRIEF NO. 4

ENABLING SUSTAINABLE, PRODUCTIVE SMALLHOLDER FARMING SYSTEMS THROUGH IMPROVED LAND AND WATER MANAGEMENT

August 2017

IN PARTNERSHIP WITH:

Acknowledgments

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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 Ecosystem (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.

DEFINITIONS

Agricultural land and water management (ALWM) – ALWM practices encompass soil, land and water technologies and management interventions from field to landscape scale. Their aim is to variously reduce soil erosion and landslides, improve soil and water health, strengthen soil fertility and crop yield, and recharge groundwater (WLE 2016; Selassie and Amede 2014).

ALWM technologies include (but are not limited to):

- Systems to enhance infiltration of water, e.g., soil bunds, stone bunds and water catchment pits (Mekuria et al. 2015; Selassie and Amede 2014).
- Systems to stabilize land and reduce erosion and gully formation, such as vegetation cover, tree planting, vegetated waterways, drainage ditches, minimum tilling, contour ploughing and bench terraces (Mekuria et al. 2015; Adimassu et al. 2015).
- Irrigation, e.g., lift irrigation, storage and distribution technologies.
- Promotion of soil heath and prevention of nutrient depletion through application of organic matter in the form of manure or compost, exclosures and other livestock management, intercropping and crop rotation (Adimassu et al. 2015).

Integrated watershed management – is the integration of technologies within the natural boundaries of a drainage area for sustainable development of land, water and plant resources to meet the needs of people and animals. The aim is to improve the livelihoods of communities by increasing their earning capacity through optimal production. It involves controlling floods as well as reducing erosion and sediment accumulation (Pathak et al. 2002). Specific land and water conservation practices include water harvesting in ponds, recharging of groundwater, crop diversification (through improved seeds varieties), and integrated nutrient and pest management practices (Wani and Garg 2009).

Agricultural innovation platforms – are fora established to "foster interaction among a group of relevant stakeholders around a shared agricultural interest." Innovation platforms seek to harness innovations related to technology processes or institutional and social-organizational arrangements as well as to promote them through partnerships with diverse actors (Pittock et al. 2017).

SUMMARY

Farmer-led investments in agricultural land and water management (ALWM) are transforming livelihoods and food security across South Asia and sub-Saharan Africa. Potential exists for even greater benefits, for even more beneficiaries. Understanding what factors influence adoption and impact of ALWM interventions can help ensure sustainable, positive effects of future investments. WLE has designed a suite of tools and investment models to support policy makers and development agents to leverage and extend the investments farmers are already making.

Recommendations

- Understand what drives farmers' decision making, management practices and their impacts on the landscape: The use of participatory tools can shed light on decision-making processes, preferences, trade-offs and the factors that influence adoption and change.
- Facilitate equitable access to ALWM technologies: Improve access to credit, information and irrigation services to enable more informed and productive investment, management and marketing choices by smallholder farmers.
- Create policy synergies across sectors: Facilitate cross-sector innovation (e.g., between agriculture and rural energy) to broaden the solution space for enhancing smallholder productivity and livelihood benefits, while minimizing potential environmental externalities.
- Promote investments in water and energy recovery and reuse: A significant development opportunity in the rural-urban interface exists to safely convert human waste into a resource that simultaneously benefits farmers, improves sanitation and generating new business opportunities.
- Invest in a watershed perspective: Successfully scaling up the benefits and effectively managing the risks posed by ALWM requires planning at a watershed scale and across sectors.

INTRODUCTION

Of the 2.5 billion people who depend directly on the food and agricultural sector for their livelihoods, 1.5 billion live in smallholder households (FAO 2012, 2013). These households manage nearly 500 million farms and contribute an appreciable share of agricultural production and food calories in Asia and sub-Saharan Africa (Lowder et al. 2016; Samberg et al. 2016). Appropriate investments in ALWM generate substantial benefits for smallholders, including increased and stabilized farm incomes as well as improved land and labor productivity. They can also provide important additional benefits such as off-farm rural and urban employment, enhanced nutrition and greater resilience to seasonal and climate shocks (Theis et al. 2016; Pittock et al. 2017).

However, a number of constraints hamper the potential of ALWM investments, including low adoption or subsequent abandonment of interventions, failure to target and engage key segments of rural communities such as women and poorer farmers, and inadequate consideration of aggregated impacts. Research to understand the factors that affect farmers' decision making can support the design of context-appropriate ALWM investments that strengthen smallholder farming's contribution to poverty alleviation and food security.

Enhancing smallholder productivity

The positive livelihood and food security impacts from ALWM investments are well documented. For example, in Ethiopia, earthen embankments to enhance infiltration of rainwater have doubled sorghum yields (Binyam and Desale 2015). In southern Niger, farmer-managed natural land regeneration—using improved, local agroforestry practices on nearly 5 million ha of land—has increased cereal production and improved the livelihoods of an estimated 2.5 million people (Reji et al. 2009). Farm ponds in Madhya Pradesh, India, have allowed farmers to produce more staple crops, extend the cropping area, increase dry-season cropping, diversify activities and increase incomes by as much as 70% (Malik et al. 2014). And long-term studies on integrated watershed management programs in dryland areas of India document multiple, positive livelihood and environmental benefits (e.g., Wani et al. 2008; Singh et al. 2014; Karlberg et al. 2015).

In both rural and urban areas, smallholder farmers themselves are increasingly initiating and financing small-scale ALWM technologies and practices (Woodhouse et al. 2017; de Fraiture and Giordano

2014). Surveys carried out in Ghana, Ethiopia and Zambia, for example, found that more than 80% of all owners of small-scale irrigation equipment used their own or their family's savings for the investment, and in many countries small private irrigation is already more important than public irrigation schemes in terms of land area, number of people served and income (Fig. 1) (Giordano et al. 2012; Namara et al. 2014).

Significant potential exists for further growth in smallholder agricultural productivity: targeted investments and associated policy interventions could double or even triple rainfed crop yields in sub-Saharan Africa and South Asia, while generating additional net household revenues for millions of people (Table 1) (Giordano et al. 2012).

However, achieving this potential requires more than just changes in agricultural production; it requires a better understanding of the complex constraints faced by smallholder farmers as well as the opportunities for integrated solutions. Solutions that cut across sectors and scales and support existing farmer-led initiatives have potential to achieve more equitable, productive and sustainable smallholder farming systems.

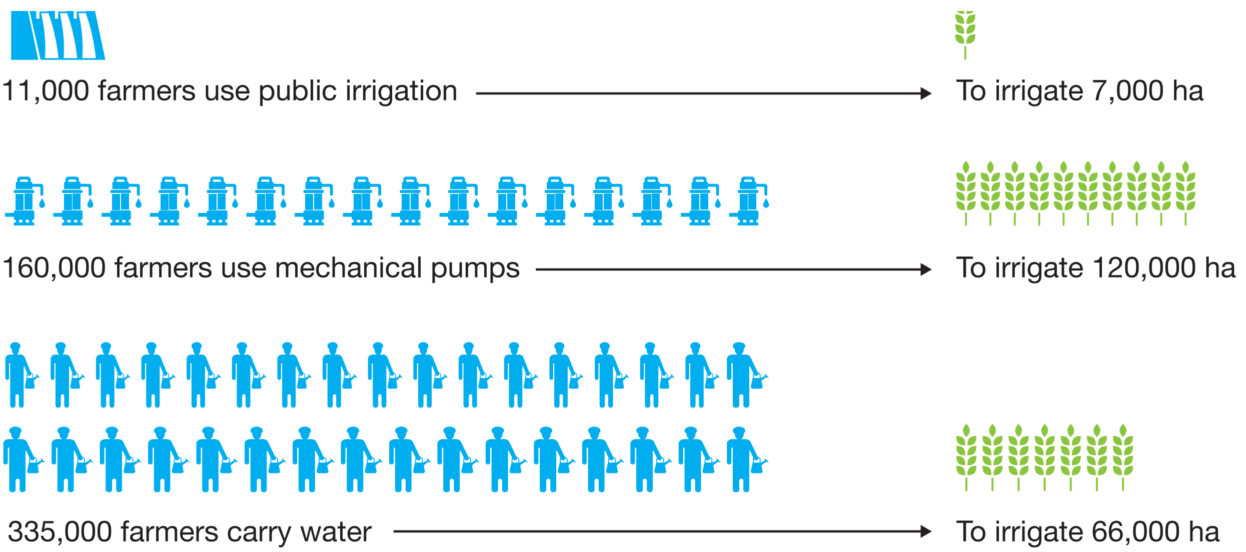
The complex challenges faced by smallholder farmers

Smallholder farming systems are influenced by an array of ecological, social, economic and political factors specific to the context in which they operate. Yet, research on improving smallholder ALWM has tended to focus on technical solutions for increasing agricultural productivity. This rather narrow view overlooks the range of factors that shape farmers' perceptions, choices, constraints and decision making as well as the broader impacts on the landscape and supporting ecosystem services (Cordingley et al. 2015; Adimassu et al. 2015; Snyder et al. 2017; Bjornlund et al. 2017).

Many technologies remain out of reach of smallholder farmers. Women and resource-poor farmers are particularly disadvantaged and face serious challenges in accessing affordable ALWM technologies. Challenges include high up-front investment costs, absence of proper financing tools and limited access to information that would enable them to make informed investment, management and marketing choices. Women are underrepresented in the use and ownership of small-scale irrigation equipment. Research in Ghana and Zambia suggests that men are more likely to own motorized pumps, and in general pump owners have a significantly higher wealth status (Namara et al. 2013).

Market inefficiencies often prevent farmers from accessing beneficial technologies and optimizing their land and water management. These inefficiencies include poorly developed supply chains; high taxes and transaction costs; and lack of information and knowledge on irrigation, seeds, marketing and equipment. Farmers are disadvantaged particularly by their lack of up-to-date market knowledge, which undermines their negotiating position and enables traders and brokers to take advantage of them (Giordano and de Fraiture 2014; Bjornlund et al. 2017).

FIG. 1: FARMERS' RELIANCE ON DIFFERENT TYPES OF IRRIGATION IN GHANA



Source: Adapted from Giordano et al. 2012.

TABLE 1: POTENTIAL BENEFITS FROM INVESTMENTS IN THREE TYPES OF AWLM

SOLUTION	SUB-SAHARAN AFRICA		SOUTH ASIA	
	People reached (Million)	Net increase household income (USD billions/yr)	People reached (Million)	Net increase household income (USD billions/yr)
Motor pumps	185	22	40	4
Rainwater harvesting	147	9	205	6
Small reservoirs	369	20	N/A	N/A

Source: Giordano et al. 2012

Finally, the uncontrolled and unregulated spread of ALWM technologies can have undesirable social and environmental consequences. If not managed and governed within the context of the wider landscape and other water users' needs, accelerated investments in smallholder ALWM could further degrade water and soil quality as well as create conflicts over shared natural resources (de Fraiture et al. 2014; Dessalegn and Merrey 2014; Van et al. 2016).

The need for integrated ALWM investment approaches

Research clearly indicates that many diverse factors influence local water and land management decisions. Consequently, narrowly defined ALWM interventions, made without consideration for the environmental and social context, will likely neither solve important, complementary issues for farmers nor address cross-scale, inter-sectoral, synergies and trade-offs (Snyder et al. 2017; Cummings et al. 2014).

Secured land tenure, for example, may incentivize farmers to make long-term investments in land and water management. However, research on land policies in Ethiopia and Ghana suggests that on their own, policies to strengthen land ownership or use rights may not be enough. Efforts are also needed to improve legal literacy about the accompanying rights, including the use of land as collateral for credit. Further, a singular focus on improving land rights may risk marginalizing other locally identified needs for productive farming systems, such as access to water resources, financial services and off-farm marketing opportunities (Quisumbing and Kumar 2014; Yami and Snyder 2015; Dittoh et al. 2015; Kumwenda et al. 2015; Bjornlund et al. 2017).

Rapid urbanization creates important cross-scale linkages and challenges. Nearly 456 million ha—an area about the size of the European Union—is under cultivation in and around the world's cities (Thebo et al. 2014). Agricultural intensification in close proximity to urban environments provides smallholder farmers with better access to markets and stable demand for produce. However, inadequate waste management compromises the water bodies used by urban and peri-urban farmers and downstream communities and thus the food safety of urban consumers. In Ghana, for example, an estimated 800,000 urban consumers benefit daily from leafy vegetables produced within the city, but these same consumers are also at risk as most of these crops are irrigated with water from polluted sources (Drechsel and Keraita 2014).

Finally, policies outside of the agricultural realm can also influence ALWM investment outcomes. Solar-powered irrigation is a classic example that demonstrates the interconnectedness of the water, food and energy sectors. Technological advances in solar pumps coupled with state subsidy programs are causing a major expansion of low-cost tube wells with a lower carbon footprint in India. It is also starting to take hold in sub-Saharan Africa, where solar-powered pumps can serve as a more versatile, off-grid, green alternative to diesel or electric pumps. However, this low-cost, climate-smart intervention may threaten already vulnerable aquifers if not integrated with interventions and incentives that jointly address the related energy, livelihoods and water resource trade-offs (Shah et al. 2016).

Solutions to support improved private and public sector investment

A range of complementary institutional and policy measures that cut across scales and sectors are needed for smallholder ALWM to sustainably achieve its productivity and poverty reduction potential. WLE is contributing tools and business models to support this aim.

Decision-making and engagement tools

Key to long-term, sustainable ALWM investments is an increased understanding of what drives farmers' choices with due consideration of gender-based differences in preference, responsibilities and access to land and water resources. WLE has developed several participatory tools that can shed light on such decision-making processes and the factors that influence adoption and change.

- The Evaluating Land Management Options (ELMO) tool uses participatory techniques to investigate the factors that influence farmers' uptake (or rejection) of sustainable land management options, supplementing conventional biophysical and socioeconomic research. It elicits explanations of the advantages, disadvantages and trade-offs associated with different land management choices as they relate to farmers' needs, aspirations, opportunities and constraints (Emerton et al. 2015).
- The Gender in Irrigation Learning and Improvement Tool (GILIT) identifies which policies and operational procedures in formal irrigation schemes need adjustment to promote gender equity. The tool can facilitate learning and support equitable standards by collecting feedback and ideas for specific actions to address gender inequities in the management of irrigation schemes (Lefore et al. 2017).
- Experimental games, otherwise known as framed field experiments, can serve to gain insights into farmers' decisions regarding resource management and as a means to strengthen cooperation on shared resources. Through a variety of applications in South Asia, Southeast Asia and Central America, experimental games have played a triple role in a) raising farmers' awareness of how their decisions influence the quantity and quality of common resources (e.g., groundwater), b) encouraging discussion and building of community-based institutions, and c) providing researchers and implementers with insights into the factors that affect farmers' choices (Meinzen-Dick et al. 2014, 2016, 2017).
- **Agricultural innovation platforms (AIPs)** provide an opportunity to engage the diversity of actors in irrigation schemes for learning, capacity development and experimentation (e.g., with crops, marketing, watering regimes). Small-scale irrigation schemes are highly complex systems and improving their efficiency (economically, socially and resource-wise) requires supportive institutional arrangements, a clear vision shared by all actors and careful attention to the incentives for change. WLE-supported research has found that AIPs can facilitate more cohesive networks, where the dynamics and feedbacks across actors, systems and processes lead to learning and adaptation, improved system efficiency and greater returns on investments (Pittock et al. 2017; Stirzaker et al. 2017; van Rooyen et al. 2017).

Investment pathways and business models

WLE is designing a suite of investment models for ALWM that policy makers and development agents may use to facilitate investments in support of smallholder farmers and the complex landscapes in which they operate.

- **Increasing equitable access to ALWM technologies:** In parts of India and increasingly in sub-Saharan Africa smallholders who cannot afford to purchase their own pump can rent one by the day or for a season. Building on this concept of pump rental markets, WLE researchers created a business model to support the development of irrigation service providers. In this model, an entrepreneur travels from farm to farm with small motor pumps to irrigate land for a fixed fee per hour. WLE is currently seeking opportunities to further pilot and sustainably scale up this business model (de Fraiture and Clayton 2012).
- **Turning waste into a valuable resource and mitigating risks:** Globally, tens of millions of households rely on wastewater irrigation to grow crops. An enormous development opportunity in the rural-urban interface exists to safely convert human waste into a resource that benefits farmers, improves sanitation and generates new business opportunities. WLE has developed and tested resource recovery and reuse business models to support entrepreneurs entering the reuse market, highlighting common barriers and opportunities (Otoo and Drechsel 2017). These business models have formed the basis for four new public-private partnerships in Ghana, with several more in different stages of review and development in other parts of Africa, Asia and Latin America.
- **Creating policy synergies for smart solar pump solutions:** Solar pump technology can be an excellent tool for expanding poor smallholder farmers' access to irrigation. However, without proper incentives, the proliferation of low-cost solar pumps could result in overuse of groundwater resources. To maximize the productivity and livelihood benefits, while minimizing potential environmental externalities, WLE is developing a set of business models tailored to different groundwater

and energy contexts. In Gujarat, India, WLE scientists and partners are piloting the first-ever solar irrigation cooperative, which enables farmers to sell excess solar power to the utility grid, thereby supplementing farmer income while incentivizing farmers to conserve groundwater resources (Shah et al. 2016). In Ethiopia, where only 14% of the population are connected to the electricity grid (World Bank 2012), WLE researchers have developed a solar irrigation business model, and supporting suitability maps, to target smallholder farmers living in remote rural areas without access to electricity (Otoo et al. Forthcoming) (Fig. 2). A WLE study of alternative business models for solar-powered irrigation pumps in the plains of Nepal has also shown high demand and promising results (Mukherji et al. 2016).

- **Taking ALWM solutions to scale:** Successfully scaling up the benefits and effectively managing the risks posed by ALWM requires planning at a watershed scale and across sectors. The watershed perspective aids to balance trade-offs and issues of environmental sustainability. WLE and its partners are adapting the lessons from decades of research in India on integrated on watershed management to apply in other Asian countries and in sub-Saharan Africa. In the Yewol watershed in Amhara Regional State, Ethiopia, researchers have worked to strengthen local capacity, facilitated collective action, introduced system compatible technologies and used research to identify niches for integration of technologies at farm and landscape scales. The results of these efforts include improved productivity, crop diversification and downstream water availability, which are benefiting some 15,000 people (CGIAR-IEA 2016). Remote-sensing tools are being used prioritize and implement watershed interventions in other locations. Where technologies and financial resources are limited, the tools allow development planners to identify watersheds in high priority zones where relevant socioeconomic and agro-ecological conditions suggest that ALWM interventions could support sustainable development and livelihoods (Gumma et al. 2016).

CONCLUSIONS

Investments in smallholder ALWM are transforming food security and livelihoods in Asia and Africa. The scale of current investments by smallholders is astonishing, and the potential in terms of benefits and beneficiaries is even greater. However, the full potential will not be reached without improved understanding of both the constraints farmers face and the factors that influence their decision making. Understanding and exploring opportunities for integrated solutions, which cut across sectors and scales, and supporting existing farmer-led initiatives will have the potential to support more equitable, productive and sustainable smallholder farming systems.

WLE is contributing ALWM decision-making tools, solutions and implementation strategies to better understand and support improved public and private investment. WLE is also developing and piloting a range of business models to specifically address many of the principle factors that limit ALWM uptake and sustained utilization, including cost, market distortions, unintended consequences, complex multi-sectoral issues and social and institutional contexts. Finally, by adopting a watershed perspective, WLE's approaches and solutions consider how ALWM practices interact at the landscape scale, critical to sustainably scaling up the food security and livelihood benefits of improved ALWM.

FIG. 2: SOLAR IRRIGATION IN AFRICA

Source: Jeffery M. Walcott/IWMI

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