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Socio-Economic Impacts of Low-Cost Water Storage Tank cum Drip Irrigation based Vegetable Production in a Mountain Community in Nepal

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Abstract

This paper summarizes socio-economic implications of low-cost water harvesting technology based vegetable crop production practices taking case study findings from a remote mountain community in Nepal. This case study was carried out in late 2004, under a part of larger-set of impact assessment tasks for set of projects funded through Hill Agriculture Research Project of Govt of Nepal and grant supported through Dfid/Nepal. Vegetable cultivation is a very labor-intensive task hence a small-scale vegetable farming is also a pro-poor enterprises, since not only land owners but many low income and land less households also benefited due to increased labor employment opportunity. Here, in the case of IDE/Nepal initiated a low cost and affordable water harvesting and drip irrigation based vegetable technology, with a cost less than US$100 per set of the technology, many of the technology adopter households were able to increase their annual income by over US$100 within 2-3 years of its adoption, largely due to cultivation of off-season vegetable provided by better access to water and more control use of water by drip-based irrigation practices. By analyzing these community and farm level impacts, this paper offers important lessons for implementation of such affordable micro-irrigation based vegetable production programme in developing countries worldwide. In order to ensure sustainable use of scarce water resources, we suggest that the rural development project needs a combination of symbiotic effects of both technology and local institutions and integrated management of technologies and farming practices (vegetable production) for livelihoods improvement, as successfully demonstrated by the IDE/Nepal project in this case.

Key words: *Irrigation impact assessment; low cost technology, affordable water storage tank, drip irrigation system, impact assessment, vegetable production, rural livelihoods, hill agriculture, Nepal.*

Introduction

The purposes of this paper are to evaluate implications of a combination of low-cost water storage tank and drip irrigation based vegetable production on farm income and employment of a household adopting the technology, employment and the well-being of the rural community, in general. By doing so this paper analyze socio-economic issues and concerns in relation to adoption of a low-cost water tank and low cost drip irrigation (or affordable micro-irrigation) based vegetable production technology, and its ultimate impacts upon the rural communities. This is done based on community level case study in one of the project sites in mid hill of Nepal, where this project intervention was initiated by International Development Enterprise-Nepal (IDE-Nepal), an INGO working in rural development issues globally. The focus of the paper is

on assessing adoption process of the technology (water storage tank) overall socio-economic implications of the technology on key components of farming and rural livelihoods.
Flooding during the monsoon and at the same time lack of water for dry season farming is one of the characteristics of monsoonal Asia, which demands special attention in managing water for successful farming in monsoonal Asia. This problem is acerbated in many places in Asia now also due to poor institutions and lack of appropriate technology demanded by the small-scale farming needs in Asia. This has created apparent water scarcity in many places though the total availability of water in annual basis is more than required for normal farming activities. This sort of scarcity of water (due to lack of control on water uses) is also one reason for low agricultural productivity and high incidence of poverty in many parts of the rural Asia and Africa now. Recently, a number of innovations in technology and ways to successful management of water uses in tropical agriculture have been initiated in many places, especially with aims of effectively managing water scarcity during the dry season. The main purpose all of these innovations are to increase on-farm water efficiency, and effectively managing (sharing) the water resources across the users (sectors) during the time of limited water availability.

For many countries in Asia, over 50 percent of the Rural Development expenditure is spent in irrigation sector (Barker and Mole 2002). Given the magnitude of investments in irrigation sector in Asia, however, most of the focus on irrigation and irrigated agriculture is largely for large-scale irrigation or for larger to medium-scale farmers' needs, with a very limited attention to the needs of the marginal and small-plot size farmers. In reality, these smallholder farmers or small-plot size farmers are the ones who need more attention and public support on technologies that enhance the farm productivity and generate year round employment opportunity.

In this context, small-scale irrigation technology, particularly micro-irrigation technologies, are recently considered as an appropriate option (than the large-scale irrigation schemes) for targeted support of irrigation to large number of smallholder farmers in the tropics (see WCD, 2000). In the developing countries, such micro-irrigation has been applied to a large number of crops though only on a limited scale and some times on an experimental basis. Micro-irrigation is mostly used either to expand existing irrigated areas, and/or enhance crop productivity and quality of high value fruits, vegetables, herbs, and commercials flowers, etc. In fact, less than 35 % of the total irrigated area under micro-irrigation is located in Asia and Africa combined, whereas about 75% of the total irrigated areas are in these two continents (Gopalakrishna, 2007).

Micro-irrigation considered to be depended upon agro-climate regions and types of cropping system adopted (vegetables, fruits, or cereal), and other several local institutions and organizational related factors. Within the component of micro-irrigation, some of the development (I)NGOs have recently attempted to develop specific type of low cost micro-irrigation technology that is specifically suited for the needs and requirements of small-holders and small-plot farmers and specific needs of the local situation of each of the country in the development countries context (Gopalakrishna, 2007). Using participatory research and on-farm trials, back in 1999-2002, the International Development Enterprises-Nepal (IDE/Nepal)-an INGOs working in Nepal, designed, field tasted and disseminated low-cost water storage cum-drip irrigation for cultivation of vegetable and community development, and utilizing the local knowledge and existing community institutions. This paper is about evaluating different pros and cons of adopting this particularly technology to the community and rural livelihoods. This same technology is also called here as low-cost and simple designed micro-irrigation technology as this very much suited to many small-holder farmers in Nepal and in other parts of tropics.

Moreover, we do not know much on factors affecting the adoption/non-adoption of such affordable water technology and so process leading to effectively managing the multiple uses of water locally. Some of the community level evaluation studies (such as, Namara, et al., 2007; IDE reports, Polak and Yoder, 2005; Westarp and Schreier, 2004) have suggested that the affordable micro-irrigation scheme (like the one developed by IDE-Nepal here) would substantially improve land and water productivity, and contributing largely for poverty alleviation of household adopting such technologies. But, we do not have details understanding on what are the enabling conditions for successful adoption of these affordable technologies at a place; and factors contribution for its wider-scale dissemination (technology up-scaling, etc).

Despite leading to increased income and reduced poverty level, in many countries in Asia, such micro-irrigation technologies have not yet been formally institutionalized by the mainstream governmental water agencies. Rather, most part of their dissemination is done by local NGOs, community groups, and INGOs led community development efforts. In many countries in Asia, the mainstream governmental water agencies are focusing more for large-scale irrigation projects and costly water schemes (in term of per hectare basis).

In this context, by carrying out a multifaceted impact assessment of a low-cost micro-irrigation -cum drip irrigation technology at a community scale, this study contributes to global literature on micro-irrigation and particularly usefulness/ requirements of an affordable irrigation technology.

What is the low-cost technology?

The term "technology" under this study means a combination of two components: a) installation (adoption) of the low-cost water storage tank (1500-3000 litters Jar), and b) off-season vegetable production using drip irrigation. This costs less than US$75 per household to install the technology. Some of the features of the technology are illustrated through figure 1 to 4 below.

As stated earlier, the technology stated in this case-study includes two major components:

- low-cost water storage cum drip irrigation scheme, and
- off-season vegetables production practices

The technology (activity) was a pilot-scale tested, on-farm verified and implemented by International Development Enterprise (IDE/Nepal), under a funding component of Hill Agriculture Research Programme of Govt. of Nepal (with support from Dfid/UK; and later the same technology ha also been up-scaling to different parts of Nepal.

Paper outlines

With this introduction and back ground, the second section provides the overall objectives and scope of this study. Then, the third section illustrates methodology adopted and the data collection procedures adopted. The forth section provides results and discussions from the community level case study in Nepal. The final section provides the author's conclusion and policy implications derived from the study.

Fig 1. Typical low-cost water tank and vegetable farm

Fig 2. A low-cost drip installed in the surveyed area.

Fig 3. A farmer and the low-cost drip set on his field.

Fig 4. A typical water tank on backyard

Explanatory Note: The figures 1 to 4 illustrate some of the key components of the affordable low-cost tank cum drip irrigation based vegetable production and farmers' field in Ekle phant village, as taken during the filed survey time.

2. Objectives and Scope of the Study

The main purpose of this study is to illustrate implications of an adoption of low-cost and simple designed (i.e., affordable) water jar based drip irrigation technology on vegetable farming and related elements of rural livelihoods. This is done by taking a case study in a high hill community in Nepal. The specific objectives of the study are to:

1) assess farmers' perceptions and attitudes, extent of adoption, towards adoption of the affordable water tank cum drip-irrigation based vegetable production technology;
2) analyze implications of the affordable water tank cum drip irrigation on crop yield, farm income, farm employment, and community livelihoods, in general; and
3) From a case study finding, draw policy implications for wider adoption and dissemination of such affordable micro-irrigation technology.

Scope of this study is limited to data collected from a community level study in Ekle Phant village in Nepal; and based on farmers' group survey, key informant survey, and survey of about 40 individual households, 20 technology adopter and 20 non-adopter households surveyed.

3. **Methodology and Data Collection**

As per objectives and scope of the study, the methodology and tools and techniques and data collection procedures were adopted to better assess socio-economic impacts and livelihood implications of the technology adoption in question.

3.1 Overall study methodology and framework of analysis

As stated earlier, the technology stated in this case-study includes two major components: low-cost water storage cum drip irrigation scheme, and off-season vegetables production practices. Therefore, the technology generated impacts analyzed here are cumulative impacts of both the water storage technology as well as drip irrigation on farming and extent of change brought on vegetable areas and productivity in the study area.

Because of short span of time for the field survey, the impact assessment exercise was confined first in capturing direct effects of the technology such as crop yield, extent of crop coverage farm income and employment. Then, some of the indirect effects of the technology adoption were also assessed as they were recalled by the surveyed farmers. The data were collected from both quantitative and qualitative survey, and both primary data collected from the surveyed community as well as from secondary data (from review analysis of the project monitoring and evaluation studies and the project outcome study, and other related project documents in Nepal.

The community level case study was carried out in a mountain village in central Nepal, i.e., at Ekle Phant village of the Tanahu district as shown below in Figure 5. In Ekle Phant village, 40 households (20 technology adopters and 20 non-adopters) were surveyed using structured household survey questionnaires. The information from community level surveyed is again also supplemented by review of secondary literature and other project documents; and other reports related to the events occurred during testing, verification, adaptation, and dissemination of the technology as available. For example, this includes review analysis of monitoring and evaluation document of the project carried out by the project implementing agencies (IDE/Nepal) and also by local funding agency of the research project in Nepal (Hill Agricultural Research Programme/Govt. of Nepal).

3.2 Data collection

As stated earlier, the data collected in this survey can be broadly cauterized into two groups as give below. This study is based on information obtained through a questionnaire survey, field observation by the research team authors, and group discussions among the community members which includes both adopters and non-adopters.

Figure 5: Map of the Nepal showing two districts of Tanahun and Pokhara in Nepal, wherein IDE/Nepal had carried out field testing of such low-cost irrigation tank during 1999-2002. This case study finding is however confined from community survey of only one community of Ekle Phant in Tanahu district.

Community level survey

Community members' perceptions and their realized impacts of the technology adoption were analyzed by adopting a framework of livelihood analysis (For details on methodology, refer to NARMA 2004, unpublished report). Ekla phant village of Tanahu district is one of the two villages where IDE/Nepal participatory tested, on farm verified the technology, and subsequently disseminated the technology to neighbouring farmers. The other places where the IDE/Nepal tested and verified the technology is in Kuan Gaun village in Kaski district, as shown in figure 5 earlier. Compared to the case in Kaski district, larger numbers of such low-cost water tank were tested and verified in Ekle Phant village so the community scale study is confined to only this site. The key informants (such as project collaborator-farmers, and local school teacher, farmers' group leader) also provided valuable information on multifaceted implications (constraints) of the technology adoption.

The community level data were compiled using the information gathering tools and techniques of Participatory Rural Appraisal (PRA). Some of them include: Focus Group Discussion (FGD), key informant survey, time line history of events, time trend of key factors, seasonal calendar and gender desegregated workload, and venn diagram based institutional analysis. To collect detailed inside of the technology adoption process, series of Focus Group Discussions (FGD) were separately done for technology adopters, non-adopters, women and other marginal social groups in the community.

Household level survey

The sample size for the household survey was determined based on the extent of the technology adopted households in a community of the pilot project of IDE/Nepal. The technology were once used by about 23 households in the surveyed community, thus out of them 20 households were selected and another 20 households from the same community who were not adopting the technology at the time of field survey.

Villagers also draw a sketch map of the Ekle phant village with key resource sites, road head, irrigation water sources, and water supply sources in the community. Working with the key informants and leaders of the farmers, the technology adaptor and non-adopter households were divided in sub-groups using wealth ranking technique. Likewise, the ranges of utilities provided by the water tank for the community wellbeing (and any potential constraints) were also discussed at these community level meetings and Focus Group Discussions. Special attention was paid to determine the factors responsible for adoption and regular maintenance of such low-cost water storage tank, and factors that hinder their adoption by a household there.

Wealth ranking

Because of limitations of the structure questionnaire based household survey (restrictive on few variables), before household survey, a wealth ranking exercise was carried out at in the village and the households were grouped in to four categories. They are details are in NARMA, 2004):

- High income class (or Better off households)
- Above average income household (or Well off households)
- Lower average income households (moderately well off households)
- Poor households

The key members of the community who participated in wealth ranking also reported main criteria that they used for wealth ranking. These criteria that the community members used for wealth ranking exercise were: farm land holding, nature and type of house construction, monthly/annual income of the household, number of government employed in the household, income from any other business, etc. The households surveyed (both technology adopters and non-adopters) belonging to four wealth raking class (economic class) are as in Table 1 below.

Table 1. Households surveyed by wealth status in Ekle Phant village, Tanahu, Nepal (in 2004).

Household category (from Wealth ranking exercise)	**Technology adopter households**		**Technology non-adopter households**		**Total households surveyed**	
	Number	%	Number	%	Number	%
High income class	7	35	4	20	11	27.5
Above average income class	4	20	7	35	11	27.5
Lower average income class	5	25	4	20	9	22.5
Poor households	4	20	5	25	9	22.5
Total No. of households	**20**	**100**	**20**	**100**	**40**	**100**

The information from the household level survey is the main basis for analysing economic and social impacts of the technology adoption including equity and poverty implications, food security, etc. Details on methodology, tools and techniques, and the empirical results can be founding in the project report prepared by NARMA (2004) and submitted to HARP/Nepal.

4. Results and Discussions

This section summarizes empirical results from the field survey in Ekle phant village, both from the community as well as household level survey. In Ekle Phant settlement, before adoption of the low-cost water storage cum drip irrigation technology, the conventional widely followed practice was to grow maize and millets on upland around home yard (i.e., Bari land) in the rainy season, and cultivation of mustard and pulses in the winter season or even keeping land fallow during the dray season because of unavailability of control water. Installation of the low-cost water tank at the backyard of households has in fact provided some levels of water security to the farmers to grow crops during the dry season, as this has improved reliability and better control over the water supplied in the dry season. The improved control and more reliability on water has facilitated the technology adopting household (farmer) to grow high value vegetable even in the dry season, and/or cultivation of off-season vegetable types for market sale. We illustrate below some of these changes (mostly direct impacts) brought by the technology adoption process (i.e., adoption of low-cost water storage jar-cum drip irrigation and high value vegetable production). This includes impacts on farmers' income and employment, and other elements of the community livelihoods, in general. Because of the limited scope, this paper only illustrates key impacts on impacts and employment; details can be found in project report (NARMA, 2004).

4.1 Adoption of Low Cost Water Storage Technology

During the Focus Group Discussions (FGD), it was reported that the farmers have greatly been benefited from installation of the water storage tank as it has now allowed them to grow dry season vegetable (and off-season fresh vegetables) which was not the case before 2000 before installation of such water tank based drip kits. It was reported that, by growing maize in the Bari land at Ekle Phant, a typical farmer in Ekle phant in 2004 could get gross farm return of Rs.700 to Rs. 1,000 per Ropani of land (i.e., from 0.05 ha of cropland) from the maize in the rainy season. (In 2004, the exchange rate in Nepal was 1 US$ = 70 Nepali Rupees (Rs)).

Whereas, from a rainy season vegetable crop in a rainy season, the same farmer can obtain now gross return of at least Rs. 5,000 per Ropani of bari land. Therefore, the gross farm return (and also net farm returns) of technology adopter households (farmers who have installed water storage tank and grow vegetables) is substantially higher than that of the non-adopter households. This applies to both per crop per season as well as per annum basis of analysis. The income, employment and associated other impacts of the technology have realized in the village largely because of growing of vegetable crops on the land areas that used to grow only low yielding course cereals (maize and millets) in the past.

The review of IDE tank construction manuals (IDE/Nepal project document in 2004) and consultation with the key informants and leader farmers suggested that the total cost for construction of one such low-cost water jar (tank) of 1500 liters size (most commonly used jar size in the surveyed village) cost about Nepali Rs. 6,000 (full costs), which is equivalent to US$90 in exchange rate in 2004. This is equivalent to Rs. 4 per liter supply cost as a fixed cost.

From focus group discussions and key informants survey and meetings at Ekle Phant area, the community members reported following changes and/or impacts that they have realized in the village after adoption of the technology (compared to 1999 situation).

- The new technology (tank based drip irrigation) has increased vegetable yield and vegetable production in the community. At the same time, it has also added complexity of growing vegetables and so marketing practices for off-season fresh vegetables in the area. Within 3-4 years of adoption of the technology, farmers were able to almost doubling of cropping intensity and farm income on the plot land with such drip irrigation.
- Not only the land productivity and cropping intensity have increased after adoption of the technology, but there has also been a shift towards growing high value fresh vegetables on the upland (Bari land) from that of earlier traditional practices of growing coarse cereal grains such as maize, millets, and mustard.
- Besides crop production and productivity improvement, such water storage tank has also provided other social benefits and water security to the household in the dry spell, particularly more to women and vulnerable members of the households for domestic and sanitation needs of water. This is also called here as multi-functionality use of the low-cost water tank in the rural livelihood and they are another sets of benefits to the technology adopting households but not quantified here in pecuniary (or monetary) value. Women members of the households were found to be aware of these benefits.

The extent of the total benefits of the technology adoption in the area can be best illustrated from the difference on farm income structures of an average adopter household after the adoption from that of the situation before adoption of the technology, as shown in figure 6 below. The income from vegetable production just double within 4 years period, i.e., it increases from around Rs 12,000 per household per annum in 2000 to about 30,000 in 2004 (see figure 6 below). Over the period, in fact the income from food crops also increased slightly

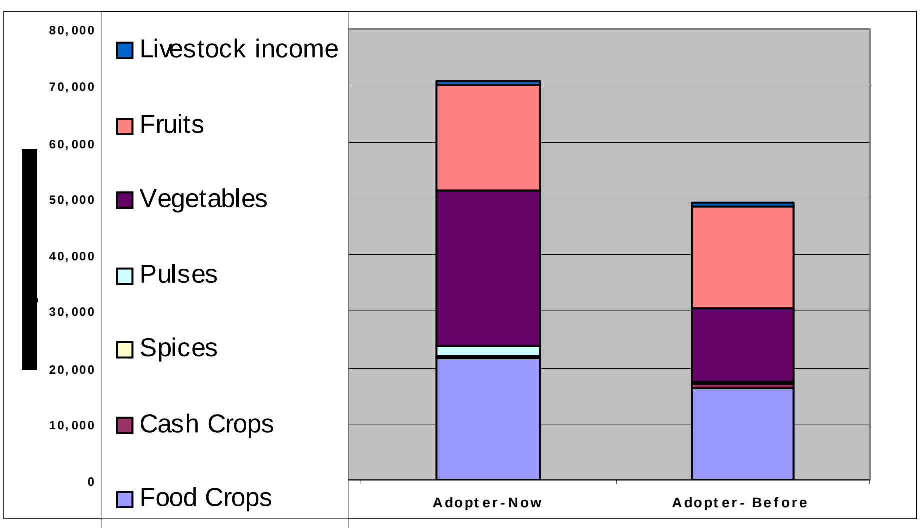

Fig 6. Change in Structures of Income of the Adopter household before and after the Technology Adoption

Because of segmented nature of vegetable markets (more in a case of high value off-season vegetables), additional efforts are required from the farmers to link off-season fresh vegetable production with local market channels. Thus, more backstopping supports needed for off-season fresh vegetable growers not only on technical aspects of production, but also for market access and training them on complexity of the agricultural marketing (and associated input markets).

4.2 Technology adoption and farmers level acceptance

The low-cost tanks were constructed in the village in three years (1999-2001) and in a phase-wise manner. Out of 20 water storage tanks constructed at Ekle Phant area over the project period of three years, all farmers had been using the tank in late 2004, and not single farmer abandoned the tank technology so far and its associated drip irrigation based vegetable production technology. This also reflects well-acceptance of this technology in the village.

Initially, IDE/Nepal introduced several designs of the low-cost tank and it finally screened best-performed design of the water storage tank through participatory approach and involvement of the farmers in the construction as well as selection of the design. Local masons in the area were trained for construction of the tank, and selection of the appropriate site and materials, as well as farmers were trained for production of the off-season vegetables and use of the drip technologies, including post harvesting and marketing aspects of the vegetables produced in the area.

Farmers in the Ekle Phant were satisfied with performances of the water storage tank cum drip irrigation based vegetable production practices that were introduced in the village by the IDE project. Given the provision of external technical support and some level of subsidy on the cost of construction of the tank, several other farmers in the Ekle Phant were interested to install such low-cost tank by 2004, which reflects its usefulness and positive impacts as perceived by the community members. Initially, the adopter-farmer got some form of a subsidy for construction of the tank. The non-adopter households now feel that if such program is again initiated by IDE/Nepal, or any other NGO, then without any hesitation, they are now ready to install the tank at their back yard but with a modest level of subsidy for construction of the tank, as followed in the past by IDE. This is also due to subsidy induced syndrome usually seen such Rural Development projects in many parts of the developing countries. Despite net economic benefits of the technology much higher than that of its installation costs (the fixed cost is recovered within a year), the rest of the non-adopter householders in the community are not willing to adopt it now, without some sort of additional support from the project outside. These are issues largely of non-economic or social prejudices attached in the community, and hierchiel issues.

4.3 Factors affecting technology adoption (non-adoption)

Most of the adopter-farmers (95 percent of households) cited increased productivity of the land (i.e., increased vegetable production and farm income) after having better access to irrigation in the dry season as a main reason for their willingness to adoption of the technology. The other reasons (stimulating factors) for adoption of the technology at Ekle Phant site, based on their importance, are as follows: harnessing new opportunity (revealed by 55 percent of households), fulfilment of households other demands for water during dry period (55 percent of households) less requirement of labor in vegetable farming for weeding (45 percent of households), high income generation and increased self employment in farming (35 percent of households).

For households belonging to low economic group as well as for high income group, some of the reasons for adopting the technology, as stated upon their priority ranked orders, are: high productivity of land, higher markets value of the off-season vegetables produced, more employment generated during the dry season, and fulfilment of household's other demands for water during the dry season. Furthermore the women and minority members of the households also got more benefit from having water security from the water storage tank. Out of 20-adopter households surveyed, not a single household reported for wanting to discontinue using the water storage tank, or abandoning the technology. This indicates a very suitability of the technology in the local context, and a well acceptance of the technology by the farming community.

4.4 Reasons for not adopting the technology

Among the survey of 20 non-adopter households, 88 percent of non-adopter households reported that they did not adopt the technology, despite being aware of it, largely due to lack of assured technical support (external project supports). Likewise, 50 percent of non-adopter households who were aware of technology reported for low technical know how and knowledge particularly for construction of such tank. Likewise, high investment needs, and lack of access to the additional water sources for irrigation were the other factors for not-adopting the technology.

Table 2: Reasons for non-adoption of the technology among non-adopter households (who were aware of the technology then).

Reasons	Non adopters aware of technology (n=16)	
	Number reporting	Proportion reporting
Lack of technical support	14	88.0
Low technical knowledge	8	50.0
Requirement of more investment	2	12.5
Lack of irrigation	2	12.5
Requires more labor	1	6.0
Lack of land	1	6.0
Lack of agricultural tools	1	6.0
Others	4	25.0

Source: Field survey, 2004

In fact, 16 out of 20 non-adopter households were aware of the technology, and out of 16 non-adopters, 14 households (88%) were willing to adopt the technology in the future, if some sorts of modest technical and financial supports are provided to them. Households from the upper income group and lower income group, as well as both upper and lower social class, were aware of the technology at the time of survey. Thus there is no major inequity in the information flow related to the adoption of the technology in the surveyed site.

Majorities (over 93 percent) of the non-adopter farmers indicated that they want to install the water storage tank in the near future because of its positive benefits (impacts) on increasing crops yield and land productivity, in particular of increased vegetable productions (and productivity) and increased farm income. Likewise, other major reasons cited by the non-adopter households for their willingness to adopt the technology are: harnessing new opportunity provided by the increased cropping intensity (almost 80 percent), to fulfil daily needs of water (and also vegetable) during the dry spell (over 50 percent), relatively modest level of costs for the construction of such low-cost water tank (45 percent), and so on.

Among the non-adopter households, the main reason cited for non-adoption of the technology, despite of substantial benefits obtained by the fellow adopter farmers, are: inadequate surplus cash income to purchase the materials (cement, iron road, etc.) for construction of the tank and drip set. Besides, there is also existence of an informal water institution (water distribution rule) in the community for managing and controlling in distribution of water for drinking, including filling the water storage tank. This water management group de facto controls the water access in the community. Those households who contributed (financial or manual labor) for construction of the water storage reservoir at the upstream (for drinking water supply) are eligible to get the water. Then, the new comer in the village does not entitled same level of water rights and access to water for filling the water tank as that of the older households who contributed resources for constructing reservoir in the village. By this arrangement, the community is also avoiding the water resources to becoming an open access resource, and rather managing water supply as common pool resources based on first arrival in the settlement (and also resources contribution for construction of the water reservoir). Those households who get only limited access to water from the existing supply sources are reluctant to install water storage tank as the limited access (sharing with neighbouring households) and unreliability of the water supply. All have led to acute water scarcity in Kathmandu during the non-monsoonal season.

5 Conclusions and Policy Implications.

In this study, using quantitative and qualitative assessment, socio-economic impacts of adoption of low-cost water storage tank cum drip irrigation based vegetable production is analysed by comparing its costs (of construction) versus additional benefits derived from cultivation of vegetables allowed after installation of such water storage tanks. Besides, comparison is also done with respect to the conventional situation of farming practices (standard check) and conventional irrigation system without such storage tank and drip irrigation kits.

The low-cost and simple designed of such water storage tank cum drip irrigation technology enhances outcomes of the IDE project by utilizing water for production of high value vegetable crops and off-season production activities (dry season production). Only water storage technology alone has less impact in the community compared to joint technology of water tank with drip irrigation, and associated improved vegetable production practices. Water storage tank and drip irrigation techniques are just means to achieve some things and that something is the increased production and sale of the vegetable and increased household income. Framers including many women have also cultivated high-value crops and are using previously unproductive land for vegetable cultivation now. Because of more labour requirement for vegetable production compared to that of the course cereals, and increased cropping intensity in the community, women are able to spend more time in other income generating activities now.

The easy manageability and affordability of a technology facilitate for easy adoption of the technology among range of farmers and even smallholder farmers or small plot-size farmers. The attached drip system also conserves water resources by minimizing water losses in the field and effectively utilizing scarce water in dry season. This technology benefited farmers also by having needs for less weeding and less soil loss on such drip based irrigation compared to without such drip system. During the PRA meetings in the community, many technology adopter farmers well articulated such benefits (and costs) of the technology (details in report by NARMA , 2004).

The technology has generated very positive impacts upon the community livelihoods. Within a sort span of 2-3 years of adopting the technology, many adopter households were successful in doubling their annual farm-income. The high market prices of the off-season vegetables also helped lots in this direction. Some other beneficial impacts of the technology as identified by the adopters are: shift in cropping pattern from cereal based to vegetable based, increased cropping intensity, increased crop and land productivity, substantially increased farm employment and income, improved health and nutrition level, and improved community well being, in general. For many cases, the technology also helped fulfilling the households' sanitation needs of water.

Vegetable cultivation is a very labor-intensive activity. Vegetable cultivation generates 3-4 times more employment than that of the cereal production. Thus, not only the land owners, but also large numbers of poor and low-income households are benefited from vegetable farming due to increased labor employment opportunity and increased labor wage. Given these merits, this particular technology (water tank-drip-vegetable farming) has a good potential for adoption to other several upland areas in Nepal, where the high unemployment rate (or partial employment) is a major concern, which is also one of the leading factors for the recent political unrest and turmoil in Nepal. In addition, this technology is affordable and appropriate for smallholders who cannot afford conventional canal (or groundwater) irrigation water because of high initial investment costs. Furthermore, this technology is good for highland and upland communities who suffer more from water scarcity, and who can not grow vegetables largely due to unavailability of the water and uncertainty on control of over water during the dry season.

The case study also clearly demonstrates that not necessary that only a large-scale water sector intervention, sometimes even from a small-scale investment in water technology (US$75/hh) can generate huge impacts in terms of increasing income, employment and in turn a significant dent in the poverty alleviation level at a place. This is particularly so when such small-scale water management technologies are also well-targeted and appropriately utilized symbiotic effects of technology with the local production practices, markets access, and with other rural settings, as demonstrated by the technology promoting NGOs (IDE/Nepal) in this case.

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