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## On the movement of agricultural technologies : packaging, unpacking and situated reconfiguration

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### ► To cite this version:

D. Glover, Jean-Philippe Venot, H. Maat. On the movement of agricultural technologies : packaging, unpacking and situated reconfiguration. Sumberg, J. (ed.). Agronomy for development : the politics of knowledge in agricultural research, Routledge, p. 14-30, 2017, Pathways to Sustainability, 978-1-138-24031-5. <hal-02613662>

**HAL Id: hal-02613662**

**<https://hal.science/hal-02613662v1>**

Submitted on 20 Dec 2023

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## AUTHOR VERSION OF

Glover, D. ; Venot, J.P. ; Maat H. (2017). On the movement of agricultural technologies: Packaging, Unpacking and situated configuration. *In* Sumberg, J. Agronomy for Development: The Politics of Knowledge in Agricultural Research. Routledge; Abingdon & New York. pp 14-30.

### **Agronomy for Development: The Politics of Knowledge in Agricultural Research**

**Edited by: James Sumberg, Jens Andersson and John Thompson**

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## **On the movement of agricultural technologies: Packaging, unpacking and situated reconfiguration**

*Dominic Glover, Jean-Philippe Venot and Harro Maat*

### **Introduction**

In this chapter, we examine how farming technologies move between places and how they are unpacked and 'grounded' in particular spaces and contexts. We argue that a better understanding of how this process occurs helps to shed light on a source of contestation within agronomy. We discuss two farming technologies that have been at the centre of controversial debates among experts, policy makers and the wider public: the System of Rice Intensification (SRI) and drip irrigation. We argue that these technologies have been contested partly because important social dimensions have been neglected, which have led to the technologies being configured and appreciated differently in different sites. Here, we use the term sites to include farmers' fields, experimental stations and laboratories, research and training centres, as well as discursive spaces such as agricultural and natural resource policies and research publications.

We selected the cases of SRI and drip irrigation in order to show that different technologies can shed similar light on the socio-technical configuration and discursive politics of farming technology. Drip irrigation epitomises a modernist package of engineer-designed hardware procured from outside the local farming systems, while SRI is promoted as an agro-ecological, low-external input methodology that relies chiefly on locally available natural resources, labour and farmers' skills. However, both technologies are associated with discourses about natural resource conservation and increased farm productivity. In practice, both have been transformed into technology packages in order to help make them mobile, and both are necessarily subject to processes of unpacking when they arrive in particular locations.

We develop our argument as follows. In the next section we discuss different understandings of technology and its role in agricultural development. We challenge the notions of 'technology transfer' and 'scaling up', which still hold key places in agricultural development narratives. We favour an alternative conception of how technologies move from place to place, emphasizing the reconfiguration of relationships among individuals and social groups and material resources, and the transformation of practices in a particular time and place. This agent-centred, practice-focused understanding of technology leads us to recognise 'technology transfer' as an attempt to reorder farmers' practices by introducing new objects and instructions. We then turn to the cases of SRI and drip irrigation in order to illustrate our practice-based notion of technology and technological change as expressions

of situated socio-technical practice. In the final section, we argue that our analysis provides an insight into the contestations surrounding these two particular technologies.

## **Understanding technology and change in agriculture**

Agronomists and agricultural engineers typically conceptualise farming technologies as assemblies of consumables and equipment, or as packages of technical and managerial practices. Conceived in this way, the introduction of farming technologies to new settings, or their movement from one rural site to another, is seen as a matter of distributing artefacts accompanied by instructions and training. Technological change is seen as a simple, merely technical process, epitomised in conventional accounts of how innovations ‘diffuse’ and how technologies ‘transfer’ (e.g. Ruttan and Hayami 1973; Rogers 2003; cf. Glover et al 2016).

This technicist conception of technology frames technical objects and their associated instructions as manifestations of objective scientific knowledge. As such, technologies are thought to have fixed functional characteristics that produce predictable effects. In such accounts, non-technical and non-economic factors are considered externalities, and they are often blamed when the results of technology transfer fall short of expectations. Low levels of uptake or disappointing impacts are often attributed to factors such as an unfavourable institutional framework, a lack of leadership or political will, insufficient financial investments, and even the ignorance and backwardness of uncooperative farmers. These obstacles are often targeted for correction through training and ‘capacity building’, while the design, delivery or performance of the technical intervention itself may go unquestioned (Glover 2010).

Since the 1980s, this conception of technology transfer and adoption has been strongly attacked, especially the privileged place it gives to scientific kinds of knowledge and practice. In particular, scholars highlighted how traditional notions of technology transfer and adoption largely ignored farmers’ agency and capabilities. This oversight effectively excluded local knowledge, which was often vital for producing lasting and positive change in farming outcomes. Social scientists pointed out that farmers might have good reasons to deviate from the prescriptions of agronomists and consequently it was important to understand their perspectives, values and priorities (e.g. Loevinsohn and Kaiser 1982; Chambers and Jiggins 1987a, 1987b; Chambers et al 1989).

However, the challenge was neither merely to transfer scientific knowledge into farmers’ practice, nor to celebrate farmers’ innate wisdom, but to promote dialogue between different systems of knowledge and practice (Richards 1985; Thompson and Scoones 1994). Farmers began to be recognised not merely as important end users of technology packages but key actors in ‘agricultural innovation systems’. Innovations were seen to emerge from

multiple sources through the interaction of different knowledge sets, including those of farmers as well as professional scientists and engineers (Biggs 1990; Biggs and Clay 1981; Douthwaite et al 2001).

It became clear that the deployment of similar technical artefacts among different actors in diverse contexts would give rise to many different, site-specific technological configurations. Farming itself could be conceived as a combination of technologies enacted through practice, situated in time and space and within a specific social and agro-ecological context (Richards 1989, 1993). Through this situated enactment of technology, locally specific configurations of social and technical components would emerge. Technology itself could be understood as a hybrid of social and technical components, comprised not only of technical artefacts and practices but also the agency of human actors embedded in a web of social and ecological relationships, expressed in many different cultural and institutional forms (Richards and Diemer 1996).

A key reason why technologies change as they travel is that they are not encapsulated in artefacts (tools, instruments, gadgets) nor even in abstract knowledge, but enacted through situated practice (Shapin 1998; Dowd-Urbe et al 2014). This means that a technology is necessarily embedded in particular social structures, symbolic practices and material conditions, and that the technology will be altered when those structures, practices and conditions are different, or modified (Pfaffenberger 1992).

Typically, new farming technologies are developed in well-resourced environments such as agricultural research stations, where cultivation is supervised by teams of technicians and often involves heavy fertiliser and chemical use. Even when experiments are conducted under farm conditions, scientists typically assemble and coordinate an array of social and material resources in a particular time and place, in order to bring unruly field conditions under control and observation. This effort helps to make the 'field' more like the 'laboratory' and allows the scientists to collect the kind of scientific-but-realistic data they need (Henke 2000; Maat and Glover 2012). The technologies that emerge from this situated practice are indelibly marked by it.

From this perspective, the processes involved in the initial development of a new technology and those involved in putting it to use may be recognised as distinct (albeit linked) enactments in situated practice. In these distinct enactments, different, site-specific configurations or hybrids of technical, social and institutional components are created and re-created. In other words, the 'same' technology will in fact be different when, and because, it is embedded in different sites, and enacted by specific networks of people and groups interacting with local material resources and biophysical conditions. Instead of asking how a technology can move from the laboratory or research station into farmers' fields, a new question comes into focus: how can the skills and 'placeless' knowledge of professional

scientists be made relevant to, translated into and integrated with forms of knowledge and practice that make sense on the ground?

To help a technology leave the experimental setting and travel to a farm situation, it must first be made mobile. It must be detached and made independent from the specific circumstances where it was developed, conveyed to a different location, and unpacked in that new context. The process by which this happens is the main focus of our discussion. To develop our analysis, we use the concepts of *inscription* and *affordance*, as developed by anthropologists of technology and Science and Technology Studies (STS) scholars.

### ***Inscription and affordance***

*Inscription* describes the work done by technology designers and engineers to build into new technical objects their expectations about how those objects are to be used. Inscriptions are programmes that call on the user to adopt certain modes of action and behaviour in order to use the object and achieve the outcomes intended by the designer. Inscription can thus be interpreted as a way of disciplining users to fall into line with the expectations and intentions of other social actors – often more powerful actors, who are trying to achieve their own objectives. This is highly visible in factory assembly lines, where a series of machines and work-stations are assembled and configured in a particular spatial order, so that trained operators may perform a sequence of choreographed steps in a complex manufacturing process. To carry out their tasks properly, the operators are required to conform to the expectations of the machines' designers, engineers and owners. Here, the inscription of a particular mode of interaction into technical objects is complemented by more obviously social and cognitive disciplines, imposed for example by training, incentives and punishments, team working, collective responsibility and managerial supervision. But the disciplining of factory workers' activities is also an intrinsic part of the function of the technical objects themselves (Latour 1991; Callon 1991; Webster 1991; Akrich 1992; Murdoch 1997).

Outside factories, everyday objects also embody the expectations of their designers and seek to govern the behaviour of users. In the case of the large and unwieldy fobs attached to hotel keys, disciplining the users – not to take the key when leaving the hotel – is an essential part of the object's purpose, deployed by the hotel manager in an effort to impose his will on his guests even when he is not present in person. In this manner, objects extend their designers' programme of action through time and across space and serve to solidify social relations including hierarchical relationships of dominance and subservience or resistance. Technical artefacts and technology packages embody scripts or programmes of action that users can adopt, subvert, change, resist or ignore (Latour 1991; Callon 1991; Webster 1991; Akrich 1992; Murdoch 1997).

A basic part of the designer's task is to consider how his or her designs are intended to be used, for what purposes, and by whom; this includes anticipating the capacities and proclivities of the proposed users, as well as potential deviations from the plan that might be undesirable (from a given point of view) or perhaps dangerous. This means that designers and users are caught up in a sort of dialogue, because the users also have work to do in interpreting what a technical object is intended for and how it may be used, whether for its intended or alternative purposes. The power of users to (re-)interpret or re-purpose technical objects – the power of 'de-description' in the difficult jargon of STS scholars (Akrich 1992) – sets a practical limit on the extent to which designers and engineers can effectively discipline users. Users can and commonly do also resist, subvert or bypass, in both trivial and significant ways, the modes of action expected and inscribed by designers (Suchman 1987; Woolgar 1991; Latour 1991; Akrich 1992; Latour 1992). This theoretical insight from STS provides a conceptual language to make sense of forms of resistance to and subversion of technological interventions that have been documented by scholars in development studies, history and anthropology (e.g. Loevinsohn and Kaiser 1982; Maat 2015, Scott 1985; Van Damme et al 2014).

To examine in detail how technical objects mediate in the relationship between designers and users, the concept of *affordance* is helpful. Affordances are the potential options for use to which technical objects lend themselves, or the opportunities for interaction that are built into the objects' designs. Affordances are partly aspects of the materiality of objects – their physical properties and characteristics, which enable and constrain the ways in which those artefacts may be employed. There are also situational or relational aspects, which is to say that the affordances may depend on the context and the capabilities of the potential users to recognise and act upon the potential uses. This perspective gives equal priority to the materiality of the objects in question and their interpretive flexibility in the perceptions of different social actors. Together these define the objects' capacities for uses and applications of various kinds, including functional, ritual and symbolic uses that may not have been intended or anticipated by the designers (Pfaffenberger 1992; Hutchby 2001).

### ***Making technology mobile: Packaging and unpacking***

To make agricultural technologies mobile, ready for transmission to farmers' fields, work is done to refine and standardise them into packages. This is an exercise in inscription. The recommended package of practices is not an exact copy of what has been developed and tested in an experimental setting, but a distillation and selection of practices, techniques and inputs deemed by technical and communications experts to be correct, coherent and appropriate. This intellectual and practical process involves simplifying the technology into a

manageably small number of essential components, which are supposed to be widely applicable. These are inscribed in the form of guidelines, recommendations, schedules, checklists, equipment and kits. Through these inscriptions, the technology is detached conceptually and materially from the particular place and context where it was developed so that it may travel to new settings. While it exists in this form the technology package may change further as it passes from one organisation to another, upon translation into a new language, and/or through the design of new training modules and materials.

The concept of affordance is key to understanding what happens when the technology package arrives in each new setting. The package is not simply 'adopted', that is, received and put to use. From the potential user's perspective we can think of the technology (inscription) at this stage as a kind of proposition comprised of a set of ideas and material components, in other words, an offer or invitation to which individuals, groups or communities have an opportunity to respond.

The affordances of the technology package help to determine what may be done with it, or how potential users may respond to the proposition. A new socio-technical configuration might emerge from the encounter between the inscribed technology package and new actors and contexts, but if so it will not be a simple case of technology transfer but a site-specific, *sui generis* enactment. Because small-scale agriculture often involves collective action and coordination within households and even across communities, the enactment of farming technology in a new situation implies a redistribution of responsibilities and activities among individuals and groups (McFeat 1972, Hutchins 1996; Richards et al 2009). As the introduced technical knowledge and techniques are interpreted, evaluated and integrated with existing local social and technical resources, local social and cultural structures and systems (such as those governing the coordination of labour) are also modified (Pfaffenberger 1992; Glover et al 2016).

From this perspective, it is axiomatic that a technology is not the same wherever it travels; it will change wherever it 'touches the ground'. A similar package of tools and methods is likely to be deployed in a more or less different way in each place by different sets of actors. In other words, the material facts of rice physiology or hydraulics may be singular but those that are salient in one situation are liable to be different from those that matter in another.

The notion that technology is enacted through situated practice is a perspective that is difficult to reconcile with the placeless discourse of science, in which technologies represent applications of scientific knowledge that are robust and general, not particular to the actions or beliefs of individuals or groups. This discourse is often used by programme designers, policy makers, journalists and marketing professionals when they evoke the potential of agricultural technology to transform the livelihood opportunities of poor people,

whereas the idea of enactment frames technologies as expressions of the capacity of people themselves, including poor people, to use tools, apply skills and organise themselves in order to solve problems and achieve goals.

In the sections that follow, we illustrate these arguments using the cases of SRI and drip irrigation. We first provide some background and briefly describe the actor-networks in which these two agricultural technologies have emerged. We then describe how they were transformed into packages to make them mobile, the attempts to inscribe certain socio-technical relations, and the processes through which users have reinterpreted and reconfigured the technologies beyond the expectations of the designers. We draw from our own fieldwork and interviews as well as from our collaboration and interactions with the Masters and PhD students who conducted in-depth field work in India, Morocco and Burkina.

### **The System of Rice Intensification (SRI)**

SRI is a method of rice cultivation that has attracted considerable international attention over the past decade. The system involves a combination of low-external input cultivation methods for raising seedlings, establishing and nurturing them in the main field, including minimal irrigation, wide spacing, soil aeration, mechanical weed suppression and fertilisation, preferably using organic sources. The SRI method is capable of producing good rice grain yields while economising on seed and water (Uphoff 1999; Stoop et al 2002; Stoop 2011; Kassam et al 2011; Uphoff et al 2011; Ezra Berkhout et al 2015; Gathorne-Hardy et al 2016).

SRI has been promoted with much energy and enthusiasm by an international network of scientists, non-governmental and civil society organisations (NGOs and CSOs), farmers' groups and others. SRI promoters emphasise that the system is a productive and ecologically sustainable method that is accessible to resource-poor cultivators because it does not require costly external inputs, such as improved seeds or agricultural chemicals. SRI advocates also argue that the method is intrinsically adaptable because it is based on a set of flexible principles rather than imposing fixed practices. They frame SRI as the opposite of Green Revolution-style crop intensification, which is often characterised as the adoption of standardised technology packages centred on high-yielding crop varieties in association with chemical fertilisers and irrigation (Uphoff 1999, 2002, 2007). For example, an important principle of SRI is that rice seedlings should be given ample space to access soil nutrients, oxygen and water, but the precise planting density to be adopted in a given situation is supposed to be adapted to suit the characteristics of the rice variety being planted, the richness of the soil in important nutrients, the risk of waterlogging, and the length of the growing season. Similar guidelines, with local adaptations, are supposed to apply to the

desirable number of seedlings to be planted in each hole or 'hill', the irrigation schedule, and so on (Glover 2011a).

SRI has been the subject of heated contestation among scientists. When it first attracted scientific attention, some agronomists and economists disputed some of the scientific claims made by SRI advocates, and questioned the originality of others (SurrIDGE 2004). One dimension of the dispute has been institutional rather than purely scientific. SRI was not developed on an agricultural research station but compiled from various sources by a field-level agronomist, development worker and Roman Catholic missionary, Father Henri de Laulanié, who worked in relative isolation in Madagascar. The inductive, empirical and 'bottom-up' origins of SRI are often emphasised by its supporters as a key attribute (Glover 2011a; Stoop and van Walsum 2013; Chavez-Tafur 2013). Meanwhile, SRI has been questioned by some influential scientists associated with prestigious university departments and research institutes, while grassroots supporters and field-level promoters of the system have reported outstanding results (Glover 2014).

One axis of the dispute has been that critics of SRI have disbelieved reports of success emerging from the field. They say that the cultivation methods actually used in some reported cases of success have appeared not to conform to the strict definition of SRI best practice. SRI's supporters respond that the critics have failed to grasp that flexibility is an essential feature of the system. On the other hand, when some mainstream scientists have tested SRI cultivation methods against alternatives, and come up with negative findings, they themselves have been attacked by supporters of SRI for failing to apply the SRI model properly (Dobermann 2004; McDonald et al 2006, 2008; Uphoff et al 2008). This has led some of the critics to complain that SRI advocates seem to claim credit on behalf of SRI whenever the results happen to be positive, regardless of whether the cultivation practices actually used conform to precepts of SRI that are thought to be essential and which are supposed to distinguish it from conventional methods.<sup>i</sup> They also complain that SRI is untestable if its definition is so flexible and vague. Our argument is that this contestation can be explained, at least partly, as a consequence of misconceptions that surround the nature of technology as a situated practice or enactment, and the way technologies are packaged and unpacked as they move from one place to another.

### ***Making SRI mobile: Simplification and standardisation***

Henri de Laulanié explicitly recognised that his recommendations concerning rice cultivation had been designed in and for the particular context of a poor, highland rice-growing community in Madagascar during a period of economic difficulty. His knowledge of rice cultivation was integrated with his understanding of the local agricultural system, including off-season crops and livestock. Although he was confident that his recommendations for rice

cultivation were firmly rooted in certain essential features of rice physiology and morphology, he nonetheless made clear that his methods should be understood as general principles that needed to be adapted for use by other communities in different agro-ecological settings (Glover 2011a).

In order to make SRI mobile, de Laulanié began the process of inscribing its basic principles, and this was taken further by others after his death. Through this inscription, SRI was simplified and standardised so that it could be communicated to others. It was translated into a much less flexible package, typically summarised in the form of a list of specific technical practices and parameters (see Box 2.1). These guidelines have helped to carry SRI well beyond its origins in recent years, however, in the process, many of the nuances and details discussed by de Laulanié at length have been downplayed. For instance, in SRI extension guides, the desirable spacing distance between seedlings is very commonly specified as 25 cm, while considerably less emphasis is placed on the desirability of adjusting the planting density to suit the rice variety, season, or local soil conditions. Other parameters are typically defined with similar exactness, downplaying the desirability of making local adjustments. Correspondingly, little attention has been given to developing heuristics that could help farmers or extension workers to make adjustments to suit particular locations (Glover 2014).

### **Box 2.1 Inscription of SRI**

Henri de Laulanié's discussion of the techniques making up SRI was extensive, detailed, and nuanced (de Laulanié 1993, 2003). Today, the SRI method is typically summarised concisely as a short checklist of technical practices, often specified rather precisely, along the following lines: (1) raising seedlings in a thinly sown, well-fertilised, irrigated and carefully weeded nursery; (2) uprooting and transplanting seedlings when they are very young (ideally 8–12 days and not more than 15 days old); (3) transplanting single seedlings, widely spaced, in grid patterns (typically this is specified as 25×25 cm); (4) sparse irrigation to promote moist, aerated soil conditions, ideally including dry periods of 3–6 days (this is sometimes known as alternate-wetting-and-drying irrigation, AWD); (5) a regular weeding schedule, typically four times at 10-day intervals after transplanting and ideally carried out with a mechanical rotary weeder that churns and aerates the soil, hand-weeding without aeration being the second-best option; (6) fertilization using organic sources (manure, compost, green manure crops) to the extent possible. This list slightly exaggerates the flexibility allowed in many real-world cases of SRI extension, since it has been compiled from several different peer-reviewed articles as well as field research observations in Madagascar, Nepal and India. In practice, the SRI methods have often been conveyed to farmers as a

remarkably inflexible package of practices (Uphoff 1999; Stoop et al 2002; Berkhout and Glover 2011).

### ***Enacting SRI in new places***

The story of how SRI touches the ground in specific sites in India is a story of farmers' and communities' intricate navigation of a locally specific range of social, cultural, institutional, agro-ecological and other factors. Typically, SRI has been introduced into communities by an external agency of some kind, usually an NGO or CSO, or a government extension agency or programme. As such, SRI usually arrives in the form of information, often conveyed through orchestrated events such as training courses and demonstrations, as well as visual presentations and printed manuals. In many instances, SRI information is accompanied by inducements such as financial or in-kind subsidies, often including mechanical implements such as rotary weeders (for weed suppression and soil aeration) and line markers, roller markers or planting frames (for marking out muddy fields with a regular planting grid or rows). It falls to the farming community and individuals within it, as well as extension staff, to work out what will be done with this package of information, artefacts and financial resources.

Multiple studies confirm that the full suite of SRI methods is quite rarely implemented. The typical pattern is that individual components of the SRI approach are used or adapted quite selectively, and practised alongside existing techniques. For example, seedlings are rarely transplanted singly when very young, because the operation is more demanding with tiny young seedlings and brings greater risk of seedling mortality, which obliges farmers to refill resulting gaps later on. Sparse irrigation or AWD can only be practised where farmers have good control over their water supply and drainage, or where there is effective cooperation among groups of neighbours in an irrigation command area. Where labour is scarce, flooding is an effective and labour-saving way of suppressing weeds. Testimony of farmers confirms that their practical decision-making about which methods to apply in each of their rice plots takes into account multiple considerations, including the characteristics of the field (soil quality, drainage characteristics, topography), distance from the home (close fields can be supervised more intensively), availability of sufficient labour at key times, access to water, land tenure arrangements, and other factors (Glover 2011b; Ly et al 2012; Noltze et al 2012; Berkhout et al 2015; Sen 2015).

SRI is often portrayed in academic papers as an open-ended script that affords a high level of flexibility for farmers to rewrite and localise it. The modularity of SRI's components is supposed to facilitate this flexibility because the individual components may in principle be taken up independently. In actual practice, SRI is often promoted rather inflexibly as a fixed package. Moreover, the tailoring of SRI to fit a local situation is not really

a question of selecting among the six practices, but giving particular specifications to the resulting practices, such as an appropriate seedling age for transplanting a particular rice variety in a given season, and so on. Heuristics to assist farmers to make these local adaptations are often lacking (Glover 2014). Local adaptations nevertheless emerge, which demonstrates that SRI's affordances are created partly by the situations and the agency of the farmers who unpack SRI and reconfigure their rice farming system, and not only by the designers' inscription.

### **Drip irrigation**

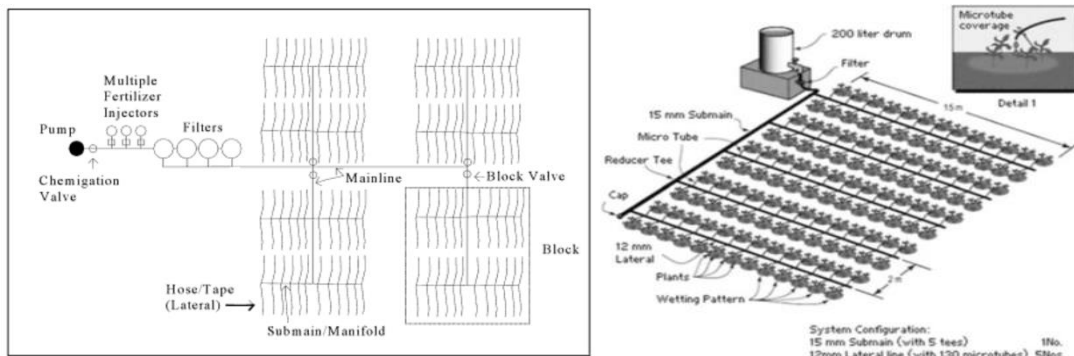
Drip irrigation is a system of irrigation whereby water is applied to each plant in small, frequent and precise doses through a network of perforated pipes and emitters. Drip irrigation originated from the drawing tables and laboratories of engineers and researchers. The technology emerged in the 1960s in Europe, Israel and the United States on experimental research stations managed by irrigation engineers (Venot et al 2014). Experiments showed that drip irrigation could save water and labour and increase crop productivity compared to conventional irrigation systems. Proponents also argue that drip irrigation enables the extension of cultivation into areas that could not be irrigated previously. Drip irrigation systems reflect a modernist, engineering approach to irrigation, geared primarily towards large-scale, intensive farmers in developed economies. Some development actors criticise the effort to target drip irrigation towards smallholder farmers in developing countries. High capital costs and intensive management requirements are seen as obstacles for small-scale farmers to benefit from the technology. Over the last decade, NGOs, social enterprises and industrial manufacturers have tried to re-design drip irrigation systems to fit the realities of small-scale cultivators in low-income countries. This has mostly involved making systems that are smaller, easier to use, and cheaper (Postel et al 2001; Venot 2016).

Proponents of drip irrigation agree that the equipment has the potential to distribute scarce water and meet crop irrigation requirements much more efficiently (Doorenbos and Pruitt 1977; Doorenbos and Kassam 1979). Contestation arises largely around technical and material questions, such as the best technical design and whether the equipment is suitable for smallholders (e.g. van der Kooij 2013; Venot et al 2014). On a larger scale, contestation revolves around the actual water saving that widespread uptake of drip irrigation would entail compared to alternative irrigation systems (Seckler et al 1996; Perry 2007).

### ***Making drip irrigation mobile: Extreme inscription through kits***

Standard textbooks typically promote an idealised model of drip irrigation comprised of uniform rectangular fields and neat drip irrigation lines. The standard layout for capital-intensive farms (Figure 2.1, left panel) hardly differs from the design for smallholder systems (Figure 2.1, right panel). Both include the same general components: a water source, a filtering system, a network of evenly spaced, neatly aligned pipes, and geometrically regular blocks representing fields or field sections. Diagrams such as these are key parts of the inscription of drip irrigation, which help to make the technology mobile (Box 2.2). The inscription also includes features not visible in these drawings, for example the need to maintain a uniform flow and pressure within the pipes. How this is to be achieved in particular cases is left to farmers themselves or to field-level irrigation system designers.

**FIGURE 2.1** Simplified drip irrigation system layouts (Sources: left panel – Burt and Styles 2007; right panel – Polak and Yoder 2006)



### **BOX 2.3 Inscription of smallholder drip irrigation**

The inscription for drip irrigation typically specifies the following features: (1) the system components – water tank, control valve, filter, mainline, laterals, micro-tubes; (2) the shape of the field served by the system – a rectangle of specified length and width; (3) distances between lateral pipes and between emitters; (4) the height and volume of the water reservoir; (5) the required flow, and (6) the schedule of watering.

A separate aspect of inscription, particularly evident in developed and transition economies (such as Morocco) occurs through the establishment of norms and standards, which are technical specifications developed by engineers and tested in experimental laboratories. These standards typically relate to indicators such as the relation between water flow and pressure, line resistance, head-losses, the uniformity in irrigation, and the emitter's resistance to clogging.

The most striking instances of inscription are 'drip kits', which are complete packages of drip irrigation equipment. Drip kits are conceived as modular units that can be infinitely combined one to another; they nonetheless come in a selection of standard field sizes. Twenty square metres, 100m<sup>2</sup>, 200m<sup>2</sup>, 500 m<sup>2</sup> and 1,000 m<sup>2</sup> are the most common, usually with a predetermined rectangular geometry of specified length and width. Although the technical artefacts distributed in drip kits are theoretically usable by any farmer, in the minds of their designers and promoters kits of different sizes are destined for use by different classes of farmers. Smaller kits are meant to be used by women, medium-sized kits by men and larger ones by cooperating groups of farmers.

Promoters of drip irrigation systems for smallholders in developing countries invoke the need for iterative 'user-based design' rather than a top-down approach of 'technology transfer'. By listening to farmers, the engineers can inscribe their feedback into redesigned and adjusted equipment (Polak 2008). Among the most noticeable adjustments observed are alternative sizes of systems and the types of emitters used (built-in emitters or 'micro-tubes').

The explicit targeting of drip kits towards different kinds of farmers reflects the engineers' gendered view of smallholder farming in developing countries, but it also suggests a key way in which the theoretically scale neutral and flexible nature of a modular kit system may be undermined by assumptions that are built into extension strategies. Likewise, the affordances of a drip kit may be modulated by gendered assumptions about how the artefacts should be used, and by whom. In other words, the affordances of the technology package are not wholly determined by the physical characteristics of the artefacts included in it, but also by the expectations of promoters and potential users.

### ***Enacting drip irrigation in new places***

Similarly to SRI, the story of how drip irrigation is enacted is highly site-specific. Morocco and Burkina Faso, for example, provide contrasting pictures. In Burkina Faso and in other countries of sub-Saharan Africa, drip irrigation is usually introduced into communities by an NGO or a government extension agency. The equipment typically arrives on the back of a pick-up truck, in the form of artefacts packed into cardboard boxes accompanied by instructions that are conveyed to farmers through community meetings, training courses and demonstrations, visual presentations and printed manuals. In many instances, the information and artefacts are accompanied by inducements such as seeds, fertilisers and pumps, not to mention the positive status attached to being a pilot farmer in a development project (Wanvoeke et al 2015, 2016).

In Morocco, drip irrigation reaches small-scale farms in a different way. Many smallholder farmers first encounter drip irrigation while working as labourers or managers on large farms owned and managed by Spanish entrepreneurs, who have imported drip irrigation equipment from Spain. As well as acquiring skills in operating drip irrigation systems from these farms, smallholders often reuse equipment that has been discarded by the large operators. Early smallholder drip irrigation thus emerged from tinkering or *bricolage*, in which individual off-the-shelf pieces of irrigation equipment were modified and adjusted (Benouniche et al 2014). A local network of small-scale manufacturers and retailers emerged, specialized in producing and marketing relatively low-tech ancillary devices (such as filters) and reconditioned second hand equipment. Informal networks of farmers, agricultural merchants and self-proclaimed experts exchange knowledge and provide practical answers to specific problems (Poncet et al 2010; Benouniche et al 2011, 2014).

In Morocco farmers are advised to bury the pipes in order to protect the plastic tubes from sunlight and accidental damage. However, it is common to see small-holder drip systems where the lines are installed above ground rather than buried (Figure 2.2). The pipes used in these above-ground systems are usually smaller and lighter than the ones in below-ground installations. This adaptation is useful because many farmers rent their land and change plots from year to year. Also, having the tubes on the soil surface makes it easier to trace and repair blockages and leaks.

**FIGURE 2.2** Widespread adaptation of drip by Moroccan farmers (credit Maya Benouniche)



Many farmers have also inserted small valves on each of the lateral lines instead of a single large valve on the secondary pipe (Figure 2.2). This allows them to direct water to parts of their field as needed instead of watering the whole area at once, which helps them to cope with uneven terrain and to manage mixtures of crops in the same field that have different growing seasons.

In Burkina Faso, inscription by engineers is stronger and, consequently, drip irrigation is less common among smallholders. Those few small growers who do use drip equipment have reconfigured the technical artefacts in various ways. For instance, it is very common to observe smallholders wetting the soil each morning, using hoses or buckets, then filling the water reservoir of the drip system before heading off to other tasks. This happens notably in the early stage of plant growth and is often repeated in the evenings, when farmers return from their day of work. Another common adaptation is the insertion of a greater number of micro-tubes than recommended by designers. Both modifications have been made to secure sufficient water supply to crops. The efficiency of these adaptations might be questioned by agronomists, nonetheless they constitute a locally specific enactment of drip irrigation, using the equipment in ways that were not envisaged by engineers and water managers.

The cases of drip irrigation in Morocco and Burkina Faso illustrate the locally contextual character of a technology package's affordances. In Morocco there was a good fit between local farming systems, which had long been oriented towards fruit and vegetable production, and the dry farming systems for which drip irrigation was originally designed. Second, patterns of employment and informal networks created channels for learning and sharing knowledge and skills between farmers. Finally, the modular nature of the hardware and the availability of second-hand equipment and consumables allowed small cultivators to acquire the artefacts they needed at low cost, and to adapt them to suit their own circumstances and capacities. Through their enactment of alternative types of drip irrigation, farmers detached the technology from its origins in large-scale commercial farming and reconfigured its social and technical components to suit their own needs.

In Burkina Faso, drip irrigation is not yet commonly used in the fields of small-scale farmers because drip kits are inscribed with expectations and assumptions based on contexts with a history of irrigation, relatively easy access to water resources through rural electrification, and a supportive informal sector. Drip irrigation has also been promoted as a new type of farming, which is expected to replace existing farming systems and enhance livelihood outcomes. In other words, the affordance of drip kits in Burkina Faso is restrictive rather than enabling, offering limited opportunities for engineers' and farmers' systems of knowledge and practice to hybridise.

## **Discussion and Conclusions**

Our analysis of SRI and drip irrigation suggests that agronomy is contested when different actors have different perspectives on the functions and purposes of technology, leading them to espouse conflicting views about how the technology should be implemented and used. This leads to disputes around definitions, standards and specifications, 'proper' versus 'improper' implementation, how the technology should be evaluated, and so on. In reality, technology does not come in the form of neatly transferable packages but is enacted by specific actor-networks in particular contexts. This means that we should expect technology to be different in different places and circumstances. Disputes arise partly because those involved have inappropriately rigid expectations based on idealised models and norms.

SRI and drip irrigation are both socio-technical systems that were developed in particular settings. They were both made mobile through processes of inscription that transformed them into packages. These packages arrive in new settings as propositions, to which local individuals and communities may respond (or not). In order to be put to work, the technology packages of SRI and drip irrigation need to be unpacked, literally and metaphorically, and (re)configured by the potential users.

The SRI and drip irrigation packages are inscribed with programmes of action, which embody the expectations and assumptions of their designers and developers about how good farming should be done and by what sorts of farmers. These scripts represent an effort to influence farmers' behaviour, regardless of whether that effort is motivated by public or private motives, benign intentions, indifference to farmers' perspectives and priorities while emphasising other goals (e.g. 'feeding the world'), or even hostility (e.g. a conviction that ignorant or incompetent farmers are obstacles to technological progress and sustainability). The inscription may incorporate, in addition to a technical prescription, ethical norms (e.g. sustainability, agro-ecology, or efficiency), modes of commercial engagement (e.g. production of a marketable surplus) and policy narratives (e.g. promoting economic growth or food security).

SRI and drip irrigation can both be understood as hybrids in a double sense – between social and technical components; and between the socio-technical worlds of agronomists and engineers on one hand and farmers on the other. A successful configuration of newly introduced technology occurs when the perspectives of designers hybridise with those of farmers. This happens more easily if the affordances of the proposed technology facilitate ready incorporation of new artefacts and practices into farmers' repertoires. Because the affordances feature in the technology package not only by inscription but also through their relation to the local context, the potential for reconfiguration and the ease with which it can be accomplished also depend on the existing capabilities of individuals and communities, as well as the modes of extension used. There is some evidence that participatory extension methods such as farmer field schools, and the existence of a healthy 'skilling' dynamic in the community (Stone 2011; Stone 2016) make it easier for farmers to learn about and experiment with the new information and artefacts they encounter. This area deserves further research attention.

This theoretical argument has several practical implications. First, making the inscriptions explicit will allow the designers and managers of technological interventions to reflect on their assumptions, better identify the presumed domain of any technological package, and consider their mission, goals, and targeting strategy. Second, maximising the affordances of technologies, in a way that is sensitive to the capabilities of target groups, calls for them to be designed and presented as flexible and malleable, in order to encourage farmers to select and adapt them to suit their circumstances. Such an approach would reduce the motivation to create rigid guidelines for the sake of replicability and scaling up. Third, the relational, contextual character of affordances suggests that the role and utility of 'pilot farmers' as a key focus for interventions should be reassessed. The farmers selected to pilot new technologies are usually chosen because they are regarded as 'leading' or 'progressive' farmers, whom others will follow. However, those other farmers may well have distinct needs, goals and circumstances which mean that they need to incorporate and adapt the new technology in a different way rather than trying to emulate the leading farmer. Therefore, instead of seeing to it that pilot farmers embody an idealised concept of the 'good farmer', and that they adopt and demonstrate the technology 'properly', extension efforts should assist farmers and their neighbours to consider and evaluate the new proposition, so that they may decide whether and how to incorporate it into their existing systems of knowledge and practice, reconfiguring these in the process.

**Acknowledgements:** Our analysis is based on research conducted by two distinct research groups at Wageningen University and their respective partners. The Knowledge, Technology and Innovation group coordinated the research project entitled 'The System of Rice

Intensification as a social-economic and technical movement in India' from 2010 to 2014. The Water Resources Management group coordinated the research project entitled 'Drip Irrigation Realities in Perspective' from 2011 to 2015. Both projects were funded by the Dutch Organisation for Scientific Research (NWO). We acknowledge the work of our project collaborators who carried out fieldwork on SRI and drip irrigation that has informed our understandings and arguments which we present in this paper, particularly Debashish Sen and Sabarmatee on SRI and Maya Benouniche and Jonas Wanvoeke on drip irrigation. Finally, we wish to thank participants in the panel "Grounding": when multiple ontologies meet material facts' at the conference of the European Association of Social Anthropologists (EASA) in Tallinn, Estonia, 31 July–1 August 2014, and the second Contested Agronomy conference at IDS, Brighton, 23–25 February 2016.

## Notes

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<sup>i</sup> This complaint was aired by some critics of SRI in relation to a report of record-breaking rice yields in Bihar, India in 2012 (Diwakar et al. 2012). As well as disputing the record yield claim itself, it was noted that the excellent results were attributed to SRI even though the farmer concerned had used modern rice varieties and other external inputs.

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