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Livelihoods and Gender Roles in Drip-Irrigation Technology: A Case of Nepal

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Summary

This paper attempts to understand gender issues in micro-irrigation technology by exploring the dynamics of gender, water and rural livelihoods. Based on an empirical study in the rural areas of West Nepal undertaken in 2003, the paper assesses the socioeconomic impact of drip-irrigation systems on men and women's lives. A combination of participatory research tools, participant observation and secondary sources were used to generate data. The study revealed that women extensively contributed to vegetable farming under the drip-irrigation systems. The total time (mean hours) spent by women in vegetable production is significantly higher than those spent by their male counterparts. The benefit cost analysis of vegetable farming has shown overall viability in terms of net present value, benefit cost ratio, internal rate of return and payback period. Based on the study findings, the paper suggests that similar technological interventions could be considered in places of similar socioeconomic and biophysical characteristics to help empower rural women. Finally, the paper raises some significant questions in relation to rural livelihoods and women's entitlements.

1. INTRODUCTION AND BACKGROUND

Increasing agricultural productivity and income of the majority of farmers in developing countries, most of whom cultivate less than one hectare of land, is a relatively untapped opportunity for finding practical solutions to rural poverty (IDE 2002). In fact, opening smallholders' access to affordable small plot irrigation can be a critical first step to wealth creation for the rural poor, and a considerable literature documenting their success has already been developed (Shah et al. 2002; Mehta 2000: Hurdec 2000; Postel et al. 2001; Polak et al. 1998; Shah and Keller 2003).

One prominent example of smallholder irrigation technologies is drip. Drip-irrigation in the developing country context generally refers to the slow application of water through a set of emitters (holes) placed along water delivery lines precisely at the root zone of the plants. Water is supplied to the lines via drums, which can be filled by hand or other means. Drip irrigation is often associated with vegetable production for both home use and sale.

Drip-irrigation systems can fill an important technology gap for the rural poor by providing a low-cost entry into irrigated agriculture. In contrast to large-scale irrigation systems, which are typically developed in more favorable agricultural areas populated by more well-endowed farmers, drip-systems can be accessed by the poorest and most vulnerable strata of society, particularly women.

Most of the literature available on drip-irrigation technology (Sarkar and Hanamashetti 2002; Narayanmoorthy 2004; Naik 2002; Phansalkar 2002; Foltz 2003) has so far been focused mainly on its hardware aspects. Not much work related to women and drip-irrigation technology has come to the fore. This is unfortunate given the disadvantaged nature of women within marginalized societies and the fact that casual observation suggests that drip technologies can have a pro-women bias and, thus their contribution to alleviating rural poverty and gender inequity may be underestimated. This study tries to bridge this gap by looking at the dynamics of drip-irrigation technology and rural households with special reference to women farmers.

The overall objective of the paper is to explore gender, water and rural livelihood connections to drip irrigation. The specific objective is to examine gendered roles, work load and perceptions in relation to vegetable farming under drip-irrigation technology; to investigate the changes drip-irrigation technology bring to the households food and nutritional intake and women's decision-making; and to analyze the economics of the technology and understand the reasons for its adoption.

The study tests the hypothesis that low-cost drip irrigation systems such as drum and bucket kits, used for vegetable farming, help improve household food and nutritional intake and also generate additional income without having any negative impact on women's work load.

1.1 Technology Dissemination in Nepal

His Majesty's Government of Nepal assigned the Agricultural Development Bank, Nepal (ADB/N) the job of promoting micro irrigation programs in early 1980s. IDE, an international non-government organization (INGO), signed an accord with ADB/N in the early 1990s to promote micro-irrigation. Since then, the IDE (International Development Enterprise) has been implementing the low-cost drip irrigation program in rural Nepal for smallholders in collaboration with several other institutions.

With regard to drip technology dissemination, the technology promoting organization (in this case, the IDE) works in close collaboration with several informal and formal organizations to market the products with the stated goal of helping rural families enhance their welfare and income by increasing cash crop production for both consumption and market. As the stepping-stone of its intervention strategy, IDE tried to motivate smallholders, with a special focus on women, to form self-help groups for vegetable cultivation under micro-irrigation technology.

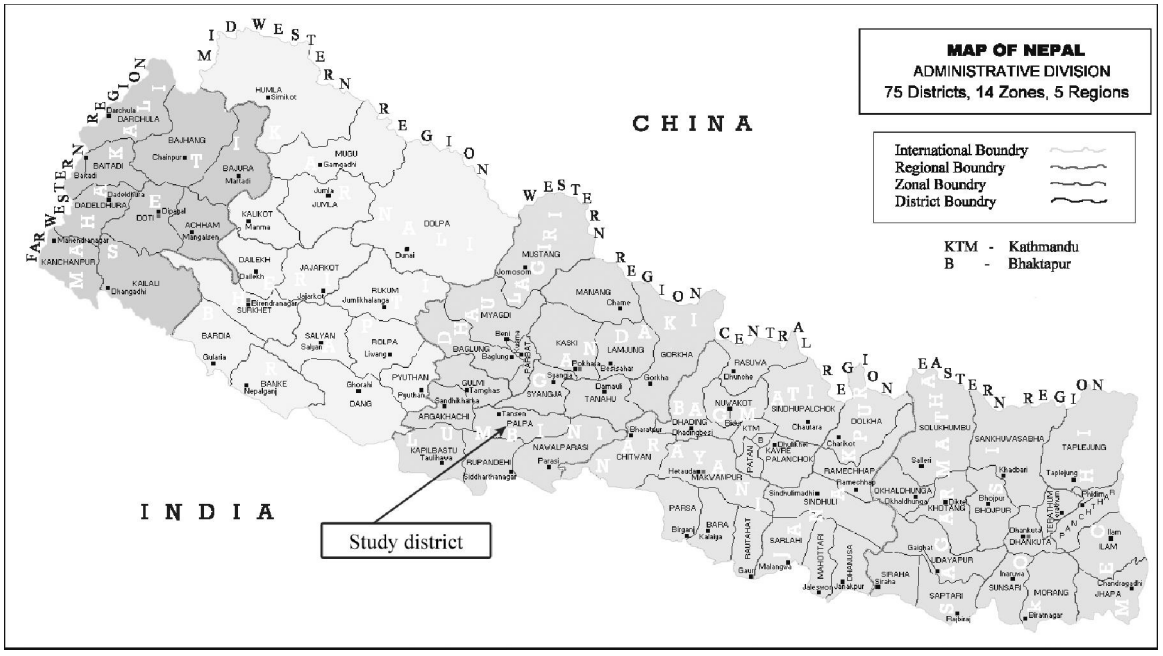
Once the farmers were motivated, a few farmers deemed especially capable were chosen as master leader farmers and trained on installation, operation and maintenance of the technology and on other agronomic and organic farming methods including the selection of quality seeds, fertilizer use and application, and pest control. These trained leader farmers then took on the challenge of assisting other interested farmers under their respective groups in installation of drip kits and of transferring knowledge.

Besides technical and social support, IDE also provided assistance in marketing the produce under its business development schemes and strategies. This contributed to the establishment of vegetable collection centers in each village, which allow farmers to simply walk in and deposit their produce and claim the return the following day.

2. STUDY AREA AND METHODOLOGY

The study is based on primary and secondary data related to Pokharathok village of the Palpa district in the western hills of Nepal (see figure 1). This particular village was selected, because it has a relatively large number of men and women drip users.

Figure 1. Map showing the study district.



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The average annual rainfall in the village varies from 1,500 mm to 2,000 mm, and the average minimum and maximum temperatures are 5 °C and 35 °C. Primary crops grown in the village are paddy, wheat and millet. Potato, mustard and buckwheat are secondary crops. Vegetables are grown only when irrigation facility is available. Livestock rearing is common, and women are significantly involved in this activity. Most of the households rear goats, buffalos and cows. Alternative livelihood and income generating options from non-farm activities such as rural business, government and private services, and wage earnings is very low. Thus, seasonal out-migration of male members is common in the region.

The total population of the district is 236,000 with 489 households. Approximately 2,900 residents form the Pokharathok village.The population of Pakharathok is made up of mixed ethnic minorities with a large concentration of high caste and relatively well off *Brahmans* and *Chhetris*. These are followed in numbers by occupational caste groups such as *Damai, Kami* and other *Dalits*. *Dalits* are under- privileged and have often been left behind by development interventions. Traditionally, *Dalits* have been treated inhumanely as untouchables, a category abolished by law in 1963 but still the practice exists in rural areas. *Dalits* frequently live in a swamp of illiteracy, exploitation, marginalization, absolute poverty and, above all, caste-based discrimination. For example, when *Dalit* women fetch water from public water sources, they risk mental torment and physical assaults by upper castes.

The study covered a sample of 131 adopter households of the village, where International Development Enterprise (IDE), in collaboration with other local nongovernmental organizations (NGOs), is in operation. Unstructured questionnaires were used to interview both men and women users, and several informal meeting were held with the *Adhyakchya* (Village Chairman), IDE and NGO field staff and *Aguwa Kishans* (leader farmers). These households are cultivating seasonal and off-seasonal vegetables for both household consumption and the market.

The total population of drip adopters in the sample village was first categorized according to the size of the landholding and the number of years of drip usage. We considered only those drip users who owned less than one ha of cultivable land, and those who had been using the drip system for at least 3 years. From that group, respondents for the study were selected randomly. Two focus group discussion sessions were also held with those who owned less than one ha of cultivable land and who did adopt the drip system. The primary goal of the discussions was to capture the reasons of their choice not to adopt the drip system.

Participation of men and women in drip irrigation was measured by actual physical labor inputs in mean working hours per season in vegetable production. To document the time allocation of men and women, a random-spot observation was done (Paolisso and Regmi 1992). In our application of random-spot observation techniques, each adult member of the household was visited on random days over 3 weeks. For selected days, the activities of men and women were recorded during the 12-hour period between 6:30 and 18:30. The activities recorded generally included vegetable farming inclusive of marketing, household chores, child-rearing and water and fuel collection.

Decision-making data were collected in discussion groups by recall method using “before” and “after” situations. Benefit cost analysis was done to obtain the net revenue generated from the use of the technology and to understand the economics of the vegetable-production enterprise.

3. SURVEY RESULTS

3.1 Differential Impact on Women’s Workload

The main vegetable crops grown in the surveyed area were cauliflower, tomato, cabbage, cucumber, bitter gourd, bottle gourd and French beans. On average, 186 hours of labor were required per season for vegetable production on an average plot of 0.127 hectares.

Within drip-irrigated vegetable production, women play a predominant role by contributing 88 percent of the total labor use (table 1). In fact, with the exception of seed bed preparation and perhaps sowing, women were found to play the dominant role in all aspects of the production and marketing process. This suggests that drip-irrigation, at least as implemented in the study site, can have a major pro-women bias in generating opportunities for female labor force participation.

Table 1. Gender division of labor in vegetable farming per season.

Activities undertaken	*Total hours used*	
	Men	Women
Seedbed preparation	10	4
Sowing seed	2	2
Transplanting	-	5
Irrigating	10	80
Fertilizer application	-	22
Harvesting	-	5
Marketing	-	10
Weeding	-	36
Total hours	22	164
Proportional mean in %	12	88

Source: Field survey 2003

The analysis of time allocation data revealed that women's workload has been reduced after the adoption of the drip system. Before the intervention of the drip system, female members of households fetched water from long distances, on average spending 1–2 hours acquiring water for both domestic use and limited homestead irrigation. It is noteworthy that the intervening agency helped identify probable alternative water sources and ways of utilizing those sources as part of the intervention package. This reduced the time required for fetching water, irrespective of the use of drip-irrigation.

Data revealed that it takes about 1–2 hours to irrigate a vegetable plot of 0.0127 ha under the conventional irrigation method. With drip-irrigation, the irrigating time for the same plot has been reduced by 50 percent. In the drip system, users have to just fill the 50-liter drum and turn on its gate valve to open the passage of water through small pipes laid in the field. They do not have to irrigate manually, as they used to in conventional irrigation. HURDEC (2000) reported that the time saving of the majority (77%) of farmers was due to the drip technology. However, the drip system has also become a time and effort saver even for non-drip users, including those who fetch domestic water, because of the identification of new supply points.

Our qualitative data revealed that women utilized the saved time for purposes such as childcare, socializing, taking rest, and tending livestock. Saving in time and drudgery also meant that women had time and energy to carry out other innovative works**.** For example, women respondents utilized their saved time by forming self-help groups and operating saving-credit accounts in the village which could be availed during times of crisis. These groups provide a platform for sharing experiences, increase social network, improve self-esteem and raise confidence.

Women of the sample village acknowledged the institutional supports provided by the promoting agency. Women respondents were very satisfied with their efforts and consequent success in vegetable farming under drip technology as they are regarded as model commercial vegetable growers by other nearby (non-intervened) village farmers, who are looking forward to replication of the model in their communities. It is noteworthy that outside the project areas, the extension and adoption system is still largely male-dominated and women receive little or no information on improved agriculture and new technology.

Studies on perception also back up this evidence. The vast majority of respondents (84%) agreed with the statement that adoption of the drip system helps generate more income than other available livelihood options. Likewise, the majority (67%) explained that their workload has not been increased

but instead hours spent on fetching water have significantly declined. The majority (75%) of respondents agreed with the statement that women are more involved than men in vegetable farming under drip irrigation (table 2).

Table 2. Perception of women on the drip-irrigation technology.

Statement	Agree	Neutral N = 131	Disagree
Adoption of drip technology helps generate more income than other available livelihood options for women.	111 (84)	10 (8)	10 (8)
Credit or subsidy should be provided to new adopters.	131 (100)	00	00
Women are more involved than their male counterparts in vegetable production under the drip system.	98 (75)	27 (21)	6 (4)
Adoption of the drip-irrigation technology has not increased women's work burden.	88 (66.7)	27 (21)	16 (12)
Drip irrigation technology brought changes in the daily vegetable intake.	(66.7) (33.3)	43 (33.3)	00

Note: Values in parenthesis are percentages
Source: Field survey, 2003

3.2 Changing Diets, Access to Income, and Power

When intra household food distribution mechanisms or nutrient intake is observed in rural Nepal, men tend to be favored over women in food allocation and serving order. Thus, in most cases, adult females and children are less likely to meet their nutrient requirements than their male counterparts. In fact, women often eat after the rest of the family finishes eating, meaning they survive on often insufficient leftover food. During lean periods in particular, the consumption of vegetables and pulses are reduced or not included in the female meals. There is evidence from qualitative surveys that the food and cash that women generate themselves are more likely to remain in their own control. Initially these women were neither employed nor involved in any income generating activity. Thus, they did not have direct access to cash. Now, they have direct access to income from the sale of the produce of drip farm. The greater the control women have over household food and cash, the greater will be the potential of satisfying the nutritional needs of children and entire family members. The analysis of the survey village indicates not only that overall food availability including that for women has improved due to drip, but that this improvement is in part because of the access drip has given women to income.

Our qualitative discussions revealed that prior to the introduction of the drip system, there were very few households (3%) producing vegetables and it was for home consumption only. After intervention, there has been a massive boom in vegetable production in the region. The major dietary change brought on by the production change has been the inclusion of vegetable dishes in every meal. Data analysis suggests that before the introduction of drip irrigation, the majority (72%) of farmers ate no vegetables at meal time. After the intervention, 100 percent of drip irrigation users consumed vegetables with their meals. Gurung (2000) found that the frequency of household fresh vegetable intakes per week increased from 9 to 14 within a year in the same area.

The great majority of the respondents (83%) reported that drip technology has created employment for both men and women. The study by Gurung (2000) revealed that the annual mean income from vegetables had increased by more than 50 percent. Income effects examined in relation with different ethnic groups showed that *Dalits* registered the highest proportion of increase in mean income from vegetables. This implies that the intervention seems to be reaching the most deprived group also.

The increase in total family income, and apparently the control of income by women, has had a positive impact on the livestock production and the consumption of livestock products as well. Since women marketed the produce, they were able to hold the purse and some utilized the savings for animal purchase. About 30 percent bought milking cows from the savings of vegetable income, and now, milk and milk products are included in their meals. It was revealed in a group discussion that some women respondents in the sample village are selling the surplus milk and buying luxury foods.

In addition to these direct consumption benefits, the advent of drip has also helped stimulate the rural economy as financially empowered farmers begin purchasing goods and services from the village markets. Local enterprises are also engaged in distribution and installation of the technology, which helps create employment in the village. Moreover, farmers in the sample study became aware of the fact that the drip technology is cost-effective, easy to operate and maintain, less-labor-intensive and suitable for places where access to water is limited.

Despite improvement in their nutritional intake, marginalized and female-headed households were able to ensure their food security (see box 1).

Box 1

Tika Maya Magar, a resident of the surveyed village is a de facto *mother with three children. She hardly had enough food for her children; needless to talk about other expenditures, as she relied on irregular remittances from her husband, who left for the United Arab Emirates (UAE) for employment. Mrs. Magar recalled, "I borrowed NRs 900 (US$11.5) from one of my relatives to buy the drip kit, as life then was very painful to me."*

"Now, my living condition has improved as I made about NRs 5, 300 (US$67.52) last year. I no more rely on my husband's irregular remittances and also have saved (some money) for my children's education. With the saving, I managed to buy one milking cow and four chickens and now I am selling the surplus milk to my neighbor. I am now able to ensure our family's food security. These days we regularly take food which includes chicken and eggs." When asked, "What helps you generate household income?" she replied, "My own hard work in using water for vegetable farming, which has been possible because of drip."

Source: Field survey, 2003.

Before adoption, the vast majority (92%) of women in the area did not have any income source. Now they have not only access to financial resources but also control over it. Because they hold the purse strings, they command greater bargaining power in both household- and community-level decision-making. Surveys showed that before adopting, women were not much consulted by their male counterparts when deciding to buy and sell agricultural inputs and produce. Similarly, only 16.1 percent of women were involved in decision making on purchasing assets before the intervention of the technology (table 3).

Table 3. Decision making by gender in percentage before adoption.

Decision variable before adoption	Jointly	Male	Female
Decision on the purchase of drip kits	9.9	80.1	10
Decision on buying agricultural inputs and selling agricultural produce	32.2	66	1.8
Decision on household expenditures	56.1	22.7	21.2
Decision on purchase of assets	49.8	34.1	16.1

Source: Field survey 2003

The scenario has been changed after the intervention. Data suggest that women are being increasingly consulted by their male counterparts before making a decision and the majority of the decisions are made jointly (table 4). Pant (2002) corroborates this finding, showing that female members of non-drip-user families have lesser decision-making power on the purchase of assets than female members of drip-user families.

Table 4. Decision making by gender in percentage after adoption.

Decision variable after adoption	Jointly	Male	Female
Decision on operation and maintenance of drip kits	36	17.4	46.6
Decision on household expenditures	10.6	9.6	79.8
Decision on buying and selling agricultural inputs and produce	66.5	21.5	12
Decision on purchase of assets	52	22	26

Source: Field survey 2003

Because of this improvement, change in gender division of labor has emerged in many households. Previously, men rarely helped their female counterparts in household chores. Our qualitative surveys show that since women started earning, men have begun to help them in domestic work. This suggests that economic independence can not only bring change in gender division of labor but also trigger shift in power relations. One member of the surveyed group even reported that male members of the family have to approach the female custodian when in need of money for their personal and other uses. And, female members are cautious because of the fear that the male may spend the money in playing cards or in drinking.

In addition to the benefits for women, ethnic minorities seemed to gain disproportionately from the use of drip. *Dalits,* in particular, were able to socialize among other community members due

to their enhanced confidence and socioeconomic status. *De facto* (household where the husband is not present and the wife makes decisions and is thus the head by default) households no longer had to wait for irregular remittances from their husbands. The higher family income had a positive impact on the investments in food, clothing, health and livestock. This implies that women have successfully broadened their roles from those of domestic to productive users of water.

With the help of a fraction of the income that women earned from selling vegetables, they were able to establish self-help saving-credit groups. Women regularly held meetings and were able to gather more than NRs 100,000 (about US$1,274) in the group fund. The group has become a network to mobilize other oppressed women in the community and motivate them to join the group.

Overall, the finding suggest that a greater participation of women in vegetable production may increase total household food availability, including improved access to, and control over, resources and increased status and decision-making power, ultimately leading them towards empowerment. As one of the agency staff recalls, these women used to run away upon sight of staff during the early days of intervention. Now, they approach the agency asking for more training on organic vegetable cultivation and crop protection.

3.3 Drip-Irrigation and its Economics

Survey evidence from this study clearly indicates that drip-irrigation technology has offered an affordable entry into commercial vegetable production, thereby giving smallholders an opportunity to generate income by selling the surplus. Financial analysis confirms these findings.

The capital investment required for a drip kit used in the surveyed area is around US$13. An average of 23.25 days (20.5 for women and 2.75 for men) days is used per season in labor for vegetable production related activities (see table 1). Maintenance costs are negligible, as only manual cleaning of clogged emitters is required occasionally. Valuing labor at the gendered rates of NRs 60 (US$0.76) per day for women and NRs100 (US$1.2) per day for men, total labor cost is NRs1, 505 (US$19.1) per season. Annual rent for an average 0.013 hectare plot is NRs1, 500–3,000 (US$19.1–38.2). The total average production cost (which includes the costs of seeds, fertilizers and pesticides) is NRs 442.

Benefit cost analysis (BCA) undertaken to understand the economics of vegetable farming enterprise shows a high payoff for drip-irrigated vegetable production. Average gross household income generated is about US$67 from the average plot. The net present value (NPV), benefit cost ratio (BCR), payback period (PBP) and internal rate of return (IRR) are US$16.1, 2.4, 1.6 years and 37.9 percent, respectively (see table 5), indicating strong financial viability of the enterprise.

Table 5. Benefit cost analysis of drip irrigation system in vegetable enterprise.

Particulars	Units
Total vegetable production/household	510 kg
Total annual revenue from vegetables	US$ 66.7
Average area under cultivation	0.0127 ha
Net present value (NPV)	US$ 16.1
Benefit cost ratio (BCR)	2.41
Internal rate of return (IRR)	37.89%
Pay-back period (PBP)	1.6 years

Note: US$1.00 = NRs 78.50
Source: Survey 2003

By this analysis, drip-irrigation should be profitable even for landless farmers who must rent land and consider the opportunity costs of labor, provided they can get credit at reasonable terms. However, all respondents in the survey had their own land and used family labor for vegetable production. If these farmers do not consider the opportunity costs of their land and labor, the payback period drops from 1.6 years to 2 months.

Pant (2002) in his study of the same region stated that the farmers use drip-irrigation when there is relative scarcity of water and vegetable cultivation is nonviable without drip-irrigation. Unless a reliable and sustained output market is established, income generation is not possible. Therefore, market opportunities provide the driving force to these users. The IDE has played a key role in linking the local and urban markets for the produce in the study village. Several vegetable collection centers have been established, where farmers deposit vegetables and collect their revenue the next day. Truckloads of vegetables collected in the centers are brought to nearby city centers and local markets for selling. Though access to water is the key factor, proper attention to supplementary aspects like market sustenance, credit access is also crucial.

3.4 Differential Impact of Adoption

Given the seemingly high benefits to drip-irrigation identified in this study, it is important to understand why some farmers still choose not to adopt this system. A number of researchers (Barnes et al. 1991; Polak et al. 1998; Postel et al. 2001; Surywanshi 1995) have reported the advantages of low-cost micro-irrigation technologies in terms of their appropriateness, affordability and sustainability. The study therefore explores these and other probable adoption factors (table 6).

Table 6. Reasons for adopting drip-technology in percentage.

Why did you adopt drip-technology? (N = 131)	To increase yield	To reduce workload	Easy to operate	Requires less inputs	To increase income	Reduces water requirement	Due to peer pressure
	10.2	7	18	9	46	6.6	10.1

Source: Survey 2003

It was observed that adopters are satisfied with drip-irrigation technology, and that systems are perceived to show good performance in terms of production and water use efficiency. With regard to appropriateness of the technology, data suggest that the small-size drip kit can be easily operated and maintained by both women and men. Women can easily fix and adjust lateral pipes and micro tubes of the kit in the filed. The great majority (97%) of women users reported that they did not encounter any problem in operating and maintaining the kit except for occasional clogging of emitter tubes.

With a lower investment and higher earning ratio compared to other rural livelihood options, the technology is financially viable and carries huge potential for poverty reduction in the rural areas. However, our qualitative discussion revealed that there were some cases where farmers could not afford the system. Some *De facto* households (household where the husband is not present and the wife makes decisions and is thus the head by default) and *de jure* households (a single female-headed household where the head has never been married or is divorced or widowed) stated that the initial investment (approximately US$13) was too high. Most of the drip users borrowed from private vendors and relatives at high interest rates. Lack of capital was, in fact, reported as the major constraint for adoption (table 7).

Table 7. Reasons for not adopting drip-technology in percentage.

Why have you not adopted drip-irrigation technology?(N = 20)	Not necessary for my field	Requires much caring	No capital available
	10	2.7	87.3

Source: Field survey 2003

In terms of availability, 90 percent of adopters mentioned that the technology is readily available. Training on technology O&M was provided by the intervening organization without any charge. Additional training on plant protection, organic farming, nursery management, knowledge on disease-control measures, and compost making was also provided.

In addition to profitability, data also suggest that drip-irrigation can save water, at least in terms of application. Approximately 18,000 liters of water—at the rate of 100 liters per day for 180 days—are required to irrigate seasonal vegetables cultivated in the average drip-system, much less than would be required in a furrow irrigation system. Still, qualitative discussion and the analysis suggest that the majority of farmers adopted drip- irrigation simply to increase their income and because it is easy to operate.

Only 6.6 percent reported that they opted for drip-technology because it requires less water than for furrow irrigation. At the same time, water supplies in the region are limited, and respondents exhibited a willingness to get bigger kits to expand vegetable farming if access to water is ensured. This explains the marketing scope for the technology. When water is scarce, expansion of farming under this technology will be difficult. Finding out new water sources is crucial for the sustainability of drip-irrigation technology in the region.

4. CONCLUSION

This paper demonstrated that the drip-irrigation systems in Nepal helped in reducing women's workload and had a significant positive impact on family food and nutritional intake. Likewise, women's participation in vegetable farming under drip-irrigation tended to improve their rights to household resources, including food and cash. Since women are more involved in overall vegetable production, they have greater access to the cash generated from the sale of these vegetables. This improves their bargaining power and decision-making roles in the household. Moreover, women's participation in self-help groups, meetings and interactions among nongovernmental organization staff and groups had helped them build their capabilities.

While benefits of drip-technology have spurred a relatively rapid adoption rate worldwide over the past few years, the technologies are still relatively unknown and poorly understood in most of Nepal. Despite the positive results shown here, farmers in most areas have been reluctant to adopt even when they have the required financial resources. Thus there appears to be a gap in most farmers'—especially the poorest—basic understanding of the technology and its uses. One solution to this problem is facilitation by intervening agencies as was done in the study village.

In this particular case, the intervention improved livelihoods in general. As important, the agency's recognition of gender issues in technology adoption resulted in significant growth in women's access to, and control over, resources. Intervening in a patriarchal community with a gender-neutral innovation is a huge challenge in itself, let alone arguing for active roles of women in socioeconomic activities. This example of rural Nepal gives an exemplary lesson that civil society organizations can help abolish traditional and rigid gender biases.

Thus the study challenges the ideas that new technologies are unaffordable and impracticable for women. If a gender-neutral technology is offered within a favorable institutional environment, women can take leading roles in realizing the technologies desired benefits. However, the report also suggests that though the drip-kit is a cost-effective irrigation technology even in extremely poor areas, many farmers may still have difficulty in arranging the capital investment. One major consideration for future expansion of drip-irrigation should be credit, in particular for those with the least access to traditional sources such *Dalit* farmers and female-headed households. Targeted collateral free loans could help overcome this problem, and the financial viability of the drip-irrigation system should make loans less-risky for credit institutions. Micro-credit lenders may be especially well placed to facilitate such lending.

In terms of resource use, it was found that drip systems reduce water applications over traditional furrow systems. However, water savings was not identified as a major factor for drip adoption though adopters did indicate a strong desire to bring a larger area under drip-irrigation as long as water supplies are ensured. The construction of private or communal water-harvesting tanks to collect rainwater could thus be one promising method for the further expansion of drip-irrigation use. Rainwater harvesting may also be promising, though education may also be required to help farmers realize the significance of the concept. Caution should be used however, because the extent to which drip systems save on water application as opposed to "real" water savings is unclear. In fact, it is likely that the introduction of drip-technology increases overall water demand.

Though the study shows that the drip-technology has been able to provide an alternative livelihood strategy for the rural populace, the long-term sustainability of this livelihood is still questionable. Returns to drip investment are dependent partially on market prices, a function themselves of the number of adopters and market development and scope. The impact of the technology on overall water resource availability is unclear—application per field may be lower but evapotranspiration and overall depletion may have increased.

Finally, the degree to which outside institutional support made the technology viable is not known. This raises some significant institutional questions. What happens to drip technology adopters' livelihoods when institutional support is withdrawn? Will these adopters be able to sustain their livelihoods? What would be the impact of withdrawal, particularly on a vulnerable community like *Dalits*? These questions can be used as factors for further research with more focus on stories from other rural communities.

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