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BEYOND THE PROMISES OF TECHNOLOGY: A REVIEW OF THE DISCOURSES AND ACTORS WHO MAKE DRIP IRRIGATION[†]

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ABSTRACT

Drip irrigation has long been promoted as a promising way to meet today's world water, food and poverty challenges. In most scientific and policy documents, drip irrigation is framed as a technological innovation with definitive intrinsic characteristics—that of efficiency, productivity and modernity. Based on evidence from North and West Africa as well as South Asia, we show that there are multiple actors involved in shaping this imagery, the legitimacy of which largely stems from an engineering perspective that treats technology and potential as 'truths' that exist independently of the context of use. Rather than ascribing the advent of drip irrigation as a successful technology to intrinsic technical features, this paper proposes to see it as grounded in the ability drip irrigation has to lend itself to multiple contexts and discourses that articulate desirable futures. We thus adopt a view of technology whereby the 'real' (i.e. the drip irrigation hardware) acquires its characteristics only through, and within, the network of institutions, discourses and practices that enact it. Such a perspective sheds light on the iterative alignments that take place between hardware and context and treat these as inherent features, rather than externalities, of the innovation process. Copyright © 2014 John Wiley & Sons, Ltd.

KEY WORDS: innovation; water resources; agriculture; Africa; South Asia

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RÉSUMÉ

Depuis plusieurs décennies, l'irrigation au goutte à goutte est présentée comme une solution possible aux problèmes d'eau, d'alimentation et de pauvreté touchant la planète. La grande majorité des publications scientifiques ou des politiques abordant le sujet considèrent le goutte à goutte comme une innovation technique qui auraient des caractéristiques intrinsèques—l'efficacité, la productivité et la modernité. Sur la base de recherches comparatives menées en Afrique du Nord et de l'Ouest et en Asie du Sud, nous démontrons que de nombreux acteurs contribuent à façonner cette représentation positive partagée dont la légitimité est ancrée dans une perspective d'ingénierie qui érige technologie et potentiel en 'réalités' indépendantes du contexte d'utilisation. Nous n'attribuons pas le statut d'innovation à succès qu'a pu acquérir le goutte à goutte à de soi-disant caractéristiques techniques intrinsèques mais plutôt à sa capacité à faire écho à divers contextes et discours qui dépeignent des futurs souhaitables et souhaités. Nous adoptons ainsi une autre perspective sur l'innovation et la technologie; dans cette dernière, le 'réel' (le matériel goutte à goutte) n'acquiert ses caractéristiques qu'au travers des institutions, discours et pratiques qui contribuent à lui donner une existence. Une telle perspective permet de mettre à jour les ajustements itératifs entre matériel et contexte et les considère comme des éléments à part entière, et non des externalités, du processus d'innovation. Copyright © 2014 John Wiley & Sons, Ltd.

MOTS CLÉS: innovation; ressources en eau; agriculture; Afrique; Asie du Sud

INTRODUCTION

The concept of micro-irrigation—the slow and frequent application of water to the root zone of crops so as to be closest to their actual needs—is as old as time. Drip irrigation is one

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[†]Au-delà de la technologie et de ses promesses: les discours et acteurs qui façonnent le goutte à goutte.

form of micro-irrigation, the most widespread and well-known today, whereby water is delivered to the crops via a network of perforated tubes or pipes.¹ The improvement in plastic technology (and related decrease in cost) after the Second World War made drip irrigation technically possible while a better understanding of crop–water relationships (see, notably, Doorenbos and Pruitt, 1977) made its potential in terms of improved agricultural productivity (broadly defined as the ratio between outputs, i.e. yields and inputs such as water and chemicals) apparent.

Since the 1960s, when the first 'modern-day' drip irrigation systems started to appear in Europe, Israel and the United States (Ayars *et al.*, 2007), research and development efforts have mostly focused on refining drip irrigation to make it more efficient through the development of increasingly 'hi-tech' systems. In the late 1990s–early 2000s, a new strand of work focused on the development of (low-cost) drip irrigation for use in the developing world—on the grounds that widespread adoption by smallholders would have beneficial impacts in terms of poverty alleviation and enhanced food security at household and global level (Postel *et al.*, 2001).

In most scientific and development literature on the topic, drip irrigation is framed as a technology whereby the term 'technology' is used to designate hardware (i.e. the system composed of plastic pipes and emitters and ancillary devices) that is exemplified by intrinsic features. In such a perspective, technology exists independently from the environment in which it is being developed and used; the drip irrigation hardware acquires essential characteristics, valid everywhere. For example, it is efficient and productive, *per se*. In this paper, we suggest that a different definition of technology can yield alternative explanations on the worldwide dynamics of drip irrigation and hence provide a useful contribution to water debates. This definition looks at drip irrigation in terms of what it 'does' (its performance)² rather than what it 'is'. By so doing, attention shifts towards the networks of *actors* (the people inventing, fabricating, promoting and using drip irrigation material, and their motives) and the *actions* and *practices* (the ways people promote and use drip irrigation, including discursively) through which the *materiality* (the hardware) of the technology is realized or, in other words, to the iterative alignments between the hardware and its context (see Jansen and Vellema, 2011 for a detailed discussion of such understanding of technology and what it entails).

From such a definition, calls to recognize that *drip irrigation is not a silver bullet* emerge almost naturally. Readers of an earlier version of this paper pointed out this was not a novel argument but a rather widely accepted idea.³ We agree, but this is not our main contention. The framing of technology we propose allows for making the broader argument that the establishment of drip irrigation as a successful

innovation is not only linked to its so-called intrinsic technical features but has been actively pursued by coalitions of actors. These have constructed a positive drip imagery that fits and reinforces their respective values, interests and mandates. To make this argument, we first map the dynamics of drip irrigation as supported by public and private sector actors at global level. We then describe the multifaceted modalities of drip irrigation development in North Africa (Morocco), South Asia (India) and sub-Saharan Africa (Burkina Faso in West Africa), before drawing generic insights in a short conclusion.

MAPPING DRIP IRRIGATION REALITIES: ALTERNATIVE PERSPECTIVES

The first challenge to understand the dynamics of drip irrigation, and micro (or localized) irrigation in general, is that of data availability and reliability. The most recent ICID survey provides data on localized irrigation for 45 countries (reporting years vary between 1999 and 2012, depending on the countries). India, China, Spain, the USA, Italy, Korea, Brazil, South Africa, Iran and Mexico are, in that order, the 10 countries with the largest area under drip irrigation (International Commission on Irrigation and Drainage, ICID, 2012). Middle Eastern countries (United Arab Emirates, Israel and Jordan) have the largest drip irrigated area when expressed as a percentage of their national irrigated area. The Aquastat website of the Food and Agricultural Organization (FAO) presents agricultural and water data for 199 countries, but in the case of localized irrigation, and for the period 2008–2012, it provides statistics for 15 countries only. The number of countries with (non-nil) data on localized irrigation increases to 85 if the option 'latest value' is chosen—but some of this information dates back to two decades (Food and Agriculture Organization, FAO, 2013).

These observations are not meant to be a value judgment (global databases such as Aquastat are extremely valuable and difficult to update and manage). The limitations we point out are mere symptoms of a broader phenomenon, that is, the fact that the development and use of drip irrigation are multifaceted and that no single actor is in a position to monitor it. National governments and international aid agencies may support public drip irrigation projects, for which it might be relatively easy to get information (at least in theory, given the lack of coordination among donors and the difficulty to collect reliable agricultural statistics), but most growth in the sector is linked to individual strategies of farmers and agribusinesses (often in a conducive political context with subsidies) who directly deal with material dealers and manufacturers. In a competitive and growing sector, information has also become a strategic resource to

tap a profitable market (market research companies, for example, sell analysis of the micro-irrigation market trends and potential for several thousand dollars; the methodology used and source of data are not made explicit to the public; for instance Transparency Market Research, 2013).

In contrast to the usual map showing the extent of drip irrigation per country (the reliability of which can only be questioned given the lack of public data discussed above), we propose alternative maps that give a qualitative idea of where and how drip irrigation development and use take place. Figure 1 maps the sales effort of the three major manufacturers of drip irrigation material (Netafim, Naandan-Jain and John Deere Water Technology). We choose to represent this sales effort because these manufacturers play a pivotal role in current drip irrigation dynamics. Countries appearing on the map are those where at least one of the three above companies have manufacturing plants, subsidiaries and/or sales representatives. The darker the shade, the more plants and sales representatives can be found in the countries. National companies that distribute products from these three manufacturers are not considered here. This notably explains why North Africa does not appear in Figure 1 despite the tremendous expansion of drip irrigation it has witnessed over the last 20 years, as will be discussed below.

Figure 2 shows countries where development aid agencies, non-governmental organizations (NGOs) and social enterprises promote low-cost drip irrigation—often against the backdrop of supportive public policies. The two maps mostly differ in their representation (or lack thereof) of the African continent. This echoes two main discursive regimes that support the development of drip irrigation, and are called upon differently in different countries: one of agricultural intensification and modernization (North Africa, Latin

America) and one of poverty alleviation (sub-Saharan Africa mostly). India appears on the two maps: there, drip irrigation is both framed in terms of intensification and poverty alleviation (see below).

The two figures below are graphic illustrations of different trends in drip irrigation development worldwide. The following sections discuss the actors involved in shaping these trends and the discourses that underpin them, in three different countries: one that does not appear in any of the maps (Morocco), one appearing in both maps (India) and one appearing only in Figure 2 (Burkina Faso in West Africa). Our underlying argument is that drip irrigation exists only through these actors, institutions and discourses rather than being a reality of its own.

DIVERSE MODERNIZATION PATHWAYS IN MOROCCO

Discursive framing

In Morocco, the promotion of drip irrigation by the government finds its roots in a broader discourse stressing the need to modernize, that is, professionalize and intensify, the agricultural sector, upon which economic growth is predicated. One of the primary ambitions of the high-profile *Plan Maroc Vert* (Green Morocco Plan) under the patronage of King Mohammed VI of Morocco is indeed to transform the agricultural sector by making it an attractive business venture.

In a Mediterranean country, this discourse of agriculture intensification is intertwined with one of efficiency, notably regarding the use of scarce and overexploited water resources. Total water availability would indeed be dwindling

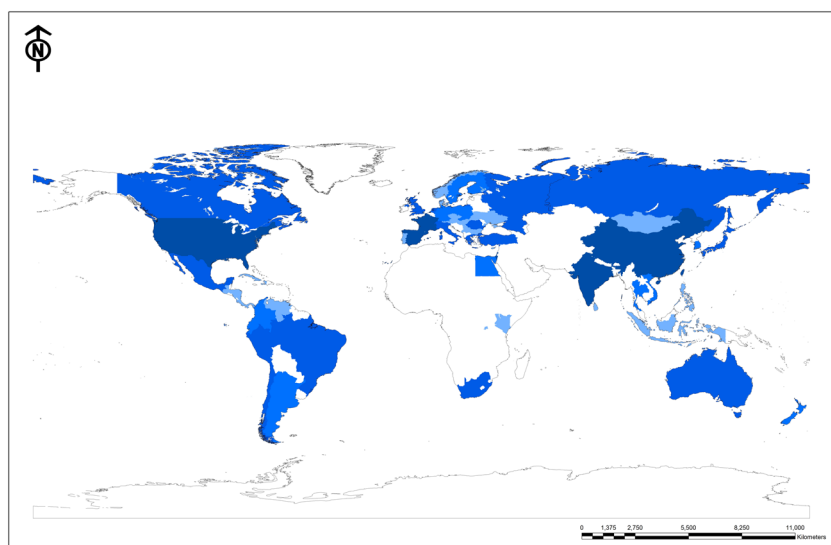


Figure 1. Manufacturing and sales effort of major drip irrigation manufacturers. This figure is available in colour online at wileyonlinelibrary.com/journal/ird

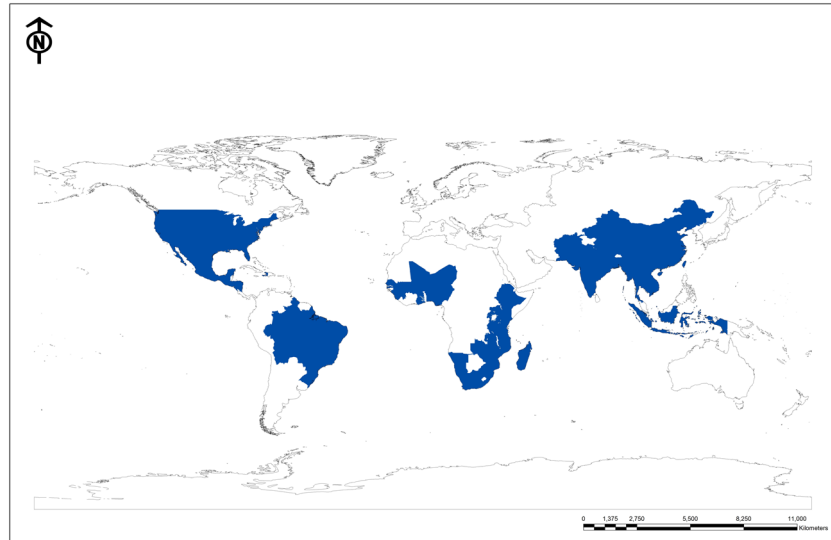


Figure 2. Promotion of drip irrigation by aid agencies, NGOs and social enterprises. This figure is available in colour online at wileyonlinelibrary.com/journal/ird

while agriculture remains the largest water use sector, in increasing competition with other more productive activities—industries and tourism notably. A large-scale shift to drip irrigation would then hold the promise of achieving the yet to be fulfilled irrigation potential while making significant water savings and reversing the trend of groundwater overexploitation (Ministère de l'Agriculture, du Développement Rural et des Pêches Maritimes (MADRPM), 2007).

Standardized systems and tinkering farmers

Since 1986, the government of Morocco has supported the development of drip irrigation through repeated subsidy programmes. The latest of these was initiated in 2006. It relaxed eligibility criteria and increased the level of subsidies from 30 to 80 and up to 100%, based on the diagnosis that drip irrigation had not spread as expected. These programmes mostly target large-scale public irrigation schemes (*grande hydraulique*) and private commercial farms, which are both seen as a priority given the scope for improving their 'high potential' (see, among others, Ministère de l'Agriculture, du Développement Rural et des Pêches Maritimes, MADRPM, 2007). Similar to other countries in the world, such subsidy programmes stress the need for quality systems. Eligibility is dependent on the use of certified equipment according to Moroccan norms (that are inspired by the International Organization for Standardization (ISO) norms), as well as on the formal recognition of a water right (either in the form of a well-drilling permit for groundwater or as a membership of a water user association). This limits the extent to which small farmers can benefit from these programmes, because of the high costs of certified material and the cumbersome administrative procedures to follow (Bekkar *et al.*, 2007).

The shift to drip irrigation in large command areas is often financially and technically supported by international donors such as the World Bank, the African Development Bank, the FAO, the Japanese International Cooperation Agency (JICA) and consulting companies. Such projects can be seen as artefacts of a public development arena involving international actors, the Ministry of Agriculture and its services at provincial and regional levels, the semi-independent Offices de Mise en Valeur, large- or medium-scale importers, manufacturers and retailers of drip irrigation material, and farmers who are generally organized in water user associations collectively shifting to drip irrigation. Converting large-scale publicly managed irrigation systems has long been a policy priority but progress has been slow and most projects are still in a pilot stage. This is partly due to the opposition of two decision-making logics, one of administrative and bureaucratic control (by state agents) and one of entrepreneurship (of farmers embedded in a market-oriented agricultural sector). Individual commercial farmers (*irrigation privée*) on the other hand obtain drip irrigation systems tailored to their needs, sometimes with the help of experts from manufacturers and retailers and with little interaction with public agencies except for submitting subsidy claims (which they do not always do).

Reinforcing the above dynamics is another more fragmented network largely based on, and supported by, farmers' own initiatives. The latter remain largely overlooked and are often not appreciated (on the grounds that they would be inefficient and non-professional) by policy makers and engineers even though they significantly contribute to the development of drip irrigation in Morocco. In large public irrigation schemes, the shift to drip irrigation often takes the form of turnkey projects whose sustainability

can be questioned as farmers are hardly involved in their design and implementation. In contrast, the diversity of systems observed in farmers' fields, outside these irrigation schemes, reflects the multiple motivations farmers may have to use drip irrigation. It is illustrative of what Benouniche *et al.* (2011) called a deconstruction of drip irrigation. This deconstruction allowed for the use of drip irrigation by a wide range of farmers because it removed the technical, financial and administrative constraints inherent in public-supported initiatives.

Two processes that reinforce each other are central to such deconstruction. First, and similar to the Indian case (see below), the emergence of small-scale manufacturers and retailers of drip irrigation material who specialize in producing and marketing relatively low-tech ancillary devices and second-hand material (such as filters imitating certified products from established manufacturers and that 'made their way' into the list of subsidized equipment). Second, the development of informal socio-professional networks of farmers, designers and agricultural merchants who progressively replace a dwindling public extension system by providing tailored expertise regarding the design, installation and management of small-scale drip irrigation systems to family farmers. These small-scale entrepreneurs do not operate in a vacuum as they generally acquire their expertise in large private farms or within the framework of large public drip irrigation projects (Poncet *et al.*, 2010; Benouniche *et al.*, 2011).

What appears central to the development of drip irrigation in Morocco is less the hardware (i.e. the system of pipes and ancillary devices) but the multi-nodal networks of innovation brokers that are shaping it in multiple ways.

THE MULTIPLE INDIAN DRIP IRRIGATION WORLDS

Discursive framing

Discussions around the promotion and development of drip irrigation in India revolve around the promises of such technology in terms of water saving. From the 1970s onwards, India has indeed witnessed a dramatic and mostly uncoordinated increase in groundwater use that was long supported by the government through subsidies for the digging of wells. Groundwater use has now reached unsustainable levels with widespread groundwater depletion, notably in peninsular India (see Shah, 2009 for a comprehensive description of groundwater development in India). Drip irrigation is being promoted by multiple actors (government, private companies and researchers alike) as a technological response to 'taming this anarchy'. The appeal of drip irrigation is reinforced by long-documented potential yield and productivity gains, as these would allow for a much needed intensification of

agriculture and a more efficient use of limited resources such as land, water and energy (electricity and inputs) (see, among others, Sivanappan, 1994 and Narayanamoorthy, 2004). The link made between agricultural intensification and drip irrigation gives grounds to current discussions and pilot projects around the conversion of large-scale surface irrigation into pressurized micro-irrigation systems (though, until now, drip irrigation has mostly been used in groundwater-based systems).

Another aspect of the drip irrigation debate in India is linked to the low expansion rate of, and aggregated area under, drip irrigation (accounting for a maximum of 5% of the total groundwater irrigated area) and on finding ways to kick-start adoption, notably among smallholders. Drip irrigation is indeed also framed as a promising innovation to enhance income generation and ultimately alleviate poverty. Attaining such social objectives would, however, require bridging what has been identified as a supply/demand gap between what the government is supporting and how (i.e. hi-tech systems through complex subsidy mechanisms) and what farmers need (simple, low-cost, easily accessible systems for higher yield; Verma *et al.*, 2004).

Public subsidies and private (social) entrepreneurs

In line with the dual debate briefly outlined above, two different coalitions of actors coexist in the Indian drip irrigation sector. These coalitions are not mutually exclusive but linked one to another, notably through the subsidy system put in place by the federal and state governments.

The government of India has long subscribed to the idea that drip irrigation has many benefits and significant potential in the country. This translated into the establishment of central schemes subsidizing micro-irrigation (and drip irrigation in particular). The latest to date is the National Mission on Micro-Irrigation (NMMI) launched in 2010 in which both the federal and state governments are meant to contribute. The federal government stresses the need for quality systems and provides general guidelines, notably by specifying the type (and costs) of systems that serve as the basis on which subsidies are calculated (Government of India (GoI), 2010). Such specifications appear disputed, for the very reason that underpins their establishment, i.e. standardization. On the one hand, large manufacturers such as Jain Irrigation Systems Ltd. and Netafim argue that it impedes the development of high-end, high-performing installations in which large agri-business could be interested (because these would not be subsidized). On the other hand, quality standards reduce incentives for registered manufacturers to produce low-cost products and limit the extent to which smallholders can benefit from the subsidy system—given the required initial investment costs that quality systems require (Pullabhotla *et al.*, 2012).

States have significant leeway to define the implementation modalities of the NMMI, notably regarding the status and composition of the implementation agency. The latter can be housed in an existing governmental agency (Andhra Pradesh, for instance) or be a form of public–private partnership (Gujarat, for instance). States also play a crucial role in registering manufacturers and suppliers whose products are eligible for subsidies (large manufacturers appear to be the most involved in the scheme) and in arbitrating allocation of funds between districts, while local self-governance institutions (at village level) set priority areas and identify potential beneficiaries. Pullabhotla *et al.* (2012) provide a description of the subsidy disbursement process in the case of Andhra Pradesh and Gujarat; a significant difference from the Moroccan case is that subsidies are received by suppliers/manufacturers—not by farmers, who pay their share in advance. Here, drip irrigation dynamics are grounded in a continuously negotiated multi-level interplay between the Indian bureaucracy, the private sector and elected local institutions (see Baviskar, 2004, for a description of the power relationships at play in another federal initiative supporting sustainable watershed development).

In parallel with large-scale initiatives promoting micro-irrigation, India has witnessed a tremendous increase in the number of small-scale manufacturers of micro-irrigation material, which constitute and supply what can best be termed a 'grey market'. Such small-scale enterprises are indeed legitimate but manufacture and market products that do not meet the standards set by the Bureau of Indian Standards. Such products are not eligible under public support programmes but they are also significantly cheaper, which makes them attractive to smallholders. Products can be assembled to form small-size low-cost/low-pressure drip irrigation systems (see Postel *et al.*, 2001 and iDE, 2005 for a detailed description of such systems). Retracing the origin of low-cost drip irrigation systems in India is like chasing rainbows. In the mid-1990s, the Non Governmental Organization (NGO) international Development Enterprise (iDE) promoted such systems on the basis of its Nepalese experience. Contrary to Nepal, India already had a well-developed drip irrigation industry (notably Jain Irrigation Systems Ltd), a multitude of small-scale entrepreneurs and a vibrant civil society. This meant that Indian low-cost systems would acquire unique technical characteristics—one of which being the indigenous experimentation and consecutive broad use of thin-wall plastic tapes and micro-tubes instead of drippers leading to further cost reduction (interview with iDE staff on 12 April 2013; Verma *et al.*, 2004). Identifying a potential market and competition, Jain Irrigation Systems Ltd started manufacturing low-cost drip irrigation kits while other civil society organizations such as the Aga Khan Rural Support Programme (India) also entered the field. With the multiplication of small-scale manufacturers, dealers,

distributors and assemblers that now characterizes the sector (Namara *et al.*, 2005), iDE branded its products under the name 'Krishak Bandu' (Farmer's Friend) as a way to differentiate them from other locally produced material said to be of lower quality. This also meant that a parallel NGO-certified network of manufacturers of low-cost drip irrigation material was established, the biggest of these manufacturers being Global Easy Water Products (GEWP; partly owned by former and current staff of iDE-India). A remarkable feature of low-cost drip irrigation in India when compared to sub-Saharan Africa is that ready-to-install drip kits are not the only option available to farmers who can also find the individual elements of these kits, manufactured by small-scale entrepreneurs, and assemble them according to their needs.

The Indian and Moroccan cases share many similarities, notably regarding the involvement of public agencies, which resort to public subsidies to support the development of drip irrigation, as well as the existence of a dynamic network of innovation brokers. In India, these are mostly manufacturing and supporting the dissemination of so-called low-cost drip systems (promoted by NGOs and social enterprises) rather than the more elaborate systems promoted by the government, as is widely observed in Morocco.

EXOGENOUS DRIVE IN SUB-SAHARAN AFRICA

Discursive framing

The debate around the promotion and development of drip irrigation in sub-Saharan Africa takes place in the broader framework of (public) development aid. Discussions are dominated by the necessity to design systems that meet the needs and specific constraints of smallholders and focus on the potential that such systems would have in terms of livelihood improvement, income generation, but also overall food security because of the sheer number of potential users (several millions; see, among others, Postel *et al.*, 2001). The focus is on designing so-called low-cost, adjustable in size, low-pressure, low-maintenance drip irrigation systems (see, among others, iDE, 2005). Focusing on the adaptability and small size of the technology allows for decontextualizing it. It gives weight to claims that such technological artefacts can be used by any farmer, anywhere (granted that farmers can access little water), and underplays the importance of structural conditions that might actually limit its applicability and potential benefits. Other narratives, of lesser importance but nonetheless regularly used to justify the promotion and use of low-cost drip irrigation, are that: (i) it allows for an efficient use of scarce resources, especially as climate change is looming; (ii) it is particularly adapted to women's needs and (iii) it is a way, among others, to intensify agriculture in a sustainable way.

Another narrative on African agriculture that has been gaining importance over the last decade is the potential, promise and need to develop agri-business on the continent. Public–private partnerships (PPPs) would then be a way to invest in the highly needed infrastructure to finally unlock the untapped irrigation potential of the continent (see e.g. World Bank, 2013). There is no specific recommendation on the type of irrigation infrastructure and technologies—though it is implicit that these should be 'efficient'. At the same time, micro-irrigation (and drip irrigation especially) is known to yield particularly good results for many commodities that are most attractive to business ventures (i.e. sugar cane, cotton, oil palm and horticultural crops; see Merry, 2003 in the case of sugar cane in Swaziland). Calls for an increasing involvement of the private sector in African agriculture go hand in hand with the development of elaborate drip irrigation systems. This will not be discussed in this paper, but is another trend that is closely related to the interplay between national government and private actors and would be worth a detailed investigation.

Drip irrigation farmers: the missing node in a far-reaching network?

This section provides a brief overview of the coalition of actors involved in the promotion of low-cost drip irrigation (LCDI), their motives and the strategies they use.

The first low-cost drip systems (called bucket kits) for smallholder farmers in the developing world were developed in the 1970s by a US-based company called Chapin Watermatics Inc. (the company also manufactured and sold typical drip irrigation systems in the US; it is now a subsidiary of Jain Irrigation Systems Ltd). Chapin Watermatics Inc. had a dedicated division called Chapin Third World Projects, which sold bucket kits to missionaries, humanitarian groups and NGOs. Many NGOs and Christian organizations, such as 'Chapin Living Waters [which] was founded as a means to express Christian love to needy people in third world nations through small-scale drip irrigation technology' (www.chapinlivingwaters.org) are still involved today in the promotion of bucket kits and other similar LCDI technologies. Inspired by the rhetoric of aid, many of these organizations give away drip irrigation kits to farmers (sometimes against a symbolic contribution).

From the early 2000s onwards, and based on an experience acquired in South Asia, other development actors started to promote drip irrigation kits in sub-Saharan Africa. These are NGOs and not-for-profit social enterprises of the like of international Development Enterprise (iDE) or Kickstart (iDE has notably played a pivotal role in refining the design and lowering the costs of drip irrigation kits; see above). They are mostly funded by bilateral and international development agencies as well as private foundations.

These NGOs and social enterprises receive a lot of attention, partly because they typify a new vision of development that emerged following a general disenchantment vis-à-vis (public) development aid—one that stresses the importance of the private sector and of approaching 'poverty alleviation as a business' (Heierli and Polak, 2000). This new vision of development tends to demystify the relationship between business and poverty, as social enterprises may have a dual goal: making a profit while contributing to a greater social good, for instance poverty alleviation or sustainable water use (for a detailed discussion see, among others, Dacin *et al.*, 2011).

One key feature of social entrepreneurship is to adopt a market-based approach whereby poor farmers are considered as customers rather than recipients of aid. In practice, however, this is still rarely the case in sub-Saharan Africa. Farmers rarely, if ever, seek drip irrigation kits and show little interest in using them. When they do so, it is often because kits are seen, or act, as a gateway to receiving other benefits such as inputs, water-lifting devices and credits (Belder *et al.*, 2007; Wanvoeke and Venot, 2013). There is a discrepancy between the discursive focus that social enterprises put on drip irrigation kits as a promising poverty alleviation tool for farmers (and women in particular) and what they actually do, that is, support the creation of a network of small-scale dealers and experts providing agricultural knowledge. Their main target (or customers) appears to be agricultural intermediaries rather than the farmers themselves and drip irrigation is only one of the technical options they promote. Most social enterprises are explicit about this strategy and justify it on the grounds that agricultural development depends on the existence of supply and value chains; they clearly articulate the fact that disseminating drip irrigation kits is not an end in itself. Yet, NGOs and social enterprises are embedded in a broader political economy of development aid and, in many cases, their existence hinges on their ability to partner with government and aid agencies. This means they often act as suppliers of drip irrigation kits to other development actors without giving much attention to developing a support network. The brief description of the drip irrigation sector in India and Morocco highlighted the importance of knowledge and technical intermediaries; these are still weak in sub-Saharan Africa, generally concentrated in the vicinity of large cities, hence distant from farmers, and, as far as drip irrigation is concerned, relying on external actors to import drip irrigation kits in the absence of a local manufacturing capacity.

In parallel with these efforts, bilateral cooperation agencies such as the United States Agency for International Development (USAID) and the Israel Agency for International Development Cooperation (MASHAV) have long supported national and international (International Crops Research Institute for the Semi-Arid Tropics, ICRISAT) research efforts aimed at assessing the potential of low-cost drip

irrigation systems in sub-Saharan Africa (e.g. Burney *et al.*, 2009; Woltering *et al.*, 2011). In some instances, this was done in partnership with large manufacturers such as NETA-FIM, which supplied drip irrigation kits of better quality but more expensive than the kits promoted by iDE. This involvement of large manufacturers has to be understood against the backdrop of a broader corporate social responsibility rhetoric that has gained in importance over the last 10 years (and is also illustrated by the support of John Deere Water Technologies for the Backpack Farm programme; www.backpackfarm.org) but is also related to discussions around the potential of profit making at the 'bottom of the pyramid' and that could be achieved by providing cheap products that would be affordable to billions of consumers (see, among others, Prahalad and Hart, 2002).

What this description highlights is that a coalition of actors has formed around the *idea* that low-cost drip irrigation has the potential to contribute to poverty alleviation in sub-Saharan Africa. What is remarkable is that this coalition sustains itself in the near absence of farmers who, in their large majority, quickly abandon the kits after gaining access to them (Kulecho and Weatherhead, 2006; Belder *et al.*, 2007). Actual drip irrigation by smallholders in sub-Saharan Africa remains marginal. A few individuals held up as successful examples of modern and innovative farmers are enough to entertain a positive drip imagery and justify widespread support and enthusiasm from governments, development agencies, NGOs and social enterprises. Such support is also legitimized by studies reporting that adopters and dis-adopters alike attribute a series of benefits to drip irrigation and that adoption challenges are linked to the context of use rather than the hardware itself (e.g. Friedlander *et al.*, 2013).

Drip irrigation gets to be defined as a successful innovation not because of what would be its inherent features (efficiency, productivity and acceptability) but because of what multiple actors *see* in drip irrigation, that is, a way to sustain a network of development discourses and practices.

CONCLUSION

The three case studies illustrate that drip irrigation systems worldwide are extremely diverse and defined through iterative context-specific alignments between hardware, actors, institutions and discourses. They shed light on a continuous and necessary re-enactment of drip irrigation, which is in stark contrast to the universal claims that have become widely associated with this socio-technological innovation—notably that of efficiency, productivity and modernity.

The emergence of drip irrigation as a successful innovation is grounded in its ability to play a part in a global narrative that tells of a desirable future. We have indeed shown that drip irrigation lends itself to three global

discourses that support the notion of sustainable development. Drip irrigation would (i) allow for an intensification of agriculture (economic development), (ii) allow for a more efficient use of scarce resources—notably water and energy (environmental protection), and (iii) contribute to poverty alleviation (social development). A wide coalition of international and national development organizations, policy makers, drip irrigation manufacturers, NGOs, social enterprises and influential spokespersons have actively shaped, promoted and legitimized what we see as a pluralistic 'drip dream'. Engineers who herald and demonstrate the technical potential of the drip irrigation hardware play a particularly pivotal role in instituting drip irrigation as a panacea. The engineering perspective indeed frames the technology and its potential as objective entities or 'truths', as is reflected in definitive statements such as 'drip irrigation works' or 'drip irrigation is efficient', which continue to be pervasive among professionals and the broader public—even though (some of) the former are well aware of the potential caveats of drip irrigation.

The first conclusion that emerges from the above is that drip irrigation is not a silver bullet, indeed. We go a step further when we argue that the imagery that 'drip irrigation can actively contribute to solving current water, food and poverty challenges' rests on a specific conceptual definition of technology. This definition ascribes the capacity to produce efficiency, productivity, modernity and fairness (pro-poor) to the technological hardware itself. We suggest it is useful to adopt a less widespread understanding of technology whereby the 'real' (in this case, the drip irrigation hardware) acquires its characteristics only through, and within, the network of institutions, discourses and practices that enact it. In this perspective, stating that 'drip irrigation is an efficient technology' becomes meaningless as it puts users beyond the frame of analysis and overlooks the continuous adjustments that take place between hardware and context and will determine whether (or not) the hardware is indeed used efficiently. This is not mere theoretical debate: considering actors and the way they use technological hardware (including discursively) as an integral part of the innovation process leads to broadening the realm of engineering design options, to recognize that the 'drip dream' is partly constructed to fit and reinforce the values and interests of specific actors, and ultimately to gain a more balanced understanding of what can be achieved, and where, in terms of sustainable water management and poverty alleviation through technological advances.

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NOTES

- ¹ There is a wide diversity of drip irrigation systems. These might be surface or subsurface; they may function at low or high pressure; water may be applied via holes directly punctured in pipes and tubes or via more elaborated inline emitters; there is also a whole range of ancillary devices: filters, injection pumps, etc. (for a discussion, see Burt and Styles, 2007).
- ² Our use of the word ‘performance’ does not entail a value judgement, contrary to how it is generally used in an engineering context whereby technologies are characterized as having a good or poor performance. Rather, we use the term in its broader sense as ‘the action or process of performing [executing] a task or a function’ (*Oxford English Dictionary*).
- ³ This paper was first presented at the First World Irrigation Forum in Mardin, Turkey, in October 2013.

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