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Cost and Productivity of Irrigation in Janakpur, Nepal

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Abstract

The Japanese Government assisted in the installation of shallow and deep tube wells (STW and DTW) in the Janakpur area of Nepal aiming to make land use more intensive through the use of irrigation in the dry season. After the completion of the program, the diffusion of irrigation is not so remarkable. The main reason of a low utilization is in the higher cost of irrigation compared to the marginal revenue of the product. The profitability of the irrigation in Janakpur is kept in the wheat production in the dry season.

Key Words: irrigation, profitability, rice, wheat, tube well.

1 Introduction

The Japanese Government assisted in the installation of shallow and deep tube wells (STW and DTW) in the Janakpur area of Nepal during the period from 1971 to 1984. The main objective of the project was to make land use more intensive through the use of irrigation in the dry season. In 1969, HMG of Nepal asked the Japanese Government to 1) establish an experimental farm, 2) assist in regional agricultural development and 3) send agricultural specialists to this area.

The construction of tube wells was expected to increase the land use ratio from 103 percent to 300 percent. JICA[1] estimated the cost-benefit ratio to be 1.242. The purpose of this paper is to clarify the cost and productivity of deep and shallow tube well irrigation in the Janakpur area.

Janakpur is located in the middle of Terai Plain, Nepal (Figure 1). The area's climate is characterized as tropical monsoon. As shown in Figure 2, more than 80 percent of the total rainfall is concentrated in the monsoon season (from June to September). It is difficult to get water for agriculture in the dry season without tube well irrigation.

[1] Japan International Cooperation Agency.

According to the sampling survey by APROSC (Agricultural Project Services Centre) , 20 percent of large farmers (more than five ha. owner) share 61 percent of total farm land and small, peasant farmers which hold less than three ha. share only 18 percent of farm land. The small and peasant farmers must be tenants. In Terai plain, 61 percent of farmers who hold less than one hectare of farm land are tenant farmers.

The typical land rotations in Terai are rice - wheat, rice - potatoes or rice- fallow. Another important crop is sugar cane. The productivity of each crops is in low level. For rice, the productivity was 1.8 tons per ha. and wheat was 1.1 tons per ha. There are quiet a large difference in per capita income among the farmers. More than five hectares owner, the largest class, get 3,051 Rs. per year and peasant farmers' income (less than 1 ha.) was only 379 Rs[2].

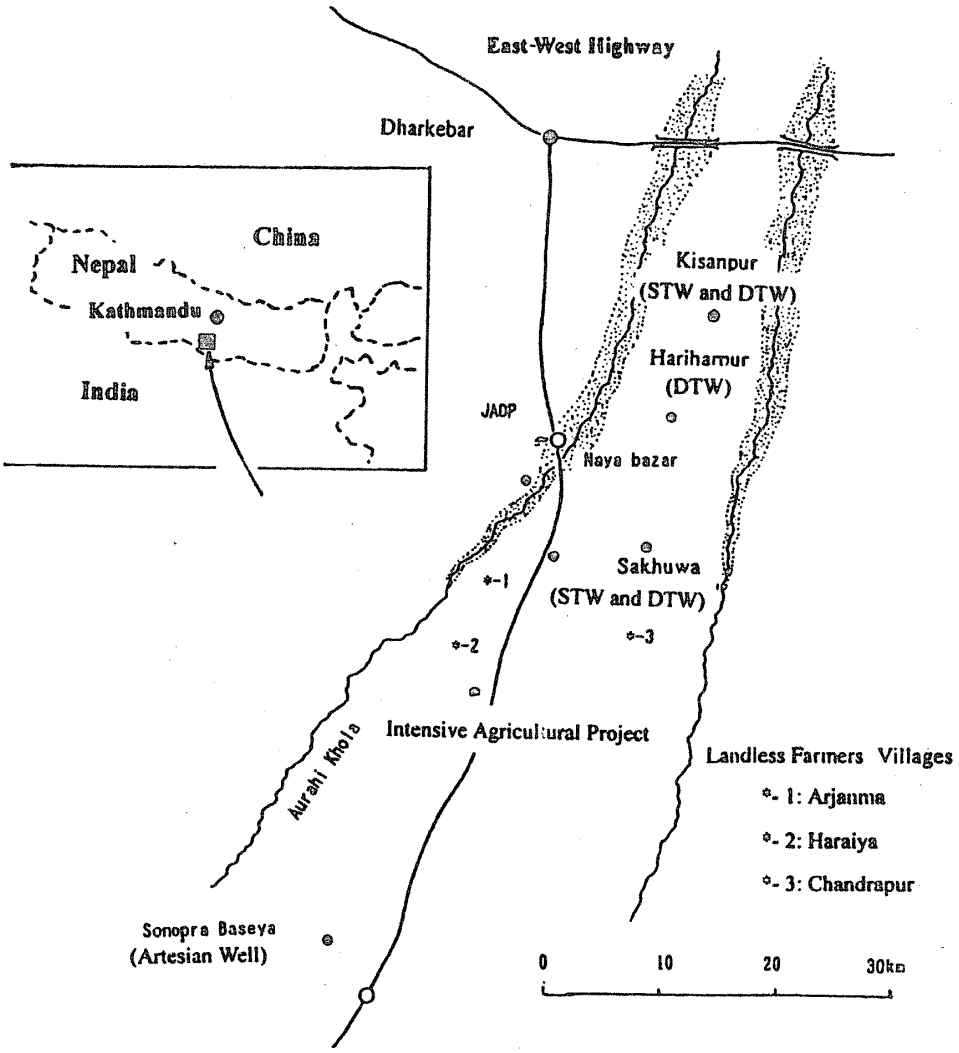


Figure 1: Outline of the Study Area

[2]APROSC(1977), pp.17 - 24.

With the help of counterpart assistance, we carried out research work in November 1997 and December 1998. We interviewed 44 farmers in Mahendranagar and Hariharpur who were using STW or DTW. As shown in Table 1, 26 farmers were interviewed in Hariharpur and 18 in Mahendranagar. The collected data are on the agricultural input and output for each field, which is called a Kitta. For some important DTWs, we checked the records of DTW usage.

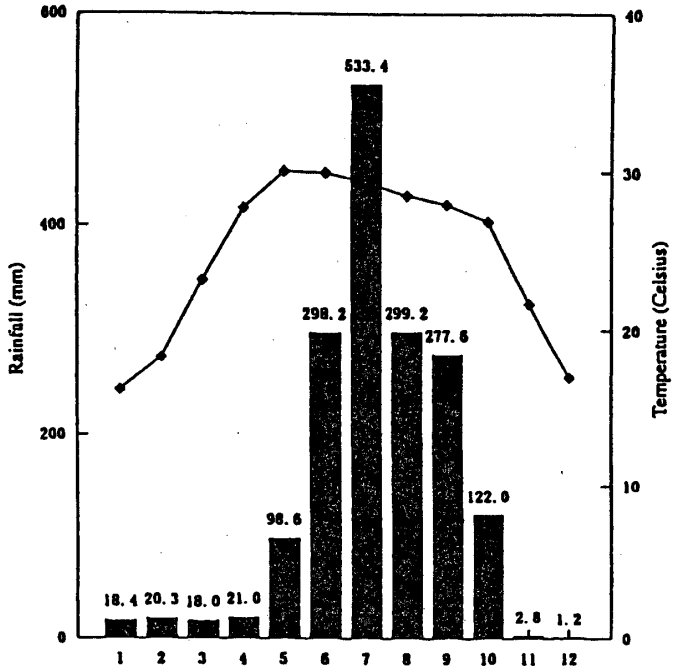
Table 1: Farmers Surveyed

	Hariharpur	Mahendranagar	Total
Number of Farmers	26	18	44
Total Farmland (*bigha*)	113	73	186
Number of *Kitta*	144	47	191

Source: Surveyed data (members of our survey group are listed at the end of this paper (Acknowledgment).
Note: *Kitta*: an agricultural field

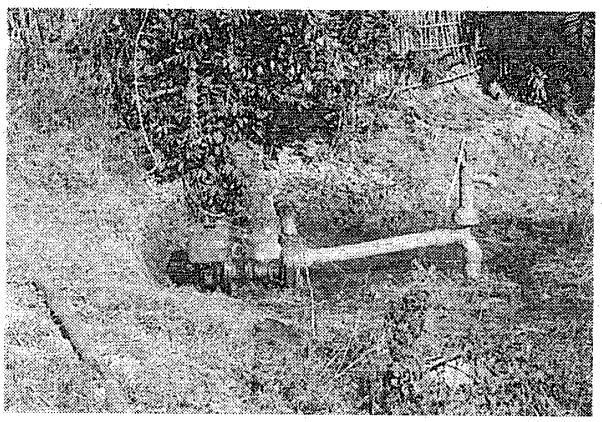
Figure 3 shows the idealized underwater condition in the Janakpur area. The underground water level near the East-West Highway is rather shallow and it is easy to install shallow tube wells. On the other hand, in Hariharpur, because of the deep underground water level, the deep tube wells (DTW) are mostly used to get irrigation water. In the more southern area, shallow tube wells (STW) and artesian wells are used because of the shallow underground water level.

Figure 2: Climatic Condition in Terai



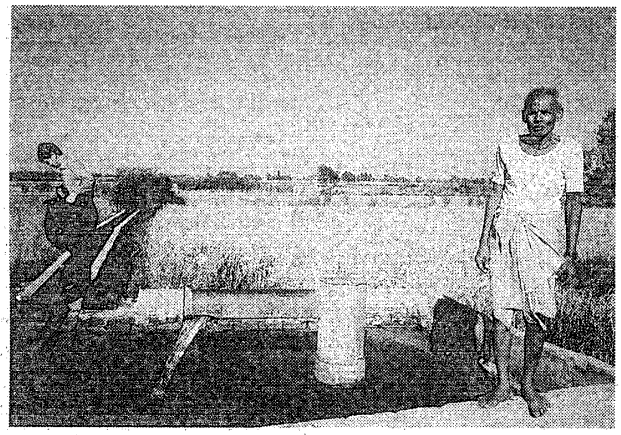
Source: Kokusai Noringyo Kyokai (Association of International Agriculture and Forestry)(1992) Agriculture in Nepal, pp. 15-16.
Note Based on the data at Bara (1971-1975): Pre monsoon: Apr. - May., Monsoon: June - Sept., post monsoon: Dec. - Mar.

Photograph 1: Shallow Tube Well (STW) (Used except Zone IV in Figure 3)



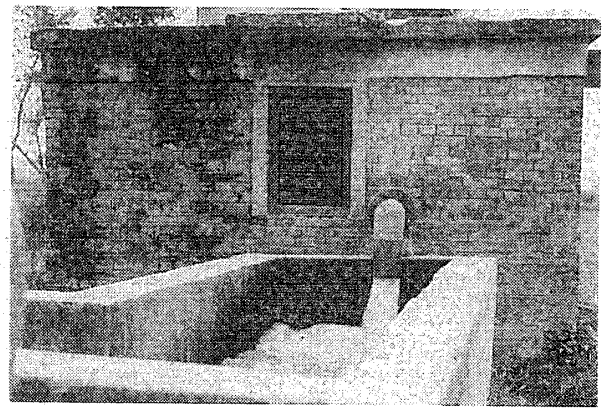
The Shallow Tube Wells (STWs) are used for small scale farm management.Diesel engines (8-15 h.p.) are used for pumping water. The diesel enginesmade in Italy and Japan are more expensive than those made in India. Theirwell worth the expense because these engines last longer. Farmers use theirdiesel engine for two or three wells (connecting an engine to a well as needed). Many of the farmers who own STWs, sell their excess water to neighboring farmers who do not have STWs.

Photograph 2: Artesian Well at Sonopra Basahiya (Zone I in Figure 3)



An artesian well was drilled at Sonopra Baseya in 1995 to a depth of 200m and now supplies water to 200 *bighas* (136ha.) Artesian wells do not need to be pumped initially, but after a few years has passed, diesel engines are required to extract water.

Photograph 3: Deep Tube Well (DTW) at Hariharpur (Zone IV in Figure 3)



DTWs are installed by the Department of Irrigation with the assistance of the Japanese Government. The depth of a well is in excess 100m. DTWs are used by more than fifty farmer groups with operators supplied by the Jankpur Agricultural Development Project (JADP). The maintenance of the DTWs is rather difficult because of the shortage of replacement parts and lack of highly skilled engineers.

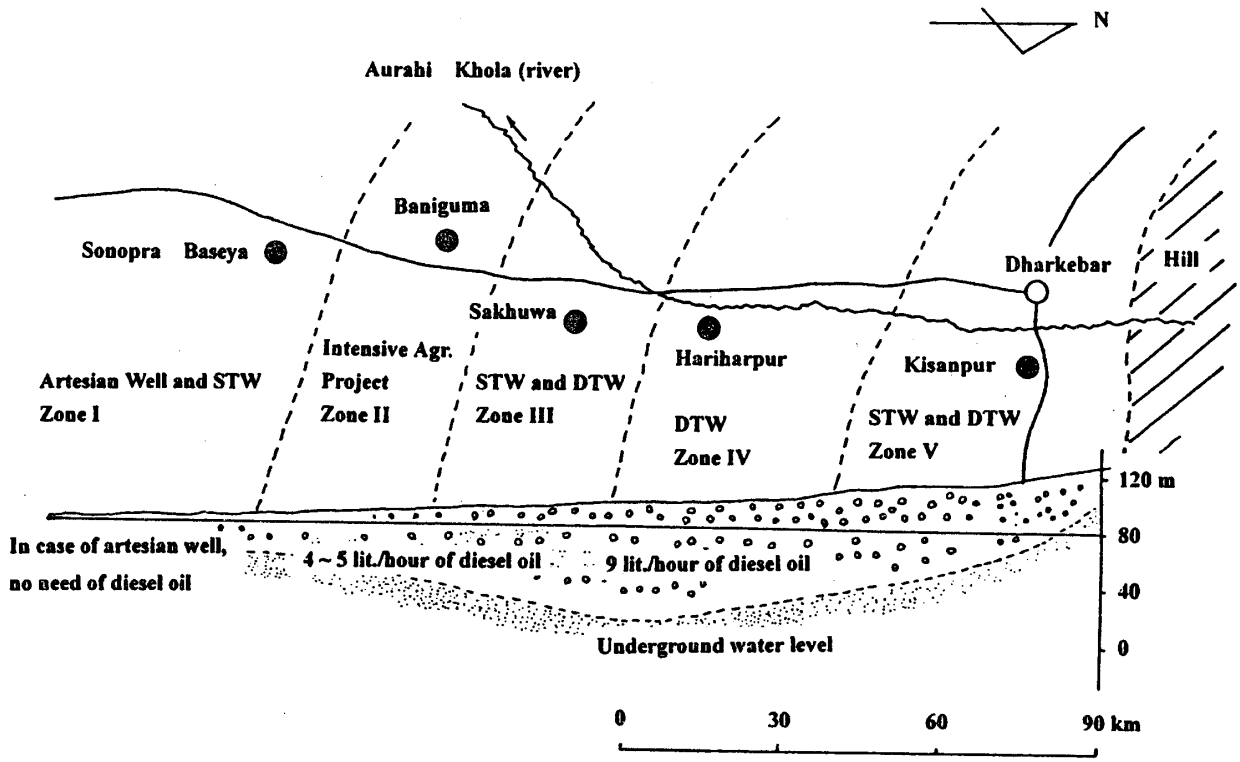


Figure 3: Idealized Underwater Condition in Janakpur

2 Difference of DTW and STW Usage

Table 2 shows the command area of DTW and STW in Hariharpur and Mahendranagar. In Hariharpur, because of a deep underground water level, farmers mainly rely on the DTW (60% of total farmland). On the other hand, in Mahendranagar they can use STW (74% of total farmland). The difference in the accessibility to the underground water in the two areas leads to the difference in the cost of well water. In Sakhuwa, a village in Mahendranagar which is located south of Hariharpur, the DTW requires 5 liters of diesel oil per hour and obtains 60 liters of water per second. In Hariharpur, the DTW requires 9 liters of diesel oil and obtains only 45 liters of water per second. One liter of diesel oil corresponds to 43.2 cubic meters of well water in Sakhuwa and only 18.0 cubic meters of well water in Hariharpur. Therefore, in Hariharpur the variable cost of water is 2.4 times greater than in Sakhuwa. The total operated hours is generally shorter in Haiharpur than in Sakhuwa. The total cost including fixed cost will be higher in the poor conditions of Hariharpur.

The agricultural products in both areas are indicated in Table 3. In the rainy season most of the cultivated area is used for rice (103.2 *bigha* for interviewed farmers accounting for

Table 2: Farmland by Irrigation Condition

	Hariharpur	Mahendranagar	Total
Area of DTW	68	19	87
Number of Farmers	17	9	26
Area of STW	45	53	98
Number of Farmers	9	9	18

Source: Surveyed data (members of our survey group are listed at the end of this paper (Acknowledgment).
Unit:*bigha*(=0.68ha)

40% of the total area). Wheat is the most important crop in the dry season. Some part of the cultivated area (32.0 *bigha*: 12%) is used for sugarcane production.

Table 3: Planted Area by Irrigation Condition

Crops	DTW	STW	None	Total	DTW	STW	None	Total
Paddy	9.3	46.4	50.8	103.2	30	48	35	40
Wheat	15.5	28.8	9.9	54.2	50	32	7	21
Sugarcane	5.4	3.4	23.2	32.0	17	4	17	12
Vegetable	0.6	5.9	9.4	15.8	2	7	7	6
Pulses	0.0	0.3	13.2	13.5	0	0	9	5
Planted Area	30.8	88.3	137.2	256.3	100	100	100	100

Source: Surveyed data (members of our survey group are listed at the end of this paper (Acknowledgment).
Unit:*bigha*, %
Note: Unit: *bigha*(=0.68ha), %, Shown main crops only.

Land use is not common in the two areas where water availability is deferent. For fields using the DTW, wheat and sugarcane account for 50% and 17%, respectively. In the STW using fields, the sugarcane area is rather small and vegetables are introduced. In areas where no well water can be used, the farmland is mostly used for sugarcane.

3 Marginal Cost and Revenue of Irrigation

For the rational usage of irrigation, farmers should use irrigated water to the extent that its marginal cost is equal to the marginal revenue. Table 4 shows the general characteristics of rice and wheat production with DTW, STW and without irrigation. Most of the rice is cultivated in the monsoon season and irrigation is supplemental. In the case of wheat production, however, irrigation plays an important role. Even though wheat can be produced without irrigation, its productivity is low. As shown in Table 5, the land productivity with STW is 1.3 times higher than without irrigation. In the case of wheat with irrigation, farmers irrigate two or three times during its growing period. They separate each Kitta (field) into several sections and supply water carefully. The marginal productivity of water is the highest among many crops in the dry season.

Table 4: Irrigated Area of Wheat and Paddy

		Planted Area (*bigha*)	Irrigated hours (hr)	Cost of Irrigation (Rs.)	Yield (kg)
Wheat	DTW	14.8	151	17,386	16,032
	STW	28.5	723	19,731	34,120
	None	6.1			5,624
Paddy	DTW	8.7	55	5,949	11,600
	STW	45.6	976	34,309	64,380
	None	43.5			61,445

Source: Surveyed data (members of our survey group are listed at the end of this paper (Acknowledgment).

Note:*bigha*=0.68ha, $1Rs \approx 2Yen$

Needless to say, the physical role of water in wheat production is the same for DTW and STW. From the economic aspect, though, the contribution of each system is different. In the case of DTW, land productivity is only 17 percent higher than without irrigation. The stability of getting irrigation water is higher with STW. Most of the STWs are owned by the individual farmers. There is limited fear of the STWs breaking down because of their good management. On the contrary, DTWs are used by many farmers and managed by water user's committees. It is not unusual for the diesel engine of a DTW to be broken or the filter of a well to be crushed. For the users of a DTW, water availability is not stable. The last column of Table 5 indicates that the marginal revenue of STW for wheat production is highest (Rs 1,372 per *bigha*). Table 5 indicates that only STW usage for wheat production in the dry season is attractive for farmers. When reading Table 5, it should be noted that the

fixed costs of the DTW and STW are not included in the calculation of the cost of irrigation. Most of the fixed cost for the DTW is not paid by farmers. When we include the fixed cost, the marginal revenue of the STW (Rs 1,372) will be reduced. Because the drilling cost for the DTW is paid by the Nepalese Government through the aid of the Japanese Government, the fixed cost is not so high for the farmers.

Table 5: Additional Product of Irrigation

Crops	Tube Well	Productivity (kg/*bigha*)	Index None=100	Additional Product (kg)	Add. Value (Rs.)	MR (Rs.)
Wheat	DTW	1,083	117	161	1,210	35
	STW	1,197	130	275	2,064	1,372
	None	922	100			
Paddy	DTW	1,333	94	-79		
	STW	1,412	100	-1		
	None	1,413	100			

Source: Surveyed data (members of our survey group are listed at the end of this paper (Acknowledgment).

Note: Price of Wheat: 7.5Rs./Kg,

MR (Marginal Revenue): Additional Value Product - Irrigation Cost

4 Some Shortcomings of DTW

4.1 Regional Cost Difference of DTW

The underground water level is differs throughout this area. It varies from fifty to over 100 meters. The highest cost DTW is Hariharpur No. 10. Here, the underground water level is 129 meters. It requires 9 liters of diesel oil for one hour of operation. Sakhuwa DTW obtains water rather easily and requires only five to seven liters of diesel oil. This DTW needs to be repaired fifteen times per year. Once the battery needs to be recharged they cannot operate the well because they do not have a spare battery. There are cases of only one year of use of a DTW. Hariharpur No. 2 was installed nine years ago. The diesel engine is 40 horsepower. It is not used now because the filter is crushed.

There are some artesian wells in Sonopra Baseya near Janakpur Airport. The well in Ward[2] No. 9 was drilled in 1995. The command area is 200 *bighas* and 125 farmers are using it. The farmers paid one tenth of the drilling cost, which amounted to Rs 70 per

[2]The smallest unit of administration in Nepal.

year. In the case of a second well in this area, they had to drill another well 10 years ago because the artesian well dried up. The water is used mainly for wheat production. Another application of water is for vegetables such as potatoes, cauliflower and eggplant.

4.2 Shortcomings of DTW

DTW drilling involves high costs. When the total operating hours are not so long, its average cost curve is in a high position in comparison to STW. Table 6 shows that the cost of DTW irrigation is higher than that of STW.

Table 6: Cost of Irrigation (Rice and Wheat)

		Cost of Irrigation (Rs./hr)	Cost of Irrigation (Rs./*bigha*)	Irrigated Hours (hr./*bigha*)
Wheat	DTW	115	1,175	10
	STW	27	692	25
Paddy	DTW	108	684	6
	STW	35	752	21

Source: Surveyed data (members of our survey group are listed at the end of this paper (Acknowledgment).

Note:1*bigha*=0.68ha

Table 7: Land Productivity of Rice by Planted Month

		Planted Area (*bigha*)	Irrigated Hours (hr.)	Cost of Irrigation (Rs.)	Yield (kg)	Productivity (kg/*bigha*)
DTW	May	3.1	21.8	2,292	4,080	1,316
	June	2.0	20.5	2,067	2,590	1,295
	July	3.6	12.8	1,590	4,930	1,369
STW	May	1.8	10.0	600	2,880	1,600
	June	24.0	518.0	20,520	33,440	1,393
	July	19.8	448.0	13,189	28,060	1,417
None	May	4.9			6,040	1,233
	June	20.4			27,938	1,370
	July	17.6			26,402	1,500

Source: Surveyed data (members of our survey group are listed at the end of this paper (Acknowledgment).

The calculations of cost are based on irrigation hours. When a farmer's field is located far from the main canal, he must make a temporary canal to take the water into his field and will lose water according to the length of the temporary canal. Accordingly, the cost of irrigation increases significantly.

Table 8

Operated Hours of DTW (*Sakhuwā*)

Crop	Month	95	96	97
Paddy	May	-	4	-
	June	-	1	29
	July	-	19	-
Subtotal		-	24	29
Sugarcane	Jan.	-	-	29
	Mar.	-	-	6
	Apr.	-	23	2
	May	-	1	-
	June	-	-	17
Subtotal		-	24	54
Vegetable	Mar.	-	2	4
	Apr.	-	4	-
	Sept.	-	1	-
Subtotal		-	6	4
Wheat	Jan.	-	-	8
	Feb.	-	53	30
	Mar.	-	35	6
	Apr.	-	1	-
	Sept.	-	4	-
	Dec.	15	79	-
Subtotal		15	171	43
Total		15	225	130

Source: Record of DTW Operation

Table 9

Operated Hours of DTW (*Hariharpur10*)

Crop	Month	93	94	95	96	97	98
Paddy	Aug.	-	2	-	-	-	-
	Nov.	2	-	-	-	-	-
Subtotal		2	2	-	-	-	-
Sugarcane	Mar.	-	-	2	-	-	-
	Apr.	-	-	3	6	-	-
Subtotal		-	-	5	6	-	-
Vegetable	Jan.	-	-	-	-	3	-
	Mar.	-	-	4	-	-	-
	Apr.	-	-	1	3	2	1
	May	-	-	2	1	-	-
	Nov.	7	-	4	-	-	-
	Dec.	4	39	-	22	-	-
Subtotal		10	39	10	26	5	1
Wheat	Jan.	-	45	12	-	39	34
	Feb.	-	-	11	-	11	-
	Mar.	-	4	30	-	8	-
	Apr.	-	-	21	-	-	-
	Dec.	104	30	-	30	-	-
Subtotal		104	78	73	30	58	34
Unknown	Jan.	-	-	-	-	-	4
	Feb.	-	-	-	-	-	5
	Mar.	-	5	1	-	-	-
	Apr.	-	1	-	-	-	-
	Dec.	-	31	-	7	-	-
Subtotal		-	36	1	7	-	8
Total		116	155	88	69	62	43

Source: Record of DTW Operation

Table 10: Water Requirement

Rice	211～200
Upland Rice	309～433
Wheat	164～191
Barley	175
Corn	94
Soybeans	307～429
Sweetpotatos	248～264

Source: Hosikawa, Kiyochika(1980),*Shokuyo Sakumotsu* (Food Plants),

Note: Water Requirement: Needed water/dry matter of each crop in weight.

Once the DTW is broken, the farmers can not use it for several days until it has been repaired. The supply of DTW water is therefore uncertain.

Table 7 shows that the land productivity incease for rice is not admitted both DTW and STW except tansplanting for STW in May. In this case, they irrigated only 10.0 hours. This case may suggest that for farmers using STW, rice priductivity incrase may be recognized but their capability is limmited for a few farmers who can use STW.

5 Concluding Remarks

As far as we have observed, a large part of irrigation water is used for wheat production. Of all crops, the marginal productivity of water is the highest for wheat production. As shown in Table 9, the water requirement of rice is high and according to our calculations, the marginal value product of water for rice may be less than the marginal cost of the water. For the farmers, irrigation for rice is not attractive in this study area. In facrt, as shown in Table 8 and 9, most of the irrigation is concentated in a period of December through March mainly for wheat followd by vegetables.

As shown in Table 5, the marginal revenue of STW for wheat production is dramatically higher than that of DTW. The reasons why DTW is more costly than STW are, as mentioned in 6.2, 1) the water loss of DTW, and 2) the rather short operation hours that lead to the higher position of the average cost curve.

Even though the cost of STW is lower than that of DTW, farmers need to pay the fixed cost of drilling the STW. For small-scale farmers, it is difficult to invest in STW. STWs in this area are owned by larger farmers.

The economic significance of irrigation by tube wells for rice production may be different

from that of wheat in the dry season. For rice production, the irrigated water is important when rainfall is insufficient. For the early paddy, which is grown partly in the pre monsoon, the role of irrigated water may be the same as its role for wheat. This different significance of water for the early and for the late paddy has not yet been clarified in our study.

There is a big difference in the cost of irrigation water in our limited small study area. The difference is determined by the underground water conditions, the scale of the irrigation pump and the management efficiency among DTWs. Clarifying the marginal productivity of irrigated water may be critical for the agricultural development of this area.

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ネパール・ジャナクプル地域における灌漑コストと農業生産性

近藤　巧・長南　史男・土井　時久

要 旨: 日本政府は、1971年から1984年にかけて、ネパールのタライ平原ジャナクプル地域の灌漑開発援助をおこなった。これにより乾期の農業生産性を向上させるのが主な目的であった。灌漑施設としては深井戸(70～100m)による地下水の共同利用を主とし、個別農家あるいは数戸共同の浅井戸（10m程度)掘削への補助もおこなった。この事業の終了後、十数年を経過した現状を調査した結果、深井戸の管理は不十分で、農家の利用度は低く、乾期の小麦生産に部分的に利用され、むしろ浅井戸の利用率が高いことが明らかになった。深井戸の管理が不適切であることに加えて、燃料としての重油購入費が農家にとって負担となり灌漑の限界費用が限界収入を上回ることが広汎な乾期の灌漑を困難にしている。

キーワード： 灌漑、収益性、米、小麦、管井戸