THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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Economics of Pump-Irrigation in Eastern Nepal

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ECONOMICS OF PUMP-IRRIGATION IN EASTERN NEPAL

Madhab Raj Khoju and John A. Wicks*

Introduction:

Agriculture is the most important sector in the economic development of Nepal. In 1975, two-thirds of the Gross Domestic Product (GDP) was contributed by agriculture alone and it provided 80 percent of the total export earnings and employment to 89 percent of the country's total labour force of 4.54 million. With a few other growth options available, agriculture continues to play a significant role in creating employment opportunities, in providing foreign exchange to fund the country's imports and development plans, and in meeting domestic food requirements.

The country has a total area of 14.10 million hectares. Of this, only 16.49 percent, or 2.3 million hectares, are suited to cultivation; 1.5 million hectares of this is in the terai (the plains) and the remaining 0.8 million hectares in the hills and mountain regions. Two-thirds of the country's 13 million population live in the hills and one-third in the terai. With an annual rate of growth about 2.2 percent (1965-75), the population density, per square kilometer of arable land, has reached 1493 in the hills and 379 in the terai. Consequently, the average size of individual family holdings is less than 0.4 hectares in the hills and 1.7 hectares in the terai. Per capita income in agricultural sector

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was only Rs 650 in 1971-72, as compared to Rs 5078 in non-agricultural sector and a national average of Rs 894. Given the dominant role of the agricultural sector, and this inequality of income distribution between the non-agricultural and agricultural sectors, there is a need to raise the per capita income of the latter. To do so will not only increase the national average income but will also act, through backward and forward linkages, to stimulate industrial growth by increasing the demand for agricultural inputs and providing markets for industrial products.

The major food grains of Nepal are paddy, maize, wheat, millet and barley. They account for 90 percent of the total cropped area and constitute 80 percent of Nepal's agricultural GDP. Annual growth in paddy and wheat output, in the 1970s, of 1.5 and 9.6 percent respectively, has been achieved mainly through the expansion of cultivated area. During the same period, the yields of paddy and wheat increased by 0.3 and 2.7 percent per annum, respectively, while the yield of maize declined by 0.7 percent per annum (Table 1). The average rice yield of 2084 kilograms per hectare is still very low compared to other countries and average annual rice exports of 500,000 t in the 1960s have declined to 200,000 t in the 1970s. In 1979-80 owing to drought conditions, the food production fell by 13%. As a result the government sought food grants totalling 39000 tones from other countries.

Studies in other countries have shown a correlation between the availability of irrigation water and diffusion of the seed-fertilizer technology. The success of the new seed-fertilizer technology in the

Ludhiana, or West Godavari region of India, Central Luzon in the Philippines, Punjab in Pakistan and Munipe in Sri Lanka was due to their good irrigation systems. Under this system of assured irrigation, crop failure was minimized, use of fertilizer was increased and production was thereby increased. In addition, irrigation facilitated planting of more than one crop on the same piece of land in a year, which resulted in the use of idle land and labour resources.

Irrigation, as one of the strategies for increasing agricultural production, has been given top priority by the government of Nepal since the launching of the first five-year plan (1956-1961). Even so, as of 1976, only 13 percent of the cultivated area was provided with irrigation. In the past large surface water irrigation projects, such as Gandak, Kosi East and Kosi West, were emphasized. Currently, ongoing extensive irrigation projects include the Kankai Irrigation Project and Chitwan Valley Development Project under Asian Development Bank loans. These are estimated to provide irrigation for a total net area of 16000 hectares. In addition, the World Bank financed Narayani Irrigation and Bhairhawa Lumbini Ground water projects are expected to irrigate 32000 and 7500 hectares of cultivated areas, respectively. The construction of large irrigation projects require enormous amounts of capital, long gestation periods and precise management. Hence, government focus in fourth (1970/71 - 1974/75) and fifth (1975/76 - 1979/80) five year plans was on cheap irrigation projects with short gestation period. With abundant ground and surface water resources in the terai region, one of the measures undertaken by the government was the distribution of low cost, five to seven horsepower (HP) diesel engine pumpsets to individual farmers. These pumpsets are used to lift water from wells (including shallow tubewells), rivers, ponds and streams with a service area of between three and six hectares per pumpset, depending upon the water source and depth. Most of the farmers get the pumpset in concessional credit from the Agricultural Development Bank and other commercial banks. The regulation for bank financing requires 3 hectares of land as the project area. Few farmers also buy in cash from private pumpset dealers.

The Problem:

In Nepal, use of pumpset for irrigation is gaining popularity. Between 1971 and 1975 the number of pumpsets increased from 2235 to 5225. Another consignment of 2058 units, 1160 under Asian Development Bank loan and 898 under Kennedy Round, were also distributed in 1976-77. Currently, 1600 of the 4000 pumpsets under an Asian Development Bank loan are being distributed by the Agricultural Development Bank.

The main objective of the government in distributing these pumpsets is to raise agricultural production through increased adoption of seed-fertilizer technology and cropping intensity. The objective of the pumpset owner-farmers is to make profit with pump-irrigation. The increasing rate of adoption of pump-irrigation makes it urgent to assess the impact these are having on agricultural production.

The study was designed with the following main objectives:

1) To assess the impact of pump-irrigation on mean levels of inputs used, yield, crop income and cropping intensity.
2) To investigate the effects of pump-irrigation on resource productivities in paddy and wheat production.
3) To assess the profitability of owning pump-irrigation.

The findings of the study should prove useful to policy makers in the government, Agricultural Development Bank and other commercial banks in determining the future role of pump-irrigation in Nepalese development policy.

The study should also provide information which will be of value in assisting farmers faced with the problem of evaluating the profitability of investment in pump-irrigation. This will also help currently pump-irrigation owning farmers to gain more profits.

Study Area:

Jhapa, Morang and Sunsari, and Saptari districts of Eastern Nepal (see Figure 1) were selected for the study since farmers in these areas were early adopters of the new technology, including pump-irrigation. The number of pumpsets in the study area reached 2729 by October, 1979. As shown in Table 2, these pumpsets are predominantly of the Kirloskar brand manufactured in India.

Selection of the Village Panchayats:

In each district, a list of farmers who own pumpsets, and their respective village panchayats (addresses), was prepared with the help of the Agricultural Development Bank and other offices concerned. The four village panchayats with the greatest number of farmers owning pumpsets were selected from the list prepared for each district. This gave a total of 16 village panchayats from which to select the sample farmers. The locations, and names of these villages, are shown in Figure 2.

Selection of the farmers

The sample of farmers with pumpsets was obtained by randomly selecting six farmers from the list of pumpset owners for each of the selected village panchayats. In each case a seventh farmer was selected to act as a substitute if required.

The most frequent range in the size of land-holding for the sample farmers with pump-irrigation was observed to be from 2 to 6.7 hectares. Therefore, to provide similarity in both agro-physical features and size of landholding, a list of 60 farmers with 2 to 6.7 hectares of landholding but without a pumpset was prepared for each of the selected village panchayats. These lists were prepared with the help of the Land Tax (Malpot) office in each district. Six farmers, plus one reserve, were selected randomly from each list. This provided an initial list of 192 sample farmers for the survey, plus 32 reserves.

Primary cross-section data for the period from November 1978 to

October 1979 were collected through personal interviews conducted from October to November 1979 with the assistance of local enumerators. A detailed interview schedule, prepared for this specific study, was used to collect data on socio-economic characteristics, cropping patterns, pumpset type and use, as well as input use and crop production. As a result of constraints on time available, and the subsequent need to disregard some questionnaires because of insufficient data, the final sample comprised 189 farmers. The distribution of these by district and irrigation type is shown in Table 3.

Results:

Socio-Economic characteristics. Some socio-economic characteristics of the pump-irrigated and rainfed farms was higher by 0.9 hectare than the rainfed farms. Similarly, the cropping intensity of 152 percent as reported for pump-irrigated farms was significantly higher than the 118 percent reported for rainfed farms. This resulted from the fact that improved paddy and wheat were planted to higher percentage of land in pump-irrigated than the rainfed farms. Traditional paddy occupied the higher percentage of the land in rainfed farms. The farmers with pump-irrigation had a larger household size and were more educated than their comparatively older counterparts with rainfed farms.

Impact of pump-irrigation on mean levels of resource use, yield, crop income and cropping intensity - Comparison of sample means. The comparative mean values (Tables 5, 6 & 7) indicate significantly higher yields, human labour used, manures and fertilizers applied, total revenue, total costs and net revenue on pump-irrigated than rainfed improved paddy, local paddy and wheat. However, plant protection use in improved paddy and plough unit[1] in all the crops were not significantly different between irrigated and rainfed crops.

The higher levels of inputs used, yields, net revenue and cropping intensity on pump-irrigated crops need not necessarily, however, imply that they have resulted from the pump-irrigation. The observed differences between the sample means might be associated with variables other than pump-irrigation which have not been controlled in the survey. Possible factors are size of holding, years of schooling of the farmer and his father, mechanization (tractor use in the land preparation of the crop) asset position, respective districts and interaction term between pump-irrigation and mechanization. A covariance analysis was used in an attempt to isolate the effects of these other variables, and hence to determine the impact of irrigation.

Covariance analysis. The covariance analysis, based on the following relation, was estimated by ordinary least squares.

$$Y_i = a_o + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_7X_7$$
$$+ a_8X_8 + a_9X_9 + a_{10}x_{10} + \varepsilon$$

where: Y_i is the level of ith dependent variable

Y_1 is human labour in days per hectare

Y_2 is plough unit in days per hectare

Y_3 is fertilizer and manures in rupees per hectare

Y_4 is plant protection in rupees per hectare

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[1]Few farms used tractor in land preparation, the plough unit equivalent of which was adjusted.

Y_5 is total revenue in rupees per hectare

Y_6 is total cost in rupees per hectare

Y_7 is net revenue in rupees per hectare

X_1 is the pump-irrigation dummy and takes a value of one if the crop is pump-irrigated and zero if rainfed

X_2 is size of land holding in hectares

X_3 is education of the farmer in number of years of schooling

X_4 is mechanization dummy and takes a value of one if the tractor is used in the land preparation of the crop and zero otherwise

X_5 is education of the farmer's father in number of years of schooling

X_6 is the asset position of the farmer

X_7 is district dummy and takes a value of one if the observation is from Jhapa district and zero otherwise

X_8 is district dummy and takes a value of one if the observation is from Morang district and zero otherwise

X_9 is district dummy and takes a value of one if the observation is from Sunsari district and zero otherwise. Reference district is Saptari

X_{10} is the interaction terms between pump-irrigation dummy (X_1) and mechanization dummy (X_4)

a_0 is intercept (constant) term

a_1 to a_{10} are regression coefficients of respective variables.

ε is random error

The "F" tests showed multiplicative effect between pump-irrigation and machine use in land preparation to be statistically insignificant in explaining the variations in all the dependent variables. So, this variable (X_{10}) was dropped from the analysis.

The results of covariance analysis are presented in Tables 8-12.

Pump irrigation is found to increase yield in all the crops. The pump-irrigated improved paddy, local paddy and wheat, respectively gave 6.858, 3.672 and 7.217 quintals per hectare higher yields than the rainfed ones. The utilization of human labour in pump-irrigated improved paddy and wheat were respectively 16 and 14 mandays per hectare more than the rainfed.

The pump-irrigation also resulted in the application of higher levels of fertilizers and manures. The pump-irrigated improved paddy and wheat used manures and fertilizers worth Rs 165.91 and Rs 209.52 higher than rainfed.

The pump-irrigation significantly increased both the total revenue and total costs per hectare in all the crops. However, the magnitude of increase in total revenue is higher than the total cost resulting in increased net revenue per hectare. The results showed net revenue of Rs 412.01, Rs 284.91 and Rs 787.76 per hectare improved paddy, local paddy and wheat attributed to pump-irrigation alone.

In addition to contributing to higher levels of resource use, yields and income, the pump-irrigation also increased the cropping intensity. The covariance analysis shows 34.6 percent higher cropping intensity for pump-irrigated farms than the rainfed.

From the result, we can conclude that pump irrigation significantly increases the mean level of resource use, yields, net revenue and cropping intensity.

Resource productivity effects of pump-irrigation. The impact of pump-irrigation on resource productivities was investigated by estimating the following log linear Cobb-Douglas production functions for rainfed and pump-irrigated crops separately, for pooled samples and for pooled samples with pump use dummy as an additional explanatory variable.

$$\log Y_i = \log A + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 D_2 + b_7 D_3 + b_8 D_4$$

where: Y_i is the physical output of ith crop in quintals per farm

Y_1 is the physical output of improved paddy (quintals)

Y_2 is the physical output of local paddy (quintals)

Y_3 is the physical output of improved wheat (quintals)

X_1 is land area (hectares)

X_2 is human labour (mandays)

X_3 is plough unit (days)

X_4 is manures and fertilizers (rupees)

X_5 is years of schooling of the farmer (years)

D_2 is district dummy and takes a value of one if the observation is from Morang district and zero otherwise

D_3 is district dummy and takes a value of one if the observation is from Sunsari district and zero otherwise

D_4 is district dummy and takes a value of one if the observation is from Saptari district and zero otherwise

Jhapa is the reference district for which $D_2=D_3=D_4=0$

A is efficiency parameter

b_1 to b_5 are elasticity coefficients of respective explanatory variables

b_6 to b_8 are coefficients for dummies

The estimated production functions are presented in Tables 13-15.

In the tests for individual regression coefficients, land input in all the regressions and fertilizers and manures in pump-irrigated improved paddy and wheat were found significantly different from zero. The production coefficients of other variables were statistically insignificant. The use of manures and fertilizers seemed to exhibit response in improved paddy and wheat production only under irrigated condition. However, even with irrigation, local paddy production was not affected by the application of manures and fertilizers. The pump-irrigation by minimizing the chances of crop failure has also contributed to the higher levels of resource use resulting in higher production.

The test the null hypothesis of no significant differences in production coefficients of resources in separate regressions for pump-irrigated and rainfed improved paddy, local paddy and wheat regressions I (rainfed) and II (pump-irrigated) are compared with the regression IV (pooled with pump-use dummy). The analysis of covariance respectively gives an F-ratio of 1.80 with 8 and 44, 0.704 with 8 and 156, and 1.776 with 8 and 93 degrees of freedom which are not significant at 95 percent level. Therefore we do not reject the hypothesis that the resource productivities are the same in rainfed and pump-irrigated crops, if the constant term in the two regressions are allowed to differ.

From regression IV, it can be observed that the intercept term for pump-irrigated improved paddy, local paddy and wheat are respectively higher by 52.86, 36.84 and 58.40 percent than for the rainfed ones. This neutral upward shift in the production functions implies higher efficiency i.e. higher output per unit of each resource with pump-irrigation than without.

The pump-irrigation seemed to be contributing to the increased production. It facilitated the adoption of improved paddy and wheat as well as contributed to the increase in cropping intensity. With increasing prices of diesel and other inputs, the cost of crop cultivation is also becoming costlier. At this stage one question seems relevant. Are the farmers making profits by owning pump-irrigation? To assess this particular objective, additional benefits and costs were computed for the following three cases (to separate the effect of pump-irrigation alone and in combination with changed cropping pattern and resource use together).

Case I - from rainfed to irrigated with no change in cropping pattern and resource use.

Case II - from rainfed to irrigated with change in cropping pattern and no change in resource use.

Case III - from rainfed to irrigated with changes in cropping pattern and resource use.

Also to be able to investigate the size of landholding required by farmers to make profit with pump-irrigation, the benefit/cost ratios were computed for farm sizes from 1 to 5 hectares.

The cropping pattern in rainfed and pump-irrigated farms is based on percentage area under different crops in table 4. The area under crops in different farm sizes are presented in table 16.

The estimated benefit/cost ratios of owning pump-irrigation for different farm sizes are presented in table 17 (Case I), 18 (Case II) and 19 (Case III).

From table 19 (Case III), under the prevailing input output prices and cropping pattern, the additional benefits with pump-irrigation are more or less just equal to the additional costs for farms between 4 and 5 hectares in size. In addition, it should be noted that the benefit/cost ratios in table 18 (Case II) are higher than in Case III for all farm sizes. In Case II, the farmers with 4 to 5 hectares farm size are able to make some profit with pump-irrigation. It implies that the additional resources used by pump-owners gave additional benefits less than the additional cost. This is more evident in wheat cultivation. The possible reasons for this include, among others, the quality of seed, method of application of fertilizers and stage of plant growth at which fertilizers were applied. In fact, some farmers were questioning the quality of seeds available to them.

Conclusions:

A comparison of average levels revealed higher resource use, income, yields and cropping intensity per hectare in pump-irrigated crops than rainfed one. The yields per hectare in pump-irrigated improved paddy, local paddy and wheat were 8.33, 4.61 and 8.82 quintals higher than the rainfed. The employment of human labour in pump-irrigated improved paddy and wheat were 24.46 and 14.02 mandays per hectare higher than rainfed.

A covariance analysis was used to investigate whether the increased resource-use, yields, income and cropping intensity, revealed by comparison of average levels, is really attributable to pump irrigation. The results indicated that the yields of 6.858, 3.672 and 7.217 quintals per hectare improved paddy, local paddy and wheat are contributed by pump-irrigation. Pump-irrigation also significantly raised the cropping intensity by 34.6 percent. In addition, the pump-irrigation significantly raised the per hectare human labour employment by 16.00 and 14.00 mandays and manures and fertilizers by Rs 165.91 and 209.52 in improved paddy and wheat, respectively. The results also revealed the net revenues of Rs 412.01, 284.91 and 787.76 from per hectare improved paddy, local paddy and wheat attributable to the pump irrigation.

The impact of pump-irrigation on resource-productivity was studied with the production function analysis. The results indicate no significant difference in output elasticities of resources except for the intercept terms which are higher for pump-irrigated improved paddy, local paddy and wheat than for the rainfed. This indicates that the introduction of pump irrigation results in neutral technical change. The higher intercept term (neutral upward shift in the production function) implies higher efficiency i.e. higher output per unit of each input with pump-irrigation than without. The farmers with pump-irrigation, on average, are found to use higher levels of resources.

With the pump-irrigation contributing to increased adoption of improved paddy and wheat, increased use of farm area (higher cropping intensity) and increased crop yields, the farmers with pump-irrigation are able to produce more from the same land area per unit time.

However, with higher levels of resource-use associated with the pump-irrigation, the cost of cultivation is also increased. The rising prices of inputs including diesel further add to the increased cost. The computed benefit/cost for the period under study indicates that a farmer with 4 hectare farm size more or less breaks even by owning pump-irrigation. Under the present level of pumpset utilization,[a/] input-output prices, cropping pattern, cropping intensity, owning pump-irrigation seemed profitable to operate in at least 5 hectares farm area. The average size of landholding being 4.54 hectares, the farms with pump-irrigation, on average, seem to make some benefits and have potentiality of increasing benefits.

The benefit/cost ratio in case II (Table 18), higher for all farm sizes than in case III (Table 19), suggest less additional benefit than the cost of additional resources used. This is more evident in wheat cultivation. However, this cannot be generalized for the whole of Eastern Nepal. This study certainly presents the tentative picture and suggests for further detailed studies to assess the real situation and factors responsible for it.

The study also shows that the farmers with pump-irrigation could substantially increase their production and net revenue by adopting improved paddy and wheat in larger proportion of their farm areas. To improve the present level of adoption of improved paddy and wheat,

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a/The average hours of pumpset use per hectare improved paddy, local paddy and wheat cultivation are 32, 22 and 44 hours respectively. A five hectares farm utilizes, on average, 287 hours per year including hours rented out and used for other crops.

the more effective policy of the government would be to integrate both the programs: distribution of pumpsets and adoption of improved technology. The farmers, presently facing the problem of disposing their wheat produce at cheaper price would also be encouraged to grow wheat in larger area if the government effectively implements the wheat price-support programs.

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NEPAL

AGRICULTURAL SECTOR REVIEW

Area, Production and Yields of Major Crops

Table 1

FOODGRAINS:	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77a/	Average Annual % Rates of Growth in the 1970sb/
Paddy:												
Area	1,100	1,154	1,172	1,173	1,122	1,204	1,142	1,227	1,240	1,256	1,261	1.4
Production	2,007	2,027	2,178	2,151	2,304	2,358	2,010	2,416	2,452	2,605	2,385	1.5
Yield	1.82	1.76	1.86	1.83	2.05	1.96	1.76	1.97	1.98	2.07	1.89	0.3
Maize:												
Area	450	412	421	433	445	435	446	453	458	452	452	0.7
Production	824	735	765	795	833	730	822	814	827	748	787	.0
Yield	1.83	1.78	1.82	1.84	1.87	1.67	1.84	1.80	1.80	1.65	1.74	-0.7
Wheat:												
Area	126	192	208	226	228	247	259	274	291	329	348	6.7
Production	159	204	233	265	193	225	312	328	331	387	362	9.6
Yield	1.26	1.06	1.12	1.17	0.85	0.91	1.20	1.20	1.14	1.18	1.04	2.7

a/ Provisional

b/ Average of 1969/70, 1970/71 and 1971/72, compared to the average of 1974/75, 1975/76 and 1976/77.

Note: Area in '000 ha. Production in '000 t. Yield in t/ha.

SOURCE: Ministry of Finance, Economic Survey, various issues.

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Table 2. Distribution of different brands of pumpset in the study area and Eastern Development Region, Nepal. (As of October, 1979)

BRAND	NUMBER	
	Study area	Eastern Development Region
1. Kirloskar	2212	2493
2. Usha	265	302
3. Kubota	74	94
4. Yanmar	178	200
Total	2729	3089

Source: Agricultural Development Bank, Agricultural Inputs Corporation, Birat Trading Company, Bhajuratna Engineering Company.

Table 3. Total sample farms: districtwise

DISTRICTS	RAINFED	PUMP IRRIGATED	TOTAL
1. Jhapa	23	23	46
2. Morang	21	27	48
3. Sunsari	24	23	47
4. Saptari	24	24	48
Total	92	97	189

Table 4. Socio-economic characteristics of the sample farms

Characteristics \ Farm group	Rainfed farms	Pump-irrigated farms
1. Average size of landholding (hectares)	3.62	4.54
2. Cropping intensity[a]	1.18	1.52
3. Size of household (numbers)	8.43	9.56
4. Years of schooling of the farmers (years)	5.04	7.85
5. Age of the farmer (years)	39.64	38.83
6. Percentage area under*		
I Improved paddy	3.52	23.99
II Local paddy	81.46	66.87
III Improved wheat	11.52	35.97
7. Percentage of farmers growing		
I Improved paddy	13.04	51.54
II Local paddy	91.30	85.56
III Wheat	28.26	90.72

[a]Cropping intensity = $\frac{\text{Gross cropped area in one agricultural year}}{\text{Net cultivated area}} \times 100$

*Percentage area under crop = $\frac{\text{Area under crop}}{\text{net cultivated area}} \times 100$

Table 5. Differences in average levels of yields, input use and income per hectare between the pump irrigated and rainfed improved paddy samples.

Items	Pump irrigated	Rainfed	Differences	Significance of difference
No. of sample farms	37	25		
Yield (Quintals)	26.36 (3.928)	18.03 (3.853)	8.33	**
Plough unit (days)	37.67 (8.741)	34.35 (6.185)	3.32	n.s.
Human labour (days)	63.63 (23.619)	39.17 (14.469)	24.46	**
Manures & fertilizers (Rupees)	280.74 (299.740)	123.84 (149.465)	156.90	**
Plant Protection (Rupees)	36.05 (59.960)	30.61 (36.423)	5.44	n.s.
Total revenue (Rupees)	4233.46 (725.244)	2918.24 (655.078)	1315.22	**
Total costs (Rupees)	2128.28 (595.229)	1524.39 (281.705)	603.89	**
Net Revenue (Rupees)	2105.18 (811.988)	1393.85 (674.782)	711.13	**

Numbers in parentheses are standard deviation

* = significant on 0.05 probability level

** = significant on 0.01 probability level

Table 6. Differences in average levels of yields, input use and income per hectare between the pump irrigated and rainfed local paddy samples

Items	Pump irrigated	Rainfed	Differences	Significance of difference
No. of sample farms	56	119[a]		
Yield (Quintals)	18.13 (3.861)	13.52 (2.87)	4.61	**
Plough Unit (days)	30.48 (7.538)	30.98 (6.497)	0.5	n.s.
Human Labour (days)	54.65 (16.449)	47.84 (26.626)	6.81	*
Manures and fertilizers (Rupees)	91.68 (130.957)	50.16 (114.482)	41.52	*
Plant Protection (Rupees)	5.15 (11.252)	0.70 (6.387)	4.45	**
Total Revenue (Rupees)	2811.53 (580.064)	2151.83 (454.249)	659.70	**
Total costs (Rupees)	1718.55 (328.919)	1407.31 (300.737)	311.24	**
Net Revenue (Rupees)	1092.98 (600.292)	744.52 (466.300)	348.46	**

Numbers in parentheses are standard deviations

* = significant at 0.05 probability level

** = significant at 0.01 probability level

n.s. = not significant at 0.05 probability level

[a] Includes rainfed local paddy cultivated by farmers with pump-irrigation.

Table 7. Differences in average levels of yields, input use and income per hectare between the pump-irrigated and rainfed improved wheat samples

Items	Pump irrigated	Rainfed	Differences	Significance of Difference
No. of sample farms	98[a/]	32		
Yield (Quintals)	20.51 (5.555)	11.69 (2.471)	8.82	**
Plough Unit (days)	34.93 (15.162)	34.72 (10.210)	0.21	n.s.
Human labour (days)	35.39 (18.459)	21.37 (14.481)	14.02	**
Manures and fertilizers (Rupees)	549.80 (269.536)	305.39 (247.571)	244.41	**
Plant Protection (Rupees)	16.84 (36.947)	3.23 (11.588)	13.61	*
Total Revenue (Rupees)	3936.34 (1255.887)	2217.21 (453.070)	1719.13	**
Total costs (Rupees)	2399.06 (454.178)	1533.94 (310.601)	865.12	**
Net Revenue (Rupees)	1537.28 (1160.478)	683.26 (468.882)	854.02	**

Numbers in parentheses are standard deviations

* = significant at 0.05 probability level

** = significant at 0.01 probability level

ns = not significant at 0.05 probability level

[a/] Include pump-irrigated wheat cultivated by farmers without pump-irrigation

Table 8 . Results of covariance analysis: cropping intensity.

INDEPENDENT VARIABLES	DEPENDENT VARIABLE Cropping intensity
Intercept	1.189*** (0.083)
Pump-irrigation	0.346*** (0.053)
Size of holding	-0.018* (0.010)
Years of schooling	0.003 (0.007)
Years of schooling of farmer's father	0.002 (0.010)
Asset of the farmer	0.001 (0.001)
Jhapa district	0.072 (0.071)
Morang district	0.007 (0.075)
Sunsari district	-0.007 (0.073)
Adjusted R^2	0.24
Number of observa_ions	189

Numbers in the parentheses are standard errors.

* = Coefficients are significantly different from zero at 0.10 probability level.
** = Coefficients are significantly different from zero at 0.05 probability level.
*** = Coefficients are significantly different from zero at 0.01 probability level.

Table 9. Results of covariance analysis for yields (quintals/hectare) obtained.

Independent variables	Crop: Improved paddy	Crop: Local paddy	Crop: Improved wheat
Intercept	14.503*** (2.810)	14.852*** (1.658)	6.414*** (2.390)
Pump-irrigation	6.858*** (0.987)	3.672*** (0.507)	7.217*** (1.095)
Size of holding	0.620*** (0.204)	0.402*** (0.093)	-0.001 (0.151)
Years of schooling	0.212 (0.130)	0.092 (0.066)	0.068 (0.125)
Machine use in land preparation	-0.652 (1.022)	4.221** (1.918)	2.295 (1.901)
Years of schooling of farmer's father	-0.236 (0.146)	-0.100 (0.091)	-0.261 (0.175)
Asset of the farmer	0.001 (0.001)	0.001* (0.001)	0.001 (0.001)
Jhapa district	-2.569* (1.332)	-1.224* (0.693)	1.299 (1.258)
Morang district	3.678** (1.409)	0.528 (0.696)	4.273*** (1.232)
Sunsari district	-3.473* (1.748)	-1.874*** (0.652)	-0.162 (1.168)
Human labour (days/hectare)	-0.064** (0.031)	0.007 (0.009)	-0.001 (0.025)
Plough unit (days/hectare)	0.053 (0.060)	0.014 (0.037)	0.039 (0.044)
Fertilizers & manures (Rs per hectare)	0.005*** (0.001)	-0.001 (0.001)	0.006*** (0.001)
Plant protection (Rs per hectare)	0.005 (0.009)	0.050* (0.027)	-0.003 (0.013)
Adjusted R^2	0.78	0.50	0.51
Number of observations	62	175	130

Numbers in the parentheses are standard errors

*Coefficients are significantly different from zero at 0.10 probability level

**Coefficients are significantly different from zero at 0.05 probability level

***Coefficients are significantly different from zero at 0.01 probability level

Table 10:
Results of covariance analysis for use of human labour (days/hectare)

Independent variables	Crop	
	Improved paddy	Improved wheat
Intercept	36.430*** (10.996)	24.300*** (5.321)
Pump-irrigation	16.239*** (5.105)	14.136*** (3.689)
Size of holding	3.135*** (1.100)	-0.058 (0.569)
Years of schooling	0.282 (0.754)	-0.521 (0.462)
Machine use in land preparation	-1.664 (5.989)	-5.452 (4.942)
Years of schooling of farmer's father	-0.450 (0.803)	0.513 (0.609)
Asset of the farmer	-0.001 (0.001)	0.001 (0.001)
Jhapa district	-22.420*** (6.912)	-8.087 (4.568)
Morang district	3.577 (8.259)	2.832 (4.298)
Sunsari district	6.450 (10.185)	3.876 (4.243)
Adjusted R^2	0.53	0.19
Residual sum of squares	15786.600	35738.876
Number of observations	62	130

[a]Numbers in the parentheses are standard errors.

*Coefficients are significantly different from zero at 0.10 probability level
**Coefficients are significantly different from zero at 0.05 probability level
***Coefficients are significantly different from zero at 0.01 probability level

Table 11

Results of Covariance Analysis for use of manures and fertilizers (Rs/ha)

Independent variables	Crop		
	Improved paddy	Local paddy	Improved wheat
Intercept	85.188 (109.993)[a/]	79.097*** (20.581)	345.061*** (70.061)
Pump-irrigation	165.911*** (70.886)	14.220 (19.005)	209.525*** (56.788)
Size of holding	12.861 (15.160)	-5.535* (3.379)	-6.092 (9.049)
Years of schooling	4.231 (10.017)	3.512 (2.539)	2.340 (7.368)
Machine use in land preparation	-52.351 (84.089)	140.541** (63.545)	236.889*** (74.644)
Years of schooling of farmer's father	4.849 (11.478)	-4.396 (3.426)	12.828 (9.453)
Asset of the farmer	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)
Adjusted R^2	0.13	0.08	0.24
Number of observations	62	167	124

[a/] Numbers in the parentheses are standard errors.

*Coefficients are significantly different from zero at 0.10 probability level

**Coefficients are significantly different from zero at 0.05 probability level

***Coefficients are significantly different from zero at 0.01 probability level

Table 12:
Results of Covariance Analysis for net revenue (Rs/ha)

Independent variables	Crop		
	Improved paddy	Local paddy	Improved wheat
Intercept	546.019 (397.652)[a]	993.467*** (128.062)	231.381 (279.872)
Pump irrigation	412.011** (184.634)	284.914*** (87.109)	787.766*** (194.045)
Size of holding	60.518 (39.809)	-34.267** (15.753)	9.682 (29.940)
Years of schooling	43.568 (27.282)	6.239 (11.569)	10.586 (24.318)
Machine use in land preparation	248.390 (216.588)	563.069* (297.904)	824.764*** (259.960)
Years of schooling of farmer's father	-56.913* (29.040)	-15.500 (16.038)	-44.367 (32.034)
Asset of the farmer	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
Jhapa district	210.155 (249.958)	-169.315 (110.885)	191.822 (240.272)
Morang district	682.497** (298.675)	-7.372 (117.191)	950.175*** (226.069)
Sunsari district	-504.818 (368.322)	-195.555* (109.951)	-172.848 (223.193)
Adjusted R^2	0.51	0.18	0.36
Number of observations	62	175	130

[a]Numbers in the parentheses are standard errors.

*Coefficients are significantly different from zero at 0.10 probability level

**Coefficients are significantly different from zero at 0.05 probability level

***Coefficients are significantly different from zero at 0.01 probability level

Table 13. Estimated Cobb-Douglas production functions for improved paddy samples[a/]

Samples	No. of observations	Intercept	Coefficient for pump use dummy	Human labour (days)	Land (has)	Fertilizers & manures (Rupees)	Plough unit (days)	Schooling of the farmer (years)	Dummy variables for: Morang District	Sunsari District	Saptari District	$\bar{R}^2$ [b/]	Returns to scale	Residual sum of squares
I Rainfed	25	2.981** (0.948)[c/]	-	-0.163 (0.174)	1.141** (0.263)	0.006 (0.018)	0.149 (0.277)	-0.246 (0.164)	0.338 (0.164)	-0.154 (0.133)	0.195	0.96	0.887	0.620
II Pump-irrigated	37	2.946** (0.145)	-	-0.066 (0.035)	1.056** (0.033)	0.023** (0.006)	0.001 (0.010)	0.040 (0.023)	0.151* (0.049)	-0.243** (0.059)	0.044 (0.050)	0.99	1.054	0.256
III Pooled	62	2.250** (0.242)	-	0.102 (0.056)	1.013** (0.067)	0.007 (0.010)	-0.005 (0.023)	-0.004 (0.047)	0.113 (0.083)	-0.113 (0.099)	-0.123 (0.084)	0.96	1.113	2.388
IV Pooled with pump use dummy	62	2.496** (0.174)	0.346** (0.046)	-0.036 (0.044)	1.078** (0.048)	0.013 (0.007)	0.009 (0.016)	0.011 (0.033)	0.157* (0.059)	-0.142* (0.077)	0.075 (0.059)	0.98	1.075	1.163

[a/] Dependent variable is output of improved paddy in physical unit (quintals)
Cobb-Douglas production functions estimated by ordinary least squares

[b/] Indicates that on the "f" test, the statistic for the regression turned out to be significant at 0.01 probability level

[c/] Numbers in the parentheses are standard errors

*Coefficients are significantly different from zero at 0.05 probability level

**Coefficients are significantly different from zero at 0.01 probability level

Table 14. Estimated Cobb-Douglas production functions for local paddy samples[a/]

	Samples	No. of observation	Intercept	Coefficient for pump use dummy	Human labour (days)	Land (has)	Fertilizers & manures (Rupees)	Plough unit (days)	Schooling of the farmer (years)	dummy variables for: Morang district	Sunsari district	Suptari district	$\bar{R}^2$ [b/]	Returns to scale	Residual sum of squares
I	Rainfed	118	2.283** (0.274)[c/]	-	0.002 (0.041)	0.927** (0.077)	-0.008 (0.012)	0.019 (0.062)	0.038 (0.020)	0.122* (0.062)	-0.029 (0.053)	0.092 (0.056)	0.93	0.978	3.605
II	Pump-irrigated	56	2.487** (0.525)	-	0.008 (0.123)	0.974** (0.130)	-0.008 (0.018)	-0.016 (0.093)	0.014 (0.040)	0.245 (0.128)	-0.039 (0.139)	0.227 (0.151)	0.91	0.956	1.956
III	Pooled	174	2.231** (0.258)	-	0.030 (0.044)	0.931** (0.071)	0.001 (0.011)	-0.046 (0.057)	0.056** (0.020)	0.209** (0.059)	-0.030 (0.055)	0.159** 0.059	0.90	0.972	7.711
IV	Pooled with pump-use dummy	174	2.339** (0.224)	0.244** (0.032)	0.003 (0.038)	0.951** (0.061)	-0.008 (0.009)	-0.036 (0.049)	0.026 (0.018)	0.150** (0.052)	-0.047 (0.048)	0.128* (0.051)	0.92	0.936	5.762

[a/] Dependent variable is output of improved paddy in physical unit (quintals)
Cobb-Douglas Production Functions estimated by ordinary least squares

[b/] Indicates that on the f test, the statistic for the regression turned out to be significant at 0.01 probability level.

[c/] Number in parentheses are standard errors.

*Coefficients are significantly different from zero at 0.05 probability level

**Coefficients are significantly different from zero at 0.01 probability level

Table 15. Estimated Cobb-Douglas production functions for improved wheat samples[a/]

Farm group	No. of obser-vations	Inter-cept	Coeffi-cient for pump use dummy	Human labour (days)	Land (has)	Fertili-zers & manures (Rupees)	Plough unit (days)	Schooling of the farmer (years)	Dummy variables for			$\bar{R}^2$ [b/]	Returns to scale	Residual sum of squares
									Morang district	Sunsari district	Saptari district			
I Rainfed	23	2.440** (0.657)[c/]	-	0.070 (0.050)	1.087** (0.178)	-0.089 (0.076)	0.012 (0.146)	0.020 (0.049)	-0.018 (0.160)	-0.245 (0.131)	0.046 (0.122)	0.97	1.100	0.317
II Pump-irrigated	88	1.871** (0.463)	-	-0.027 (0.052)	1.032** (0.109)	0.175** (0.059)	-0.077 (0.073)	-0.018 (0.034)	0.174* (0.090)	-0.060 (0.090)	-0.040 (0.082)	0.93	1.085	4.258
III Pooled	111	1.442** (0.420)	-	0.113** (0.040)	0.945** (0.104)	0.133** (0.055)	-0.036 (0.074)	0.019 (0.032)	0.096 (0.090)	-0.185* (0.086)	-0.095 (0.079)	0.93	1.174	6.917
IV Pooled with pump use dummy	111	1.866** (0.376)	0.369** (0.065)	0.021 (0.038)	1.064** (0.093)	0.096* (0.048)	-0.089 (0.066)	0.008 (0.028)	0.115 (0.079)	-0.138 (0.076)	-0.064 (0.069)	0.95	1.100	5.274

a/ Dependent variable is output of improved paddy in physical unit (quintals).
Cobb-Douglas Production Functions estimated by ordinary least squares.

b/ Indicates that on the f test, the statistic for the regression turned out to be significant at 0.01 probability level.

c/ Number in the parentheses are standard errors.

*Coefficients are significantly different from zero at 0.05 probability level

**Coefficients are significantly different from zero at 0.01 probability level.

Table 16. Area under different crops.

CROP	FARM SIZE (hectares)				
	1	2	3	4	5
Rainfed:					
Improved paddy	0.0352	0.0704	0.1056	0.1408	0.1760
Traditional paddy	0.8146	1.6292	2.4438	3.2584	4.0730
Improved wheat	0.1152	0.2304	0.3456	0.4608	0.5760
Others (unspec.)	0.2150	0.4300	0.6450	0.8600	1.0750
Irrigated:					
Improved paddy	0.2399	0.4798	0.7197	0.9596	1.1995
Traditional pa-dy	0.6687	1.3374	2.0061	2.6748	3.3435
Improved wheat	0.3597	0.7194	1.0791	1.4388	1.7985
Others (unspec.)	0.2517	0.5034	0.7551	1.0068	1.2585

Table 17. Estimation of benefit/cost ratios of owning pump-irrigation for different farm sizes.

CASE I

ITEMS	FARM SIZE (hectares) 1	2	3	4	5
A. Revenue					
(i) Paddy and wheat[a/]	477	902	1322	1738	2150
(ii) Renting out and pump-use in other crops[b/]	703	772	841	911	980
Total Revenue	1180	1674	2163	2649	3130
B. Costs					
(i) Fixed costs[c/]	2806	2806	2806	2806	2806
(ii) Variable costs[d/]					
a. Paddy and wheat	113	225	338	451	564
b. Renting out & pump-use in other crops	303	331	358	385	413
Total Costs	3222	3362	3502	3642	3783
Benefit/cost ratio	0.36	0.50	0.62	0.73	0.83

a/Production is estimated using regression IV in tables 13, 14 and 15. Input levels per hectare are based on tables 5, 6 and 7. Average price per quintal improved paddy, local paddy and wheat are Rs 151.67, Rs 145.04 and 184.04, respectively.

b/Average renting out hours are 59 and use in other crops estimated at 30 hours per hectare. The rental rate is Rs 10.74 per hour.

c/Comprises Rs 1988 for 4" pumpset, Rs 568 for shallow tubewell and Rs 250 repair and maintenance costs. Average price of pumpset and tubewell are Rs 7000, and Rs 2000 respectively. These are purchased at 14% interest per annum payable in equal installments over five years.

d/Variable costs based on tables 5, 6 and 7. Pumpset use 1.1 litre diesel per hour. Diesel and mobil cost per hour is Rs 4.25.

Table 18. Estimation of benefit/cost ratios of owning pump-irrigation for different farm sizes.

CASE II

ITEMS	FARM SIZE (hectares)				
	1	2	3	4	5
A. Revenue					
(i) Paddy and wheat[a/]	1262	2619	4048	5506	6932
(ii) Renting out and pump-use in other crops[b/]	715	796	877	958	1039
Total Revenue	1977	3415	4925	6464	7971
B. Costs					
(i) Fixed costs[c/]	2806	2806	2806	2806	2806
(ii) Variable costs[d/]					
a. Paddy and wheat	660	1321	1981	2642	3302
b. Renting out and pump-use in other crops	283	315	347	379	411
Total Costs	3749	4442	5134	5827	6519
Benefit/cost ratio	0.53	0.77	0.96	1.11	1.22

Footnotes a, b, c and d as in Table 17.

Table 19. Estimation of benefit/cost ratios of owning pump-irrigation for different farm sizes.

CASE III

ITEMS	FARM SIZE (hectares) 1	2	3	4	5
A. Revenue					
(i) Paddy and wheat[a/]	1317	2738	4234	5761	7257
(ii) Renting out and pump-use in other crops[b/]	715	796	877	958	1039
Total Revenue	2032	3534	5111	6719	8296
B. Costs					
(i) Fixed costs[c/]	2806	2806	2806	2806	2806
(ii) Variable costs[d/]					
a. Paddy and wheat	914	1828	2743	3657	4571
b. Renting out and pump-use in other crops	283	315	347	379	411
Total costs	4003	4949	5896	6842	7788
Benefit/cost ratio	0.51	0.71	0.87	0.98	1.06

Footnotes a, b, c and d as in Table 17.

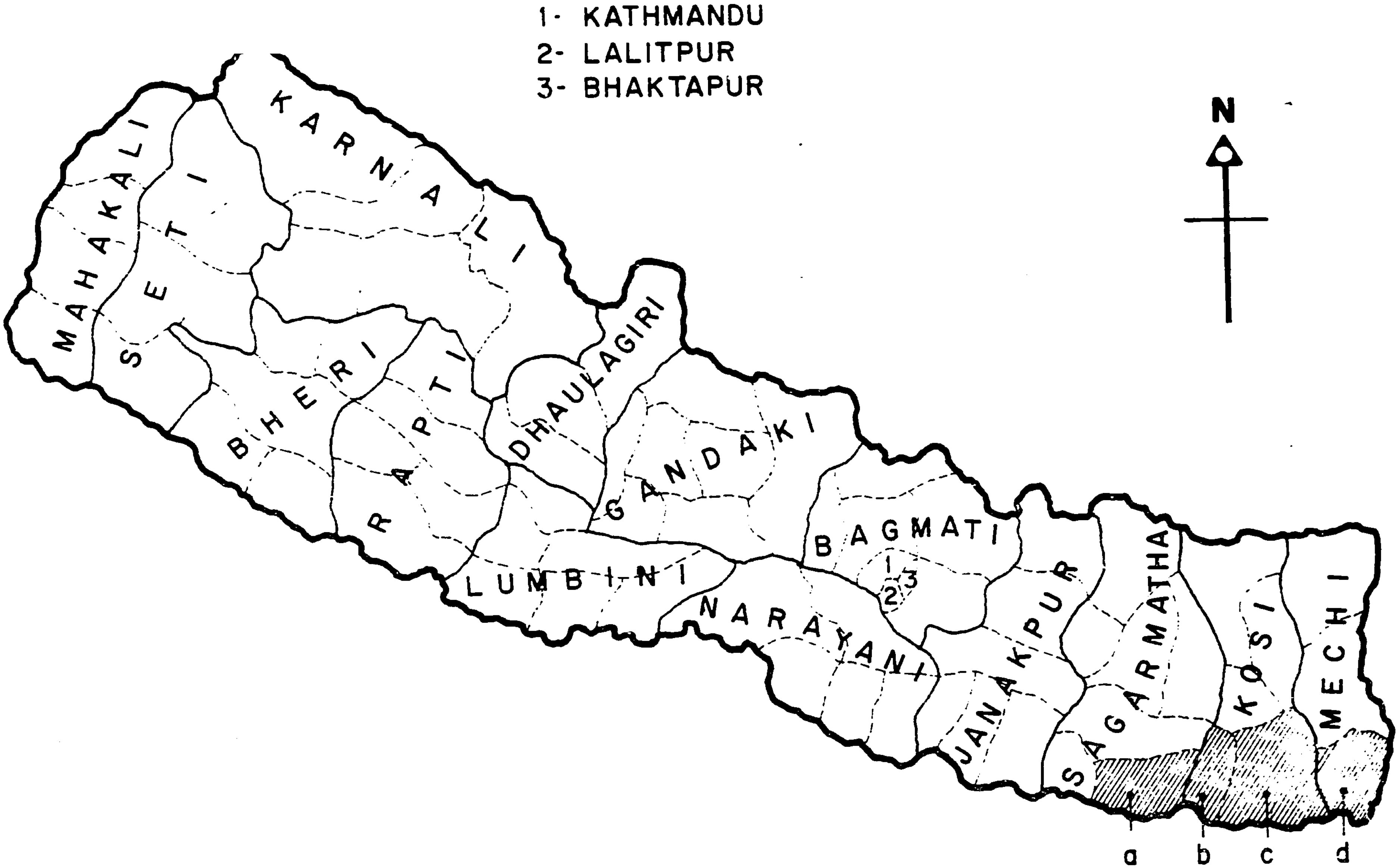

Fig. 1 Map of Nepal showing study area (a. Saptari, b. Sunsari, c. Morang, d. Jhapa.)

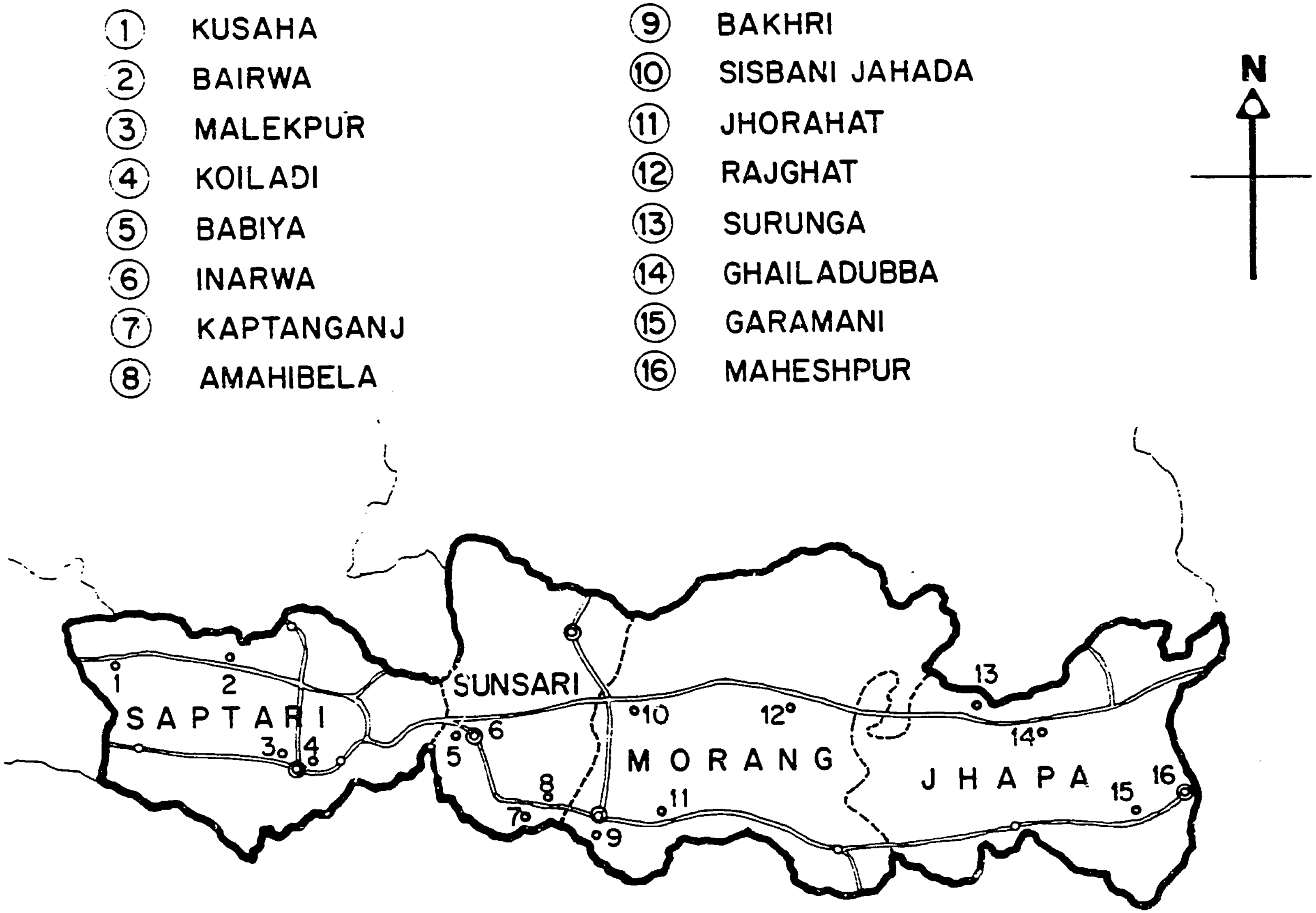

Fig. 2 Map of study area showing sample village panchayats.

CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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