SOCIO-ECONOMIC ASPECTS OF IRRIGATION TECHNOLOGY CASES FROM NEPAL AND INDIA

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ABSTRACT

This paper examines social and economic issues pertaining to the micro-irrigation technology based livelihoods of smallholders in villages of Nepal and India. The paper therefore aims to help in policy making by bringing in the ignored micro perspectives. Both qualitative and quantitative methods were applied to generate data on livelihoods of respondents. The paper concludes that in order to achieve the policy goals of poverty reduction, smallholders should be provided with opportunities to adopt appropriate technology for sustained income generation.

Key Words: Nepal, India, irrigation technology, smallholder, households

INTRODUCTION

South Asian countries have been blessed with valuable water resources. Most of these countries have vast alluvial deposits as the main source of groundwater, where aquifers are being recharged continuously through seepage from surface water bodies and rainwater. In these countries, groundwater is the primary source of water for areas not having access to surface water supplies and where rainfall is not sufficient for meeting crop water requirements (Bhatti, 2002). In addition, most South Asian cities depend on groundwater for their drinking and domestic water needs. Majority of farmers of South Asia's so called poverty square—which comprises eastern India, Nepal *terai* and Bangladesh— own an average of 0.8-0.9 ha of farmland (Shah *et al.*, 2000). Thus, these poor farmers are in the need of a technology that is suitable to their unique local environments.

This paper is an attempt to examine the technology based livelihoods with a view of understanding how technology fares in any particular society. In this regard, the following research questions are pondered upon: What has been the role of micro-irrigation technology in farmers' agricultural environment? How does a society perceive any technological change? Are farmers any better- or worse-off with the technology?

What are the implications on women—are they still marginalized? Which socio-economic factors should be considered for a technological intervention?

Recognizing the significance of improved irrigation water availability to complement other inputs as a key element of agricultural strategy, the policy documents of Nepal and India aim to promote year round irrigation. Recent effort by both countries to expand the small scale irrigation coverage is one of the important steps towards achieving this aim. For example, the new irrigation policy approved by Nepal cabinet on August 4, 2003, reinforces the same objective with special focus on promotion of conjunctive use of ground and surface water along with the initiation of non-conventional irrigation systems such as drip irrigation, sprinkler, treadle pump, to increase farm income (MoWR, 2003). Likewise, the Indian Water Policy emphasizes that irrigation planning either in an individual project or in a basin as a whole should take into account the irrigability of land, cost-effective irrigation options possible from all available sources of water and appropriate irrigation techniques for optimising water use efficiency. It further says that scientific water management and sprinkler and drip system of irrigation should be adopted (NWRC, 2002).

With a view of realizing the Millennium Development Goals (OECD, 2001), all these government documents emphasize rural poverty reduction, empowerment, participation and equal representation of vulnerable groups. In order to facilitate the successful implementation of these policies, it becomes even more crucial than in the past to learn lessons, to acquire practical guidance from the local level, to learn about opportunities and constraints, and local experiences in pursuit of viable and livelihoods. This paper is an attempt towards that end.

Most literature so far on water research has focused on hardware aspects of a technology, thereby largely ignoring the software issues. The purpose of this paper is thus to bridge this gap by analyzing social and economic aspects related to the micro-irrigation technology designed for smallholders. Special reference has been given to micro-irrigation technology based alternative livelihood strategies pursued by smallholders in rural areas of Nepal and India.

NEPAL AND INDIA BACKGROUND

Out of Nepal's total area of 147, 181 sq km, only about 3.1 Mha is cultivated. The irrigable area is 1.9 Mha of which 1.6 Mha is in the plains (known also as *terai*) and 0.3 Mha is in the hills. Groundwater is the only sustainable and dependable source for irrigation water in plains and some inner valleys. There are three distinct and parallel ecological zones which run east to west: the southern terai plains starting from less than 300 meters above mean sea level to the mid-hills (301 to 3,000 m) and then up to the northern mountains (3,001 to 8,848 m). This agro-ecological variation corresponds with microclimates ranging from tropical to temperate regimes. Land distribution is skewed and almost half of the holdings are less than 0.5 ha with about 70% of landholding less than 1.0 ha. The average size of landholding is 0.96 ha with substantial regional variation. The Terai covers 17% of the total land, whereas mountain and hills cover 20% and 63% respectively (Sharma, 2000; Bajracharya, 2001).

India's total geographic area is 328.76 Mha, of which 197 Mha represent arable land. About 57 Mha is irrigated which constitutes 30% of the total cultivable area. Physio-graphically, India has a variety of features, high mountains, foothill areas, vast plains and deserts. Its water resources are almost unlimited, but still falling short to provide adequate water supplies to irrigate available arable lands. India has a history of groundwater use since 3,000 BC. In the modern age, first large scale development of groundwater for irrigation was taken in 1934, with the installation of 1,500 deep tubewells in the Ganga Basin (Bhatti, 2002).

METHODOLOGY

The paper is based on empirical work done by the authors in Nepal and India as well as the work of other colleagues at IWMI and elsewhere. In Nepal, districts and villages with the highest rate of adoption of micro-irrigation technology were selected for the fieldwork. In the chosen villages, promotion of the technology is being led by International Development Enterprises (IDE). In the hills, drum kits[1] program was implemented in 1995 while treadle pumps[2] program was started in 1993 in the Terai plains. In order to comparatively assess the uses and associated benefits of the two different kinds of technology, two agro-ecological districts—Siraha from the Terai and Palpa from the hills—were chosen.

Siraha covers an area of 1,188 sq km with total population of 572,000. Palpa is situated in altitudes ranging from 500 m to 2,500 m above sea level and records temperature in the range of 5 to 35 degree celcius. The population of Palpa is 215,924. The cultivable land in Palpa is 47,520 ha, with irrigated area about 4,209 ha only. Siraha and Palpa districts were chosen to capture the adopters' livelihoods dependent on vegetable farming as the primary source of income. Lists of drum kit and treadle pump adopters from each district were obtained to select the villages where the rate of adoption was high. A total of four villages, two from each district, were selected (Table 1).

Table 1. Study villages and number of adopters

District	Name of the villages	Number of adopters
Siraha	Sishawani	445
	Bastipur	315
Palpa	Chidipani	103
	Chirtundhara	291

Source: Survey, 2003 and 2004

In order to avoid the shortcomings of any single methodological approach, both qualitative and quantitative approaches were used (White, 2002). Qualitative methods were used to mainly capture policy and institutional aspects and quantitative approaches for financial aspects, assets, daily activities, etc. In each village, PRA wealth-ranking exercise was conducted, which identified three wealth groups that served as the sampling frame for stratified random sampling. A sample size of 30 households from each village gave the total sample size of 120. The respondents were categorized as—well-off, middle and poor on the basis of their arable landholding size. Households owning less than 0.165 ha, and more than 0.676 ha, were classified as poor and well-off, respectively, while those in between (0.165 to 0.676 ha) were categorized as middle households. Field study was undertaken in the first quarters of 2003 and 2004.

Qualitative information that emerged from in depth survey and extended focus group discussions (FGDs) was used for analysis. Descriptive statistical analysis was also undertaken to calculate benefit-cost ratio and internal rate of return to examine the direct economic impact of the technology on households. Moreover, random-spot observation[3] was done, to capture time allocation of working women and men of households over a 12-hour time period by visiting them randomly.

The study area from India is known locally as the Nimar Valley, which forms the west most parts of the Narmada basin in Madhya Pradesh (MP). The average annual rainfall varies from 800 to 1,800 mm, which mostly occurs between mid June and mid September following an erratic pattern, and the average annual temperature ranges between 22.5° C to 25° C (MoEF, 1999). The region is all hard rock with shallow soils and usually wells and tubewells are connected to shallow confined aquifers. These recharge during the rains frequently and there are cases of a few tubewells and hand pumps overflowing in the monsoon season while running dry in summers (Bhamoriya, 2004). The study villages are from Kasravad and Maheshwar blocks**,** whose total population is 294,158 (Table 2). Based on water availability, the study area can be classified into lowland and upland areas. The lowland area, situated around the banks of the Narmada river, is water abundant, while upland area is water scarce. Lack of water and high temperatures with hot tropical winds restrict summer cultivation.

Table 2. Land use and population of Maheshwar and Kasravad, MP

Particulars	Maheshwar	Kasravad	Total
Geographical area (ha)	80,400	101,130	181,530
Forest area (ha)	12,997	11,393	24,390
Net cropped area (ha)	44,866	58,517	103,383
Irrigated Area Kharif (ha)	16,566	16,143	32,709
Irrigated Area Rabi (ha)	8,875	10,720	19,595
Total Population	107,275	186,883	294,158
Scheduled Casts	20,433	20,345	40,778
Scheduled Tribes	25,429	26,649	52,078
Others	61,413	139,889	201,302

Source: Survey, 2004

Case studies, FGDs, in-depth personal interviews, and participant observation were used in MP to gain qualitative insights for this paper. A total of 5 in-depth case studies, personal interview with 34 men and women farmers and FGDs with 32 farmers were done. In addition, local government officials and village elders provided further information that enabled the researchers to cross-check and verify the validity of data. The field study was conducted in early 2004. IDE, in collaboration with Swiss Agency for Development and Cooperation (SDC), has promoted micro-irrigation technology in the study area.

IDE PROGRAMS

IDE, an international non-government organization (INGO), was established in 1978 in Denver, Colorado, USA. It has country offices in various countries of South Asia, Africa and South East Asia. IDE's approach has been developing low-cost technology and offering it to adopters in such a way that after its departure (from the community) the technology use is sustained by the people so that similar intervention can be made in another needy community. Improving social, economic and environmental conditions of small and marginal farmers by identifying and marketing low cost sustainable appropriate technologies that can be manufactured locally has been the IDE mission. IDE goal is to ensure more productivity, more income, more employment and sustained poverty reduction in rural areas.

In 1994, IDE started developing simplified low cost drip irrigation system as an appropriate small-scale irrigation technology for mid hills of Nepal. IDE in Palpa has focused on three major activities in order to promote commercial farming among smallholders. First, capacity building of leader farmers through intensive training on vegetables production and marketing; second, promotional activities carried out through the farmer groups and finally creation of linkages among private entrepreneurs, commercial farmers and farmer groups through meetings, workshops and contacts. IDE began the testing of treadle pumps in Nepal Terai in 1993 and since 1994 it has gone for full scale marketing in 10 districts of central and eastern Terai with the financial support from Interchurch Organization for Development Co-operation (ICCO).

In the early stages of marketing, IDE developed a supply chain of three manufactures and now there are 274 dealers and 943 installers. For the demand creation, IDE has adopted several promotional activities, like announcements in *haats*[4] farmer's demonstration plots, target group meetings, farmer tours, etc., along with static methods such as billboards, posters, calendars, slides, brochures, wall paints, banners, etc. Training has been an important part of IDE strategy and different sets of training is offered to farmers, installers, dealers, manufacturers, partner institutions and staff.

Likewise, the key task of IDEI (IDE/India) during 1997 was to adapt micro-irrigation technology to suit the needs of poor farm families and to make the technology appropriate and affordable for small and marginal farmers as conventional technologies had a high capital cost and were high tech in nature—thereby making it complicated to install and maintain. Hence, the IDE program was introduced in MP with the slogan of "affordability and appropriateness". IDE then worked on establishing market supply chain in rural areas to develop, manufacture, install and maintain the systems locally.

FINDINGS

Cropping Pattern

In Nepal, since treadle pump is mostly being used in irrigating vegetables, only negligible number of Siraha users irrigates paddy and wheat fields by treadle pump. Onion and potatoes are given high priority than other crops. It has been the trend among these villagers to allocate relatively larger plot to those vegetables that can fetch better market price. The average area of vegetable cultivation under treadle pump during winter is 0.160 ha. Of this, 0.036 ha is used for intercropping.

Primary crops grown in Papla are maize wheat and millet. Potato, mustard, and buckwheat are secondary crops. These are usually rain-fed crops. Vegetable cultivation is mostly done in homesteads. The size of plot used under micro-irrigation is the same across entire sample size because the adopted drip kit is good for irrigating 0.0127 ha of land. However, the percentage of allocation of land for any particular vegetable varies according to the perception of farmers about the market price of the vegetables. During summer, beans, gourd, eggplant, cucumber and lady's finger are usually grown, while spinach, cauliflower, tomato, radish, garlic, cabbage, are common winter crops.

In the study villages of India, majority (53%) of cultivated land is under cotton. Cotton is grown in rotation with wheat, gram and maize in the *Rabi* (winter) season and pulses, soy bean, pigeon peas, gram, sorghum and maize in succeeding year's *Kharif* (rainy) season. In the areas where ample irrigation is available, sugarcane, vegetables, bananas and perennial fruits are also grown. As told in the FGDs, most farmers grow cotton, pigeon pea and maize or sorghum in Kharif and wheat in Rabi. Farmers stick to biannual crop rotation patterns, alternating cotton with pulses, maize, sorghum or chilly. Most farmers sow cotton at the offset of monsoon in June. If irrigation water is available before monsoon, cotton can be sown in May. By October, about two third of the cotton balls reach maturation, and most farmers uproot this crop and sow wheat. Those who don't have irrigation water keep the cotton crop until the end of the vegetation period i.e., until February or March.

Gender Issues

Majority (90%) of the women in the surveyed area pedal the pump for as longer as men do. After finishing their household chores, they come to the field for irrigating and take their turns while men rest. This behavior was noted in random-spot observations. It takes about 2-4 hours of pedaling per day to irrigate 0.0676 ha, depending on the water requirement of the crop and the soil moisture of the land. Normally, women and men take 15-20 minutes rest after every hour of pedaling. FGDs revealed that there are certain castes that do not allow women to pedal. These are high caste groups, particularly *Chetris* and *Brahmins.*[5] They are relatively well-off compared to lower caste people. Women of these groups are relatively less involved in agricultural production as these rural elites prefer to hire laborer for the field activities and limit their roles as those of supervisors.

Data suggest that there is hardly any activity in vegetable farming under drip system that women do not participate in. They spend 80 hours every 90 days in irrigation, which includes fetching water from the source and filling up the storage drum. On an average, 186 hours of labor is required per season for vegetable production on 0.0127 ha of land. In terms of overall labor contribution per season, women's contribution is found to be significantly higher (88%) than that of their male counterparts (12%). Women were found not only having hands-on experience in vegetable production and marketing, but also assuming important roles in deciding on associated activities such as, crop selecting, planting, harvesting and marketing. Active involvement of women was also noted in Indian case studies, for example see Box 1.

Property rights in India and Nepal are largely vested in men. Thus, women in normal circumstance are denied land titles despite their full involvement in agricultural activities (Upadhyay, 2003). These communities are guided by the patriarchal norms (Agrawal, 1998) and inheritance from one generation to another means further fragmentation of land.

Box 1. Manjubai's story in her own words

"We are one of the adopters of drip irrigation system in Kasaravad. We paid about Indian Rupees (IRs.) 9,800 (approximately equivalent to US$ 205) to install the system, with a three hp pump, in a 1-acre plot. Soon after the system was installed, my husband taught me how to use and maintain the system. I now independently handle the system. Last year, our yield was 800 kgs. I have personally experienced water saving of as much as 75%. Before adoption, we were unable to grow crops in summer due to scarcity of water. But, due to water saving possible with drip, we were able to plant vegetables last summer. We are planning to invest additional amount this year to expand cotton plantation area under drip to three acres. We plan to gradually expand our cotton plantation coverage to eight acres, 60% of the total land we have. We realized this potential and could thought of expansion of acreage just because of drip. We visualize a shift in our status of subsistence farmers to commercial growers over a period of next seven years."

Source: Field survey, 2004

The inference drawn is that women are not only strongly involved in farming but also are capable of operating and maintaining the technology. Empowerment of women is another major achievement as women of these patriarchal communities are trading agriculture produce and having access to and, in most cases, control over income. As disclosed during FGDs, involvement in these economic activities is associated with greater bargaining and decision-making power in households. Roles of these women would have otherwise been limited to the domestic and household spheres. The technology has given them an opportunity to engage in productive enterprises and enhance their capacities and skills.

Financial Viability

Poor producers put high priority on access to water for agricultural production (Rijsberman, 2003) and micro-irrigation technology in studied villages has offered smallholders an affordable entry into commercial farming. Benefit cost analysis (BCA) shows that a household can generate Nepalese Rupees (NRs.) 5,238[6] in six months from a 0.0127 ha of land. The cost benefit ratio (CBR), pay back period (PBP) and internal rate of return (IRR) are 2.42, 1.6 years and 37.89% respectively[7] (Table 3), indicating strong financial viability of the enterprise. The capital investment required for a small size drip kit is around NRs.900.

Table 3. Benefits and Costs, Nepal

Financial Indicators	Palpa	Siraha
Benefit Cost Ratio (BCR)	2.42:1	1.3:1
Internal Rate of Return (IRR)	37.89%	23.34%
Pay Back Period (PBP)	1.6 years	10 months

Source: Survey, 2003 and 2004

PBP significantly declined from 1.6 years to two months when opportunity costs of land and labor were not taken into account. This revealed that even if an interested landless farmer wants to install a drip kit on loan for commercial vegetable production, s/he would be able to repay the loan within 1.6 years. Therefore, it can be inferred that the enterprise is financially viable even for landless farmers. BCA of treadle pump shows that vegetable cultivation in a 0.033 ha of land can generate NRs.4,700. BCR, PBP and IRR are 1.3, 10 months and 23.34% respectively at a discounting rate of 15%[8] (Table 3). The capital investment required for a pump is NRs.1,500, which is far cheaper than the costs of diesel and/or electric pump.

Every household interviewed had surplus family labor and a small plot of land suitable for vegetable farming. In those households where men have out-migrated or are involved in off-farm activity, female members are found to be taking charge of vegetable farming. Cases of children helping elders in using treadle pump for irrigating vegetables were also reported. Landless people preferred off-farm activity since the chance of getting seasonal job is very limited because of the surplus labor in the study locations. Thus, men prefer out-migration to neighboring Indian cities seeking alternative livelihood options.

BCA of Indian cases present the following scenario[9] (Table 4). In both countries, the systems have proved that they are profitable for smallholders.

Table 4. Benefits and Costs, India

Financial indicators	Bucket kit	Drum kit
Ideal Land Size	20 sq mt	100 sq mt
Internal Rate of Return (IRR)	49%	39%
Capital Investment	250 IRs.[10]	1,200 IRs.
Net Present Value (NPV)	80 IRs.	580 IRs.

Source: Phansalkar, 2002

A research study to understand the socio-economics of treadle pump technology led by IWMI team (Shah, *et al*, 2000) covered four regions of India. In Uttar Pradesh and north Bihar, adopters harvested average potato yields in the range of 16-17 mt/ha, which was 60-70% higher than the yields of diesel pump owners. The study also reported that the treadle pump technology had led to significant improvements in cropping intensity, cropping patterns, crop yields and incomes. A gross income of US$300-400 per acre was reported among adopter households, thereby challenging that Polak (n.d.) and Postel

(1999)'s claim of US$100 might be an underestimate. The study concluded that the treadle pump technology is a super-performer for the marginal farmers of the Ganga-Brahmaputra-Meghna (GBM) basin and recommended that the technology be promoted widely with a view of reducing poverty.

Household Income and Food Security

Current understandings of poverty place considerable emphasis on ownership or access to resources that can be put to productive use by which the poor can make their own ways out of the poverty (World Bank, 1999; Ellis & Mdoe, 2003). Access to land has been cited as an indicator of food security and poverty by a large-scale study in Nepal (Adhikari & Bohle, 1999; WFP, 2001). In Nepal, majority (above 70%) of the treadle pumps and drip kits owners are holding plots smaller than 0.165 ha, which is below the national landholding average of 0.95 ha (ICID, 2001). Table 5 reveals some key differences in household income composition across the poor, middle and well-off farmers. Almost similar patterns of income sources in both districts signify the limitation of livelihood diversification options. Most of the non-farm income is from remittances from out-migrated family members. Vegetable farming has been the main source of income for poor farmers in both districts.

Nepal has slid from a food surplus country two decades ago to a net food importer today (Tiwari, Ojha, Upadhyay, Maharjan, & Huddleston, 2002). Nepal's vegetable output meets only 60% of the demand. Nepal produced 1.6 million tons of vegetables in fiscal year 2000/2001 and imported vegetables and fruits worth NRs.900 million and NRs.300 million, respectively, in 2001 (Poudel, 2002).

Table 5. Composition of household income by wealth category (%)

Income Source	Palpa *n* = 60			Siraha *n* = 60		
	Poor *n* = 61	Middle *n* = 22	Well-off *n* = 7	Poor *n* = 56	Middle *n* =18	Well-off *n* =16
Vegetables	92.4	62.3	30.2	79.5	55.1	18.0
Other crops	4.8	20.1	48.2	5.6	14.3	52.1
Livestock	2.1	10.2	12.7	11.4	17.4	12.8
Non-farm	0.7	7.4	8.9	3.5	13.2	17.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Survey, 2003 and 2004

FGDs revealed that prior to the introduction of the micro- irrigation program there were very few households (3%) that used to sparingly produce vegetables. As the household income increased due to commercial vegetable farming, families started accumulating livestock as the productive rural assets in Palpa. Hence, milk intake has come out as spill-over benefit of micro-irrigation system. Improvement in nutritional intake has been noted as significant enhancement in sample farmers' normal diet, given the fact that malnutrition among children in Nepal is around 53% and almost 75% of pregnant women and 68% of women aged 15-59 years are anemic (Gill, & *et al,* 2003).

The clearly visible change in their normal meal intake has been the presence of vegetable in every meal. Data suggest that before the introduction of the technology, majority (72%) of the farmers did not include vegetable in their meals. After the introduction, all households serve vegetables in their meals. This improved dietary intake parallels findings of others (For example, see, Gurung, 2000; Sharma, 2000; Devkota, 1999; RITI consultancy, 2002).

Being asked to list their impression about farming under drip, husband and wife belonging to a Patidar (local caste) family of MP took turns explaining, "Last year, our cotton yield was on average 20% higher than that from neighbouring conventional farms. As yields tend to increase every following year, we hope at least 30% higher yield this year. Yields of other rotational crops such as wheat, soya and chilli were 10% up. Wheat attracted local market premium because of its superior taste. All this has contributed to a 55% higher family income."

Likewise, 56% households reported that their income from drip was in the range of IRs. 2,500-3,500 per season. More than a third (36%) reported that this constituted the highest contributor in household income compared to livestock and non-farm income. Almost similar number of respondents (37%) reported improvement in food security situation and better dietary intake.

CONCLUSION

The paper demonstrated that the micro-irrigation technologies designed for smallholders are gaining momentum. They have some promising features—they are within the reach of poor category of farmers as they come very cheap, the benefits associated with their use far outweigh the costs and they are gender-neutral and user-friendly—which reinforce their poverty reduction potential. Above all, they have offered poor women and men an opportunity to start commercial ventures on their own. This holds greater importance mainly because there are very limited earning opportunities in these rural settings and viable alternative livelihood means are almost non-existent. Hence, promotion of these technologies should be there to create a facilitative environment for a thriving rural economy, which is a prerequisite for poverty reduction.

A review of the history of irrigation in Nepal and India suggests that several institutional mechanisms have evolved and perished over the past five decades. Farmer managed irrigation system (FMIS) and Participatory Irrigation Management (PIM), for example, deemed successful in most localities, badly failed in other communities. These failures have given the lesson that local institutional context—which encompass local customs, rules, culture, regulations, that set the norms what one is or is not supposed to do— in which poor people attempt to build-up their livelihoods, largely determines whether or not a particular institutional arrangement will work in a certain area no matter how successful the arrangement has been elsewhere. The same is very true with a technological intervention. Hence, analysis of software aspects related to the technology and potential users should be done besides hardware aspects consideration prior to any such intervention.

Nepal particularly needs to develop a long-term strategy to become self-reliant in vegetable production. The recent focus of irrigation policy on promotion of systems like drip and treadle pump is a relevant step in this direction. Prior to embarking on implementation stage, it is important to scrutinize the actual conditions of potential adopters to ensure that the programs offered are based on reality and thus responsive to the needs of the adopters.

In both countries, it was noted in the qualitative discussion that the micro-irrigation program for smallholders carried a price tag as well, i.e., excluding the poorest households. Households unable to afford either the drip kit or treadle pump, are simply denied this opportunity of paving their way out of poverty. Therefore, it is essential to provide resource poor farmers with access to credit or subsidy to enable them to obtain the necessary technology for improvement in their living conditions.

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End notes

[1] Drip irrigation using drum kits refers to the slow and frequent application of water to soil through mechanical devices or holes—known as emitters and located along the water delivery lines. It eliminates spraying or running water down furrows and allows water to dissipate under low pressure. Water is carried through a network of pipes to the root of each plant. Likewise, a standard bucket kit for drip irrigation includes a plastic bucket (instead of drum) of 20-30 liters capacity, attached to laterals and micro-tubes. It can irrigate up to a 20 sq mt area.

[2] Treadle pump is a simple human powered device basically intended for small-scale irrigation and particularly ideal for fragmented land common in developing countries. It operates as a suction pump to lift groundwater from shallow aquifers. It consists of a couple of pistons that are placed inside two cylinders. Once the operator stands on the treadles and thereby presses the pistons up and down in a rhythmic motion, water gets lifted up to the pump and gets discharged. A 76 mm pump is capable of maintaining a discharge rate of 1 litre per second up to a suction limit of 8.5 m. A basic metabolic rate (BMR) of 92- 112 watts is required for comfortable pumping activity. Pumping for 20 minutes and resting for next 10 minutes would allow a healthy person to pump comfortably for 5-6 hours a day, which means that up to 14 m^3 of water could be pumped in a day (Upadhyay, 2004).

[3] Random-spot observation of time allocation is a method of survey of each adult member of the household using random visits to work spots during a 12-hour period usually between 6.30 and 18.30 hours (Paolisso and Regmi, 1992).

[4] A Haat is an open air market that usually takes place once every week in a public field of a village. Also known as “Hatiya” in the Terai, this is the major venue for transacting local produce.

[5] Nepal is the only Hindu kingdom in the world. The caste system is closely related to Hinduism. The Vedas - the 2500 years old sacred Sanskrit texts which Hinduism is based upon - separate the population into four groups: Brahman, Chetri, Vaishya, and Sudra. The four groups are hierarchically ordered with the Brahmins in the top and the Sudras in

the bottom. Socially and politically, Brahmins and Chetris have been the dominant caste groups in Nepal for a long time.

[6] In 1995, US$1 was equivalent to NRs. 51.89. In 2003 the rate has slid to US$1= NRs. 74.35. In September 2004 US$1 is equivalent to NRs.74.84.

[7] The labor cost used is NRs.60 per day for woman and NRs.100 per day for man, the present going rates in these areas. Similarly, the on-going rate of land rental for a year varies from NRs. 1,500 to NRs. 3,000 per 0.0127 ha, depending on the location of the plot.

[8] The ongoing wage rate for a man for any agricultural activity is NRs 12.5 per hour without any food, while a woman is paid just NRs 10 for the same job. NRs. 800 per 0.033 ha is the on-going annual land lease rate.

[9] Prof. Phansalkar (2002) analyzed benefits and costs based on the data gathered during the filed survey. A discount factor of 12% has been used. Mixed vegetables, pomegranate and cotton were the main crops under the analysis. Opportunity cost of land was valued at IRs.32 for bucket kits and at IRs.160 for drum kits.

[10] Currently US$ 1 is equivalent to Indian Rupees (IRs.) 45.92.