LOW COST DRIP SYSTEMS: OPPORTUNITIES AND CHALLENGES OF A DEVELOPMENT MODEL

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ABSTRACT

Low cost micro drip kit is being touted in South Asia and other developing countries by International Development Enterprises (iDE) with an objective to empower 'poor' smallholder farmers to invest their way out of poverty. 'Success' stories are told of the technology being adopted by farmers in India. With this assumption, the development of drip was replicated in Zambia without the much anticipated success. Thousands of low-cost drip kits were sold to targeted farmers but, after a few years, only few were still functional on farmers' fields. Most of the farmers either did not use the technology or abandoned it after using it for a brief period of time. A number of social, economic, physical, technical as well as institutional challenges can explain this. This study reviewed conditions that characterized the success and challenges of drip in India and Zambia respectively, focusing on the technical configuration of drip systems in the latter. The authors argue that the drip technology was transferred from India to Zambia without the support system or network of organization that made it work in India thus imposing constraints on the use of the kit by farmers in Zambia. Few farmers who used the kit configured their drip systems by modifying its characteristics to overcome these constraints. The study concludes that the configuration of drip on farmers' field was determined largely by farmer innovation, availability of spares and costs of drip equipment, profitability of markets, labour, system capacity and technical knowledge of farmers as well as the availability and depth of groundwater

INTRODUCTION

The past few decades have seen a revolution in the development and commercialization of new irrigation technologies such as automated canals and pressurized water delivery systems, surface and sub-surface drip irrigation technologies, automated sprinklers and highly sophisticated control systems developed to manage these new innovations. The design and development of these technologies were directed towards relatively large and sophisticated irrigation systems in developed countries populated by well-resourced farmers (Keller, 2004). However, the vast majority of the world's farmers who live in developing countries (van Hofwegen & Svendsen, 2000) are resource poor and cultivate on small plots of less than two acres. They have been excluded of the use of these innovations by design and cost (Postel, 1996; Polak et al, 1997; Postel et al, 2001, Keller, 2004).

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Although a small proportion of smallholder farmers may benefit from subsidized canal irrigation schemes by local governments, most are found in locations where these schemes are "too expensive or impractical to build" (Postel et al, 2001, p.4).

In the face of increasing global population, water scarcity and the need to tackle poverty in developing countries, International Development Enterprises (iDE) took up the challenge to re-engineer conventional irrigation technologies with the explicit objective to meet the needs of smallholder farmers. These drip irrigation systems are characterized by low investment cost, rapid returns on investment, suitability for various small plots, simple operation and maintenance (Polak et al, 1997; Postel et al, 2001; Keller, 2004). Technologies developed include low-cost plastic tanks for collecting and storing rainwater, pressure and suction treadle pumps for water lifting, low pressure sprinklers and drip emitters for efficient water application. Shifting from the traditional practice of simply 'handing-out' technological innovation to farmers, iDE adopts a "business approach" whereby farmers are supported so that they can invest their way out of poverty by increasing crop productivity and income from marketable surplus by means of: (1) water control, (2) private sector supply chain, and (3) profitable marketing of high-valued crops (Heierli & Katz, 2007; IDE, 2007).

Krishak Bhandu (KB) or "farmers' friend" in local Hindu parlance is a low-cost drip kit developed and promoted by iDE in India and other South Asian regions over the past decades. High adoption rates and widespread use of these kits have been reported (Heierli & Katz, 2007; IDE, 2007) leading to their promotion in Zambia and other African countries. The Zambian experience was however without the much anticipated success. An evaluation of iDE's projects showed that thousands of low-cost drip kits were sold to targeted farmers but few were found being used by farmers on their fields. Most of them either did not use the kit or abandoned it after using it for a brief period of time. The evaluation revealed that a number of social, technical, physical, and economic as well as institutional challenges were the bane on the unsuccessful replication of the 'Asian' success in Zambia (Tuabu, 2012a; 2012b).

We focus on the configuration of drip-kits under different circumstances to review the conditions that contributed to the success of drip kits in India and the challenges to replicate the same in Zambia.

ANALYTICAL FRAMEWORK

We use the technological system perspective (Hughes 1983; 1987), social construction of technology (Pinch & Bijker, 1993; Bijker 1993) and the innovation theory (Reij & Waters-Bayer, 2001) to analyse how the KB drip was perceived as a success in India and how it apparently failed to work on the field of farmers in Zambia. By doing so, we adopt a sociotechnical approach whereby technology development is a social activity influenced and shaped by different social actors or forces that constitute the environment (or technological system) in which a technological artefact or object is being developed (Pinch & Bijker, 1993; William & Edge, 1996).

Technological systems are developed by systems builders (inventor-entrepreneurs) mainly with an objective of solving problems (or correcting a reverse salient) to fulfil specific goals. In doing so they end up inventing technological objects or artefacts (Hughes, 1987; 1992). Technological objects do not work in isolation but are made to work by being part and parcel of already existing (or created) systems (Hughes, 1987; MacKenzie & Wacjman, 1999). Constraints however arise when relatively 'new' technologies are being integrated into existing systems and care must be taken they are designed to 'fit' in order to work (MacKenzie & Wacjman, 1999). This happens as a result of real confrontation between users and the technology who end up finding their way round to 'de-scripting', 'reconfiguring' and re-shaping the technology (Bolding, 2004).

When technological objects are made to work, adopted and used, then they constitute innovations otherwise, they still remain an invention (Rosenberg 1982; Woodhill et al, 2011). Hughes argued that whenever existing systems do not favour the production of innovations, system builders create their own conditions (or systems) with unique characteristics in which the artefacts or objects are adapted to make them work. He explained that although technological systems may differ from one setting to another, transfers are possible but constraints may arise when the object of technology is transferred without the systems or organizations that made them to work in their previously existing setting (Hughes, 1987, p. 66 – 68).

METHODOLOGY

Data for this paper were derived from three months of field work with iDE, iDE project partners and farmers as part of the International Development Research Centre (IDRC) sponsored project on "Gender Differentiated adoption of Low-cost Irrigation Technologies in Zambia" jointly implemented by International Development Enterprises (iDE) Zambia and Wageningen University and Research Centre. The process included semi-structured interviews and in-depth unstructured or open conversation with iDE staffs, project implementing, and farmers. Interviews helped in understanding the influences and contribution of different actors to the process of development of the low-cost drip at three levels: (1) iDE and its partners (also referred to in this paper as 'technology input level'), (2) farmers (or 'on-farm level') and (3) market agents and traders (or 'output level').

The main implementing partners of iDE are the Mennonite Economic Development Associates (MEDA) and international NGOs. These provide initial vouchers for farmers to purchase drip kits and treadle pumps and train microfinance institutions, which will eventually provide lending to farmers. Microfinance institutions involved are the Christian Enterprises Trust of Zambia (CETZAM) and Micro Bankers Trust (MBT). They provide loans to farmers to buy drip and other micro irrigation technologies (MTIs). Others actors involved are Cropserve, an agricultural input supply shop involved in the importation of KB drip from India in collaboration with iDE, enterprises or shops involved in the manufacture, import, supply and distribution MITs and iDE trained market agents.

An ethnographic study was done of the history of the drip kit in Zambia, as well as case studies of farmer innovation involved in the configuration of different drip systems. Snowball sampling was used for identification of different categories of farmers who did not use drip, who abandoned the kit and who still used the technology. Personal observation and field note book was used for the documentation of farmer innovations and field water management practices. The method of triangulation was used to crosscheck and verify data generated from iDE management staffs, iDE field officers and iDE partners as well as information from farmers and secondary data obtained from iDE Zambia.

Data on the development of KB drip in India were obtained from a literature review, involving project documents from the iDE India website database, academic articles and documentary videos on micro irrigation technologies developed by iDE India.

IDE PROJECT DESIGN

iDE projects are said to be designed using the Prosperity Realized through Smallholder Markets (PRISM) methodology. PRISM is characterized by two main project activity phases i.e. formulation and implementation. Preceding the two phases however is an initial scoping activity to study targeted regions within a country to determine suitability for an intervention programme. After this, project formulation starts with detailed field activities such as boundary definition, market opportunity survey, constraints analysis, partnership development and intervention design (IDE, 2003).

Boundary definition is a continuous process of demarcation of areas of intervention within which smallholder market systems would be developed. This is followed by the identification of three to six market opportunities that have the potential to generate good income for farmers. iDE also conducts a sub-sector analysis of different crops, including the mapping of commodity chain followed by a gap analysis of business development services (BDS)[3] at three levels: input/service supply[4], on-farm[5] and market output[6] segments of the commodity chain.

IDE looks for Business Development Services (BDS) partners who have the capacity to contribute complementary expertise in service provision such as facilitation and direct service provision (DSP) in the development of markets. Partner identification is carried out by conducting series of focus group discussions, interviews, market surveys, formal and informal discussions with farmers and key informants in the private sector, government and civil society (IDE, 2003, p. 18).

Intervention strategies are designed to address priority constrains identified around factors such as technology, finance, capacity, information, policy and infrastructure at the levels of input, on farm and output markets. iDE expects that after five to six years of market intervention, smallholder farmers will be sufficiently integrated into market systems to make incomes amounting to $500 and more per year (IDE, 2003, p. 21).

Implementation is the second phase of project design. This is determined by the outcome of project formulation. iDE's role in project implementation is the establishment and maintenance of "platforms" upon which iDE partners can work to achieve target objectives of increasing income by $500 per year. This phase is also characterized by regular monitoring, reflection, feedback and evaluation to assess whether the goals and objectives are being met. The intervention is adapted, as needed, based on the learning generated from the evaluation (IDE, 2003; 2007).

DESIGN AND PROMOTION OF KB DRIP IN INDIA

Low cost drip kits were designed and promoted in India by IDE after series of trials and redevelopment of the micro tube drip (Polak et al, 1997) and *Pepsee* drip kit into the KB drip (Verma et al, 2004; WOCAT, 2007). The objective of this re-development was to develop a product that would fit the need of smallholder farmers and support them in managing scarce water resources, producing food for their families and selling marketable surplus for income. In this section, we review the conditions that contributed to the acclaimed success of drip in India, focusing on the organization of technological system support for the drip kit to work on the field of farmers.

Here, 'success' is premised on actual adoption and use of the KB kit on the field of farmers. Conditions for success entailed a structure of support services made up of

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[3] These are iDE's project partners who are either Direct Service Provider (DSP) or Facilitators. DSPs are market actors who are aligned with the objectives of iDE's projects and receive support from the project to increase their efficiency and effectiveness. These are mainly private enterprises, micro-finance institutions, farmer groups located in the project area. (IDE, 2003, p.20).

[4] This includes enterprises and organization that provide goods, services and information required for agricultural production (IDE, 2003, p.19).

[5] These are household production units that utilize inputs to cultivate crops for self-consumption or market exchange (ibid).

[6] These include enterprises and organizations that provide goods, services and information required to facilitate small farm production from domestic consumption to market exchange at economically remunerative prices (ibid).

local manufactures of drip, distributors, dealers of KB drip. These were further backed up by helpers, fitters (or village based mechanics) and IDE staffs who support farmers accessing, installing, maintaining and repairing the drip kits on their farms.

At the input/service supply level, the development of KB drip was supported by a production and marketing channel made up of manufacturers, distributors and dealers. It is further supported by a marketing team made up of Manager, Business Supervisors and Business Associates (BAs). BAs were responsible for conducting and organizing the promotion of KB kits and providing support to KB dealers. They are paid fixed salaries and 4% commission of total sales on turnover by dealers (IDE, no date). These are partners of iDE who support the supply, installation and use of KB kit on the field of farmers. Dealers buy directly from distributors and supply to farmers. The kits are sold with a one year warrantee card to farmers and delivered to farmers fields (EQUITY FOUNDATION, 2010). A typical dealer employs about 2 to 5 fitters and 8 to 10 helpers who install KB drip for farmers who cannot install the facility on their farms and are paid (IDE, no date). Dealers also carry out after sales services such as repairs and maintenance if farmers cannot do it themselves. Most farmers in India replace laterals of their kits almost every year (TERI, 2007; EQUITY FOUNDATION, 2010). Besides dealers, other village based mechanics and IDE staffs also help farmers with installation and other aftersales services (EQUITY FOUNDATION, 2010).

Although farmers using KB experienced challenges such as laterals flying with strong winds, rat and ant bites among others, the support and other available services and opportunities for irrigation development (Merrey & Sally, 2008) in India support farmers to adapt, adopt and use KB drip at the farm level.

At the output level of project intervention, iDE made attempts to understand farmers' views on the KB drip; their perception, expectations as well as suggestions. Farmers made recommendations on problems they faced citing the modification of existing products or the introduction of new ones (EQUITY FOUNDATION, 2010).

DESIGN AND PROMOTION OF KB DRIP IN ZAMBIA

The development of drip in Zambia was premised on the positive experience acquired in India and other South Asian regions. Three donor funded projects namely the Practical Micro Irrigation Technology Development (PMIT) Programme funded by the World Bank (1997 – 2002), The Smallholder Market Creation (SMC) project funded by USAID (2003 – 2005) and the Rural Prosperity Initiative (RPI) project funded by the Bill and Melinda Gates Foundation and the Dutch Ministry of Foreign Affairs (2006 – 2015) played a pivotal role regarding the introduction of low-cost drip kit in Zambia. The development of low-cost drip was initiated in the first two projects, and later upscaled during the RPI project. The objective of the RPI was to assist 14,000 smallholder farmers invest their way out of poverty in the first phase of the project (2006 – 2010) and 11,200 in the second phase (2011 – 2015) and raising their income by $300 a year through the sale of treadle pumps, low pressure sprinklers, small motorized pumps and low cost drip. The kits were promoted on the basis it allowed labour, cost, water savings and increased crop productivity. In the first phase of the project, over 4,000 drip kits were sold to farmers through a voucher program programme supported by the Mennonite Enterprise Development Associates (MEDA), an implementing partner of the RPI project. The KB kits were sold to farmers at discount prices after farmers had participated in training session on drip installation, maintenance and use organized by IDE field and technical staffs. 'Trained' farmers receive discount vouchers and top up with their own savings or loan arrangement with collaborating microfinance institutions (MFIs) to buy the drip kit. The vouchers provided discount of 60 – 80% at different stages of the project. The voucher, however, only covers the purchase of part of the drip system namely main laterals, laterals, drippers and other accessories (joinery and water control). It however does not include an overhead tank. Farmers had to purchase it separately.

The KB kit however did not experience the success much accorded to it in India. An evaluation of the first phase of the RPI project reported various constraints and challenges for farmers to use the kit. Most farmers abandoned the drip kit after having used it briefly for diverse socio-economic, physical, technical and organizational/ institutional reasons (Magwenzi, 2011; Tuabu 2012a; 2012b).

Technical

The main technical reasons why farmers did not use the drip kit were: (1) the farmers' inability to purchase all the components of a drip system, and (2) their inability to configure their drip systems properly. Some farmers purchased only the subsidized drip kit (main lateral, laterals and microtubes) without the 200 litre tank sold separately by iDE. Others had all components required but could not install the components properly due to lack of technical competence even after having received some form of training from iDE.

Our study revealed that farmers abandoned the KB kit due to: (1) unavailability of spare parts especially laterals that were damaged by rodents or weeding tools, (2) frequent clogging problems experienced due to presence of calcium deposits in groundwater and dirt accumulation, (3) uneven water distribution and their system 'blocking' due to the 'soft' material nature of the kit especially on 'not fairly levelled' fields, (4) few cases where farmers experienced drudgery with the use of buckets to lift and fill overhead tanks as they did not have water lifting devices such as treadle or small, and (5) a unique case of a farmer who claimed the repeated filling of 200 litre tank to meet crop water need with a motorized pump was not cost effective.

Physical

Prevailing physical conditions on farmers' fields also constrained the use of the KB kits. The material nature of the kit is such that it becomes soft and easily takes the shape of the field under high temperatures resulting in uneven water distribution. The light weight nature of the kit drip made them to be easily blown away by strong winds. Some farmers had challenges with low water yields as well as drawdown in their wells in the dry season. Although this condition only limited their production potential, most farmers who abandoned the kit experienced frequent clogging due to the presence of calcareous deposits in groundwater while others experienced build-up of green algae in their tanks (that were transparent).

The selection of water lifting devices is determined by the depth of groundwater. Water at depths of 6m or less can be accessed by a bucket, pressure and suction treadle pump and a motorized pump. A depth more than 6m eliminates the pressure treadle pump which cannot lift water beyond 6m. Similarly, with depths of more than 7m the suction treadle cannot function thus the farmer needs either a bucket, a motorized or submersible pump.

Socio-economic

Farmers who did not use their kits or abandoned them were not only constrained technically but socio-economically as well. Those who did not buy the overhead tank argued that they were expensive and could therefore not afford them. Farmers who used buckets in lifting water did not have the economic means to purchase a treadle pump or motorized pump.

Market conditions were not conducive for farmers due to price fluctuations, untarred roads in the rainy season and high transport cost to distant markets. For some farmers, this caused production losses and subsequent dis-adoption of the kit (Borsboom, 2012; Tuabu, 2012a).

Farmers who installed a complete drip system bought their kits using savings from sale of previous harvest (especially maize or vegetables) or loans from microfinance institutions. An interesting social condition that motivated some farmers to use the kit in some communities was the proximity of homestead and fields These farmers learned to configure and repair the drip from each other. Those who were not so 'technically' inclined were helped by their fellows or hired labourers to set up their drip systems. It was however observed that communities where farmers where far away from each other had challenges using the drip kit.

Organizational/institutional

The decision to promote and support the dissemination of drip kits in Zambia did not emerge in-country but was rather pushed from outside, largely because of the positive imagery surrounding the technology as expressed by an iDE official:

"(…) to some extent, there was a push out there saying drip is a brilliant programme, you need to promote it (…) we are scoring highly from the numbers (or adoption of drip) and getting the technology out there (...). And we've been rushed to promote it (...). So we more or less convinced Cropserve (our implementing partner) that drip was a fantastic technology (...)" (Tuabu, 2012b, p.50).

iDE Zambia was also operating on a 'lean' budget for the RPI project. According to an iDE official, budgetary allocation for the RPI was almost half the allocation to the previous SMC project. Under the SMC, iDE had more staffs and regional offices comprising a team of specialists such as agronomist, irrigation technician, a team leader with a background in business administration and field staffs. They were resourced enough to operate and provide better services to farmers. Under the RPI however, this setup was restructured. Most of the agronomists and irrigation engineers could not be employed anymore due to budgetary constraints leading to a loss in expertise regarding the design of the drip-kits (only 2 remained in the headquarter in Lusaka). Similarly, few field staffs were employed to promote, train, and sell micro irrigation technologies. The average field staff to farmer ratio is 1:2000, meaning they have little incentive –and means- to provide aftersales service.

The four year allocated for the project was identified as another challenge hampering the adoption and use of the KB drip. Like for every development project, meeting targets was a primary criteria for evaluation by donors, leading iDE-Zambia to focus on aspects that would allow them to disseminate the 14,000 targeted kits as fast as possible such as promotional activities, subsidy systems and linkages to microfinance institutions. In their 'hurrying' quest, technology development processes like field testing and evaluation to ascertain whether the kit meets farmer's use requirements were overlooked and limited attention was paid to input/supply chain, while these appeared crucial conditions to success in South Asia. Finally, after-sales services were not incorporated in the project – also due to lack of staff (see above).

EVIDENCE FROM THE FIELD: TECHNICAL (RE) CONFIGURATIONS OF LOW-COST DRIP SYSTEM

The different constraints outlined above characterize the socio-technical environment in which low-cost drip kits are being developed in Zambia and hampered their adoption and use by farmers. However, some farmers who use drip kits on their farms overcame these challenges by reconfiguring the technological package promoted by iDE, based on their direct and daily encounter in "running" the drip systems. These are generally farmers who were influenced by model trained farmers whose responsibility is to train other farmers. They visit each other frequently to observe how their fellows overcome common problems they faced with the use of the kit.

Due to the unavailability of spare parts, farmers devised innovative ways of dealing with damaged components of the drip kits by replacing them with elements from other drip packages available in the region (such as those of Netafim and Metzerplast) or local material. Some farmers repaired their drip kits by making clean cuts of laterals and joining them together using polyvinyl pipes. They secured the joints from leaking by wrapping polythene sheets round it, and tied ropes around them (Tuabu, 2012a.; 2012b). Another adjustment was to tie the end of the drip lines with wooden pegs to keep them taut.

A farmer who experienced frequent clogging and uneven water distribution on his field improved his filtering system by covering his tank with an old mosquito net. Another one who experienced draw down in water level to about 12 m deep dug a trench about 5 meters deep and 5 meters long near the well and punched a hole in the concrete lining the well to access water. Farmers also bought different types of tank than those promoted by iDE.

DISCUSSION AND CONCLUSION

The low cost KB drip is reported to be a successful innovation in India where, at the input/supply service level, private sector actors involved in local manufacture, distribution and dealership supported its adoption and modification by farmers. There, drip kits were sold with one year warrantee to farmers and variants of the KB drip available on the market. Farmers were also provided with after sales and other services related to the repair, replacement and maintenance of their kits. At the output level, marketing conditions were favourable (Merrey & Salley, 2008). Finally, feedback mechanisms were put in place to evaluate the experiences of farmers in order to improve the KB products and services.

In Zambia, the technological system in which KB drip kits was embedded was less conducive for the kits to be used sustainably on farmers' fields. The object of the technology (i.e. the KB kit) was largely transferred with scant attention being given to replicate or adapt the support system that made it worked in India. At the input/supply service level, shops imported, stored and distributed drip kits. The kits were promoted by iDE field officers who "had to" convince farmers to purchase the kits due to the incentive structure (i.e. reaching targeted sales) that dominated the overall project. They did so by linking farmers to microfinance institutions. Little attention was given to after sales services to make sure the kits were tailored to farmers' field conditions. Other conditions that hampered the use of drip kits were low local manufacturing capacity, the lack of support services for installation, repairs, spare parts and the lack of a warrantee system. Finally, output markets were not conducive enough and there was little feedback mechanisms to evaluate farmers' experiences and adjust the approach accordingly. This can be seen as an example of lack of 'fit' between the technological object and the existing technological system. A few farmers however found their way round the challenges of the technological system by re-configuring the technical object (i.e. the drip kit). In the absence of after sales support, they configured their drip kits themselves or with the help of other farmers or experienced farm labourers who worked in commercial drip farms. Farmers repaired their kits or replaced them with other available technological packages and local materials such as tanks, rubber bands, wooden pegs etc.

At an institutional level, and as is often the case in development projects, the incentive structure was strongly biased towards "reaching sales target" within a limited time frame (i.e. 4 years) rather than making sure that the sold drip-kits would be used sustainably on farmers' fields – even beyond the project's life time. iDE field staff focused on linking farmers to micro-credit institutions such as MEDA for buying the kits at discount prices or on loans, thus hampering the implementation of the business approach advocated by iDE. Finally, establishing attractive output markets proved to be a challenge, leading to disappointing financial results for the farmers and subsequent abandonment of the drip kits after a “trial” season.

In conclusion, we argue that the life line for the reported success of KB kits in India was the “fit” between the socio-technical environment (i.e. the technological system) and the kits themselves (i.e. the technological object). In Zambia, a combination of social, economic, physical, technical as well as institutional constraints limited the scope for the kits to be used. However, few farmers who had preferential access to knowledge and support network found innovative ways to overcome these challenges. They did so by re-configuring the drip systems promoted by iDE thus constructing “hybrid systems”. These adjustments are similar in scope to those that were observed during the initial stage of drip-kits promotion in south Asia. Learning from farmer’s initiatives and establishing a system supporting these must become a priority if drip-kits are to fulfil their promises in sub-Saharan Africa.

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