Agricultural Systems 128 (2014) 13–24

Contents lists available at ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

From transfer to translation: Using systemic understandings of technology to understand drip irrigation uptake

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ARTICLE INFO

Article history:
Received 2 October 2013
Received in revised form 15 April 2014
Accepted 23 April 2014
Available online 15 May 2014

Keywords:
Drip irrigation
Technology diffusion
STS
Innovation systems
Development
Socio-technical systems

ABSTRACT

Drip irrigation is a technology with great potential for improving the efficiency of water use, and for increasing crop production and food security by enabling agriculture on marginal land. Yet drip irrigation's uptake is patchy, with conspicuous successes in some locations and failures in others. In this paper we compare the history and circumstances of the mostly failed uptake of drip technology in sub-Saharan Africa with those of its deep and robust uptake in the Israeli context in which many of the failed African systems originated. We do this not only to throw light on the contextual dependence of this particular technology, and highlight strategies that have been attempted to protect it from this dependence, but also, more broadly, to use the notion of "technology translation" to consolidate several streams of socio-analytic thinking that offer improved understandings of how technologies evolve and travel.

Israel has long been a major player in the development and distribution of drip irrigation, with exceptionally extensive national level uptake. We suggest that this emerged from an integrated technology innovation system with a capacity for ongoing multi-leveled learning and dynamic evolution of the technology in light of context-specific potential and problems. Conversely, the failed uptake of drip irrigation in many sub-Saharan African countries can be viewed as a consequence of the transfer of static physical artifacts into new contexts lacking similar local systems into which these could be absorbed and evolve (re-innovated). We interpret two contrasting attempts to boost drip irrigation adoption as efforts to overcome this dependence: simplifying the hardware to become system-free, or creating a kind of remotely operated autonomous small-scale innovation system in which self-contained installations are bundled with resources and linkages to a directing hub.

Drawing on several vibrant streams of literature in the sociology of technology and technical innovation, we suggest that the emerging metaphor of "technology translation" provides a better way of thinking about and improving what happens when technologies such as drip irrigation travel to new settings. Technology translation, rather than transfer, suggests a more dialogical approach emphasizing learning and using the local "languages" of the contexts into which artifacts will be translated, making artifacts supple enough to be readily modifiable within these, and finding ways to bolster the local innovation systems that will re-invent and re-link them into new relationships.

1. Introduction

The rising demand for food, and thus, irrigation water, presses against considerable constraint in many countries, which are already experiencing water stress and in which agriculture already dominates the allocation of freshwater resources (World Water Assessment Programme (WWAP), 2009). As a result, increasing the extent of irrigated land to increase agricultural production cannot be the primary solution for responding to increasing demand for food as the corresponding rise in water demand cannot be sustained. Global climate change and increasing populations will only worsen the problem: the WWAP (2009) predicts that 47% of the world's population will live in highly water stressed regions by 2030. Against this background, irrigation technologies and practices that increase the agricultural yield per unit of water are critical.

Drip irrigation is one of the most promising options for increasing the efficiency of irrigation (e.g. Bucks et al., 1982; Goldberg et al., 1976; Ibragimov et al., 2007; Kang et al., 2004; Shoji,

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http://dx.doi.org/10.1016/j.agsy.2014.04.003
0308-521X/

1977). The hardware delivers steady, low quantities of water directly to the root area of a crop in a precise and parsimonious manner that increases efficiency, allowing the irrigation of crops in areas where water costs or ecology might otherwise prohibit this, boosting and stabilizing crop production, and thereby increasing the amount and stability of the food supply (e.g. Burney et al., 2010; Polak and Sivanappan, 1998; Postel, 2001; Shah and Keller, 2002; Verma, 2004). Though advanced drip irrigation systems offer the greatest efficiency gains, systems have also been redesigned for simpler and smaller-scale irrigation with little reduction in observed benefits (Polak and Sivanappan, 1998; Polak and Yoder, 2006; Polak et al., 1997; Postel et al., 2001; Woltering et al., 2011).

Despite academic and practitioner recognition of the advantages of drip irrigation and extensive promotion over the past two decades, global adoption remains below 4% of total irrigated land area (International Commission on Irrigation and Drainage (ICID), 2012). This paper explores the reasons for this patchy and marginal fulfillment of drip irrigation's potential globally. We do this through a case study of the "failed transfer" of drip irrigation to two sub-Saharan African (SSA) countries (Ethiopia and Senegal) to offer not only pragmatic insights into how such failures might be reduced, but, also, to force a rethinking of the notion of technology transfer itself. We do this by drawing on a dynamic emerging cluster of new ways of thinking about technologies-in-context (i.e. technological systems), and what these imply for thinking about how technologies arise, travel, and evolve.

A full generation has passed since major works such as Pacey (1983) and Blaikie (1985) demonstrated the extent to which agricultural technologies and practices are deeply mediated by and responsive to their cultural and political-economic contexts. Since then, various research traditions have offered increasingly nuanced and powerful understandings of socio-technical systems. We suggest that their collective interlocking insights render traditionally conceived notions of technology transfer and diffusion obsolete, and suggest that the notion of "technology translation" offers a more apt metaphor. Specifically, we review relevant aspects of Science and Technology Studies (STS) and allied vibrant literatures on technology and innovation, and agricultural innovation in particular.

The goals and outline of this paper are the following. We begin with a review of how STS and other research traditions on socio-technical systems have shifted our understandings of socio-technical systems and recast our understanding of the dynamics of what was traditionally referred to as "technology transfer." We then discuss the fate of drip irrigation technology internationally, and our choice of two different cases for more detailed examination: the spectacularly successful establishment of drip irrigation technology as a mainstay of agriculture in Israel and the ways in which the very same hardware often turned out to be completely useless in the sub-Saharan African context. We then suggest that this discrepancy is due to the deep institutional embedding of the technology as it evolved in the context of its deepest and earliest emergence (Israel), and the vulnerability of sheer physical apparatus "transferred" to the African context in the absence of this broader systemic socio-technical envelope. We then describe two diverging strategies taken by drip irrigation practitioners, interpreting these as questionably successful attempts to protect "transferred" hardware from this kind of contextual dependence. We suggest that the literatures reviewed offer an alternative to this kind of brittle fortification: a series of organizational, communication, and policy efforts that would boost the ability for more fluid translation between the contexts in which technology travels and mutates. We believe this account may be useful not only for understanding the global uptake of drip irrigation, but for advancing the synthesis of theoretical efforts for rethinking technology transfer and their application in various domains.

1.1. Theoretical background: rethinking technology transfer

The systemic nature of technology has emerged as a key theme in studies of technology, especially the academic sub-disciplines of STS (Science and Technology Studies), the History and Sociology of Technology, and agricultural systems research. Beginning with the early work of historians of technology in the 1960s, these literatures have offered an increasingly compelling and nuanced understanding of a technology as not simply the thing we usually point to ("telephone," "car," "drip irrigation"), but an eponymous artifact that emerges from, and, in a real sense, is constituted by an extended socio-technical network. These perspectives emerged as part of a broader challenge to earlier deterministic understandings of the trajectory of technical development. By underscoring the contexts in which technological innovation and adoption occur, these newer accounts challenge conceptions of technological development as unilinear (evidencing an inherent technological momentum from less to more advanced technologies), or deterministic (with overly simple accounts of technology shaping the nature of society or society alone determining the directions in which technologies develop).

Drawing on these beginnings, the SCOT (social construction of technology) school within STS (Bijker et al., 1987) offered a more complex account of the socially-located development paths and meanings of technology—in fact, it advanced a notion of socio-technical systems, in which the separation of technology and society is blurred. It argued that technology cannot be spoken of as simply hardware and its "functions," but is co-constructed in a social context—each shapes and bears the imprint of the other. Thus, a technology's functions and implications are not fixed but can be interpreted differently—indeed, are different—in different contexts and for different social groups. The question of the "best technology" is, therefore, to some extent an open one; for whom is this technology the best technology? When is this the best technology? How is this the best technology... and so on. This mediation by social contexts and processes of an artifact's nature, function and effectiveness has obvious implications for our understanding of the dynamics of technology adoption, evolution, diffusion, and rejection.

Several scholars, notably John Law (1999), Callon (1991), and Bruno Latour (1991), further elaborated these perspectives of technology as a heterogeneous socially-embedded system saturated with power relations. Over the course of the eighties and nineties, they added insights drawn from Foucault, semiotics, and ethnomethodology to forge a vibrant and evolving body of work that came to be known as Actor Network Theory (ANT). ANT proposes a processual, performative, and relational vision of socio-technical systems: "entities achieve their form as a consequence of the relations in which they are located... they are *performed* in, by, and through those relations" (Law, 1999).

The links and structures of a system are not given but continually produced. But, at the same time, they gain a degree of solidity and regularity. A key notion in ANT's description of socio-technical dynamics is that of stabilization. This occurs when a system or parts of it are robust enough so as to become routine and invisible: a black box that can be used and relied on, with no need to question or even examine its innards. Networks (human and nonhuman) struggle to achieve such stabilization by "enrolling" other actors into using and strengthening durable links that "serve" them. Stabilization (and the related notion of "closure") occurs when such an assembled web of alliances, linkages and understandings becomes too robust to challenge or unravel. The notions of technological closure/stabilization have been drawn on and developed in useful ways. Star (1999), for example, describes a kind of stable background system, which she characterizes as "infrastructure"—an invisible support system that people rely on,