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► **To cite this version:**

Jean-Philippe Venot. From obscurity to prominence : how drip irrigation conquered the world. Venot, Jean-Philippe (ed.); Kuper, M. (ed.); Zwartveen, M. (ed.). Drip irrigation for agriculture : untold stories of efficiency, innovation and development, Routledge, p. 16-37, 2017, Earthscan Studies in Water Resource Management, 978-1-138-68707-3. hal-03510531

HAL Id: hal-03510531

<https://hal.science/hal-03510531>

Submitted on 17 Dec 2023

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FROM OBSCURITY TO PROMINENCE: HOW DRIP IRRIGATION CONQUERED THE WORLD

Jean-Philippe Venot

Chapter 1 of the manuscript as accepted for publication in the Routledge/
[*Earthscan Studies in Water Resource Management*](#)

Venot, J.P.; Kuper M.; Zwarteveen, M. (Eds.). (2017). Drip Irrigation for Agriculture: Untold stories of efficiency, innovation and development. Routledge: Abingdon, UK.

Abstract

Over the last 60 years, drip irrigation has been envisioned according to a multiplicity of lenses: a way to extend agricultural land, to increase agricultural production and productivity, to modernize irrigation and use water efficiently and, more recently, to preserve water and contribute to poverty alleviation. This imagery has been progressively shaped first by public agricultural and irrigation engineers and now mostly by the private interests of large equipment manufacturers who manage to enroll policy makers and development operators. These narratives reinforce each other and this explains why drip irrigation “conquered the world”: the technology appears to be able to address global challenges, hence shaping a better future.

Introduction

Over the last 60 years, drip irrigation has evolved from an *experimental technology* tested in a few research stations in a limited number of countries to a truly *global phenomenon*. This chapter recounts the journey of how drip irrigation has become one of the most popular technologies in the field of irrigation and agriculture for professionals and the wider public alike.

This, the chapter will argue, partly hinges on the ability of drip irrigation to lend and reinvent itself in line with continually evolving dominant environment and development discourses. This “malleability” was not a given and emerged progressively as ever more people and organizations became interested and involved in the use and promotion of drip irrigation. These actors now form a loosely-bound but wide-reaching coalition through which drip irrigation artifacts (plastic pipes and emitters) are attributed inherent characteristics such as that of efficiency, productivity and modernity. The malleability of the technology and its systemic nature, in turn, allows multiple actors (including farmers; see chapter 15 and 16 for instance) to engage with it, adapt it to their context of use and specific needs, thus giving weight to far reaching claims of environmental preservation, agricultural modernization and poverty alleviation.

This chapters' objective is not to assess whether those claims are “real” (or not) but to understand how they have come into being; neither do we aim at a detailed ethnography of the way drip irrigation systems have evolved over time. Rather, we recognize their diversity but use the term *drip irrigation* to designate a concept (the frequent application of small quantities of water directly at the root zone of crops) and a suite of objects through which this concept is put into practice (a system of perforated plastic pipes, emitters and ancillary devices).

The chapter adopts a diachronic and geographic perspective and identifies “significant trends” regarding the way drip irrigation has been, and still is, envisioned. This is done on the basis of an extensive review of documents published since the 1970s (grey literature, journal articles, policy documents), an analysis of wide audience media pieces (news articles, blog posts, public statements) and key informant interviews with irrigation professionals who have been active in the field for several decades. The analysis also benefitted from the multiple interactions the author had with colleagues when preparing this edited volume.

The chapter starts by showing how data on drip irrigation, and the way they are discussed and presented, contributes to establishing drip irrigation expansion as a global imperative, notably pursued through far-reaching public subsidy schemes (section 1). The chapter then turns towards identifying the main discourses that have been associated with drip irrigation since the 1960s, and how these play out today in different regions/countries of the world (see the color section for a spatial illustration). Section 3 highlights that such drip irrigation discourses are not “de-incarnated” but have been actively shaped by multiple actors whose influence has waxed and waned with time. We notably show the importance of “mythical figures” to bring an “expert technology” out in the open, and the fact that agricultural and irrigation engineers working in public organizations have progressively lost ground vis-à-vis private manufacturing companies in shaping the debate around drip irrigation. A short conclusion recaps the findings.

Uncertain data but a general consensus to promote drip irrigation

As pointed out by Venot et al. (2014), a first challenge in attempts to understand the dynamics of drip irrigation relates to the availability and reliability of data. Most current drip irrigation development indeed takes place outside large scale public irrigation systems (whose extent is relatively well known) and is largely driven by private initiatives, which makes monitoring more difficult for governmental and international organizations.¹

The first multi-country assessment of the extent of drip irrigation use dates back to 1975 (Shoji, 1977). The International Commission for Irrigation and Drainage (ICID) conducted its first world-wide micro-irrigation survey in 1982 and has regularly updated it since (data is obtained from national irrigation and drainage committees). These surveys, however, remain largely incomplete (only 25 countries were listed in 1982 and 45 countries are listed in the most recent 2012 survey).² The surveys as well as the literature highlight that large scale use of drip irrigation

started in the 1970s in countries such as Israel, the United States, and South Africa. Countries in the south of the European Union joined the trend in the 1980s (Bucks, 1995; Reinders, 2000). Since the mid 1990s, most drip irrigation development is occurring in emerging economies; notably on the southern shores of the Mediterranean Sea, Latin America and Mexico, and above all China and India (which together are estimated to account for more than one third of the entire area irrigated with drip worldwide; see box 1 for a brief description of trends in China).

Box 1. China: A (not so) hidden giant?

In 2012, ICID evaluated at 1,6 million hectares the drip irrigated area in China, and some manufacturers do not hesitate talking of a growth rate of 20% a year,³ but it remains very difficult to assess the extent to which drip irrigation is used in China, especially for non Chinese scholars.

What is sure, however, is that China has emerged over the last few decades as a drip irrigation power house, both in terms of manufacturing capacity (alongside Israel and India) and drip irrigated area (alongside India). This has notably happened because of the strong support of the Chinese government whose priority is to support an agricultural boom in the country but is increasingly concerned by the unsustainable rate of groundwater abstraction in some of the most productive regions of the country (the north-western plains). The commitment of the Chinese government to promote drip irrigation has to be understood in this context and was clearly illustrated by the No. 1 document of the Chinese government of 2011. This high level policy document that identifies the government priorities focused on irrigation and identified “water-efficient irrigation technology” as a way to pursue the policy goal of “water conservancy” (USDA, 2011; Burnham et al., 2015). This priority notably translated in the form of subsidies to farmers for purchasing drip irrigation equipment (of more than 50% of the equipment cost), as well as low interest loans and tax reductions or exemptions for manufacturing companies.

If drip irrigation systems have long been used by smallholders in ‘traditional’ Chinese greenhouses for the production of vegetables, it is now mainly used for cotton cultivation, most noticeably in the semi-autonomous arid region of Xinjiang in the extreme west of China, but also for sugarcane and maize production. Apart from the Xinjiang region, the semi-arid provinces of the northwestern plains (such as Gansu, Shaanxi, Ningxia) are a hot-spot of drip irrigation use as well. It is no surprise that the major equipment manufacturers are located there.

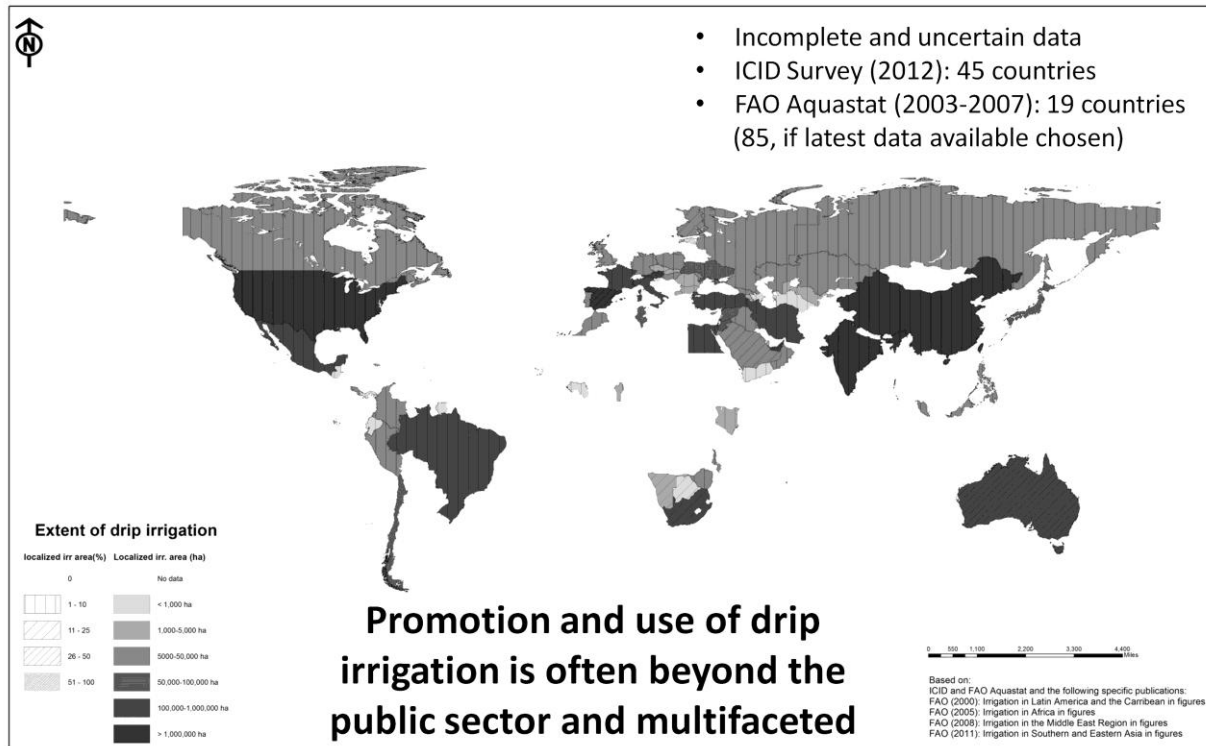
Drip irrigation was introduced by governmental research institutes in the 1970s but it is only in the 1990s that the drip equipment manufacturing sector got structured. The three biggest equipment manufacturing companies were set up in the late 1990s (Xinjiang Tianye Water Saving Irrigation and Dayu Conserving Water Group in 1999 and Gansu Yasheng Industrial Group in 1998); since the mid 2000, they are registered on the Chinese stock market. In addition to these giants, there are probably over 500 small and medium scale manufacturing companies. Taken together, the manufacturing capacity of Chinese companies would reach about 2 billion meters of drip line a year (that is, if a spacing of one meter is considered, the equivalent of

200,000 hectares/year) (Tianye, on its website, announces that the total cumulative irrigated area that could be equipped with the equipment it manufactured reaches 4 million hectares in China – this includes other equipment than drip irrigation such as sprinklers and pivot <http://www.tianyejieshui.com.cn>). Chinese manufacturing companies conduct most of their business in China but some also try to enter the international market – notably through acquiring foreign companies. On the other hand, many large non-Chinese drip irrigation companies have offices and distributors in China. They tend to highlight the quality and ‘high-tech’ nature of their products as most Chinese companies still manufacture relatively simple (and cheap) products. Entering the Chinese market for international actors does not seem to be an easy task, as can be illustrated by the history of Netafim in the country. The company first entered China in 1994; in 2000s it partnered with a Chinese company and built two plants there that were shut down in 2008. Only in 2016 did Netafim open a new plant in Ningxia, hoping to benefit from the booming wine industry of the region. The company is also looking at partnering with Chinese fertilizer companies to expand its business, communicating on the potential of drip irrigation in terms of input optimization through fertigation (the use of soluble fertilizers) (<https://www.netafim.com/news-item/231841>; <http://www.ft.com/intl/cms/s/2/24e45b40-3b00-11e2-bb32-00144feabdc0.html#axzz303cS9mWm>) (see also see Guerra et al., 2009 for an overview of the irrigation industry sector, in relation to John Deere Water investments).

In 2012, and still according to ICID, India, China, Spain, the USA, Italy, Korea, Brazil, South Africa, Iran, and Mexico were, in that order, the 10 countries with the largest area under drip irrigation (ICID, 2012). Middle-eastern countries (United Arab Emirates, Israel and Jordan) had the largest drip irrigated area when expressed as a percentage of their national irrigated area (ICID, 2012) (see Figure 1). The statistics as well as scholarly analysis further show that drip irrigation is mostly used for vegetable crops (in open fields or greenhouses), fruit trees (including vine), as well as industrial crops such as cotton and sugarcane (Ayars et al., 2007; Narayanamoorthy, 2004). Indeed, countries in which such crops are common are also the countries in which drip irrigated areas are largest (see the list above).

Although data are few and unreliable, there is a striking commonality in how the data that are available become part of larger narratives. For scholars, governments and the wider public, the tremendous growth observed over the last few decades (though it is not supported by consistent statistics) serves as proof of the multiple benefits that drip irrigation can bring to farmers and the society as a whole (indeed, why would it spread so quickly if it was not good?). Most scholars and policy documents further highlight, however, that drip irrigation **still only** represents a marginal share of all irrigation worldwide (about 5%; ICID, 2012), especially in emerging economies and developing countries (see GoI, 2004; Narayanamoorthy, 2008 on India and Zhu et al., 2013 or Zou al., 2012 on China). They also stress that drip irrigation is concentrated in a limited number of countries (when taken together, the USA, Spain, China and India account for two thirds of all drip irrigated areas) and lament the fact that its benefits are still largely eluding smallholder farmers notably because of high investment costs (Hillel, 1988; Postel et al., 2001).

Figure 1: A worldwide map of the importance of drip irrigation: data shortcomings



- Incomplete and uncertain data
- ICID Survey (2012): 45 countries
- FAO Aquastat (2003-2007): 19 countries (85, if latest data available chosen)

Contrasting the tremendous expansion with the limited actual extent of drip irrigation use is not a neutral way of telling the drip irrigation story. It serves as a justification for massive public investment and lending schemes, in support of the promises of drip irrigation for a better future (and that even if a large share of the world’s irrigated food crops – rice, wheat, maize are little adapted to existing drip irrigation systems). Many governments have engaged in aggressive policies to increase the share of the irrigated area under drip irrigation.

Public policies often take the form of subsidy programs that are, depending on the country, said to contribute to broader agricultural development and/or water resources management policies. They are also invariably justified on the ground that high initial investment costs still constitute a major barrier for farmers to adopt drip irrigation (drip-kits put aside), especially in emerging economies and developing countries (Postel et al., 2001; Ayars et al., 2007).

The map in the color section spatially represents the main discursive frameworks that underpin public policy and international development programs promoting drip irrigation around the world (the level of analysis is the country; the map is based on a review of available policy and development projects documents). In India, for instance, federal level financing schemes to promote drip irrigation have been launched in the early 1980s and have remained un-interrupted since then, culminating in the National Mission on Micro-Irrigation (NMMI) in 2010 (Venot et al., 2014; chapter 18). Drip irrigation was first seen as a way to promote a “modern” (i.e.

productive) agricultural sector; over the last two decades, however, the government primarily justified subsidy schemes on the basis that extending the area under drip irrigation (a technology that allows efficient water use) would alleviate the current pressure over groundwater resources, which are unsustainably tapped in many parts of India. Subsidizing drip irrigation is also presented as a way to include smallholders (who have limited financial resources) in the on-going efforts to build a modern and intensive agricultural sector (see Chapter 18 for further discussion on a subsidy scheme adopted in one particular state of India, Gujarat). In the same way, in Morocco, drip irrigation has been at least partly subsidized since 1986 onwards (Venot et al., 2014). The recent national plan for water saving in irrigation (PNEEI) as well as the Green Morocco Plan (the national agricultural policy) have led to a massive conversion and extension of areas under drip irrigation. In Morocco, subsidies schemes are said to serve the objectives of preserving groundwater resources and modernizing low performing public irrigation schemes (see chapters 5, 6 and 10, this volume).

Among the 10 countries with the largest drip irrigated areas in the world (see above), Mexico (since 2003; see chapter 9), Iran (since 1990), and China also subsidize the installation of drip irrigation systems. In Mexico and Iran, subsidizing drip irrigation is part of broader irrigation modernization projects and is also said to contribute to water preservation (for Iran) and agricultural intensification (for Mexico). In China, the primary stated objective to subsidize drip irrigation is “water conservancy” (see box 1). Other countries such as Chile, Iraq, Oman, Pakistan, Peru (through the irrigation sub-sector project, which started in 1996), the UEA, Syria, Tunisia, and Turkey provide direct subsidies to the installation of on-farm drip irrigation systems.⁴ Broadly speaking, governments in South America generally justify subsidizing drip irrigation as a way to trigger a shift towards a modern and intensive agricultural sector; in the Mediterranean region and the Middle-East, the “(ground)water conservation argument” is more prominent. In both regions, and notably in countries with large canal-based irrigated schemes, subsidizing drip irrigation is seen as a way to modernize low performing irrigation systems, which also receive significant attention from international development organizations (this is also the case in Egypt where drip irrigation is seen as a way to extend irrigation in desert areas while improving the management of irrigation systems in the Nile delta).

Support to drip irrigation can also take the form of tax exemption (e.g. Uzbekistan); low-interest loans on drip irrigation equipment (e.g. Iran, Syria, Brazil, micro-credit in sub-Saharan Africa); and subsidized seedlings for crops seen as particularly adapted to drip irrigation (such as date palm trees in Saudi Arabia, where the government also buys dates at a fixed price).⁵ Agricultural policies and water laws may also indirectly favor the use of drip irrigation, as for instance is the case in Peru where getting water rights is tied to using “efficient technologies” (see chapter 8). Finally, in the least developed countries, support to drip irrigation does not take the form of direct subsidy schemes but of projects funded and implemented by public agencies and the third sector (NGOs, development agencies, private foundations, and national government; see chapters 12, 13, 14).

The multiple and reinforcing framing of drip irrigation

The map in the color section provides a snapshot of current discursive framings of drip irrigation, taking countries as the unit of analysis. However, the way drip irrigation has been seen, perceived and discussed in each of these countries has evolved with time, in relation to global discourses in the inter-related sectors of irrigation, agriculture and water management. The current “multiplicity of drip” was not a given when the first large scale experiments took place after the second world war; it emerged with time and several periods can be identified since the 1960s.

The 1960s and 1970s (when experimentations with drip irrigation were increasingly taking place in the United States, Europe, Israel but also in India) are the decades of the Green Revolution, a term that refers to a tremendous increase in the production and productivity of agricultural crops. At the time, it is the *yield increase* allowed by drip irrigation (thanks to better matching crop water requirements)⁶ together with the facts that the technology made it possible to *extend irrigation* to areas that could not be otherwise cultivated as well as to *use low quality water* that attracted most attention. That drip irrigation allowed extending cultivation in arid regions (with sandy and little fertile soils) led to the fact that the technology became closely associated with the attractive image of a ‘blooming desert’ (see, picture 9 and 10 in the color plate). This was recently re-highlighted when Daniel Hillel was awarded the World food Prize in 2012, and also underpins current drip irrigation dynamics in the coastal area of Latin America (see chapter 8 and the map in the color plate). At the time, the fact that drip irrigation allowed *optimizing fertilizer application* (through fertigation, which consists of applying soluble fertilizers together with irrigation water) and *saving labour* (in developed economies) was the object of much attention too. In short, in the 1970s, drip irrigation was mostly discussed in relation to *agricultural intensification*. This is still the case, as highlighted above, in developed economies, many South American countries as well as China.

In the mid to late 1980s, things started to change. These were the times when irrigation performance started to be questioned and there were increasing calls for irrigation “modernization”, intended as “a process of technical and managerial upgrading combined with institutional reforms, with the objective to improve resource utilization (labour, water, environment, economy) and water delivery service to farmers” (Facon and Renault, 1999). In some contexts, the modernization debate led to talk of pressurizing open canal systems or building pressurized systems from scratch (US, Europe but also the Middle East, most noticeably Israel and Jordan and the United Arab Emirates) in order to increase irrigation efficiency (that is, limit water losses through evapotranspiration and open conveyance systems). The consequences of shifting from canal to pressurized drip irrigation have been particularly intense in Spain where the government supported massive irrigation modernization programs (see for instance, Lopez-Gunn et al., 2012). In policy discussion, the *high efficiency* of drip irrigation as a *modern technology* was often contrasted with the wastefulness of traditional irrigation methods, and it was this efficiency that took centre stage (see van der Kooij et al., 2014 and chapter 5 for critical

reflection on the notion of efficiency and the uses made of it). Such framing has now “lost” in importance at global level but still plays out in countries with large publicly managed irrigation systems such as Turkey, Egypt, Pakistan, Mexico, Brazil, and countries of Central Asia.

The most significant change may have happened in the early 1990s. It can be traced back to the 1992 Earth Summit held in Rio de Janeiro, which established “sustainable development” (a term first coined in WCED, 1987) as a global policy goal and dominant development discourse. The fact that the global debate on sustainable development influenced the way drip irrigation was perceived is clearly reflected in the 5th micro-irrigation congress, the first of the series to have a title that reflects environmental concerns: “*Microirrigation for a changing world: Conserving resources/preserving the environment*” (ICID, 1995). Drip irrigation became to be seen through the lens of the environment, and with it the *potential water savings* produce became its most important feature; irrigation modernization programs started to be assessed and evaluated through this lens, most notably in Spain (see above).

The 1990s are also the decade during which irrigation largely fell out of the favor of the international community. Returns to public irrigation investments had been notoriously disappointing, whereas the negative consequences of large infrastructural works (notably in dams and canals) started raising critical questions at international level. In addition, the rapid rise in the popularity of neo-liberal ideologies (after the collapse of the Soviet Union and the fall of the Berlin Wall had reduced the appeal of and belief in socialist forms of government) made it increasingly difficult to defend spending so much public money on the construction, operation and maintenance of public irrigation systems. In the late 1990s and early 2000s, the water issue started to be framed as a tension between the environment and agriculture in a context of growing scarcity and competition over water. Agriculture was pointed out as being the single main water user and irrigation as wasting a significant share of it, as many observers emphasized the low efficiency of most irrigation worldwide (for instance, Postel, 1997; Gleick, 2003). The question became: how to save water in agriculture so that it can be allocated to other uses – including the environment. Despite a growing debate on the water saving potential of drip irrigation in absolute terms (see for instance, Seckler, 1996; Perry, 2007; Molle et al., 2010 as well as chapter 5, this volume), the alleged *high efficiency* of drip irrigation continued to be a defining element of the discourse.

Rather than being framed from an engineering point of view (as had been the case in the 1980s when modernizing irrigation was hot on the agenda), the question of efficiency was primarily discussed in relation to the alleged potential that drip irrigation held in terms of *preserving water resources* from overexploitation. This happened at a time when groundwater use in irrigation skyrocketed worldwide (especially in the developing economies of India, China and the southern shore of the Mediterranean) leading to declining water tables (see Shah et al., 2007 for an analysis of groundwater development trends in the agricultural sector). This focus on the potential that drip irrigation would hold in terms of preserving (ground) water is very much to the

fore in North African and Middle Eastern countries as well as China and India (see chapter 5 for a critique of this argument, on the basis of a case study in Morocco).

The mid 2000s, characterized by a renewed concern for food production and food security (notably heightened by the 2008 food crisis) constitute another turning point. Bringing together two distinct narratives, that of *agricultural intensification* (prominent in the 1970s) and of *water use efficiency* (prominent in the 1980s), drip irrigation became the material embodiment of a broad agricultural development discourse stressing the need for “more crop per drop”, which combines calls for intensifying agriculture with the need to preserve natural resources as well as a technology for adaptation to climate change (UNFCC, 2006; Clements, 2011; ADB; 2014).⁷ In recent years, in relation with the emergence of the new water-food-energy nexus vocabulary (see Allouche et al., 2015) drip irrigation is also increasingly framed as *an energy saving* technology, notably in India. The energy saving argument is closely linked to the water saving idea that underpins many drip irrigation promotion initiatives. Indeed, by supplying water more efficiently to crops, drip irrigation would allow pumping less water per unit area (see chapter 5), hence using less energy.⁸ This is a contentious issue as other scholars highlight that the need to pressurize water to use drip irrigation is a reason for the booming energy consumption in agriculture (see, for instance, Rodriguez-Diaz et al., 2011 in the case of Spain).

At the same time, a parallel discourse the basis of which had been laid out as early as 1988 when Hillel (1988) highlighted that most drip irrigation development eluded small farmers in the developing world, started to take ground. This discourse centered on the potential of drip irrigation as a *poverty alleviation* tool. This new “feature” of drip irrigation is related to what Postel et al. (2001) identify as the existence of “*a new spectrum of drip systems [that] can form the backbone of a second green revolution, this one aimed specifically at poor farmers in sub-Saharan Africa, Asia, and Latin America*”. The late 1990s and early 2000s have indeed been marked by significant efforts from Non Governmental Organizations (supported by national and international aid agencies), social enterprises, international agricultural research centers, and private irrigation equipment manufacturers to design and disseminate systems that would soon become to be known under the generic term of “drip-kit”. Drip-kits are widely presented by those promoting them as being affordable, small-size, and infinitively expandable. These are all features that make them (seem) particularly suited for meeting the specific needs of smallholders in the developing world. Their small size, low cost and aptitude for irrigating vegetables, in addition, makes it easy to align them with goals of **women’s empowerment**, based on the idea that female farmers can make use of the technology in their kitchen gardens (see among others, Polak, 2008; see also chapters 11, 12, 13 and 14 as well as picture 12 and 13 in the color plate).⁹

If the main discursive justification of NGOs disseminating these drip-kits is to support smallholder farming and contribute to transforming it into an entrepreneurial venture, large scale equipment manufacturers promote these smallholder drip irrigation systems as part of a broader Corporate Social Responsibility rhetoric¹⁰ but also in an attempt to tap into an important market;

the so called “Bottom of the Pyramid” (see Venot, 2016 for a critical analysis of these processes). The *poverty alleviation* potential of drip irrigation currently underpins efforts to promote the technology in most of sub-Saharan Africa, some countries of South and Central America (Bolivia, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, etc.) and others in South and south-east Asia (Bangladesh, Nepal, Myanmar, Cambodia, and Indonesia).

What is striking in this short historical review is that, over time, and at global level, drip irrigation has increasingly come to be discussed in relation to water resources management (and more broadly poverty and the environment) and less and less for its agricultural benefits (higher yields, input optimization, labour savings) that had made its early fame and are still the main reasons why farmers start using it. But what is also central to explain how drip irrigation “conquered the world” is the fact that one story does not replace the other, rather they “add-up”, reinforce each other, with the emphasis shifting depending on context as shown in Figure 1, thus defining a true “panda” (see the introduction of the book). The following section highlights that the discourses and (policy and development) initiatives promoting drip irrigation are not de-incarnated; they have been actively shaped and the trends described also reflect changes in the actors who are the most influential in shaping the debate around drip irrigation.

A wide reaching and multi faceted advocacy coalition

The “Mythical” figures

One of the reasons drip irrigation “conquered the world” is linked to the fact that the technology found powerful advocates in a number of people from different backgrounds, pursuing different goals, and embedded in different social networks. To use the term of Madeleine Akrich (Akrich et al., 1998a,b) , these individuals acted as “spoke persons” and created “interessement” in an ever widening coalition of actors who supported the dissemination of drip irrigation. These individuals came to personify some of the key discursive regimes of drip irrigation; hence lending it weight.

Most authors agree that the concept of drip irrigation (that is the slow and frequent application of water to the root zone of crops) is as old as agriculture (for instance Goyal, 2015) and trace back “modern day” drip irrigation to experiments with underground clay pipes that took place in the second half of the 19th century (1860s-1880s) in Germany and the United States (Ayars et al., 2007). The introduction of perforated pipes in the 1920s in Germany constituted a significant breakthrough as did the improvements in plastic technology: during the Second World War, perforated plastic pipes were used for vegetables production in greenhouses in the United Kingdom, France and Germany (Ayars et al., 2007; Goyal, 2015). Experiments in the 1950s followed in the United States and Israel and led to patents on emitters. This is when the personalization of (the history of) drip irrigation really begins.

Simcha Blass, a water engineer also known for having played a key role in the early years of Mekorot (the national water agency of Israel) and the elaboration of a “fantasy plan” to irrigate the Negev in the late 1930s (a plan that would lay the basis for supplying water to Jewish settlements in the area and also formed the start of the future National Water Carrier)¹¹ is commonly attributed (together with his son, Yeshayahu) the first patent of a coiled in-line emitter (allowing the slowing of water flow and avoiding clogging) (Shoji, 1977; Ayars et al., 2007). That the role of Simcha Blass in drip irrigation development has attracted significant attention and has found its ways in collective memories can partly be explained by the fact that the contract he signed with the Kibbutz Hazerim led to the establishment of the NETAFIM company. This company would later become the largest manufacturer of drip irrigation equipment worldwide (see below) and pursues very aggressive communication campaigns. He became to be seen as an example of an Israeli innovator-entrepreneur, who allowed for making the Israeli desert “bloom”. In the same vein, Daniel Hillel has received recent attention for the role he played in the development of drip irrigation, first in the Negev desert of Israel in the 1960s and in its dissemination in other countries of the world during the following decades. A soil and water scientist who has been affiliated to several Israeli and American universities, he closely worked with international organizations such as the United Nations and the World Bank. He was awarded the 2012 World Food Prize on account of “*his role in conceiving and implementing a radically new mode of bringing water to crops in arid and dry land regions - known as “micro-irrigation”.*” (<http://www.worldfoodprize.org>). Daniel Hillel impersonates this ambition to make “the desert bloom” but also an aspiration for making agricultural transformation and modernization benefit smallholders in developing countries – which has been most noticeably associated to other individuals since the 1970s.

Richard D. Chapin, the founder of a small irrigation equipment manufacturing firm in the United States, Chapin Watermatics, is also presented as an individual having been instrumental in developing drip irrigation. He is notably attributed with the development of drip-tape (thin plastic tubing) and early experiment with plastic mulch in the 1950s (Ayars et al., 2007); but also with designing and disseminating (through a dedicated foundation) the first small-scale drip irrigation systems specifically targeting farmers in developing countries in the 1970s, at the request of the NGO Catholic Relief Services (Keller, 2000; Venot et al., 2014; chapter 11). In the late 1990s and early 2000s, the poverty alleviation potential of drip irrigation has also been impersonated by yet another American entrepreneur, Paul Polak, founder of International Development Enterprises (iDE) and by an Israeli researcher, Dov Pasternak. The former attracted attention less for his role in developing drip irrigation systems per se and more for his unapologetic call to adopt a “business approach to poverty alleviation”. He advocated a system based on the sale of affordable products to farmers. The enterprise would make a small margin on each sale (hence being a profitable venture, e in itself); that poor farmers bought the product acted as a proof of the added value of the latter and of the fact that farmers derived economic benefits from it.. (Polak, 2008; Polak and Warwick, 2014; see Venot, 2016 for a critical analysis). The latter has been pivotal in harnessing support from development aid agencies and private manufacturers of drip

irrigation equipment for the dissemination of “drip kits”, notably in sub-Saharan Africa (see Wanvoeke et al., 2015).

Through these individuals and their work, a picture of the different types of actors who have played and still play an active role in shaping the imagery of drip irrigation worldwide emerges too. The supportive coalition for drip irrigation includes irrigation and agricultural engineers (and their professional organizations); public research centers and universities; private companies; NGOs and social enterprises; and international or national development agencies. When tracing the history of drip irrigation, what becomes clear too is that drip irrigation is far from the “neutral” technology that is often described. On the contrary it has long been, and still is, clearly associated with particular political and ideological movements and agendas (the Kibbutzim in the early years of Israel; the dream to make the desert bloom in the same country but also others such as the USA, Peru and Algeria (see chapters 8 and 16); the “will to improve” that drives development agencies; or the search of modernity through technology and entrepreneurship as articulated by social enterprises).

Public irrigation research: Highlighting efficiency and productivity

Less publicized but also central in establishing drip irrigation as a technology that would become to be associated with notions such as efficiency, productivity and input optimization is an “army” of agricultural and irrigation engineers working in research and development organizations, universities of developed countries, as well as extension services and agricultural ministries. ICID, the main professional body for irrigation practitioners and researchers, constituted the main platform through which international experiences with drip irrigation were shared. Even though most work in the sector still related to canal based irrigation, an increasing number of actors became involved in drip irrigation research and development during the 1970s-1980s (in 1985, the contributions of more than a 100 individuals were already acknowledged; Bucks, 1995).

The increasing attention towards drip irrigation among irrigation professionals is illustrated by the existence of a series of International Microirrigation Congresses, the first of which was organized in Israel in 1971. From the mid 1970s to the mid 1990s, engineers and researchers from the US Department of Agriculture-Agricultural Research Services (USDA-ARS) appear to have been particularly active in these events, as shown by the fact that 3 of the successive 4 international micro-irrigation congresses were held in the United States in 1974, 1985 and 1995 (in 1988, the congress was held in Australia).¹² Such congresses played a key role in establishing the technical and scientific legitimacy of drip irrigation as a technology allowing to (1) use water (more) efficiently than canal irrigation; (2) save labour in intensive agricultural systems; (3) and improve yields (both in quantity and quality (see, for instance, ICID, 1995). At the time, the debate and discussions revolved on identifying and establishing the conditions for drip irrigation to fulfill a potential that had been demonstrated in experimental plots as well as closely monitored farmers field. It involved significant expert-led refinement of the technological

artifacts and discussion around the elaboration of (quality) standards (see box 2) and certification by professional authorized bodies.

The fifth international microirrigation congress organized in 1995 marks the height of this era of irrigation engineering research. At the time, research focused on (1) determining water requirement and irrigation scheduling; (2) development in nutrient management, fertigation methods, and water quality issues, (3) system design and uniformity; (4) the development of decision support tools and simulation models (Phene, 1995). From 1995 onwards, the influence of ICID as a global knowledge broker on drip irrigation progressively waned. Three subsequent international micro-irrigation congresses were organized in South Africa (2000), Malaysia (2008) and Iran (2011). These attracted less interest and attention than the 1995 congress (a much lower number of papers were presented during these meetings), but provided room for discussing drip irrigation in the context of emerging and developing economies.

That ICID became less pivotal perhaps can be attributed to the fact that drip irrigation became increasingly discussed in relation to water rather than agriculture while its members are first and foremost ageing (male) agricultural and irrigation engineers. It is also linked to a widespread feeling among these individuals that the potential of drip irrigation (in terms of efficiency, productivity, and scope of use) had been clearly demonstrated and that little interesting work (read: technical oriented research) remained to be done, as well as to dwindling investment (at least in Europe and the United States) in training, research and education in the field of irrigation engineering.

Box 2. An elusive search for standards?

At a time where certification schemes (built on a sets of ideas and standards; see box in Chapter 8 for instance) are gaining in importance in the agricultural and water sectors, the drip irrigation sub-sector stands aside and is conspicuous by the near absence of standards.

The issue of elaborating standards for drip irrigation systems has, however, long been debated among irrigation professionals as illustrated by the existence of an ISO subcommittee on “irrigation and drainage equipment and systems” since the late 1970s (Baudequin and Molle, 2003).¹³ The “proponents” of elaborating standards argue that the latter can act as a guarantee of “quality” (material and installation), which they see as a prerequisite to fulfill the potential of the technology (be it in terms of water saving or yield improvement). The “opponents” to elaborating standards, on the other hand, stress that, given the systemic nature of drip irrigation systems (they are, by essence, networks), this is an impossible task. Indeed, standards could not possibly account for the diversity of on-farm situations and would act as impediments to innovation by users (see, for instance, Solomon and Dedrick, 1995). The opponents to “strict standards” see the boom of drip irrigation development as a proof that the latter are not needed. They however also stress that many systems observed function in a sub-optimal way, and attribute this to the fact (1) that the systems are not designed or used according to “good engineering practice” or (2) that the actual discharge of the drippers differ from the nominal value displayed by the manufacturer.

These discussions over standard development mostly take place among private manufacturers, industry associations whose *raison d'être* is to further develop and promote irrigation businesses (such as the US-based irrigation association and the EU based European Irrigation Association), national and international standard agencies, and public testing laboratories. Farmers (who use drip irrigation systems and are presented by irrigation professionals as being the ultimate beneficiaries of standard development) are rarely contributing to these debates and meant to be represented by research laboratories –though the latter appear to be far from farmers’ realities (see box on field-measurement performance level in Chapter 5).

Against this backdrop, and since its creation, the ISO sub-committee has endorsed over 30 international standards. A similar number of standards have also been developed by the American National Standards Institute (ANSI) and the European Committee for Standardization (ECS). Several countries such as Morocco and India also have their own standards, which need to be followed by farmers if these want to benefit from the public subsidies.

Most existing standards at international level are “design standards” for specific pieces of equipment (notably ancillary devices such as filters or pumps) and “procedural standards” that set the conditions under which irrigation equipment shall be tested. Most commonly, drip irrigation pipes and emitters are tested for (1) the degree of variation the material has when compared to manufacturing specifications (notably in terms of the relation between water flow and pressure), and (2) the level of uniformity across emitters. How this relates to water use efficiency, the

quantity of water used or yield levels is never discussed – these are indeed seen as beyond the realm of the tests and solely attributed to farmers’ practices rather than to the equipment.

There is a conspicuous lack of “performance standards” and, despite the name of the subcommittee, no “system level” standard according to which systems need to be designed and their performance measured (again, this is ‘justified’ by the fact these are seen as depending on designers and farmers practices rather than to the equipment).¹⁴ In such conditions, it is difficult to hold private manufacturers accountable to farmers or policy makers when promises of improved efficiency or productivity are not met. They can, as a result, continue to promote their products on the basis of their water savings and efficiency potential irrespective of whether this potential is ever realized. Very much aware of this discrepancy between efficiency claims and the ways the irrigation equipment works in farmers’ fields, and in a context in which they are sidelined from the processes of standard development, several testing laboratories (among which the IRSTEA-France, the INCTEI-Brazil, the UCLM-Spain, and CIT-USA; see picture 4 in the color plate for an illustration of a drip irrigation test bench) have formed the International Network of Irrigation Testing Laboratories (INITL). They aspire to conduct independent cross tests of drip irrigation equipment to form an alternative informal certification mechanism among peers.¹⁵ Yet, the laboratories are limited in terms of the tests they can conduct and are also in a delicate situation as they derive part of their funding from private manufacturers (when the latter need a certification of their material to qualify for public tenders notably), who may (threaten to) sue them if they do not comply with internationally standardized tests.

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When private companies gain in importance

The lower influence of networks such as ICID and public research organizations happened as the private sector, partly structured through industry associations, played an increasingly pivotal role in developing drip irrigation systems and supporting their dissemination through very aggressive marketing policies – including lobbying national governments and organizations such as the EU so that they would consider subsidizing so called “water efficient” technologies.

The first drip irrigation manufacturing companies were set up in the 1960s (for instance, Chapin Watermatic in 1960 and Netafim in 1965). In the 1980s and 1990s, several companies that had been active in the field of agriculture and/or irrigation (such as Jain irrigation in India and Toro in the USA¹⁶) specifically started manufacturing drip irrigation equipment. In countries such as Cyprus, Greece, France, Italy and Spain a multitude of smaller scale manufacturers also emerged.

From the 2000s onwards, two different trends can be identified. First, the emergence of a local manufacturing capacity and private companies in countries such as Turkey, Jordan, Morocco and evidently Korea and China, which have seen a tremendous increase in the use of drip irrigation. Second, a tendency towards a consolidation of the drip irrigation equipment market, which goes

hand in hand with a financialization of the sector (see box 3). Through a series of acquisition (Chapin Watermatic in 2006 and the Israeli Naandan in two stages, in 2007 and 2012), Jain irrigation for instance emerges as a second power house alongside the Israeli company Netafim (both companies are valued at more than 1 billion US\$). Alongside this trend, the profile of the decision makers of these companies has also evolved. While the directors and CEO of the “early age” drip irrigation equipment companies had often been trained as agriculture and/or irrigation engineers, this is less and less the case today; they rather have MBA training or the like. This has come together with a change in the way drip irrigation is discussed: there is far less attention to the technical aspects of the technology (the technical potential of drip irrigation is seen as a given) and much more emphasis on overarching claims of water preservation and agricultural productivity that are difficult to actually grasp and assess.

Box 3. Global finance and drip irrigation

That drip irrigation has entered the world of “big-business” is evidenced by the publication of reports on market trends and potential, which are sold for hefty sums (for instance Sustainable Asset Management, 2004; Transparency Market research, 2013).

Maybe more significant is the fact that pension funds such as the London based private equity firm, PERMIRA, acquired a majority share of 61% of Netafim in 2011 for \$850 millions (Kibbutz Hatzerim and Kibbutz Magal remain minority share holders with 33% and 6% respectively) and justified this investment on the ground that “*Netafim [was] the undisputed market leader and [...] ideally positioned to be the market maker in one of the most attractive segments of the agriculture industry worldwide*” (Permira, 2011). In February 2013, PERMIRA further reported on its webpage that “*Through the cycle, Netafim has delivered strong double digit revenue growth and it targets a similar growth rate over the coming years. It will continue to pursue a growth strategy built around enhancing its leadership position as a market maker in drip irrigation. Specific growth opportunities include a significant expansion in emerging market businesses, particularly India and Latin America, entrance into the Chinese market and further penetration of large commodity crops.*” For the CEO of Netafim, “*having the backing of an international investor like the Permira funds [was] invaluable*” to accelerate the company’s international growth (Permira, 2011b). This is not the only example of the involvement of global finance in the drip irrigation equipment sector. FIMI, one of the largest Israeli private equity funds also acquired John Deere Water in 2014 (which had itself been set up in 2006 and acquired Plastro and T-Systems, two other drip irrigation companies, in 2008).

What is striking in the two cases here is the terminology used. The focus is on economic growth and profit making; the technology – let alone the farmers- are conspicuously absent. There are tentacular implications to such trend. Netafim has 28 subsidiaries and 16 manufacturing plants worldwide, and employs 4,000 workers, some of which commented during interviews that the sales target for regional managers increased after the acquisition of PERMIRA to support the

double digit growth objective of the pension fund, while field workers benefit-sharing schemes were cut. More surprising, maybe, is the fact that Dutch civil servants (including contributors to this book) are part of the story. Indeed, PERMIRA is financed by other funds among which ABP (the Dutch pension fund for civil servants) through Alpinvest.

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Conclusion

Over the last 60 years, drip irrigation has been envisioned according to a multiplicity of lenses, which tend to reinforce each other in a never ending process. It was first seen as a way to extend agricultural land and a means to increase agricultural production. It then became associated with the idea of irrigation modernization and improved efficiency and productivity. Agricultural and irrigation engineers working in public and/or international agencies started losing their influence from the mid 1990s onwards as drip irrigation travelled from experimental sites to farmers' fields, the political sphere, and global water arenas. In the latter, and in line with the dominant discourse of sustainable development, drip irrigation started to be discussed as a technology to preserve water resources and later as an adaptation strategy to climate change, including by and for the benefits of small farmers in the developing world. As the technology travelled from the realm of self-proclaimed irrigation experts and moved into a broader public sphere but also the world of big businesses and international water arenas, caution regarding the prospects it held largely gave way to definitive claims on the potential of the technology. This is partly because of the ever higher political and economic stakes linked to the promotion of drip irrigation.

What is striking in this “traveling process” is that new sets of characteristics ascribed to the technology do not replace earlier ones; they rather add up to form a mythical artifact, which we called a panda or a hydra in the introduction. As such, drip irrigation has the characteristics of a boundary object (Star and Griesemer, 1989), that is, an artifact that is multivalent in character, can be cast in different ways to speak to various social worlds and communities of practices, and embodies multiple discourses in the process acting to mediate between different actors.

A multiplicity of drip irrigation narratives co-exist, which, when taken together, make the technology seem capable of addressing a number of current challenges in order to contribute to the shaping of a better future. Beyond the technical attributes commonly associated to the artifact (efficiency, modernity, productivity), it is this widely shared positive imagery that explains the attraction that drip irrigation exerts among a wide variety of actors.

Acknowledgements

The author would like to thank the four reviewers and his fellow co-editors for their valuable comments on earlier versions of this chapter. I also greatly acknowledge the insights from the many people interviewed in the course of this research project who shed light on the multiple aspects and dynamics of drip irrigation worldwide.

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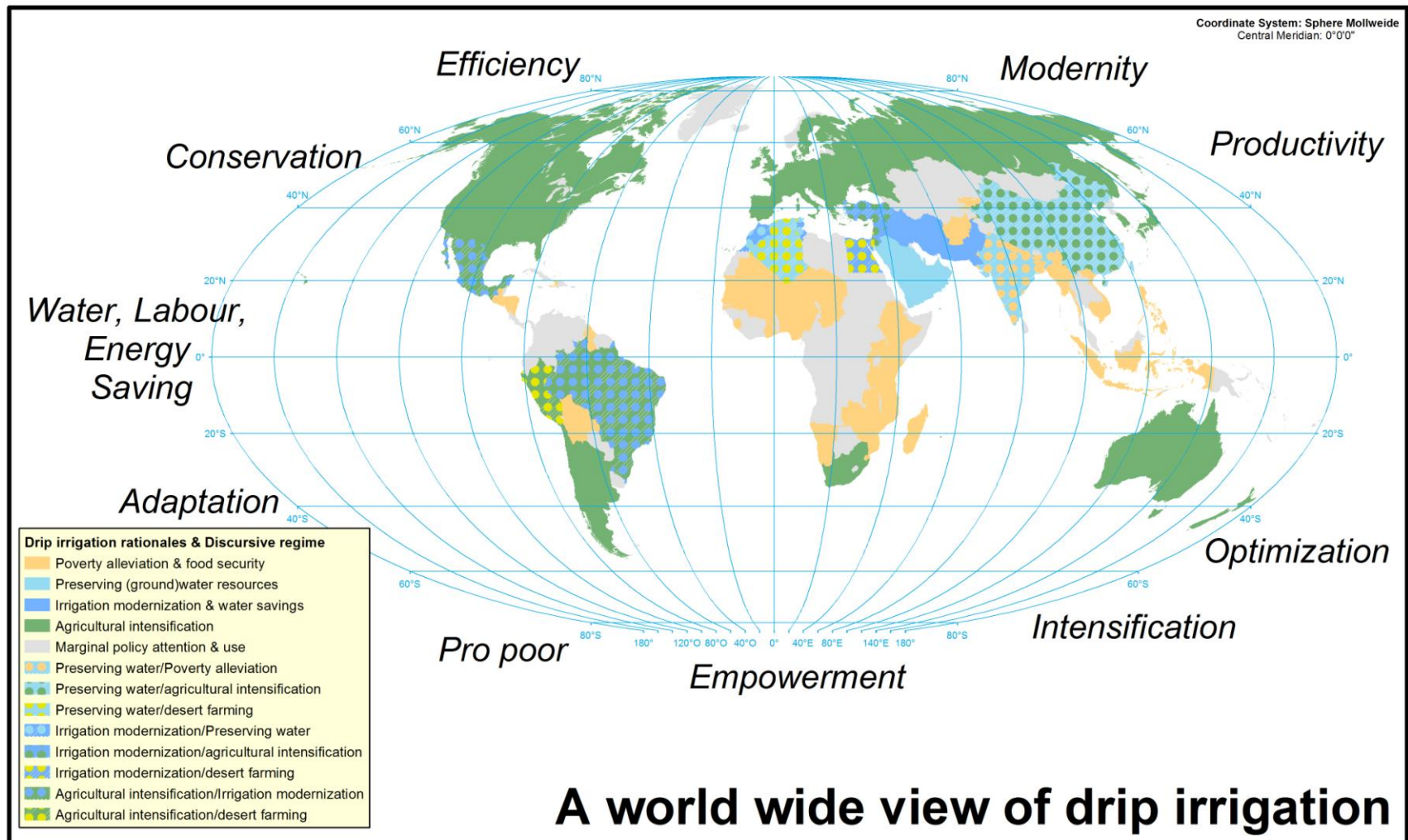
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The map is a simplification of a complex reality; it only represents the main discursive framings of drip irrigation at country level. For each country only one or two main discourses are identified, even though other ideas of drip irrigation may also exist. Within a country, different discourses may play out differently across regions. Finally, the map may give the impression that different discursive regimes are neatly bounded; this is not the case as different discourses and imageries overlap and reinforce each others (see chapter 1). Author: Jean-Philippe Venot



Endnotes

¹ In countries where the installation of drip irrigation is subsidized (see below), consistent monitoring of subsidy schemes at national level could be a proxy to assess the extent of drip irrigation development. It would, however, overlook the fact that many farmers (often smallholders) purchase drip irrigation equipment on the market, without resorting to any subsidy scheme (see, for instance, chapters 5, 7 and 16 in this volume). Further, volumes of subsidy or sales are do not always reflect actual use by farmers, as demonstrated in chapter 13).

² FAO Aquastat gives data on “localized irrigation” (meant to include drip and sprinkler irrigation) for 85 out of 199 countries, with some records dating back to over two decades (FAO, 2013; Venot et al., 2014).

³ <http://www.breakingisraelnews.com/21745/china-buys-israeli-smart-irrigation-tech-company-20-million/>

⁴ In Algeria drip irrigation was heavily subsidized in the early 2000s but subsidies have been progressively cut down.

⁵ From the 1970s onwards, Saudi Arabia pursued an elusive objective of food sufficiency and, in order to do so, heavily subsidized its agriculture sector, notably wheat production under pivot irrigation (Elhadj, 2004). Since the early 2000s, wheat subsidies have been phased out in part due to concern over groundwater over abstraction and the government is now prioritizing vegetables under greenhouses, using drip irrigation (FAO/GIEWS, 2015).

⁶ Many experiments consisted in assessing the yield-response of different crops under drip.

⁷ IPCC (2014) identifies “efficient irrigation” as an adaptation strategy, without mentioned drip irrigation explicitly.

⁸ This concern over the energy use of (drip) irrigation has led some organizations to test associating drip irrigation systems with solar pumping together.

⁹ Interestingly, small drip irrigation systems such as drip kits are also promoted in the United States, though in very specific contexts, that of the reservations of Native Americans. There, drip kits are promoted on the ground they could contribute to better health through improved diets and physical activity (vegetable gardening) in a context of very high incidence of diabetes.

¹⁰ Netafim, the largest manufacturer of drip irrigation equipment worldwide for instance widely advertise that (1) by selling drip irrigation systems, the company contributes to preserving water resources worldwide and that (2) by partnering with NGOs, research centers and international development organizations in projects promoting drip kits, it contributes to poverty alleviation worldwide (see <http://www.netafim.com/corporate-responsibility>).

¹¹ See <http://www.mekorot.co.il/> as well as Siegel (2015). These early plans to develop the Negev desert were part of a Zionist strategy that aimed at influencing the drawing of the boundaries of the future State of Israel. The National Water Carrier plays a key role in the Israeli identity as does drip irrigation repeatedly presented as one of the innovation Israel “brought to the world”.

¹² Between 1979 and 1997, ICID had a dedicated working group on “micro-irrigation”, which would then be renamed “on-farm working group” in 1998 (www.icid.org). Irrigation and agriculture engineers from Israel, South Africa, several European countries as well as India were also particularly active during these two decades.

¹³ Currently, the ISO/TC23/SC18 counts 11 participating and 18 observing members (www.iso.org) among which the countries where drip irrigated areas are the largest and the irrigation industry well developed (among the 10 countries with the largest drip irrigated areas, only South Africa and Mexico do not contribute). Solomon and Dedrick (1995) highlight that Israel, France, the U.S.A, Canada, Spain, and Italy are the most active countries.

¹⁴ A noticeable exception of “performance standard” is a US standard on the performance of drip irrigation tape. Due to the opposition of Israeli manufacturers to the idea of standardizing tape, there is no equivalent ISO standard (American and Israeli manufacturers are competitors on the drip irrigation tape market). The difficulty to develop (material) performance standards at international level can also be illustrated by the ‘journey’ of a proposition that aimed at developing a standard on drippers’ sensitivity to clogging, which, after ten years, has been registered as a “technical report” rather than a standard (hence is not bounding). In terms of system standards, the ASABE (American Society of Agricultural and Biological Engineers) has devised an “Engineering Practice” which specifies practical engineering methods for field evaluation of existing microirrigation systems. India and Morocco have their own (national level) quality and dimensioning standards that farmers need to adhere to if they want to benefit from

public subsidies. Whether the material and the system respect the standards is assessed by certified companies and engineers (the equipment of all major drip irrigation manufacturers is eligible to the subsidy).

¹⁵ Many of these laboratories are not certified by their national standard organizations, let alone by ISO, due to the costs this would imply for them in regard to a rather limited “market” for testing drip irrigation equipment.

¹⁶ TORO is specialized in turf & landscape management. It entered the irrigation equipment sector in 1962 (turf and landscape) and expanded into drip irrigation for agriculture in the mid 1990s through acquisition. Rainbird, set up in 1933, is another major player in the irrigation equipment sector – specialized on sprinklers.