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THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

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THE ECONOMICS OF PUMP IRRIGATION IN EASTERN NEPAL

By

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ABSTRACT

The impact of pump-irrigation on cropping intensity, resource use and crop yields is investigated, and the profitability of pump irrigation ownership assessed. Dat were collected from 189 farms in the terai of the Eastern Development Region of Nepal. Results suggest that pump-irrigation has promoted higher cropping intensity, higher levels of resource-use and higher crop yields. More than 79 percent of the increase in improved paddy, local paddy and wheat yields is attributable to irrigation. Similarly for 34 percent increase in cropping intensity. Pump-irrigation also increased employment through increase in labor input per crop and increase in cropping intensity. Net farm income for a 4.54 hectare pump-irrigated farm was estimated at Rs6532 as compared to Rs4003 for a similar sized rainfed farm. The results of the study support the current expansion program for pump-irrigation in the terai of Eastern Nepal.

INTRODUCTION

Agriculture is the most important sector in the economic development of Nepal. This sector alone contributes around two-thirds of the gross domestic product and provides eighty percent of the total export earnings. Moreover, the agriculture sector also employs 94 percent of the total labour force. The low productivity in agriculture, as well as underemployment[1] of the labour force, has contributed to an average per capita income of only US$79 in this sector against the national average of US$120 (Upadhyay, 1981). In fact FAO has reported that nearly two-thirds of the rural population live under absolute poverty. With few growth options available, and in view of the very heavy dependence of population on agriculture, it is obvious that economic development depends, to a great extent, on the growth of agriculture. His Majesty's Government of Nepal has, therefore, been allocating a considerable proportion of the total capital outlay in each of the Six Five Year Plans to the development of agriculture, including the expansion of irrigation facilities.

In Nepal, effective development of irrigation is a prerequisite for increased agricultural production. It facilitates planting of more than one crop on the same piece of land in a year, sometimes even three, thereby allowing the greater use of resources such as land and labour. However, as of 1979-80, only 13.6 percent of the cultivated area was provided with irrigation. In addition to the government owned irrigation projects, privately owned small irrigation projects, often using pump-irrigation[2] are helping expand the irrigation facilities. Pump irrigation is becoming increasingly popular in most of the terai[3] districts of Nepal. These pumpsets are mostly of five horse power capacity and lift water from ground (shallow tubewell, dugwell) and surface water sources with an average command area of 5 hectares. While the large irrigation projects require huge investment and longer gestation period, pump irrigation is an easy and cheap way to develop the farmers' own irrigation system within a very short span of time. Since pump-irrigation is within the control of the individual farmers, they provide irrigation services whenever needed and without any outside constraints. On account of these reasons, perhaps, the National Development Plan also emphasizes the urgent need for shallow well schemes at the farms to provide the irrigation facilities needed for effective growth in agriculture (Asian Development Bank, 1980).

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[1] Remaining idle sixty percent of the total potential work days.

[2] Use of diesel operated pumpsets for irrigation.

[3] The plains in the southern region of the country.

The objective of the government in expanding pump-irrigation is to raise the adoption of seed-fertilizer technology and cropping intensity thereby increasing the production per unit of cultivated land, creating employment opportunities to the increased labour force and also to increase the net income to the pumpset owner farmers. In this paper the production, employment and income effects of the pump-irrigation in the Eastern Nepal terai are investigated.

HISTORY OF PUMP-IRRIGATION IN NEPAL

Pump-irrigation is not new to Nepalese agriculture, having been practiced since the early sixties. The early adopters purchased pumpsets from nearby Indian border towns. In 1964, the privately owned Kalpana Trading Company became the Nepalese distributor of India made Kirloskar diesel engine pumpsets. In the succeeding years, farmers continued buying pumpsets in both the local as well as Indian border markets and pump-irrigation got a major boost in 1969 when the former Land Reform Saving Corporation (LRSC) imported 1000 units from Japan. From its inception in 1967, the Agricultural Development Bank (the former LRSC was merged with the bank in 1973) started financing the agricultural sector. From 1975, two other commercial banks namely Rastriya Baniya Bank and Nepal Bank[4] also provided finance for agricultural enterprises including pumpsets. With the increased awareness among the farmers about the usefulness of pump-irrigation, the demand for pumpsets rose rapidly. To meet this, the Agricultural Development Bank imported 1160 in 1976 and 1400 in 1978 as part of the second and third Agricultural Credit Projects funded by the Asian Development Bank. In addition, the Agricultural Inputs Corporation also imported 898 pumpsets in 1976 in addition to the regular imports by private dealers. With all of these imports, the number of pumpsets in the country increased to more than 9200 in 1979. Assuming, on average, 5 hectares of command area per pumpset, the present pumpset population irrigates 46000 hectares which is about 3 percent of the total cultivated area in the terai.

Because of ever rising demand most of the integrated agricultural projects also have provision for expansion of pump-irrigation. Consequently the number of pumpsets targetted to be distributed in the Sixth Five Year Plan Period (1980/81-1984/85) alone reached more than 5900.

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[4] In 1975, Nepal Rastra Bank, the central bank of Nepal directed the commercial banks to finance agricultural sector at least 7 percent of their total deposits.

OBJECTIVES OF THE STUDY

The main objective of the study was to document the production, employment and income effects of pump-irrigation. Additional objectives were:

1) to document the land utilization pattern and adoption of high yielding varieties (improved) of crops in rainfed and pump-irrigated farms.

2) to study the impact of pump-irrigation on inputs use including the employment of human labour, crop yields and crop income per hectare.

3) to assess the profitability to farmers of owning pump-irrigation.

RESEARCH DESIGN

Study Area and Sampling Design:

Jhapa, Morang, Sunsari and Saptari, the four terai districts in the Eastern Development Region of Nepal (Figure 1) were purposively selected for the study since the farmers in these districts were early adopters of the new technology including pump-irrigation. In each district, four village panchayats with the maximum number of farmers owning pumpsets were identified (Figure 2). In each of these village panchayats seven with and seven without pumpsets were randomly selected from each of the two separate lists of specified farmers. Thus, the primary cross-section data on socio-economic characteristics, cropping pattern, pumpset type and use, inputs use and crop production, etc. for the period November 1978 to October 1979 were collected through personal interviews from a total of 224 farmers. However, as a result of constraints on time available, and the lack of data from some respondents, the final sample was 189 farmers. The distribution of these by district is shown in Table 1.

RESULTS

Socio-economic Characteristics

The two categories of farmers differed from each other in some of the socio-economic characteristics (Table 2). The pumpset owner farmers had larger size of landholding, household size and were more educated than their slightly older counterparts without pumpsets (rainfed farms).

Impact of Pump-irrigation on Land Utilization:

Agricultural production is increased either through more intensive use of land (higher cropping intensity) or through the increased crop yields or by both. To study the impact of pump-irrigation on the utilization of land, per farm cropping pattern and cropping intensity are presented in Table 3, for rainfed and pump-irrigated farms. Paddy and wheat were the predominant crops as the area under these crops was more than 84 percent in both types of farms. As is clear from the table, a larger percentage of the cultivated area was allocated to high yielding improved paddy and wheat in the pump-irrigated farms than in the rainfed ones. Thus, pump-irrigation might facilitate the adoption of improved technology. Because of assured irrigation, the farmers with pump-irrigation were able to cultivate a larger area of wheat in winter season. This was the main reason for the higher cropping intensity on pump-irrigated farms, it being 29 percent higher than the 118 percent cropping intensity of the rainfed farms.

Impact of Pump-Irrigation on Input Use and Crop Yields:

To assess the impact of pump-irrigation on the inputs used and yields obtained, per hectare input levels and yields of three important crops namely: improved paddy, local paddy and wheat are presented in Table 4 for rainfed and pump-irrigated farms. The use of all the input-manures and fertilizers, plant protection and human labour were higher in the pump-irrigated than the rainfed farms. The human labour input measured in mandays of eight working hours included all human labour used for all operations other than harvesting and threshing. The impact of pump-irrigation on total employment of human labour would be even greater if the human labour required for these excluded operations was also included because of increased crop yields. Furthermore, the figures reported in Table 4 are per hectare of cropped area. Due to higher cropping intensity on pump-irrigated farms, human labour and plough unit use per hectare of cultivated land were even higher. In rainfed farms, agricultural production depends upon the monsoon, so farmers try to reduce risk by using inputs at lower levels than on pump-irrigated farms. On pump-irrigated farms, because of assured irrigation, crop failure was reduced and use of inputs including fertilizer was increased. As a result the yields of all three crops were also higher on pump-irrigated than on rainfed farms (Table 4).

Impact of Pump-Irrigation on Per Hectare Costs and Revenues of Cultivation of Different Crops:

The per hectare total revenue, total costs and net revenue of improved paddy, local paddy and wheat cultivation are presented in Table 5. Because of the greater quantity of inputs used per hectare, and pump-irrigation, both the total costs and total revenue per hectare for all three crops were higher in pump-irrigated farms. However, the increase in total revenue was higher than the increase in total cost, resulting in higher net revenues per hectare under pump-irrigated conditions. The cultivation of improved paddy, local paddy and wheat per hectare yielded a net revenue of Rs 2105, Rs 1093, and Rs 1537, under pump-irrigated condition compared to Rs 1394, Rs 745 and Rs 683, respectively, under rainfed conditions.

In other words, crops grown under pump-irrigated conditions resulted in a net revenue per hectare which was 51% higher for improved paddy, 47% for local paddy and 125% for wheat when compared to rainfed conditions.

However, the higher levels of inputs used, including the employment of human labour and the higher cropping intensity, on pump-irrigated farms need not necessarily, have resulted from the pump-irrigation. The observed differences between the pump-irrigated and rainfed farms might be associated with variables, other than pump-irrigation, which were not controlled in the survey. Possible factors are size of landholding, 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 effects between pump-irrigation and mechanization. A covariance analysis was used in an attempt to isolate the effects of these other variables, and thus to determine the separate impact of pump irrigation.

Covariance Analysis

A covariance model, based on the following relation, was estimated for those dependent variables[5] whose observed differences between rainfed and pump-irrigated farms were found to be statistically significant, i.e. cropping intensity, the use of human labour, manures and fertilizers, crop yields and net revenue per hectare.

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[5] Plant protection was dropped because of its negligible share in the total cost of cultivation per hectare.

$$Y_i = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 + a_6x_6 + a_7x_7 + a_8x_8 + a_9x_9 + a_{10}x_{10} + E$$

where:

Y_i = is the level of ith dependent variable.

Y_1 = is cropping intensity of sample farms.

Y_2 = is human labour in days per hectare.

Y_3 = is manures and fertilizers in rupees per hectare.

Y_4 = is crop yield in kilograms per hectare.

Y_5 = is net revenue in rupees per hectare.

x_i = is the level of ith independent variable

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 landholding in hectares.

x_3 = is education of the farmer in number of years of schooling.

x_4 = is education of the farmer's father in number of years of schooling.

x_5 = is mechanization dummy and takes a value of one if a tractor is used in land preparation of the crop and zero otherwise.

x_6 = is the value of the farmer's assets in rupees.

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.

The reference district was Saptari.

x_{10} = is the interaction term between pump-irrigation dummy (x_1) and mechanization dummy (x_5).

a_0 = is the intercept (constant) term.

a_i to a_{10} are regression coefficients of the respective independent variables.

E = is the random error.

In the model explaining crop yield the following additional independent variables were also included: human labour (mandays/ha), plough units (days/ha), manures and fertilizers (Rs/ha) and plant protection (Rs/ha).

In the model explaining cropping intensity, X_5 (the mechanization dummy) and X_{10} (interaction term between mechanization and pump-irrigation) were not included because only very few farmers used a tractor and that also only on a limited proportion of their land. Similarly, the X_1 (pump irrigation dymmy) took a value of one for pump-irrigated farms and zero for rainfed.

The covariance models were estimated and the coefficient of pump-irrigation dummy in each of five models are presented in Table 5. The coefficients are all significant and positive, which indicates that pump-irrigation increases cropping intensity, input use, crop yields and net revenue in all the crops. The detailed results of estimating the various models are reported in Khoju (1980).

Pump-irrigated improved paddy, local paddy and wheat respectively yielded 686, 367 and 722 kg per hectare higher than the rainfed ones. In other words, of the observed differences in the yields per hectare of improved paddy, local paddy and wheat betwen the pumm-irrigated and rainfed farms, 82, 80 and 82 percent can be attributed to pump-irrigati while the rest is due to other factors. Similarly, the employment of human labour in pump-irrigated improved paddy and wheat was respectively 16 and 14 mandays per hectare more than under rainfed conditions. Pump-irrigation also resulted in an increase in net revenue of Rs 412, Rs 285 and Rs788 per hectare of improved paddy, local paddy and wheat respectively. In addition to increasing cropping intensity by 34.6 percent, pump-irrigation also contributed to the use of an additional Rs166 and Rs 210 worth of manures and fertilizers on improved paddy and wheat respectively.

Pump-irrigation seems to be contributing to increased production. It facilitates the adoption of improved paddy and wheat as well as contributing to the increase in cropping intensity. However, with increasing prices of diesel and other inputs, the cost of cultivation is also going up. At this stage, one question seems to be important, that is are farmers making profits by owning pump-irrigation? To assess this particular objective, net farm incomes based on the following assumptions were computed for rainfed and pump-irrigated farms.

Assumptions:

1. The average size of pump-irrigated farms was 4.54 hectares, the same size was assumed for the calculations for rainfed condition.

2. The respective cropping pattern and cropping intensity of rainfed and pump-irrigated farms were used.

3. Per hectare cultivation costs and revenues of rainfed and pump-irrigated improved paddy, local paddy and wheat were based on Table 5, while costs and revenues of other crops were computed from survey data reported in Khoju (1980).

4. Average annual hours of renting out the pumpset was 59. The rental rate was Rs 10.74 per hour where as the variable cost per hour of pumpset operation was Rs. 4.25.

5. The average cost of pumpset and tubewell were Rs 7000 and Rs 2000 respectively. These were purchased at 14 percent interest per annum payable in equal installments over five years.

6. Repair and maintenance costs of pumpset and tubewell were estimated at Rs 250 per year.

Based on the above assumptions the benefits and costs were computed for rainfed and pump-irrigated farms and are presented in Tables 7 and 8.

The tables reveal higher total costs and total revenue in pump-irrigated than rainfed farms. However, the net farm income realized from pump-irrigated farms was also higher than the one from rainfed farms. Pump-irrigated farms had a net farm income of Rs 6532 which was 163 percent higher than the Rs 4003 realized under rainfed conditions from the same size of landholding. This indicated that the farmers on average, were making profits with pump irrigation.

CONCLUSIONS

The results of covariance analysis show that most of the observed differences in cropping intensity, input use, crop yields and net revenue between the rainfed and pump-irrigated farms could be attributed to the pump-irrigation. With pump irrigation contributing to an increased adoption of improved varieties of paddy and wheat, to higher cropping intensity and to increased crop yields, farmers with pump-irrigation were able to produce more from the same land area per unit of time thereby obtaining higher net farm incomes.

Furthermore, pump-irrigation created increased employment in two ways, first by increasing use of human labour per unit of cultivated land and second by employing labor in winter crops, the cultivation of which was made possible with assured irrigation.

The results of the study justify the present program of expanding pump-irrigation. However, improved results may be expected if the following two shortcomings in the present pump-irrigation distribution program are overcome. First, the funding agencies require at least three hectares of land as the project area for investment in pump-irrigation. This discourages farmers with less than three hectares from applying for pump-irrigation loans. Second, those farmers with more than or equal to three hectares of land are being given the same size of pumpset (generally 5 HP capacity) irrespective of actual crop water requirements. In addition, the government should implement alternative policies to benefit the farmers with less than three hectares. These constitute the majority of the population. One possible strategy for them might be to distribute smaller pumpsets (below 5 HP capacity).

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Table 1. Total Sample Farms: Districtwise.

District	TYPE OF FARM		
	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 2. Socio-economic characteristics of the sample farms

Characteristics	FARM GROUP	
	Rainfed farms	Pump-irrigated farms
1. Average size of landholding (ha)	3.62	4.54
2. Size of household (numbers)	8.43	9.56
3. Years of schooling of the farmers (years)	5.04	7.85
4. Age of the farmer (years)	39.64	38.83

Table 3. Cropping pattern and cropping intensity of rainfed and pump-irrigated sample farms.

Crops	Rainfed (n = 92)		Pump-irrigated (n = 97)	
	Area in hectares	Percentage of total cultivated area	Area in hectares	Percentage of total cultivated area
Improved paddy	0.13	3.52	1.09	23.99
Local paddy	2.95	81.46	3.04	66.87
Wheat	0.41	11.52	1.63	35.97
Other crops [a]	0.78	21.50	1.14	25.17
Total	4.27		6.90	
Cropping intensity [b]		118.00		152.00

[a] Includes jute, maize, mustrard, pulses and ragi.

[b] Cropping Intensity = $\frac{\text{Total cropped area in one agricultural year}}{\text{Total cultivated area}} \times 100$

n = Number of sample farms

Table 4. Input use and crop yields on rainfed and pump-irrigated crops.

Items	Improved paddy		Local paddy		Wheat	
	Rainfed N = 25	Pump-irrigated N = 37	Rainfed N = 119 a/	Pump-irrigated N = 56	Rainfed N - 32	Pump-irrigated N = 98 b/
1. Manures and fertilizers (Rs)	124 (149)	281 (300)	50 (114)	92 (131)	305 (248)	550 (270)
2. Plant protection (Rs)	31 (36)	36 (60)	1 (6)	5 (11)	3 (12)	17 (37)
3. Plough Unit (days) c/	34 (6)	38 (9)	31 (6)	30 (8)	35 (10)	35 (15)
4. Human labour (days) d/	39 (14)	64 (24)	48 (27)	55 (16)	21 (14)	25 (18)
5. Crop yield (kg)	1803 (385)	2636 (393)	1352 (287)	813 (386)	1169 (247)	2051 (555)

N = Number of sample farms.

Figures in parentheses are standard deviations.

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

b/ Including wheat cultivated in rainfed farms by renting pump-irrigation.

c/ Plough unit (consisting of one man and a pair of bullocks) measured in days of eight working hours.

d/ Human labour measured in mandays of eight working hours.

Table 5. Per hectare revenues and costs of rainfed and pump-irrigated crops

Items	Improved paddy		Local paddy		Wheat	
	Rainfed (n=25)	Pump-irrigated (n=37)	Rainfed (n=119)	Pump-irrigated (n=56)	Rainfed (n=32)	Pump-irrigated (n=98)
Total Revenue (Rs)	2918 (655)	4233 (725)	2152 (454)	2812 (580)	2217 (453)	3936 (1256)
Total costs a/ (Rs)	1524 (282)	2128 (595)	1407 (301)	1719 (329)	1534 (311)	2399 (454)
Net Revenue (Rs)	1394 (675)	2105 (812)	745 (466)	1093 (600)	683 (469)	1537 (1160)

Figures in parentheses are standard deviations.

a/ Excluding the fixed costs of pump-irrigation.

Table 6. Results of covariance analysis.

Dependent variables	Coefficient of pump-irrigation dummy
1. Cropping intensity (%)	34.6* (5.3)
2. Use of human labour (days/ha)[a/]	
a) Improved paddy	16.2* (5.1)
b) Wheat	14.1* (3.6)
3. Manures and fertilizers use (Rs/ha)	
a) Improved paddy	165.9* (70.8)
b) Local paddy	14.2 n.s (19.0)
c) Wheat	209.5* (56.7)
4. Crop yields (kg/ha)	
a) Improved paddy	685.8* (98.7)
b) Local paddy	367.2* (50.7)
c) Wheat	721.7* (109.5)
5. Net revenue (Rs/ha)	
a) Improved paddy	412.0** (184.6)
b) Local paddy	284.9* (87.1)
c) Wheat	787.7* (194.0)

* Significant at 1 percent level.

** Significant at 5 percent level.

Numbers in parentheses are standard errors.

n. s. Not significant at 5 percent level.

a/ For local paddy preharvest labour is not significantly different between rainfed and pump-irrigated condition.

Table 7. Net farm income from 4.54 hectares under rainfed condition.

Cropping pattern	Area in ha,	Cost of cultivation/ha	Total cost of cultivation	Revenue per ha.	Total Revenue
a. Improved paddy	0.16	1524	244	2918	467
b. Local paddy	3.70	1407	5206	2152	7962
c. Wheat	0.52	1534	798	2217	1153
d. Jute	0.38	2829	1075	3616	1374
e. Maize	0.20	1041	208	1580	316
f. Mustard	0.17	878	149	1715	292
g. Pulses	0.19	221	42	797	151
h. Ragi	0.04	768	31	1033	41
Total	5.36		7753		11756

Cropping intensity = 118 percent

Net Farm Income = Total revenue - Total costs

= 11756 - 7753

= 4003

Table 8. Net farm income from 4.54 hectares under pump-irrigated condition.

Cropping pattern	Area in ha.	Cost of cultivation/ha	Total cost of cultivation	Revenue per ha	Total Revenue
a. Improved paddy	1.09	2128	2320	4233	4614
b. Local paddy	3.04	1719	5226	2812	8548
c. Wheat	1.63	2399	3910	3936	6416
d. Jute	0.52	2829	1471	3616	1880
e. Maize	0.15	1176	176	1950	293
f. Mustard	0.20	878	176	1715	343
g. Pulses	0.22	221	49	797	175
h. Ragi	0.05	768	38	1033	52
Total	6.90		13366		2321
Cropping intensity = 152 percent					
Pump irrigation: a) Fixed cost			2806		-
Variable cost			251 a/		634 b/
			16423		22955

Net farm income = 22955 - 16423 = 6532

a/ Includes variable cost of 59 rented out hours at the rate of Rs 4.25 per hour.

b/ Includes revenue from 59 rented out hours at the rate of Rs 10.74 per hour.

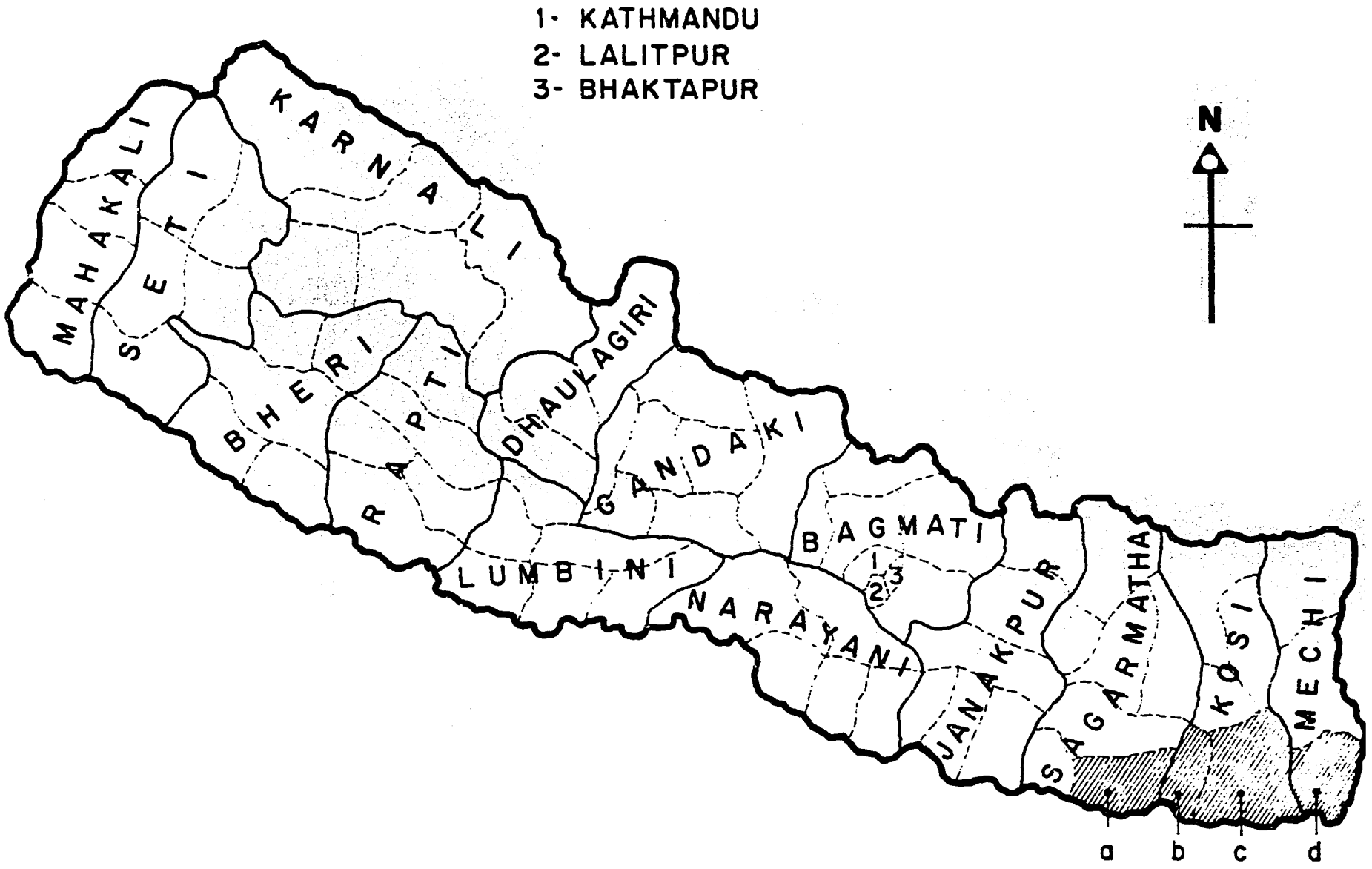

Fig. 1 Map of Nepal showing study area (a. Saptari , b. Sunsari , c. Morang , d. Jhapa.)

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

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