IWMI Research Report

161

Is 'Social Cooperation' for Traditional Irrigation, while 'Technology' is for Motor Pump Irrigation?

Mengistu Dessalegn and Douglas J. Merrey

International Water Management Institute

CGIAR

Research Program on Water, Land and Ecosystems

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Dessalegn, M.; Merrey, D. J. 2014. *Is 'Social Cooperation' for traditional irrigation, while 'Technology' is for motor pump irrigation?*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 37p. (IWMI Research Report 161). doi: 10.5337/2015.201

/ social aspects / cooperation / traditional farming / small scale farming / irrigation schemes / irrigation methods / agriculture / technology / pumps / rural areas / poverty / productivity / groundwater / water resources / farmers / rivers / case studies / Asia / Africa / Ethiopia /

ISSN 1026-0862
ISBN 978-92-9090-811-1

Front cover photograph shows irrigated production of onions in Fogera, Ethiopia (*Photo*: Mengistu Dessalegn).

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Acknowledgements

The authors are grateful to the anonymous internal reviewer and especially the external reviewer whose comments helped to improve the content of this paper. The support provided by Madar Samad (Acting Theme Leader – Water Futures, IWMI) is greatly appreciated, and the authors would like to thank him for his patience and support as they worked on several revisions of this paper. The authors extend their thanks to Yenenesh Abebe (GIS expert) for her support in map preparation. Despite all the assistance provided, the authors remain responsible for the content of this paper.

Project

CGIAR Challenge Program on WATER & FOOD
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This research was initiated under the project 'NL2: On integrated rainwater management strategies – technologies, institutions and policies' – a part of the Nile Basin Development Challenge (NBDC)/ CGIAR Challenge Program on Water and Food (CPWF), a partner of, and funded by, the CGIAR Research Program on Water, Land and Ecosystems (WLE).

Donors

Funding for the research carried out in this report was provided by the following organizations, among others, through the CGIAR Challenge Program on Water and Food (CPWF).

UKaid from the British people — UK Department for International Development (DFID)

European Commission

IFAD Enabling poor rural people to overcome poverty — International Fund for Agricultural Development (IFAD)

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Agency for Development and Cooperation SDC — Swiss Agency for Development and Cooperation (SDC)

The views expressed herein do not necessarily reflect the official opinion of DFID, European Commission, IFAD and SDC.

This work has been undertaken as part of the CGIAR Research Program on Water, Land and Ecosystems (WLE). IWMI is a member of the CGIAR Consortium and leads this program.

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Summary

The widespread use of motorized pumps has revolutionized irrigated agriculture in many parts of Asia by increasing productivity and reducing rural poverty. A similar pump revolution has begun more recently in sub-Saharan Africa. To date, the focus of both policy and research in Africa has been on facilitating supply chains to make pumps available at a reasonable price. In Asia, there is rising concern that mining of groundwater is threatening the continued viability of pump-based irrigation. This has led to policy changes in some places. In Africa, pump irrigation is mainly based on two sources: (a) shallow groundwater aquifers, and (b) small streams and rivers. Both these sources usually have limited and variable water yields. We present a case study from Ethiopia where pump irrigation based on small rivers and streams is expanding rapidly. We show that, while farmers understand the social nature of community-managed irrigation, they share with policymakers a narrow understanding of pump irrigation as being primarily 'technical'. They perceive pumps as liberating them from the 'social' limitations of traditional communal irrigation. However, the rapid expansion of pump irrigation is leading to increasing competition and conflict over limited water resources. This report analyzes the wider implications for Africa of this blindness to the social dimension of pump irrigation, and offers suggestions for future policy and applied research to address the problem before it becomes a widespread crisis.

Is 'Social Cooperation' for Traditional Irrigation, while 'Technology' is for Motor Pump Irrigation?

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Introduction

Governments and their development partners have been investing in community-managed small-scale irrigation for decades. These investments usually involve either rehabilitating existing farmer-managed irrigation schemes or supporting the construction of new schemes, which farmers are expected to manage after completion. In the early years, these investments were largely in the construction of infrastructure, with little attention being given to ensuring that the institutional capacity will be in place to manage the irrigation schemes. However, governments and their partners learned a critical lesson that informs most such investments today: the social and institutional context and framework, including resource governance, are no less important than the hardware or infrastructure, if the scheme is going to be productive, profitable and sustainable.

In the past few decades, an 'irrigation revolution' has led to large numbers of farmers investing in small motorized pumps in Asia and, more recently, in Africa. There are no reliable figures, but the scale of this change is millions of farmers in each of the large Asian countries, and many thousands (even hundreds of thousands) in some African countries, as summarized by de Fraiture and Giordano (2014). These pumps have enabled smallholders to diversify their farming systems, mitigate the impacts of rainfall variability, and grow high-value crops for urban and international markets. The benefits have contributed to a 'snowball' effect – neighboring farmers see the potential and also invest in pumps. Pump irrigation now dominates the irrigation scene in South Asia and North China, accounting for over 60% of irrigation in South Asia, for example (Mukherji et al. 2009). It also constitutes the fastest growing irrigation sector in sub-Saharan Africa (SSA) (Burney and Naylor 2012; Giordano and de Fraiture 2014). However, the social and institutional context and framework for governing pump irrigation has been largely ignored, especially in SSA. This is leading to growing competition for scarce water supplies, conflicts among farmers, and mining of small rivers, streams and aquifers.

While agreeing that this growth in private pump-based irrigation is a welcome development in SSA, we argue that sustainable private pump-based irrigated agriculture requires no less social cooperation and collective action than community-managed irrigation. However, the kind of cooperation required for pump irrigation is more complex and less amenable to direct government support. The necessity of cooperation – the incentive to cooperate – for the management of community-managed schemes is relatively clear: if farmers fail to work together to maintain their scheme and share water, they will all be harmed as no one will receive water. However, in the case of multiple farmers using their own pumps to extract water from an 'invisible' aquifer or a river, the incentive itself is invisible: each farmer will respond to growing shortages by increasing his or her rate of pumping (or digging deeper, chasing the aquifer), in a vicious cycle reminiscent of the 'tragedy of the commons' paradigm. Yet, such a trajectory may not necessarily be the result of a lack of capacity for collective action. It may occur even in a situation where local people already have effective social cooperation and coordination arrangements for managing shared natural resources, including the use and management of traditional irrigation. This calls for understanding whether there are ways to facilitate local people to build on their social cooperation traditions to manage the negative outcomes (externalities) of the expansion of motor pump irrigation, or whether there are other arrangements that can facilitate sustainable motor pump irrigation.

The skewed technological orientation among most actors regarding the conception, planning, diffusion and implementation of motor pump irrigation exacerbates the problem. In particular, studies and investment programs of policymakers and development agencies increasingly focus on developing the 'value chain' needed for a sustainable and successful pump-based irrigation economy, i.e., provision of low-cost pumps, spare parts, servicing, etc., as well as output markets to profit from pump-based irrigation. There is an emphasis on investments and policies to expand privately owned and managed irrigation, calling on governments, donors and nongovernmental organizations (NGOs) to improve the supply chain of motor pumps to accelerate private irrigation (Burney et al. 2013; Colenbrander and Koppen 2013). There is a tendency to think that pump irrigation based on shallow aquifers or small rivers and streams does not require giving attention to collective action as done in community-managed irrigation schemes. However, this leaves a huge gap that threatens the sustainability of pump irrigation in terms of livelihood benefits as well as the management of limited water resources. There are no systematic data on the potential and limitations of water in the numerous small rivers and streams found in SSA. Studies of the groundwater potential in SSA are at an early stage and broadly demonstrate that there is a large untapped potential, but in most cases the capacities and recharge rates of local aquifers will at some point limit the expansion of irrigation (MacDonald et al. 2012; Villholth 2013).

The use of individually-owned small pumps has grown exponentially in parts of Asia, bringing huge benefits to smallholders as well as consumers but also creating difficult challenges, including aquifer depletion and unsustainable electricity costs, during the past decade. In Africa, the pump revolution is at an earlier stage than in Asia, and in most places is taking place in a different agroecological context: farmers are largely exploiting relatively small rivers, streams and shallow aquifers on small- to medium-sized watersheds. This report uses data from qualitative field research on one such small watershed (Fogera) in Ethiopia, and draws parallels to experiences in other African countries. It examines the roots of the problem, proposes some ideas on how social cooperation and institutional arrangements could contribute to the sustained productive use of these limited water sources, and identifies further research that could contribute to sustainable motor pump-irrigated agriculture and livelihood benefits in Africa.

Methodology

This report is based on qualitative field research in Fogera, a small watershed located in the Blue Nile River Basin in Ethiopia. In terms of administrative structure, Fogera is a *woreda* (district) in the South Gonder zone within the Amhara National Regional State of Ethiopia. The study involved field research that was conducted in successive years in three selected *kebele*s (sub-districts) of Fogera District, namely Alem Ber, Dibasifatira and Kokit, which represent differing landscape features - upland, midland and lowland, respectively, and also constitute interconnected landscape units in terms of the use and management of natural resources. Initial fieldwork was conducted in 2012 under the Nile Basin Development Challenge (NBDC) of the CGIAR Challenge Program on Water and Food (CPWF). NBDC was part of a larger multi-disciplinary research for development program aimed at finding ways to improve the management of rainwater and resilience of rural livelihoods in a landscape framework[1]. Subsequent fieldwork for the investigation of small-scale irrigation was conducted in 2013, and this was followed up with fieldwork for a wider study on livelihoods, landscapes and decision making on land use which was conducted in 2014.

The research employed a combination of qualitative and participatory methods of data collection, including informal and formal interviews, semi-structured interviews, key informant interviews, observations, focus group discussions, participatory problem identification and a participatory mapping exercise. The use of a combination of different techniques facilitated data triangulation and validation. Data collection at the local level was supported by a set of interview guides, the structures of which varied depending on the context. Sources of data included a range of community members such as men, women, youth, elders, development agents and agricultural professionals. Relevant secondary sources and written information were also gathered from agriculture offices in *kebeles* and *woredas*. The study also involved a systematic review and analysis of pertinent literature.

The irrigation situation in Fogera, particularly motor pump irrigation, parallels the experiences of other developing countries where this method of irrigation has been expanding. Thus, while this paper begins with research from a small watershed in Ethiopia, its findings, analysis and arguments have wider global and theoretical implications. They highlight the prevailing focus on the technical and economic aspects of irrigation, disregarding its social aspects. Likewise, the study has wider theoretical and practical implications for the growing private, small-scale irrigation sector in Africa.

The Social Dimensions of Irrigation

Our approach to the social dimensions of motor pump irrigation is based on several related conceptual trends in the analysis of agriculture and natural resource management. First, we view irrigation as a socio-technical system (Mollinga 2003; Veldwisch et al. 2009). This approach emphasizes that the social dimensions of irrigation are as important as the technical dimensions. Social dimensions entail a range of interrelated social factors, including the organization of water use and management as well as issues of participation, equity, conflict resolution, collective action and institutions. The persistent perspective among technically-trained implementing agencies that irrigation is largely an engineering problem underlies the disappointing outcomes of irrigation investments.

However, by itself, this paradigm is too narrow, as it does not adequately address the extent to which irrigated agriculture is embedded in larger agroecological systems. Researchers have come to recognize the importance of engaging with farmers to encourage innovation, and embedding this work in a wider conceptual socioecological framework characterized in the recent literature as "integrated agricultural research for development", "sustainability science" or "integrated landscape initiatives" (e.g., Sayer and Cassman 2013; Sayer et al. 2013; Milder et al. 2014). There is no universally agreed definition of landscape approaches, but most agree that it involves an attempt to approach agricultural intensification in a systems perspective that recognizes that there are multiple interactions and

[1] For more information, visit http://nilebdc.org/ (accessed August 13, 2014).

trade-offs with other uses and users or resources. Sayer et al. (2013) identified ten "principles" of the landscape approach, which include a strong emphasis on participation, continued learning, transparent communication, adaptive management and strengthening stakeholder capacities.

This study focuses primarily on the social dimensions of irrigation, which we approach from an innovation systems and institutional creativity perspective. Not only do institutions play a critical role in enabling people and communities to cope with the problems they face, they also transform this capacity into a more creative and sustainable capacity to adapt to change (Berman et al. 2012). Institutions are defined as "the rules of the game in society" by institutional economists; but it is important to understand that these rules embody values, often deeply and subconsciously held, which are interpreted differently by different people, and are dynamic and contested (Merrey and Cook 2012). Therefore, although institutional arrangements for collective management of shared resources are characterized by a set of "principles" (e.g., Ostrom 1992), this does not mean they are amenable to being applied in the same way as the principles of physics are applied in designing and constructing physical infrastructure: "social engineering" does not work (Merrey et al. 2007).

Therefore, we follow the lead of Francis Cleaver in adopting an approach to institutions which she refers to as "critical institutional thinking" (Cleaver 2012). This approach is difficult to characterize simply, but the basic idea is that humans are motivated by a complex set of perspectives, values and interests, some consciously held but many unconscious, which are derived from their social milieu. Therefore, institutional change and innovation are often the result of a messy, largely unpredictable, iterative, but ultimately creative process involving the engagement of local change agents with the institutions shaping and being shaped by the process. Cleaver refers to this creative process as "institutional bricolage" (Cleaver 2012; Merrey and Cook 2012). The "bricoleur" pieces together institutions in response to changing situations. These institutions are neither completely new nor completely traditional, but rather a dynamic hybrid combining elements of 'modern', 'traditional', and the 'formal' and 'informal" (Cleaver 2012). We return to the implications of this perspective for motor pump irrigation in the conclusions.

Irrigated agriculture has been an important feature of people's livelihood activities for many centuries. In Asia, Africa and the Americas, rural people have long-standing irrigation traditions. Communities having well-established 'irrigation cultures' – irrigation embedded in traditional irrigation societies – continue today. For example, in Bali, Indonesia, traditional irrigation has existed for over a thousand years, and farmers continue to use a complex system of canals managed through associated temple complexes to grow rice (Lansing 1991; Lansing and Kremer 1993; Lansing et al. 2009). Indigenous systems of irrigation also continue to function in other parts of Asia, including Nepal, India, Philippines and Sri Lanka, as well as in the Andes region of Latin America. In the hills of Nepal, farmers collectively manage small and even rather large irrigation systems; most of these systems continue to operate today with little or no government involvement (Sharma et al. 2009; Ostrom et al. 2011). The system of tank irrigation is another form of tradition in southern India and Sri Lanka with a history of nearly two thousand years. Rural people use small reservoirs or "tanks" to irrigate their fields, both for supplementary irrigation of rice during the rainy season and to grow other crops in the dry season (Engberg-Pedersen 2011; Leach 1961).

Such traditional irrigation schemes require effective collective action to construct, reconstruct and maintain canals and weirs, and to deal with resource mobilization, settling disputes and sharing scarce water resources. They employ various social arrangements to facilitate and structure the use and management of irrigation schemes. Ostrom (2008) highlighted that farmers in Asia have long relied on their own knowledge to develop complex irrigation systems, including dams, tunnels and water diversion structures, forging joint responsibilities to provide the resources needed and set rules that are agreed upon for allocating water and enforcing the rules.

Examining the experiences of farmer-managed irrigation schemes in Asia and other developing countries, Ostrom and Gardner (1993) argued that self-governing irrigation systems can work if they have been allowed to self-organize. This observation is supported by many other studies documenting how local communities have long been able to use and manage their natural resources held as commons (e.g., McCay and Acheson 1987; Berkes 1987; Ostrom 1990; Feeny et al. 1990; Wade 1987).

The Green Revolution of the 1960s and 1970s bolstered the importance of irrigation as an essential agricultural input. The Green Revolution involved the intensive use of irrigation combined with improved varieties of seeds and chemical fertilizers. It has been stated that, "the Green Revolution was as much a story of water as it was of modern crop technology" (Burney et al. 2013). Small-scale as well as large irrigation systems have been developed, expanded and "modernized" by governments and donors for decades (Pinstrup-Andersen and Hazell 1985; Borlaug 2000; Roy et al. 2007; Burney et al. 2013).

In the wake of the Green Revolution, orientations that primarily associate agricultural development with technological advancement seem to have been strengthened, providing the impetus for a growing focus on technological solutions – in essence, returning to an older and seemingly discredited perspective. Over a decade ago, Norman Borlaug envisaged a "Blue Revolution," where technology would lead the way toward higher water use productivity (Borlaug 2000). Borlaug stressed that the main concern should be on how farmers would be able to use new and modern technologies. Accordingly, the dissemination and application of modern technologies is seen as a way forward for improving food production.

This emphasis on technological solutions particularly focuses on SSA, which is seen as having failed to benefit from modern irrigation. In recent years, new initiatives are responding to that vision. This particularly refers to initiatives that call for a "uniquely African Green Revolution" or "New Green Revolution in Africa." New inter-institutional alliances for agricultural development, involving governments, private foundations, United Nations organizations, and transnational collaborative agricultural research programs and corporations have emerged (Burney et al. 2013; Daño 2007). Irrigation constitutes the most capital-intensive component of these initiatives (Daño 2007), but the model also envisions farmers purchasing expensive high-yielding seed varieties accompanied by fertilizers and pesticides. To facilitate this input-intensive model of agriculture, there is a growing interest in expanding irrigation in SSA. African governments and national policies have recently placed particular emphasis on irrigation expansion as an important strategy to enhancing food security and securing livelihoods (World Bank et al. 2007; Karina and Mwaniki 2011; Lankford 2003). The Comprehensive Africa Agriculture Development Programme (CAADP), promoted by the African Union's New Partnership for Africa's Development (NEPAD) Planning and Coordination Agency (NPCA), gives very high priority to expanding irrigation as a basis for transforming African agriculture (Bwalya et al. 2009).

In Africa, the development of new small-scale irrigation schemes with government and donor support, shadowing traditional schemes, continues to be biased towards the technological dimension of irrigation and its exaggerated benefits (e.g., Yami 2013). This is despite the rhetoric on farmer participation. It reflects what is described as a "persistent mind-set" prevalent among interveners that emphasizes modern irrigation technology as the essential route to modernizing agriculture (Veldwisch et al. 2009). In the early years of government and donor investments in irrigation, the focus was on introducing more 'modern' technology in traditional community-managed schemes, and designing and constructing new schemes with little or no reference to the social and cultural dimensions of irrigation. There have been changes over time, with increasing attention being given to organizing farmers in the form of water users' associations (WUAs) and promoting irrigation management transfer (IMT) on larger schemes. However, such reforms are usually too limited, in that they focus too much on farmers and not enough on the wider institutional framework; for example, IMT has largely sought to transfer the financial burden of governments to farmers (Merrey et al. 2007). In addition, the African rural context makes farmer-managed irrigation especially challenging: in addition to supportive institutional arrangements and policies, it is critical to enhance opportunities for wealth-creation through irrigated agriculture (Shah et al. 2002).

Irrigation involves multiple stakeholders with varying interests. We emphasize the importance of carefully considering the context of user participation in water use. "Participation" is often understood in terms of the actors and stakeholders using water and their involvement in water governance (Montaña et al. 2009). It generally implies empowering users to varying degrees to take responsibility for their scheme. While agreeing with this general notion of participation, the call for considering the broader context of user participation in water use refers to understanding the embedded power dynamics and social categories of resource users as well as the various uses of water in a landscape perspective.

Water sources used for irrigation largely belong to the public and their uses affect a wide range of local stakeholders. How different categories of people participate in water use has significant implications in terms of their social relationships over resource use. Some researchers have noted the importance of considering the multiple uses and users of water as well as the actors that are included and excluded (van Koppen et al. 2009). The conception and practices of irrigation should pay attention to the multiple dimensions of water uses and users, and their interactions for and impacts on successful resource use.

Equity is another critical issue in water management. It encompasses a wide range of issues pertaining to water access, use, distribution and benefits. Equity in access to and use of water, and the distribution of its benefits, involves analytically different but overlapping forms (Phansalkar 2007). These include spatial equity, social equity, gender equity and inter-generational equity. Thus, it is important to consider how access to and use of water as well as the distribution of its benefits differ across different categories of communities, and the implications for sustainable irrigation use and livelihood benefits. Put differently, 'equity' is a socially defined concept. For small farmers investing in a community-managed irrigation system, it is often defined in terms of receiving benefits commensurate with the size of their investment; in other cases, it may be defined in terms of all households having equal access to water or all households of a particular status. Local concepts of equity rarely include the concept of 'equality', for example, between men and women, or landowners and laborers. However, traditional community-managed irrigation schemes usually recognize the critical importance of long-term mutual relationships and patterns of reciprocity.

On the other hand, interventions that contradict such functional patterns of social relationships around water use will negatively alter existing social relations and patterns of equity. Ostrom and Gardner (1993) noted that external interventions that disregard these mutual dependencies and reciprocal relationships among users often prove destructive. Recent observations have also highlighted the unintended and undesirable effects of interventions that result in inequitable access to water. Lankford (2004) found that irrigation improvement projects in Tanzania affected the long-standing equity of water distribution among small farmer-managed schemes sharing a river, leading to inequitable access to water: with the introduction of 'modern' off-takes, upstream users greatly benefited while reducing water supply for those downstream. Similarly, in Bangladesh, water resources development projects that mainly focused on promoting the intensive use of water for irrigation have created inequity in the distribution and allocation of water resources among different stakeholders (Rasul and Chowdhury 2010). There are other examples from Asia, some of which were documented many years ago; in one case in the Philippines, the donor and irrigation agency initially ignored existing community-managed irrigation schemes that were very old and proposed to build entirely new ones that would have obliterated them (Yabes 1994; Siy 1982).

Inequitable access to water, and differential water use and benefits are often the causes for conflicts over scarce water resources. Natural resource management involves competing interests; it is a “form of conflict management” (Castro and Nielsen 2003). Conflicts may arise out of competition for scarce water resources and disagreements over its use. Such conflicts need to be managed for sustainable water use. Elinor Ostrom argues that irrigation systems are among the most important forms of common-pool resources; they require conflict resolution mechanisms to resolve conflicts among users (Ostrom 1990, 1992, 1999). Long-standing traditional irrigation schemes are noted for their success in settling disputes and sharing scarce water resources. They rely on a familiar social framework to resolve conflicts among users, thereby providing guidance for the distribution of water and the sharing of scarce common water resources.

In community-managed irrigation schemes, cooperation is essential for pooling labor and other resources to construct and maintain canals and channels, allocate and share water, regulate and monitor the provision and use of water, and facilitate other necessary joint ventures. The cooperation of users for irrigation plays a significant role in shaping responses to issues of social trust, reciprocity, competition, conflicts, equity, and other mutual concerns related to water access, use and management. Appropriate social organization and rules for collective action are essential to coordinate cooperation for irrigation use. These rules shape interactions, and are contested and revised over time through social actions.

How to promote or create effective institutions is a complex issue. A package of institutional designs imposed from outside is unlikely to fit the multi-dimensional conditions of irrigation schemes in diverse social, cultural and economic contexts, with linked constraints and opportunities. Where institutional innovations are needed, they should build on existing or potential institutional arrangements. This requires a careful examination of these relationships and exploration of spheres of complementary relationships for natural resource management (Dessalegn 2009). The search for enabling institutional arrangements must also consider multiple options. This process can be characterized as “facilitated institutional bricolage,” promoting and facilitating the creation of institutions from a diverse range of sources (Merrey and Cook 2012; Cleaver 2012). Such a locally-driven, but possibly externally facilitated, process is more likely to lead to effective legitimate institutional arrangements than structures imposed from outside.

The discussion of irrigation as a socio-technical phenomenon and the need to encourage local institutional solutions applies to small-scale private irrigation technologies as well, although it has received very little attention. In recent years, small-scale private, individualized irrigation technologies have taken off, first in Asia and more recently in SSA. This is due to a combination of factors, including increased availability of low-cost pumps, sprayers and drip irrigation systems, and urbanization, which creates local markets for high-value products and, in some cases, global markets (Giordano et al. 2012; de Fraiture and Giordano 2014; Burney et al. 2013; Namara et al. 2011). Although there are exceptions, for example, the *fadama* projects in Nigeria and the private irrigation projects in Niger (both supported by the World Bank; see Abric et al. 2011), much of this development has occurred with no formal government investments or even policy attention.

Promotion of private, small-scale irrigation is perceived as an alternative to collective schemes with their high transaction costs and the need for social cooperation. There is an assumption that getting the markets and value chains set up, and putting in place more encouraging policies (e.g., favorable exchange rates, taxes, etc.), is sufficient on the “institutional” side (e.g., Colenbrander and van Koppen 2013). In addition, farmers too are likely to see pump irrigation as a way of escaping the often onerous transaction costs associated with collective schemes. The result of this is insufficient attention being given by all parties – government, donors, farmers – to the need for institutional arrangements to manage water resources, which are still ‘shared’ even if ‘invisible’. This refers to water from small streams and rivers, and also to groundwater, which is now recognized as a potentially significant source of water for irrigation as well as for other uses in Africa (e.g., Pavelic et al. 2013; Villholth 2013). There is no doubt about the claim that groundwater is a significant but underused resource, but there are cautions as well. In some places, for example, in parts of South Asia, China and the USA, the un-regulated, rapid expansion of wells and pumps has led to serious depletion of groundwater resources. In some areas in South India, it has also resulted in the depletion of water in small tanks, by pumping groundwater that is dependent on the water level in tanks (Shah et al. 2007). There are also less well-documented cases of over-pumping from small rivers and streams leading to conflict.[2] Veldwisch et al. (2009) cautioned against the tendency of rushing toward new irrigation infrastructure. This applies to the emerging pump revolution in Africa.

The rapid spread of irrigation pumping technology, disregarding its social dimensions, is likely to have significant adverse implications. Innovations and improvements achieved in the technical aspects of irrigation, without considering the social factors, will not necessarily guarantee successful irrigation experiences (Montaña et al. 2009). While the potential solutions to the social side of community-managed irrigation schemes are understood fairly well, the equally critical importance of addressing the social dimensions of private, small-scale irrigation is not well recognized, and the possible solutions are not clear. The next section of this paper brings this issue into sharper focus through a case study in Ethiopia.

Small-scale Irrigation in Fogera, Ethiopia

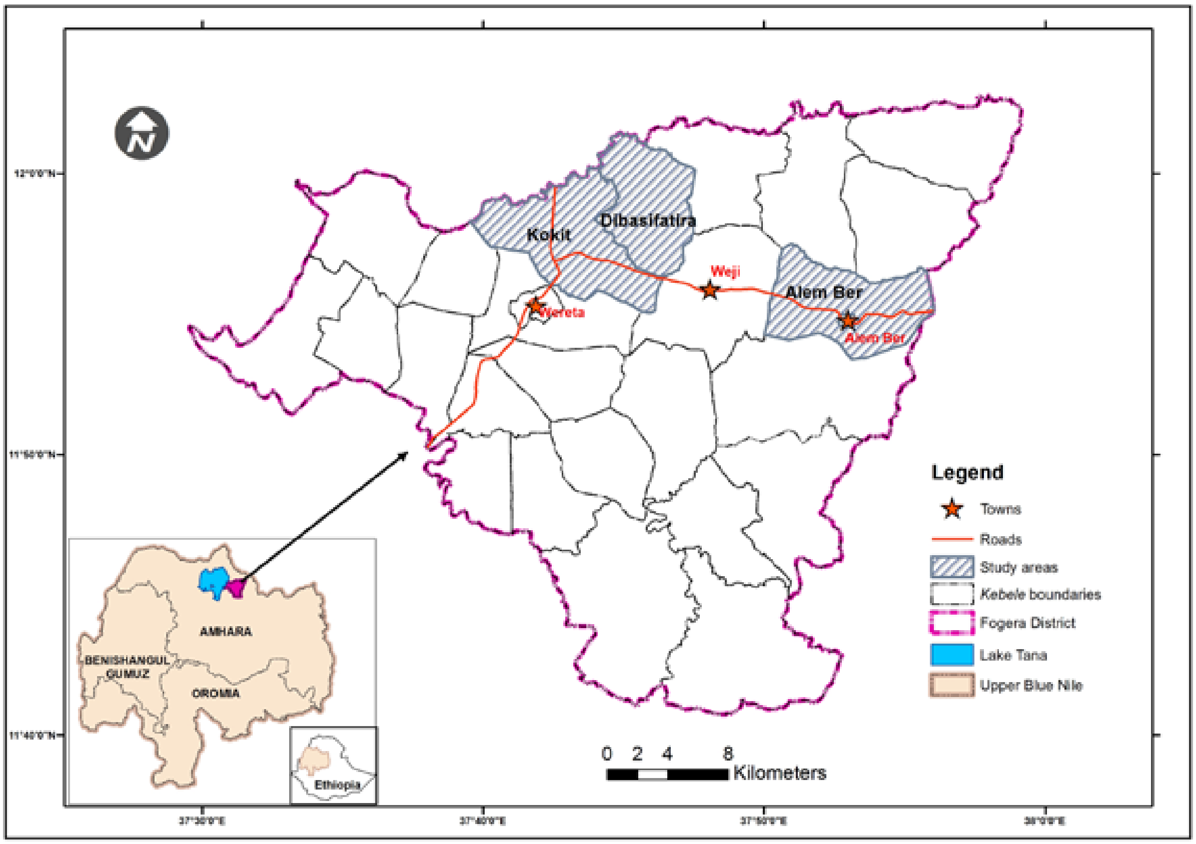
Fogera lies in the Blue Nile River Basin of Ethiopia, upstream of Lake Tana. It is a *woreda* (district) of the South Gonder administrative zone within the Amhara National Regional State (ANRS), which is one of the regional states that make up the Federal Democratic Republic of Ethiopia (FDRE) (Figure 1). The population of Fogera is estimated at 228,449, of which 203,259 are rural inhabitants and the remaining 25,190 are urban dwellers (CSA 2007). Data obtained from rural *kebele* (sub-district) offices indicate that the population of the three study *kebeles*, Alem Ber, Dibasifatira and Kokit is 7,005, 7,703 and 5,190, respectively.

Rural people in Fogera depend on agriculture for their livelihoods. They practice plow-based agriculture using oxen as the main draft animal power. Farmers grow various crops depending on the season – wet and dry seasons. The main cultivation season is the wet season, from June to September. Livelihood zone profiles of the region also indicate that most agricultural activities depend on this single rainy season (MoARD 2007). The major wet season crops include *teff*, maize, millet and rice. The cultivation of rice has been introduced recently. Some variations in crop cultivation exist depending on specific agroecological conditions; for example, rice is largely cultivated in the lowland and midland areas, but not in the upland areas.

The agricultural calendar, i.e., planting and harvesting, starts in May/June and ends by December, depending on the type of crop (Table 1). Dry season cultivation depends on access to irrigation and it may continue from October to March/April. Dry season crops include cereals, such as emmer wheat, chickpea, grass pea and lentils, as well as vegetables, such as onion and tomato.

[2] For example, Douglas J. Merrey, a co-author of this report, has observed two such cases that are based on the expansion in the use of treadle pumps in Kenya and Malawi.

FIGURE 1. Map showing the location of Fogera, Ethiopia.



Source: Prepared with the support provided by Yenenesh Abebe, a geographic information system (GIS) expert at IWMI, Addis Ababa, Ethiopia.

TABLE 1. Reported planting and harvesting times for wet-season crops.

Crops	Planting and harvesting times											
	May	June	July	August	September	October	November	December	January	February	March	April
Teff			Planting				Harvesting					
Millet	Planting	Planting					Harvesting					
Maize	Planting				Harvesting	Harvesting						
Rice		Planting					Harvesting	Harvesting				

Planting

Harvesting

Source: Interviews held with farmers during fieldwork conducted in 2012.

Fogera is largely considered to be self-sufficient in food production. The *woreda* is included in the Tana Zuria Livelihood Zone, where households' own crop production contributes to a very high percentage of its food consumption (MoARD 2007).

Livestock are also central to the Fogera farming systems. Farmers rear different types of animals such as oxen, cows, sheep and donkeys. While the number and types of livestock vary depending on the situation of the households, cattle (particularly oxen and cows) constitute the largest proportion of the livestock reared in the area (Table 2). This relates to the vital role of oxen for plowing, the importance of cows for milk and the cash value of cattle in times of need. Sheep are largely reared for sale, while donkeys usually serve the purpose of transporting goods from rural to urban areas.

Farmers generate income from the sale of grains and vegetables. The district center, Wereta, as well as other nearby cities are among the market centers where farmers sell grains, vegetables, and livestock either directly or through brokers. While sheep and cattle are often traded within the surrounding towns and cities, cattle have also been supplied to export markets, particularly to Sudan (Akalu et al. 2009; MoARD 2007).

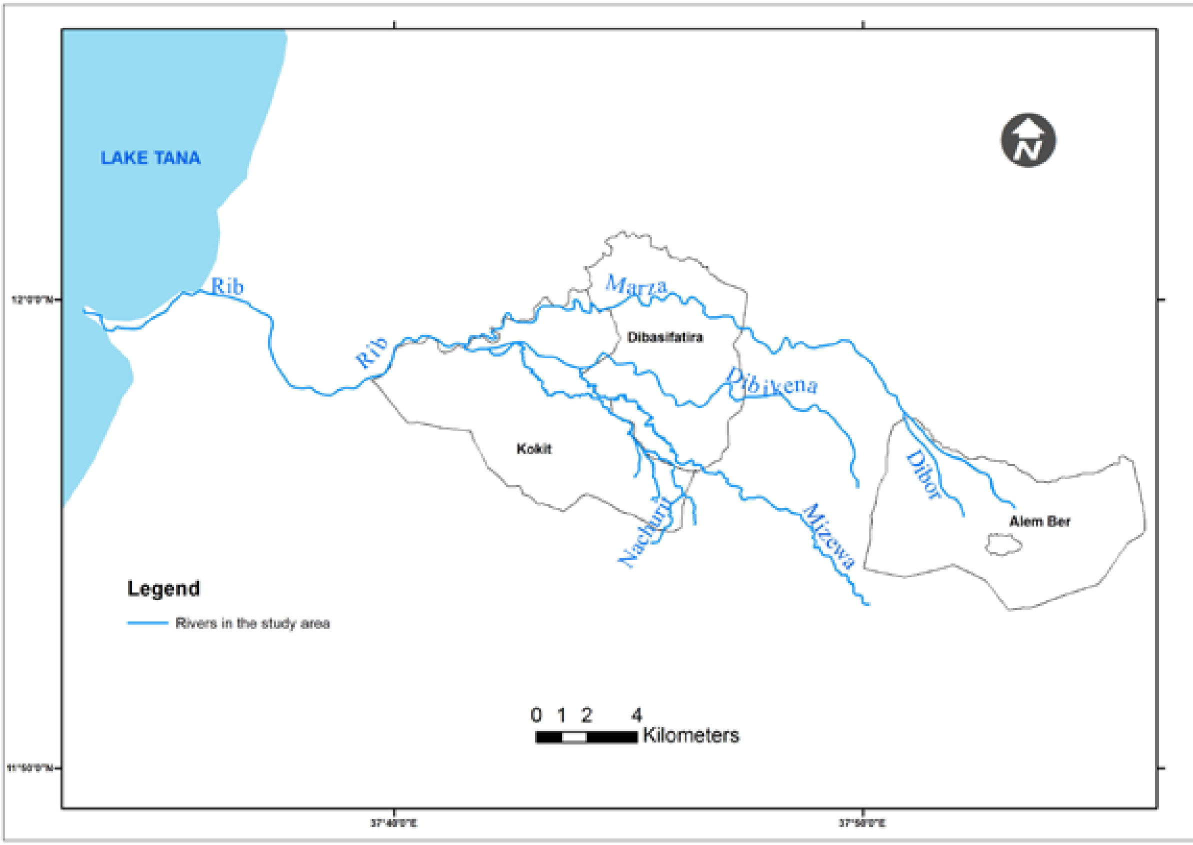
Agriculture is the mainstay of the Ethiopian and Fogera economies, and the main source of living for the majority of the rural population. It is largely based on smallholder rainfed farming. However, the reliance on rainfed agriculture is often problematic. It is vulnerable to rainfall uncertainties, i.e., erratic rainfall, recurrent droughts and other linked factors that threaten farming as a livelihood. Therefore, in recent years, small-scale irrigation has expanded in Fogera. Farmers practice both motor pump irrigation and traditional irrigation based on the diversion of water from rivers and streams. Other observers have also noted the diversity of small-scale irrigation in the Blue Nile River Basin of Ethiopia (e.g., Eguavoen et al. 2012). Some of the rivers used for irrigation in the upper and lower zones of Fogera include Rib, Alemayehu, Marza, Mizewa and Dibikena (Akalu et al. 2009). Data obtained from farmers and agricultural extension officers in our study *kebele*s also indicate that these rivers and other rivers, such as Nachurit, Dibor and Bastkwa, are the basis for farmers' small-scale irrigation endeavors. Rib is a perennial river that flows through several *kebeles*, including Dibasifatira and Kokit, while the others are seasonal rivers that flow across different *kebeles* (Figure 2).

TABLE 2. Livestock population in the study *kebele*s.

Livestock type	Livestock population by *kebele*			
	Kokit	Dibasifatira	Alem Ber	
Oxen	1,267	4,198	966	6,431
Bulls	536	3,524	296	4,356
Cows	1,281	2,518	992	4,791
Heifers	652	2,617	420	3,689
Calves	814	3,220	256	4,290
Sheep	717	2,422	569	3,708
Donkeys	375	1,190	201	1,766
Total	5,642	19,689	3,700	29,031

Source: Basic information of rural *kebeles* obtained from rural agricultural offices of Kokit, Dibasifatira and Alem Ber *kebeles* in Fogera.

FIGURE 2. Map showing rivers in the study areas.



Source: Prepared with the support provided by Yenenesh Abebe, a GIS expert at IWMI, Addis Ababa, Ethiopia.

There has also been a growing interest within the government and among its partners in expanding irrigation at the national level. Recently, the Ethiopian government has ranked irrigation development as high priority in its agricultural and rural development agenda. Irrigation is addressed in key government policy documents, including 'A Plan for Accelerated and Sustained Development to End Poverty (PASDEP)' and the more recent 'Growth and Transformation Plan (GTP)', where irrigation is identified as a key instrument to enhance agricultural production, food security, economic growth and agrarian development (FDRE 2006, 2010). The government is promoting large- as well as small-scale irrigation; the latter includes modernizing and expanding 'traditional' irrigation schemes as well as encouraging private small-scale irrigation. For example, expanding 'household irrigation technology' – mainly pump irrigation – is a major priority of the Ethiopian Agricultural Transformation Agency (ATA).[3]

Farmers in Fogera assert that irrigation has brought important benefits through the cultivation of multiple crops for both food consumption and sale. Farmers practicing irrigation emphasized that they used to cultivate mainly rainfed crops, such as *teff* and millet. Now they are able to shift from producing only during the rainy season to producing during both the rainy and dry seasons. Irrigation has enabled them to produce multiple crops, including onion, tomato, grass pea, wheat, emmer wheat, maize, chickpea,

[3] For further information, visit http://www.ata.gov.et/programs/system-programs/household-irrigation-hhi-project/ (accessed on December 6, 2014).

lentils and fenugreek. This situation has spurred enthusiasm, particularly for motor pump irrigation. The use of motor pumps has transformed local irrigation practices, expanding irrigated agriculture beyond the scope of traditional irrigation. Data obtained from *kebele* agricultural offices during fieldwork indicate that 4,682 ha of land are irrigated in the three study *kebele*s. This accounts for over 50% of the total cultivated land (8,131 ha). In Fogera District, at large, 27,141 ha are irrigated, accounting for 47% of the total cultivated land (57,444 ha) (FWARDO 2013). Fogera is in the Lake Tana Basin, an area that is especially favorable for irrigation in terms of gradient, soils, water availability and climate.

Traditional Irrigation

In Fogera, traditional irrigation, locally referred to as *mesno*, is practiced through river and stream diversions, and the construction of channels. The history of traditional irrigation in the area dates back to the pre-1974 imperial regime of Ethiopia. A key informant in Fogera recalled that *mesno* was practiced during the Haileselassie regime and was administered by *dagna* (judges). Local representatives of the regime would provide the authority for enforcing activities agreed upon for irrigation use. Another key informant in Alem Ber *kebele* indicated that they started to practice *mesno* in 1977 during the Derg regime due to lack of rain. Traditional irrigation schemes have also existed in other parts of northern Ethiopia, involving a system of water allocation through the mediation of 'water fathers' and 'water judges' (Pankhurst 2002; Dessalegn 2001; Teshome 2003). Case studies conducted in northern Ethiopia also indicated that, while irrigation was generally limited during the imperial regime and largely controlled by landlords, it expanded under the Derg government (1974-1991) due to the threat of famine and efforts at collective farming; market forces and investment by the government and donors have subsequently resulted in further expansion under the current government (Pankhurst 2002; Awulachew et al. 2005; Teshome 2006).

In Fogera, although traditional irrigation was practiced in the past, its expansion is a recent phenomenon. Local people indicated that its wider practice only emerged since the turn of this century. A combination of factors, including increased rainfall uncertainty, and a growing realization of the importance of irrigation and extension support, has re-invigorated local interest in experimenting with traditional irrigation. In explaining this shift, a key informant in Dibasifatira said, "When the rain stopped in September, we would also stop cultivation. The canal came about 11 years ago. When the rain decreased, we tried the canal. We have continued to use it thereafter." The informant was referring to the *mesno* scheme located in Kero village, which is based on a diversion of water from Mizewa River. Key informants indicated that the scheme serves more than 70 households. A *kebele* document regarding irrigation use shows that it is practiced by more than 100 households and the irrigated area is about 40 ha. The size of irrigated plots ranges from 0.25-1.0 ha; most farmers' irrigated plots are 0.5 ha.

Farmers around Bila village in Dibasifatira also use a *mesno* by diverting the Nachurit River. Key informants as well as agricultural extension officers indicated that the number of users of this *mesno* is between 60 and 70 households, and the irrigated area covers about 30 ha of land. The average size of irrigated plots is 0.5 ha. In Alem Ber, around Mikael and Wendegere areas, farmers use another *mesno* by diverting water from Bastkwa River. A discussion that involved a group of *mesno* users and agricultural extension officers revealed that this scheme serves more than 50 households and the irrigated area is about 15 ha. *Mesno* is practiced by an even smaller groups of farmers. For instance, in Alem Ber, a dozen households who work on adjacent crop fields in Tilik-mesk village use a *mesno* by diverting water from Aguwa-Dibor River. A discussion with a group of *mesno* users and agricultural extension officers revealed that the irrigated area is about 5 ha and most farmers' irrigated plots are about 0.5 ha.

Farmers are eager to take advantage of the streams and rivers passing through their villages. During interviews, such farmers passionately reported their recent experiences and accomplishments by emphasizing how they have managed to make use of hitherto 'idle' water sources. This was also evident during focus group discussions with farmers. For instance, during a discussion with a group of farmers in Dibasifatira, participating farmers strongly shared the view of their colleagues who emphasized that, "In the past, the water would just go through cutting the land. Today, we are asking her where she is going." Similarly, participants of the focus group discussions in Alem Ber underlined that, "Today, there is no water that freely goes around the field. If found, she will be diverted." Thus, farmers seem more determined to utilize the available water. This situation reflects how local perceptions of irrigation have changed recently, with farmers attaching more value to its importance.

In rural Fogera, social cooperation is an important defining feature of traditional irrigation, as it involves social cooperation from the onset of planning the scheme through to water use and irrigation schedules. Local users pool their labor, ideas and commitments to work on irrigation facilities, i.e., river diversion, dam construction and the preparation of water channels. The social cooperation and coordination that such activities entail are not a one-time activity. It is work that requires continuity, involving the construction and subsequent dismantling of the traditional dam. Users build a small dam from soil. Key informants indicated that they are often cautious about the potential adverse impacts of this small dam, particularly during the rainy season, in that it may overflow and inundate the surrounding area. They avoid this danger by dismantling the dam once the period of irrigation (October to January) is over and rebuilding it after the rain stops. Farmers also try different ways to maintain traditional irrigation structures. For instance, they reinforce mud-weirs by mixing dry straw and mud as plaster while using stones to support it. They also use soil-filled sacks (soil bags) to prevent erosion of the mud structure.

In many respects, the users' readiness to accept social cooperation reflects their understanding of traditional irrigation as a social undertaking. The social trust embedded in their joint efforts also has a significant implication for collective action in irrigation use and management. This was evident from farmers' remarks regarding the norms and practices of water use. For instance, in response to whether users adhere to norms of shared water use or tend to be self-centered, disregarding others, a farmer in Alem Ber emphatically stated that, "We have equally worked together to bring the water, and we all have to use it equally." Water usage is regulated by water use turns and irrigation schedules depending on water availability.

Key informants explained that people who work together during initial preparations jointly discuss and arrange irrigation schedules and water-use turns. Then, individuals use water turn by turn based on specific schedules. The system is coordinated by water judges. Several water judges from each user's village constitute a water committee of five to six members. The practice of irrigation schedules based on water-use turns is instrumental in avoiding destructive competition and ensuing conflicts over water use. Local users are aware of the negative implications of uncoordinated water-use practices. A key informant stressed that, "irrigation has to be used on the basis of turns, so that people should not fight." However, this does not necessarily suggest that irrigation water use involves no competition and conflict: traditional irrigation users in Fogera indicated that competition and conflicts do arise between users over scheduled water turns. However, they can be mediated by the local institutional arrangements. Individuals may violate the 'water turn' system to pursue their own advantages at the expense of other users, but the water committee will intervene and address such situations.

Scholars maintain that the rule of exclusion/inclusion is an important principle that guides collective use and management of natural resources (McCay and Acheson 1987; Ostrom et al. 1999). This is reflected in traditional irrigation practices in Fogera. However, the local notion of inclusion/exclusion is not rigid and does not focus on restricting or denying access to water. It facilitates social cooperation that enables irrigation water use. Who is included for water access in irrigation schedules depends on whether they have participated in joint activities during the preparation of the traditional irrigation scheme. In principle, those who have failed to participate in such activities will be excluded. However, this customary principle is flexible, in that such individuals can be included later if they pay a fine. The fine represents a form of punishment for failing to take part in the social cooperation required for irrigation usage, while the individual will ultimately get access to irrigation water by paying his fair share in cash.

A study conducted in several districts, including Fogera in eastern Lake Tana, also revealed that traditional irrigation schemes are practiced across these areas (Akalu et al. 2009). The study corroborates our observations on traditional irrigation. Traditional irrigation schemes involve water allocation and irrigation schedules whose management is done by *Yewuha Abbat* (water fathers), with the assistance of a group of water distributors and guidelines that include informal bylaws, operational norms and provisions for penalties (Akalu et al. 2009). In Fogera, this study was conducted in the upper and lower zones, including two of our study *kebele*s, Dibasifatira and Kokit. Other observations that focused on a village-level *mesno* scheme in a different *kebele* in Fogera (Deneke et al. 2011; Eguavoen et al. 2012), while noting the self-organization of traditional irrigation including water allocation and irrigation schedules, highlighted irregular practices. Variations in traditional irrigation practices may exist between different localities depending on differing political-ecological contexts and other conditions. Further research should be conducted to understand the scope and relevance of variations in irrigation experiences.

Motor Pump Irrigation

The history of motor pump irrigation in Fogera dates back to the period of cooperative farming during the previous socialist (Derg) regime. After overthrowing the imperial government, the new Derg government introduced a wide range of agrarian reforms including land tenure changes and state-organized farm cooperatives. The initial experience of motor pump irrigation in the area can be traced back to a cooperative farm which operated over two decades ago. A key informant in Kokit recalled this situation and explained their experiences by stating, "During the Derg in 1979/80, they organized us under a cooperative farm in Shega *kebele* and gave us motor pumps. We used the motor pumps to cultivate rice and got a good harvest." Nevertheless, key informants indicated that the recent practice of individual use of motor pumps for irrigation was introduced less than 10 years ago. This involved collaboration between 'investors' and local farmers. A key informant explained that,

> "Initially traders were coming from the Wereta town with motor pumps to work with farmers here. The farmers would contribute labor and land, while the others would bring the motor pump, seeds and fuel. Later, they would share the harvest equally. After two years, the farmers became free from dependence. They were able to buy their own motor pumps and became self-sufficient."

The wider expansion of motor pumps is a very recent phenomenon. Interviews revealed that the use of motor pumps began expanding rapidly only in the past three years. Farmers' favorable views regarding its benefits have spurred their enthusiasm for motor pump irrigation. A total of 20,916 pumps were reportedly distributed in the region at the end of 2009 alone (Namara et al. 2013). This figure is likely to have risen in subsequent years. Important enabling factors have facilitated the dissemination of the technology. Credit to buy motor pumps is now available through the Amhara Credit and Savings Institution in conjunction with the *woreda* agriculture office. While the latter delivers the motor pumps, the former provides the credit to purchase them. Credit facilities with facilitated supply of motor pumps have enabled farmers to acquire the technology.

Besides, the use of motor pumps has expanded through local arrangements. Interviews and discussions conducted with farmers revealed that sharecropping has been an important factor in enabling farmers to gain access to motor pumps. Farmers have drawn upon experiences from their traditional sharing and exchange arrangements. They have engaged in sharecropping arrangements for a long time, involving those without oxen for plowing and others with oxen or landless people and landowners. This relationship has been extended to motor pump irrigation, in that farmers who have no motor pump engage in sharecropping arrangements with those that own motor pumps. In this arrangement, the former contribute land and labor, while the latter provide the motor with fuel and seeds, and they share the harvest equally. Thus, motor pump irrigation has been incorporated into local farming practices through traditional sharecropping arrangements.

Farming enterprises boosted by motor pump irrigation now provide better income opportunities. Farmers use the grains and vegetables they produce for alternate purposes – cash and food, depending on the household's particular needs. Interviews with farmers indicated that onions, tomatoes and emmer wheat are largely sold. In particular, onions are widely grown as a cash crop. Farmers appreciate how onions have become an important source of cash. For instance, a farmer in Dibasifatira expressed his appreciation by stating, "We can now earn ETB 5,000[4] from the sale of onions harvested from a small plot of land." A government agricultural extension officer in the area mentioned that a farmer could generate up to ETB 80,000 from onions produced on 0.25 ha. A recent assessment of agriculture in the Lake Tana Basin (Akalu et al. 2009) also indicated that onion production in Fogera has been increasing and the area has become a source of onion seeds for other areas of the Amhara region. A key informant in Kokit stated the importance of this crop by stating, "It is onions that have changed the farmer these days. People who cultivate onions have changed a lot. They have acquired new assets; some have also owned grinding mills."

Current motor pump irrigation practices in Fogera suggest that their pump-based irrigation is focused on pumping water on an individual household basis. A household usually relies on its own labor to transport the motor pump and pipe to a convenient water point where it sets the machine up to pump water and irrigate a field (Figure 3). In this way, farmers in Kokit draw water from the Rib River and irrigate their plots around the river path. Pump users in Dibasifatira pump water from the Mizewa and Marza rivers, and irrigate their lands in the vicinity of these rivers.

FIGURE 3. (a) Transporting pump equipment, and (b) pumping river water in Fogera.

a)

b)

Photos: Mengistu Dessalegn.

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[4] Current (2013-2014) exchange rate: ETB 1 = USD 0.052; ETB 5,000 = USD 260.

A household may also use a donkey to transport the machine, depending on the distance to a convenient water point or to the place where the motor pump was rented (Figure 3).

The use of motor pumps has facilitated access to river water for irrigation on an individual basis. However, the technology is being implemented without social cooperation and institutional arrangements for sharing of the common resource – the small rivers. Irrigation using a motor pump is an individualized undertaking, with no coordination and restrictions. This situation differs from the joint responsibilities required for the successful use and management of traditional irrigation. The lack of institutional arrangements to guide motor pump irrigation is widespread.

This is also perpetuated through conceptions of irrigation that differentiate motor pump irrigation from traditional irrigation. This was identified through the analysis of local explanations in the course of the fieldwork. The local term for irrigation is *mesno*. Key informants described its features in terms of water use turns, schedules and other forms of collaboration related to utilizing river water for irrigated agriculture. During the fieldwork, such explanations were followed up with probes and queries regarding how such forms of collaboration related to motor pump use. Key informants clearly emphasized that their focus of description was *mesno*, separate from motor pumps. They responded to such queries by insisting that they were talking about *mesno* and *mesno* use, while emphasizing that individuals use the "motor" to draw river water and use it on their own. The notion that motor pump irrigation is different from traditional irrigation is reflected in other descriptions as well. In villages where both motor pump and traditional irrigation are practiced, informants described collaborative irrigation use in relation to *mesno*. In areas where only the motor pump is used, informants responding to queries regarding cooperation in utilizing river water tended to emphasize that they do not practice *mesno*. During a participatory mapping exercise with a group of farmers in Kokit, participants classified crop cultivation as 'crops grown with rain' and 'crops grown using the river'. When asked whether the latter refers to *mesno*, they explained that it is not *mesno* but "motor".

Thus, local conceptions of motor pump irrigation versus traditional schemes differ depending on whether they refer to the source of water or social cooperation for water use. Motor pump irrigation is linked with traditional schemes when referring to ways of watering fields by extracting water from rivers and streams: artificially supplying water to crops versus depending on rainfall. On the other hand, motor pump irrigation differs from traditional irrigation, *mesno*, which is conceptualized as including social cooperation for water use. Motor pump irrigation does not involve the social attributes of irrigation embedded in the notion of *mesno*. Farmers use the term 'motor' to refer to individual pump irrigation. They associate the presence of a system that coordinates water use and irrigation schedules with traditional irrigation in contrast to motor pump irrigation. They link the latter with a situation of uninhibited usage, which is further revealed in the discussion below.

Motor pump irrigation practices lack mechanisms for water allocation and irrigation scheduling. Interviews and discussions held with farmers clearly emphasized this situation. For instance, a key informant in Dibasifatira stated that, "There is no water use turn with motor pump use. Water is used as one wants to use [it]. People stop when the water stops." Similarly, a key informant in Kokit indicated that, "Motor pump use has no water committee. It has no turn. It is possible for everyone to irrigate as they would like to." Such explanations were widely shared among a range of local people contacted during the fieldwork. Focus group discussions conducted with groups of farmers in the three study *kebele*s also revealed that motor pump irrigation practices are devoid of water use turns and irrigation schedules. Observations of motor pump irrigation practices during fieldwork and interviews held with such pump users also reflected that irrigation with a motor pump is an individualized undertaking.

Our examination of motor pump irrigation in Fogera suggests that priority is given to acquiring and using the technology, i.e., the motor pump.

The new technology has also quickly assumed its position as an important implement to be possessed by farming households. Government institutions and affiliated development personnel have been keen to facilitate the use of the technology at the local level. These efforts have focused on facilitating credit arrangements and delivering motor pumps. At the global level, the focus is largely on promoting the expansion of individualistic irrigation through improving the supply chain of motor pumps (Burney et al. 2013; Colenbrander and van Koppen 2013; Merrey and Sally 2008). Indeed, the use of motor pumps is a significant and welcome development of small-scale irrigation. However, we argue that the emphasis placed on motor pumps for improved irrigation performance should move beyond the sole focus of acquiring the technology and disseminating its use.

Pump-based individualistic irrigation practices based on small rivers and streams, without effective institutional arrangements and collective action for managing the shared resource, have counterproductive implications. Information obtained through interviews and discussions held with farmers in Fogera revealed the emerging problems. Farmers have begun to experience the consequences of the lack of social cooperation as motor pump irrigation expands. Motor pump users have become concerned about how the competition for water use is growing, limiting the duration of water availability and creating water shortages. Irrigation users in Tachawa said that the water they use from the Rib River does not come easily to their area due to there being many motor pump users in upstream areas. A woman farmer in Kokit described this situation as frustrating. She emphatically stated that, "Now the motors are randomly placed in every direction, so there is a shortage of water." This remark was shared by other people as well. A 50-year old farmer who was disappointed by this situation said, "Now the main problem is water shortage. Otherwise, the area is gold." Another study also reported that communities around the Mizewa River complained about water shortages due to pumping of water in upstream areas (Zemadim et al. 2013).

This situation of increased competition for water use was reported by a range of motor pump users. It should be noted that motor pump use is not limited to owners of the machines. Farmers who do not own motor pumps also gain access to them through sharecropping arrangements. In addition, the use of motor pumps has expanded through rentals, which generate income for farmers who possess motor pumps while enabling others to irrigate. The rental cost of motor pumps is in the range of ETB 12-15/hour (about USD 0.80) plus the cost of fuel.

Farmers pumping water from the downstream portions of streams insist that users in the upstream parts always use the water as they want and deprive them of their share. They complain about the lack of any mechanism to check and deal with water blocking or over-pumping. Government agricultural officers who provide farmers with extension support also emphasized the growing competition for pumping river water. An extension agent in one of the study *kebele*s explained such problems of irrigation use, emphasizing that, "There are too many motor pumps now. Everybody has a motor pump and it is difficult to follow-up. If we were to try and follow-up in our *kebele*, it would be difficult for us to follow-up things in another *kebele*." Not only does this situation reveal the lack of inter-village coordination for water use, it also indicates how the gap in social cooperation goes beyond inter-village relations, in that irrigation use and associated problems crosscut *kebele* boundaries.

Shortage of water has been identified as a growing problem during interviews and focus group discussions conducted with farmers in Fogera. They have indicated that the amount of water available for irrigation is decreasing. Rivers are getting 'weaker' and drying up before their regular seasonal period. For instance, during a group discussion, farmers in Dibasifatira indicated that, "There are so many motor pumps now that the Marza River we use for motor pump irrigation has dried up earlier than its season. Before the presence of many motors, we could use the river from October to February. Now it has dried up at the start of January. As a result, the crops we planted collapsed." In interviews, farmers who pump water from the Mizewa River also remarked that the amount of water available for irrigation has decreased due to increased motor pump users. These pump users mentioned, in particular, that the cultivation of a cash crop, which has recently begun in their upper surrounding area, has reduced the amount of water available to them. As a middle-aged farmer indicated, “Before this increase in *chat* (a cash crop) cultivation using pumped water, the water that comes to our area would last until March or April. However, now the water flow has become weak around February.” A study that involved a participatory approach to hydrometeorological monitoring (Zemadim et al. 2013) stated that the pumping of water for irrigation reportedly resulted in one of the main tributaries of the Mizewa River going dry in the dry season.

Interviews held with farmers during fieldwork conducted in 2013 revealed the increasing impacts of problems related to uncoordinated individualistic motor pump use based on rivers. Farmers in Wenbel indicated that they have now stopped cultivating onions due to a shortage of water. They attributed the reduced water availability to an increase in motor pump users in their area as well as in the upstream areas. In particular, they emphasized the effect of increased competition from pump users in the upstream areas that are included in a different *kebele* (sub-district). A key informant stated, “They (upstream users located in a different sub-district) started using motor pumps after us. But, now, the number of motor pump users has increased there and the water has decreased here. Therefore, we stopped cultivating onions due to fear of crop failure.” A farmer who contrasted the current situation with prior experiences explained that,

> “We have benefited from the cultivation of onions for some three years. Now, there are many motors in use and the water has reduced. So, we have abandoned the onions. I haven’t planted onions this year. In the past, the water used to serve us from October to February. But, now, it serves us until December, at most. It stops after that. If the water is not available until February, it is useless for cultivating onions.”

Information obtained during fieldwork conducted in 2014 also suggests an increasing trend in the competition for water use. For example, motor pump users extracting water from the Marza River insisted that water availability had declined. Farmers interviewed indicated that the problem of water shortage has affected their cultivation of onions. A motor pump user stated that, “We do not have water from January onwards. This is because the river dries up. Last year, we planted onions, but the river dried up in January. For onion cultivation, there needs to be a supply of water until February.” An interview conducted with a rural *kebele* official also highlighted the increasing competition for water use and linked the impacts this had on onion cultivation. He stated that,

> “Now, the number of people extracting river water using motor pumps has increased. Competition among those pumping water from here and there has reduced water availability. This has hindered the cultivation of onions. So, this year, farmers have shifted to cultivating *aja* (emmer wheat); it requires a smaller amount of water. Onions need to be irrigated six to seven times, but it is sufficient if *aja* is irrigated three times.”

There seems to be an emerging response in terms of changing cropping patterns due to the declining water availability. For example, *aja* (emmer wheat) cultivation, which requires less water, may be replacing onion cultivation. Farmers we interviewed indicated that many people are getting involved in *aja* cultivation. This shift towards *aja* cultivation indicates an emerging response to decreased water availability for onion cultivation. Further investigations should be carried out to understand the scope and implications of such responses. This trend, if confirmed, is of particular concern because onion cultivation is far more profitable than *aja* cultivation. Motor pump users greatly appreciate the benefits of onion cultivation that has been achieved through motor pump irrigation. They expressed their concern by emphasizing that, “if water is available, cultivating onions is more beneficial.”

The increasing competition for water threatens the sustainability of motor pump irrigation and diminishes the livelihoods of motor pump users. In addition, it affects traditional schemes by reducing the amount of water available for traditional irrigation. For instance, farmers who practice traditional irrigation in the downstream portions of the Alemayehu River insist that the expansion of motor pump use in the upstream areas has reduced the flow of water to their area, thereby jeopardizing their *mesno* irrigation. In Alem Ber, farmers who irrigate by diverting water from the Aguwa-Dibor River described a case of conflict between motor pump use and *mesno* irrigation, whereby motor pump users are alleged to be blocking water and stopping its flow to the *mesno* waterway. They explained that this situation was threatening their onion cultivation, but the blockage was later removed through the intervention of a *kebele* official. Also, in Dibasifatira, farmers using *mesno* by diverting water from the Nachurit River described a situation of conflict between traditional irrigation and motor pump irrigation. They stated that some motor pump users surreptitiously remove weir structures and redirect water to the river, so that more water flows through the branch of the stream from which they pump water and irrigate fields. Key informants indicated that this kind of sabotage often takes place at night and it has forced *mesno* users, during their turns of water allocation, to be vigilant against such activities that jeopardize their water share and irrigation schedule.

In some instances, the competition between motor pump use and traditional irrigation becomes more complex at the ground level. This is related to situations where a farmer who owns a motor pump may also be involved in traditional irrigation. A key informant in Dibasifatira indicated that, at times, some of these users resort to using their motor pumps through covert interference with traditional schemes. Such motor pump owners, like other motor pump users, consider motor pumps as a means of ‘avoiding’ the ‘inconvenience’ of traditional irrigation. Interviews with some irrigation users clearly reflected this situation. For instance, an irrigation user in Billa stated that, “*mesno* is less convenient, because we use it by *worefa* (water use turns). When *worefa* takes longer, I prefer to use “motor” (i.e., motor pump).” Similarly, another irrigation user stated that, “If you get ‘motor’ , you do not expect to wait for *worefa* to access water. You will have easy access to water by using the ‘motor’.”

Thus, motor pump irrigation has led to increasing competition for water use even within *mesnos*, potentially undermining their institutional arrangements. The growing shortage of water threatens their sustainability. Competition and conflict are increasing between motor pump irrigation and traditional irrigation. The reduction in water supply for traditional irrigation puts its users at a disadvantage. The end result is becoming a lose-lose situation for users of both types of irrigation. We anticipate the situation will worsen and become more widespread over time, if unabated.

To date, there has been little institutional response at the *kebele* level in terms of institutional arrangements to guide motor pump irrigation and ensure its sustainability. However, information obtained from Kokit *kebele* indicated that a kind of ‘committee’ was reportedly attempted in one village. However, its function was limited to mediating a conflict over land. As a key informant in Kokit explained, “Someone pumping out water might want to bring the water to his field by trespassing another person’s land, thereby creating a conflict with the landowner. The committee tried to mediate such conflicts over land. This was tried only in our village.”

However, there are important government institutional and policy contexts that recognize the importance of appropriate use and management of water resources. A key government policy document, the GTP, has emphasized the importance of irrigation development and improved water utilization, as well as building the capacities of farmers and government support structures. Associated key documents of the Ministry of Water Resources, such as the Water Resources Management Policy (MoWR 1998) and the Water Sector Strategy (MoWR 2001), have also identified the importance of developing irrigation and appropriate institutional structures for the implementation and management of irrigated agriculture. In 2013, the government issued a "Proclamation to Provide for the Establishment of Irrigation Water User Association" (FDRE 2013). Such institutional and policy provisions and enactments can have their own implications in terms of facilitating a context for the creation of local institutional solutions for pump-based irrigation. There is also a wider government-initiated institutional context whereby rural people have been mobilized for watershed management activities. Information obtained from the *woreda* agriculture office in Fogera described watershed management as an important part of its natural resource management agenda. Farmers have been engaged in collective soil and water conservation activities through *woreda* and *kebele* structures, and watershed management task forces which are organized from the village through to *kebele* levels. Nevertheless, so far, there has been little direct official response to the growing shortages of water in small rivers resulting from the expansion of motor pump irrigation.

Motor Pump Revolution: Reflections from Asia and Africa

Until recently, irrigation investments in Asia and Africa consisted almost entirely of public investments; although farmers did invest in small-scale individual and community-managed irrigation schemes, these investments were invisible to governments. Colonial governments invested in large-scale schemes based on canals, barrages and dams, especially in South Asia, Sudan, West Africa and South Africa. The main exception was public support for the rehabilitation of small community-managed 'traditional' irrigation schemes in Asia. These types of investments continued in the post-colonial period, and were scaled up in conjunction with the Green Revolution in Asia. However, from the 1980s, there was growing public and private dissatisfaction with the performance of public irrigation schemes. Quietly and almost invisibly, beginning in the 1950s in India, Pakistan, Bangladesh and elsewhere, individual farmers began investing in motor pumps. A report on treadle pumps published in 2000 was an eye-opener with its title, "Pedaling out of poverty" (Shah et al. 2000). However, it soon became clear that the real story was not so much about treadle pumps, but about the low-cost portable pumps that came onto the market in the 1990s. Initially, these were mostly powered by petrol or diesel. More recently, with rural electrification, the use of electric pumps became more common in Asia; and most recently, solar pumps are coming onto the market in South Asia and at least at an experimental level in West Africa (Shah et al. 2007; Tewari 2012; Burney et al. 2010).

By the mid-2000s, the area under private irrigation constituted over 60% of India's irrigation, exceeding the area under public schemes despite continued public investments (Mukherji et al. 2009). In SSA, motor pump irrigation got off to a slower start, but is now also growing rapidly in many countries (Shah et al. 2013). In some African countries, for example, Ghana, the area under private small-scale irrigation now greatly exceeds the area under public irrigation (Villholth 2013). African governments have become interested in supporting this expansion: private pump-based irrigation does not require long lead times and huge outlays of public funds; it mobilizes significant private investment; and it is making important contributions to the food supply of growing cities as well as to agricultural exports.

The significant impacts of pump-based irrigation in terms of poverty reduction and higher agricultural productivity are also impressive in both Asia and Africa (e.g., Shah et al. 2007, 2013; Mukherji et al. 2009; Burney and Naylor 2012; de Fraiture and Giordano 2014). However, as with all good things, the rise of individually owned pump-based irrigation has led to new problems. In parts of western and southern India, northern China and North America, over-pumping of groundwater has led to serious depletion of both shallow and deeper aquifers (on the other hand, shallow aquifers that are annually recharged by monsoon rains continue to be under-exploited in eastern India). Recent research in SSA finds that groundwater remains an under-exploited resource in most places, but there is growing evidence of over-exploitation and degradation of, and conflict over, groundwater resources (e.g., Villholth 2013).

In addition to groundwater, vast areas of the semiarid and humid tropic zones of SSA are characterized by the existence of multiple small streams and rivers. In the driest areas, these are ephemeral; in nearly all of them, their flows vary dramatically between the wet and dry seasons. With a few possible local exceptions, data on the locations and flows of these streams are nonexistent. Indeed, recent estimates on the potential for motor pump irrigation focus entirely on groundwater and ignore the potential for pumping from small streams (e.g., Namara et al. 2013).

As pump irrigation expands in SSA, it seems highly likely that competition for water from small streams and rivers as well as aquifers will become increasingly serious. This problem will require creative solutions at local levels.

India, China and North America have experimented with institutional and technological approaches for managing the problem of aquifer mining. In North America, the Ogallala Aquifer Initiative supports a range of measures to reduce depletion of a major source of agricultural water, including encouraging conservation agriculture, more efficient irrigation and changes in cropping patterns[5]. Other measures include systems of enforceable permits for water extraction and spacing of pumps, pump metering, promoting community-based and even larger-scale groundwater recharging (e.g., Gujarat, India), and reconfiguration of rural electricity systems that separate supplies for domestic and industrial purposes, and supplies using dedicated lines to agricultural pumps. In the latter case, electricity supply for agriculture is highly reliable but rationed (Shah et al. 2004; Mukherji et al. 2009). It is likely that some parts of Asia have evolved approaches to dealing with competition on small rivers, but these are not well documented.

African and South Asian countries need to be cautious about adopting solutions that work under different conditions. Shah and van Koppen (2006) argue that the promotion of integrated water resources management models, borrowed from wealthier countries with more developed economies and institutions, has done more harm than good in countries where the vast majority of water users are very small-scale and operate in an informal economic and institutional context. In other words, it is important to understand "what works on the ground and what does not, and devise indirect policy instruments to encourage or compel private institutional arrangements to meet public policy goals." (ibid.) Their argument is basically an evolutionary one: in countries where most water management arrangements are local and informal, governments have a limited capacity to influence these; they should, therefore, try to create a policy environment that encourages the evolution of effective local institutional arrangements, but also focuses direct interventions only on large-scale water users. Their argument is also cautionary: we cannot assume that direct interventions – social engineering – by the government or NGOs are feasible responses to the problems created by the motor pump revolution in Africa.

[5] Refer to http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/?cid=stelprdb1048809 (accessed on December 6, 2014).

Conclusion

Motor pump irrigation is beginning to revolutionize irrigated agriculture and rural development in SSA, in much the same ways as it has done in Asia. As in Asia, it is likely to enable millions of smallholder farmers to create wealth and move out of poverty, while also contributing to non-farm rural development as well as national economic growth. It is also likely to create a new generation of problems related to the management of and equitable access to scarce water resources, as it has in many parts of Asia. This is still an emerging issue in SSA, though it is already taking shape in some localized areas, including the Fogera case. We argue that the root of the problem is that, while traditional community-managed irrigation is perceived by both farmers and governments as having both technical and social dimensions, motor pump irrigation is viewed largely as a technological innovation. This narrow focus on technology repeats an earlier error committed by governments and donors promoting small-scale irrigation. Researchers and governments have focused on one institutional dimension: the need for an effective supply chain for pumps, spare parts and maintenance services; and markets for agricultural products. However, the need for institutional measures to guide pump-based irrigation and manage common water resources, such as small rivers and streams, remains a blind spot.

Local users' involvement and accomplishments in traditional irrigation reveal their experiences with collective action and their understanding of traditional irrigation as a social undertaking. The events that unfolded following the spread of motor pump irrigation is a result of over-reliance on a technological perspective, disregarding the social requirements of irrigation. If governments and farmers continue along this path, it will generate increasingly serious and intractable conflicts among users, concentration of resources in the hands of the more powerful local elites and ultimately serious degradation of a valuable resource. The impacts will go beyond agriculture and food security: shallow aquifers are a major source of domestic water in rural Africa, and indeed some governments, including that of Ethiopia, encourage "self-supply" of domestic water using pumps as an alternative to community-managed water supplies (Butterworth et al. 2013).

What can be done? We view the problem as a socio-technical issue in an integrated landscape context. There is growing evidence of positive outcomes of integrated landscape initiatives in SSA and elsewhere (Milder et al. 2014). While we are skeptical of the efficacy of direct government intervention in such complex local issues, there is considerable evidence that people can find creative institutional solutions for local resource management problems with facilitation and policy support from the government and NGOs (e.g., Komakech and van der Zaag 2011; Komakech 2013; Merrey and Cook 2012). More specifically, the promotion and facilitation of "innovation platforms", forums that include a wide range of stakeholders with shared interests, can enable people to identify a problem and potential solutions, test the possible solutions and implement them more widely if they work (Nederlof et al. 2011; Tenywa et al. 2011; Kilelu et al. 2013; Duncan 2011)[6]. In this case, such a platform might include the farmers pumping water from a shared stream or aquifer, local water and agricultural officials, wholesalers of agricultural products, and pump suppliers. All of these parties have a strong interest in the sustainable management of the common resource. Facilitators (who may be local extension agents, for example) can introduce solutions that have been tried elsewhere, and encourage discussion of how to share the limited water resources sustainably and equitably while also maximizing its productivity.

[6] In a *woreda* close to Fogera, the Global Water Initiative (GWI) is promoting "Learning and Practice Alliances," similar to "innovation platforms" (GWI 2013).

Encouraging the adaptation of institutional arrangements already used in other contexts to this new problem may also be effective. Transparent participatory monitoring of pumping and streamflow or aquifer levels can provide the information needed on the scale of the problem and trends over time. Depending on local conditions, local governments or community-based organizations can play a critical role in this process of monitoring, raising awareness and proposing solutions. Effective solutions will be context-specific: what works well in one country or even within a watershed in the same country may not be the best solution in another. Some governments may be tempted to try to limit the number of pumps through licensing or regulations based on their location and capacity. There is very little evidence from developing countries that such direct interventions have been successful. However, this may work where local governments are effective and have adequate resources. As rural electrification expands in the future, more opportunities may arise to use electricity management as a means of rationing of pumping as done in Gujarat, India. We recommend that governments should play a leading role in raising awareness among pump users and facilitating local problem solving.

Finally, further research can contribute greatly to promoting and sustaining motor pump-irrigated agriculture and its benefits. First, there is an urgent need to carry out more localized and detailed assessments of both aquifers and small streams: their locations, estimated flows or yields, aquifer recharge rates, water quality, and both the threats and opportunities affecting their sustained use. Second, we suggest that researchers carry out detailed multi-disciplinary case studies in areas where motor pump irrigation is expanding rapidly to identify emerging problems and responses, complemented by more extensive comparative studies, in order to understand the scale of over-use of common water resources. Evidence of the scale of the problem is critical to get the attention of policymakers. Third, returning to our theme of 'institutional creativity' discussed above, we would encourage participatory action-oriented research and experimentation in places such as Fogera to identify how external agents can best facilitate the emergence of local social arrangements or adaptation of existing institutional arrangements to address a new problem. Solutions cannot be imposed; they must emerge from recognition of the problem and agreeing to test solutions on the ground.

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RESEARCH PROGRAM ON
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ISSN: 1026-0862
ISBN: 978-92-9090-811-1