CHAPTER IV

THE SAMPLE STUDY : BROAD RESULTS

4.1 Introduction

Studies of irrigation in India have derived a lot of impetus from the growing emphasis on irrigation works made in programmes for agricultural development, especially since the Third Plan. The period since the Third Plan has also been marked by shifting focus to minor irrigation works, leading to near doubling of their share in total irrigation outlays. This shift in emphasis has led to a recognition of the importance of ground-water resources as a means of providing a conjunctive water source to normally rain-fed agriculture. Because of the high involvement of public investment, optimum use of the irrigation capacities created becomes a subject of economic interest. The smallest of the minor irrigation schemes, in general, are low cost-intensive and are financed by fast-disbursing loan assistance, with an element of subsidy thrown in as an incentive. Other irrigation works, however, owe their existence to direct government finance.

Hitherto, studies on irrigation impact have concentrated on the productivity dimensions of the resultant agricultural growth. Productivity studies, however, have a wide compass that tends to obliterate micro-level distinctions between the various scheme-types, as far as minor irrigation works are concerned, some comment is found with respect to irrigation impact by source. It has been noticed that with irrigation, more intensive use is made of land and that irrigated areas grow more of high-productivity, high-value crops which either cannot be raised at all, or do not do as well under rain-fed conditions. Micro-studies, nevertheless, have presented conceptual problems in assessing the impact of irrigation because of strong complementarities between water-use and the use of other agricultural inputs. The reason is that irrigation affects crop yields directly, as also through its influence on the scope for using other inputs and on their efficiency.

Cost-efficiency of irrigation schemes offers an interesting area for micro-level studies of the impact of irrigation on cultivator-behaviour, inasmuch as changes in such behaviour can be attributed as responses to changed investment perceptions on the part of the cultivator. The reasoning underlying any such study is obvious - with irrigation, comes both awareness of and capacity to apply new agricultural technology, and since such application involves an investment decision by the cultivator, it has economic implications. To lay a foundation for such a study, it is necessary to preserve scheme-differences in the data so as to be able to assess differential impact, if any.

For the purposes of classification, minor irrigation schemes can be clubbed under two broad energy-heads i.e. electrified schemes and diesel-powered schemes. Within each head, further classification can be made in terms of irrigation capacities, which follows the technical distinctions between pumping capacities. The higher capacity pumps serve deep tubewell [DTW] and river-lift irrigation [RLI] schemes, of which the former are electrified while the latter draw their energy from diesel. The two schemes are operated by government departments, with scheme- beneficiaries being entitled to water-sharing rights at scheduled rates. The smaller schemes are privately owned and financed through loan assistance. They consist of shallow tubewells energized by electricity [STW(e)] where electrical connections are available, or else by diesel [STW(d)]. The actual schemewise mix is dictated by availability of finance for the smaller schemes, and availability of pumping capacities for the larger schemes. Availability constraints also dictate the source of energy, with the number of pumpsets energized through electricity being commensurate with the rate of rural electrification.

It might be thought that homogenous cultivator-responses are created by irrigation, irrespective of scheme-type, so that the irrigated sector constitutes a uniform group. However studies found in the literatures have demonstrated better performances in the case of privately-owned tubewells. Other evidence exists to show that cultivator-responses are also marked by a preference shift to a more water-intensive cropping pattern. In view of this, it is instructive to study differential responses, and to see if irrigation costs in general, and energy factors in particular have any role in determining such shifting preferences.

Both these aspects are addressed within the simple framework of a regional sample-study, which lays special emphasis on the impact of irrigation on input-use. It is hoped that thereby, new light will be shed on the complexities posed by the complementarites between water-use and the use of other agricultural inputs alluded to above, which have hitherto reduced the effectiveness of micro-level studies. It needs, however, to be mentioned that in the region studied, the use of irrigation is supplemental because of an extensive monsoon, and that the findings pertain, *per se*, to conjunctive use of minor irrigation capacities with normally rain-fed agriculture.

METHODOLOGY

4.2 The Field Survey

Data was drawn from a total of 74 respondents spread over 8 villages in Tufanganj I and Dinhata I blocks in Cooch Behar district. Block selection was made purposively, on the basis of the following criteria :

i) state of agricultural development; and

ii) nature of irrigation schemes at block level, in order to include both good-performance as well as average-performance blocks, as also to cover the gamut of irrigation schemes available by source.

Actual respondents within the stratification of 8 villages were drawn on random basis. Roughly 30% of the sample was drawn from such cultivators, hereinafter referred to as non-beneficiaries, who had not availed of any irrigation scheme, in order to provide a control-group against whom data from the beneficiaries of irrigation schemes could be compared and evaluated. The questionnaire covered four cropping seasons, viz. boro (January to April), pre-kharif (February to May), kharif (June to September) and rabi (October to December), which are predominant in the district following introduction of multiple cropping via irrigation. Each respondent was asked to supply information on cropping, use of inputs and expenditure thereon, land-holdings and land-acquisition, etc., with reference to two distinct points of time, namely,

i) prior to the introduction of any irrigation scheme in the village, and

ii) at the time of the interview.

This was done in order to provide a "before and after" picture of the overall position of cultivators in the sample, which was to form the basis of the impact-study. The time-gaps between the above periods generally vary between 3 to 5 years, indicating that introduction of irrigation (except for traditional systems) is a relatively recent phenomenon in the district.

4.3 Computation

Initial compression of the data was achieved by subtracting pre-irrigation data from post-irrigation data per cropping season. This yielded incremental differences, or impact variables under each of the information-heads. Thereafter, seasonal differences by cropping season were further compressed into annual figures which provided a distribution of impact variables on 20 heads of information. An analysis of schemewise averages under these heads was undertaken for initial identification of impact patterns, salient parts of which are reproduced later in this chapter.

It was found necessary to concentrate on the cost dimension of the use of various agricultural inputs instead of physical quantities thereof, because of wide disparities in magnitudes and units of measurement, for example, pesticide-use measured in grams and manure-use measured in (thousands) kilograms, or between the above and labour-use measured in man-days. Thus only cost magnitudes of input-use were retained for further analysis. It was also found necessary to standardize the cost data because of disparate ranges in their distribution. This is because agricultural inputs of different kinds do not have equi-proportionate weighting in the total investment basket of a cultivator. Standardization of the data yielded a standardized data-matrix to which multivariate methods were applied for further analysis in order to identify, particularly, aspects of joint-variability.

The Method of Principal Components* is a useful method for identifying joint-variability patterns in multivariate data as it affords compacting of total variance within the data into the principal components of variance, each of which is defined as a linear combination of the distributions of individual component variables. The method is particularly useful in handling explanatory data where the presence of a high degree of multicollinearity is suspected, as the PC-transformations yield new explanatory data series that are statistically independent of each other.

The cost variables considered were seed costs (*SEEDCOST*), manure costs (*MANURCOST*), fertilizer costs (*FERTCOST*), pesticide costs (*PESTCOST*), other miscellaneous costs such as land-preparation costs (*OTHCOST*), labour costs (*LABCOST*) and energy costs of irrigation (*ENERGYCOST*). From the standardized data-matrix, the correlation matrix was computed as below :

* e.g. Johnston J. Econometric Methods.

Table 4.1

Correlation Matrix

	1 SeedCost	2 ManurCost	3 FertCost	4 PestCost	5 OthCost	6 EnergyCost	7 LabCost
1 SeedCost	1.000	0.339	0.346	0.273	0.263	0.047	0.343
2 ManurCost	0.339	1.000	0.562	0.386	0.629	0.109	0.599
3 FertCost	0.346	0.562	1.000	0.691	0.623	0.267	0.739
4 PestCost	0.273	0.386	0.691	1.000	0.486	0.199	0.503
5 OthCost	0.263	0.629	0.623	0.486	1.000	0.134	0.782
6 EnergyCost	0.047	0.109	0.267	0.199	0.134	1.000	0.116
7 LabCost	0.343	0.599	0.739	0.503	0.782	0.116	1.000

Source : Sample Survey

As the correlation matrices and dispersion matrices are identical for standardized data with mean = 0 and unit variance, solution of the correlation matrix yielded the following eigenvectors and eigenvalues tabulated below in the Table of Principal Components:

Table 4.2

Matrix of Principal Components
Table of Eigenvectors

	1 SeedCost	2 ManurCost	3 FertCost	4 PestCost	5 OthCost	6 EnergyCost	7 LabCost
PC1	0.25	-0.27	0.91	-0.05	0.13	0.10	0.04
PC2	0.40	-0.18	-0.07	-0.46	-0.76	-0.06	-0.11
PC3	0.46	0.13	-0.04	0.25	0.03	-0.64	0.54
PC4	0.38	0.18	0.00	0.73	-0.29	0.38	-0.24
PC5	0.44	-0.11	-0.30	-0.24	0.32	0.60	0.44
PC6	0.14	0.90	0.20	-0.34	0.05	0.07	-0.08
PC7	0.46	-0.13	-0.10	-0.11	0.47	-0.26	-0.66

Source : Sample Survey

Table 4.3

PC Variances

	Eigenvalues	%Var	CumVar
PC1	3.657	52.25	52.25
PC2	1.008	14.40	66.64
PC3	0.815	11.64	78.29
PC4	0.656	9.37	87.65
PC5	0.418	5.98	93.63
PC6	0.288	4.12	97.75
PC7	0.158	2.25	100.00
Total Variance	7	100	

CumVar = cumulative variance

Source : Sample Survey

Row-variables in the table above indicate combinatorial weights for each cost variable by principal component. It is seen that good compacting of sample variance has been achieved by reference to the percentage-transformation of variances via the eigenvalue.For example, PC1 accounts for 52.25% of total sample variance, PC2 for 14.40%, PC3 for 11.64%, PC4 for 9.37% and the first four PCs cumulatively account for as much as 87.65% of total variance.

In order to analyze the proportional importance of each cost variable in each PC, vis-a-vis scheme characteristics as reflected in the cost-variables, PC-scores were computed for each PC on standardized values by substituting within the following family of linear equations, each of which is a linear combination of the original standardized data-values:

PC1-SCOR=.25SEEDCOST-.27MANURCOST+.91FERTCOST-.05PESTCOST+.13OTHCOST+.10ENERGYCOST+.04LABCOST

PC2-SCOR = .40SEEDCOST-.18MANURCOST-.07FERTCOST-.46PESTCOST -.76OTHCOST-.06ENERGYCOST-.11LABCOST

PC3-SCOR = .46SEEDCOST+.13MANURCOST-.04FERTCOST+.25PESTCOST +.03OTHCOST-.64ENERGYCOST+.54LABCOST

PC4-SCOR = .38SEEDCOST+.18MANURCOST+.00FERTCOST+.73PESTCOST -.29OTHCOST+.38ENERGYCOST-.24LABCOST

PC5-SCOR = .44SEEDCOST-.11MANURCOST-.30FERTCOST-.24PESTCOST +.32OTHCOST+.60ENERGYCOST+.44LABCOST

PC6-SCOR = .14SEEDCOST+.90MANURCOST+.20FERTCOST-.34PESTCOST +.05OTHCOST+.07ENERGYCOST-.08LABCOST

PC7-SCOR = .46SEEDCOST-.13MANURCOST-.18FERTCOST-.11PESTCOST +.47OTHCOST-.26ENERGYCOST-.66LABCOST

Each PC-SCOR can be interpreted as a new cost-variable (*COMBCOST*) or combined cost which is a weighted sum (not a simple aggregation) of individual cost variables, the weights themselves representing the responsiveness of each Principal Component to variations in the cost variables themselves.

The PC-SCORs for each PC defined over 74 respondents were analyzed over irrigation schemes and yielded distinct schemewise rankings for each PC, in terms of average PC-SCOR per scheme. These results are reproduced in Table 4.4 & Table 4.5, later. The rankings themselves indicate schemewise-bias present in each PC, this being attributable to the different weightings assigned by each PC to the impact variables. It may be noted that, for example, the apparent inversion of rankings between PC1 and PC2, as far as the category NB is concerned is due to the fact that PC2 gives primary importance to those sources of variation excluded under PC1.

4.4 Findings

It must be noted that the base-data was in incremental form and not in actual magnitudes of cost variables per respondent. Hence correlation between any two data-series is a measure of joint-variability of incremental rather than actual costs. As each set of PC-weights consists of both positive and negative values, it is obvious that two cost-variables for which PC-weights possess the same sign are directly related for that PC, whereas they are inversely related when PC-weights differ in sign. Economic meaning can be assigned to the above, insofar as each cost-variable reflects usage of particular physical inputs. Thus direct relationships between cost-variables indicate, for each PC, complementarity of the inputs concerned, while inverse relationships indicate substitutability of inputs.

PC1 assigns highest weighting to *FERTCOST*, with complementarity, in decreasing order, between it and *SEEDCOST*, *OTHCOST*, *ENERGYCOST* and *LABCOST*; a substitute relationship with the above input-factors is, however, indicated for *MANURCOST* and *PESTCOST*. PC1 is highly sensitive to *FERTCOST* and *SEEDCOST* and to *MANURCOST* (inversely). Schemewise rankings place STW(e) highest of all in terms of PC-SCORs followed by STW(d), then RLI(d) and DTW(e) together, and last of all NB.

PC2 weights relate *SEEDCOST* (inversely) to other cost-variables. PC2 is highly sensitive to *OTHCOST* and *PESTCOST* (inversely) and *SEEDCOST* (directly). The ranking places NB highest, followed by STW(e),RLI(d),DTW(e) and STW(d) last of all.

In the case of PC3, *FERTCOST* and *ENERGYCOST* are inversely related to the rest of cost-variables. PC3 sensitivity is as follows : *ENERGYCOST* (inversely) and *LABCOST*, *SEEDCOST* and *PESTCOST* (directly). PC3 rankings place DTW(e) highest of all followed by RLI(d), STW(e), STW(d), and NB last of all.

PC4 relates *LABCOST* and *OTHCOST* inversely to other cost variables. PC4 sensitivities are as follows: *PESTCOST*, *SEEDCOST*,*ENERGYCOST* and *MANURCOST* (directly) and *OTHCOST* & *LABCOST* (inversely). PC4 rankings place STW(d) highest followed by RLI(d), STW(e), DTW(e) and NB last of all.

PC-SCOR patterns over the different schemes are reproduced below in two tables. The first tabulates schemewise average PC-SCORS over PC1 to PC7 along with variances within the scheme. Scheme rankings per PC, on the basis of PC-SCOR averages are reproduced as an adjunct to this table. Rankings from PC1 to PC7 are evident therein. However, since PC1 to PC4 explain 87.65% of the total variance, it is not necessary to go into detailed exposition of the later PCs here.

Table 4.4

Principal Component Scores : Schemewise Averages over All Impact Variables (PC-weights from Table 4.3)

PC - SCORS

		PC1	PC2	PC3	PC4	PC5	PC6	PC7
NB	avg	-1.23	1.46	-0.96	-0.97	-0.88	-0.95	0.45
	var	0.10	0.18	0.09	0.06	0.10	0.16	0.03
RLI(d)	avg	0.40	-0.58	0.83	0.39	-0.03	0.65	-0.01
	var	0.53	0.60	0.70	0.40	0.46	0.62	0.45
STW(d)	avg	0.50	-0.88	-0.09	0.60	0.71	0.13	-0.32
	var	0.58	1.29	1.32	1.16	0.86	0.60	0.59
STW(e)	avg	0.82	-0.17	0.24	0.38	0.35	0.40	-0.31
	var	0.59	0.86	0.77	0.62	0.27	0.60	0.15
DTW(e)	avg	0.40	-0.79	1.08	0.02	0.24	0.63	-0.05
	var	0.41	0.56	0.85	0.29	0.36	0.55	0.18
ALL(e)	avg	0.63	-0.45	0.62	0.22	0.30	0.51	-0.19
	var	0.56	0.82	0.98	0.51	0.31	0.59	0.18

avg = ArithMean, var = SchemeVariance

Source : Sample Survey

Table 4.5

Ranking Table over all Principal Components
Schemewise Rankings over PC-SCORs

PC1	PC2	PC3	PC4	PC5	PC6	PC7
STW(e)	NB	DTW(e)	STW(d)	STW(d)	RLI(d)	NB
ALL(e)	*STW(e)	RLI(d)	RLI(d)	STW(e)	DTW(e)	*RLI(d)
STW(d)	*ALL(e)	ALL(e)	STW(e)	ALL(e)	ALL(e)	*DTW(e)
RLI(d)	*RLI(d)	STW(e)	ALL(e)	DTW(e)	STW(e)	*ALL(e)
DTW(e)	*DTW(e)	*STW(d)	DTW(e)	*RLI(d)	STW(d)	*STW(e)
*NB	*STW(d)	*NB	*NB	*NB	*NB	*STW(d)

** = negative placings*

Source : Sample Survey

The next table, i.e. Table 4.6, pertains to PC-SCOR averages, for the first four PCs,over each impact variable. The table itself results from assigning respective PC coefficients from Table 4.2 to each impact variable over standardized values and computing schemewise averages thereof for PC1 to PC4. Analysis of the average score per impact variable gives sufficient idea of their relative weights in each PC as also their explanatory role in defining the schemewise ranking in the earlier table.

Table 4.6

Ranking Table over all Impact Variables
Schemewise Rankings over PC-SCORs
Average PC-SCOR per Impact Variable

	PC1		PC2		PC3		PC4	
1	RLI(d)	0.12	RLI(d)	0.19	RLI(d)	0.22	RLI(d)	0.18
SeedCost	STW(e)	0.12	STW(e)	0.19	STW(e)	0.22	STW(e)	0.18
	ALL(e)	0.12	ALL(e)	0.19	ALL(e)	0.21	ALL(e)	0.18
	DTW(e)	0.12	DTW(e)	0.18	DTW(e)	0.21	DTW(e)	0.18
	STW(d)	0.05	STW(d)	0.07	STW(d)	0.09	STW(d)	0.07
	NB	-0.22	NB	-0.34	NB	-0.39	NB	-0.32
2	NB	0.28	NB	0.19	RLI(d)	0.10	RLI(d)	0.14
ManurCost	STW(d)	-0.05	STW(d)	-0.04	DTW(e)	0.09	DTW(e)	0.13
	STW(e)	-0.07	STW(e)	-0.05	ALL(e)	0.06	ALL(e)	0.09
	ALL(e)	-0.13	ALL(e)	-0.09	STW(e)	0.04	STW(e)	0.05
	DTW(e)	-0.19	DTW(e)	-0.13	STW(d)	0.02	STW(d)	0.03
	RLI(d)	-0.21	RLI(d)	-0.14	NB	-0.14	NB	-0.19
3	STW(e)	0.71	NB	0.08	NB	0.04	NB	0.00
FertCost	ALL(e)	0.58	STW(d)	-0.03	STW(d)	-0.01	STW(d)	0.00
	RLI(d)	0.47	DTW(e)	-0.03	DTW(e)	-0.02	DTW(e)	0.00
	DTW(e)	0.41	RLI(d)	-0.04	RLI(d)	-0.02	RLI(d)	0.00
	STW(d)	0.36	ALL(e)	-0.04	ALL(e)	-0.02	ALL(e)	0.00
	NB	-1.10	STW(e)	-0.05	STW(e)	-0.03	STW(e)	0.00
4	NB	0.05	NB	0.51	STW(d)	0.15	STW(d)	0.43
PestCost	STW(e)	-0.01	STW(e)	-0.09	RLI(d)	0.14	RLI(d)	0.39
	ALL(e)	-0.01	ALL(e)	-0.13	DTW(e)	0.09	DTW(e)	0.27
	DTW(e)	-0.02	DTW(e)	-0.17	ALL(e)	0.07	ALL(e)	0.20
	RLI(d)	-0.03	RLI(d)	-0.25	STW(e)	0.05	STW(e)	0.14
	STW(d)	-0.03	STW(d)	-0.27	NB	-0.28	NB	-0.80
5	DTW(e)	0.10	NB	0.85	DTW(e)	0.02	NB	0.32
OthCost	STW(d)	0.08	STW(e)	-0.09	STW(d)	0.02	STW(e)	-0.03
	RLI(d)	0.05	ALL(e)	-0.31	RLI(d)	0.01	ALL(e)	-0.12
	ALL(e)	0.05	RLI(d)	-0.31	ALL(e)	0.01	RLI(d)	-0.12
	STW(e)	0.02	STW(d)	-0.44	STW(e)	0.00	STW(d)	-0.17
	NB	-0.15	DTW(e)	-0.58	NB	-0.03	DTW(e)	-0.22
6	STW(d)	0.09	NB	0.04	NB	0.43	STW(d)	0.34
EnergyCost	STW(e)	0.04	DTW(e)	0.02	DTW(e)	0.26	STW(e)	0.15
	ALL(e)	0.00	RLI(d)	0.02	RLI(d)	0.18	ALL(e)	0.02
	RLI(d)	-0.03	ALL(e)	0.00	ALL(e)	-0.03	RLI(d)	-0.11
	DTW(e)	-0.04	STW(e)	-0.02	STW(e)	-0.26	DTW(e)	-0.15
	NB	-0.06	STW(d)	-0.05	STW(d)	-0.58	NB	-0.25
7	DTW(e)	0.03	NB	0.12	DTW(e)	0.41	NB	0.27
LabCost	ALL(e)	0.02	RLI(d)	-0.04	ALL(e)	0.31	RLI(d)	-0.09
	STW(d)	0.02	STW(e)	-0.05	STW(d)	0.23	STW(e)	-0.10
	STW(e)	0.02	STW(d)	-0.05	STW(e)	0.22	STW(d)	-0.10
	RLI(d)	0.01	ALL(e)	-0.06	RLI(d)	0.20	ALL(e)	-0.14
	NB	-0.04	DTW(e)	-0.08	NB	-0.59	DTW(e)	-0.19

Source: Sample Survey

Schemewise variances in Table 4.4 are useful in ascertaining dispersion within the schemewise sub-samples, as a yardstick of differential irrigation impact. Thus it is seen that NB displays low variances indicating greater uniformity within the NB sub-sample, the larger schemes i.e. DTW(e) and RLI(d) display variances within the medium range, while the smaller schemes i.e. STW(e) and STW(e) display higher variances. Thus, among the irrgated sub-sample as a whole, impact-responses for the larger schemes possess more homogenous group-characteristics, while group-responses for the STW schemes are more disparate. The point is better brought out by study of the clustering behaviour in the PC-plots attached below.

From Table 4.6, it can be seen that STW(e) holds its own position over PC1 to PC3 and is well ahead of the diesel sector. DTW(e) is comparatively poorer in its rankings in PC1 and PC2 but moves to first place in PC3, with the energized sector (through electricity) i.e. ALL(e), remaining consistently ahead of the diesel sector. It is only in PC4 that the diesel sector moves ahead.

Average scores over impact variables in PC1 indicate the pre-eminence of *FERTCOST* in determining scheme rankings, followed, to a lesser degree by *SEEDCOST* and *MANURCOST*. In the case of STW(e), which occupies first place among the schemes in PC1 the score for *FERTCOST* is much higher than for other scheme categories, implying higher intensity of fertilizer-use. The score for *SEEDCOST* is also high, although this is also replicated by RLI(d) and DTW(e). *MANURCOST* has an adverse weighting in PC1, which combined with low manure-use intensity accounts for positive score obtained for this impact variable by NB. Other schemes show negative values although STW(e) has a relatively higher value within this negative range, suggesting lower intensity in manure-use which is, however, made up by its higher intensity in fertilizer-use. NB, which stands at the other end of the ranking scale, exhibits opposite patterns.

Under PC2, NB moves to the top on the strength of high scores for *OTHCOST*,*PESTCOST* and *MANURCOST*. It must be noted that weighting of impact variables under PC2 is negative for all variables other than *SEEDCOST*, and also the positive magnitudes of NB scores indicate lower intensity of input-use by NB for the variables indicated. STW(e) occupies second spot mostly on the strength of lower scores under *OTHCOST*,*PESTCOST* and *MANURCOST*, and a satisfactory score under positively-weighted *SEEDCOST*. STW(d), which occupies bottom spot, is weighted down by its scores for *OTHCOST*,*PESTCOST* and *SEEDCOST*.

PC3 rankings, with DTW(e) at the head of the scale are attributable to higher scores overall, under *LABCOST*,*ENERGYCOST* and *SEEDCOST* followed by *PESTCOST* & *MANURCOST*. Of these, *ENERGYCOST* is weighted negatively under PC3, which obviously places the larger schemes i.e. DTW(e) and RLI(d) in an intrinsically better position because of their lower unit-cost of irrigation. The negative score for *ENERGYCOST* in STW(e) is obviously because of increased intensity of irrigation-use rather than unit-cost, since unit-costs of energy for STW(e) compare favourably with RLI(d). The high score of NB under *ENERGYCOST* is initially confusing till it is remembered that energy costs for this category are nil and that the non-zero score here is the result of the standardization procedure. STW(e) is however, still ahead of STW(d), particularly in *SEEDCOST*.

PC4 rankings are headed by STW(d) primarily on account of better scores obtained by it under *PESTCOST* and *ENERGYCOST*. Ranking for the other schemes follows for the same reason, except that *SEEDCOST* replaces *ENERGYCOST* as a determining factor. Once again,the part played by *ENERGYCOST* in placing STW(d) at the head is because of the much higher unit-cost of irrigation for this scheme. On the other hand, the difference in scores between RLI(d) and STW(e), which have comparable unit energy costs, would indicate greater intensity of irrigation use for the latter.

Individual PCs give rise to clear and precise analytical interpretations via Table 4.6. This ranking table shows, for the first four PCs, schemewise rankings of average PC-SCORS on the 7 impact variables. Negative/positive magnitudes have, however, to be interpreted with due consideration to inverse /direct weightings in Table 4.2. However, PC1, which accounts for the largest part of sample variance,is clearly weighted in favour of *ENERGYCOST*,*SEEDCOST* and *PESTCOST* (negatively). Ranking patterns over individual impact variables concur with schemewise ranking on the overall PC1-SCOR (allowance having being made for negatively weighted *MANURCOST* and *PESTCOST*, where the ranking is a mirror transformation). Schemewise rankings can be read from Table 4.5.

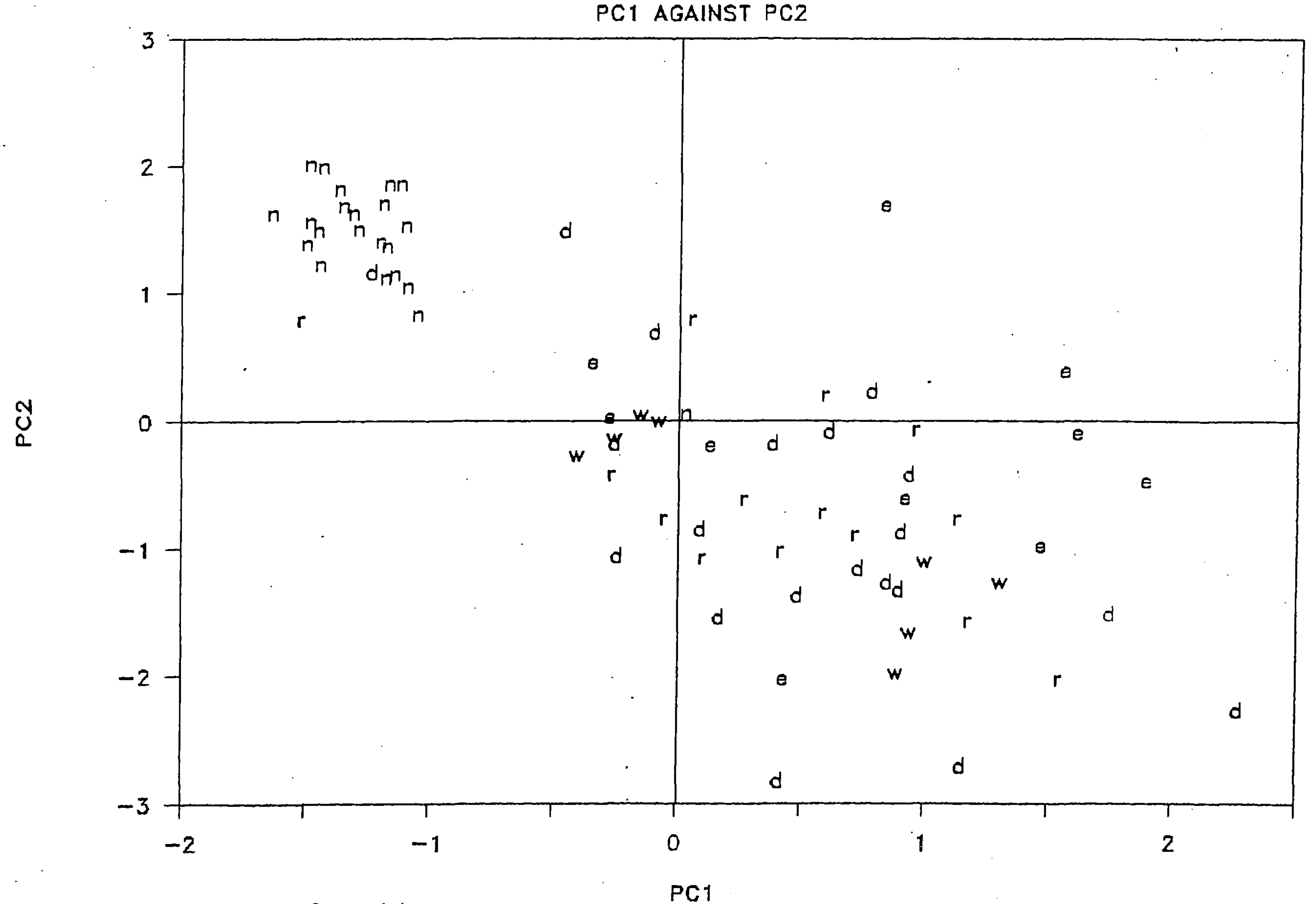
PC2, which explains the second-largest component in sample variance, is weighted on, sequentially, *OTHCOST*, *PESTCOST*,*MANURCOST* and *SEEDCOST*, and to a smaller degree on *LABCOST*. Of these only *SEEDCOST* has positive PC-weight, where NB has the lowest PC-SCOR. In other impact variables, all of which have negative PC-weights, NB records high PC-SCORS, which are a reflection of the inverse relationship whereby NB performances are lowest on all counts. On the other hand, all other schemes have positive PC-SCOR for *SEEDCOST* and negative PC-SCOR for all other, negatively-weighted, impact variables. Among these schemes,second-placed STW(e) records better scores in *FERTCOST* and *SEEDCOST*, as in PC1 where it places first.

PC3 weights are towards *ENERGYCOST* (negative),and *LABCOST*, *SEEDCOST*,*PESTCOST* and *MANURCOST*. DTW(e) which occupies first position scores significantly better in the first three of these categories. STW(e) fares poorly because of negative weighting to *FERTCOST* where its performance, in general, has been strong. STW(d), on the other hand, is dragged down to second-last place mostly on account of the higher negative weight to *ENERGYCOST* for which its unit-costs are significantly higher.

These findings are consistent with PC4 where STW(d) occupies top position on account, primarily *PESTCOST*, (positively weighted) *ENERGYCOST* and *OTHCOST*. Other schemes score better under *LABCOST*, *SEEDCOST* and *MANURCOST*.

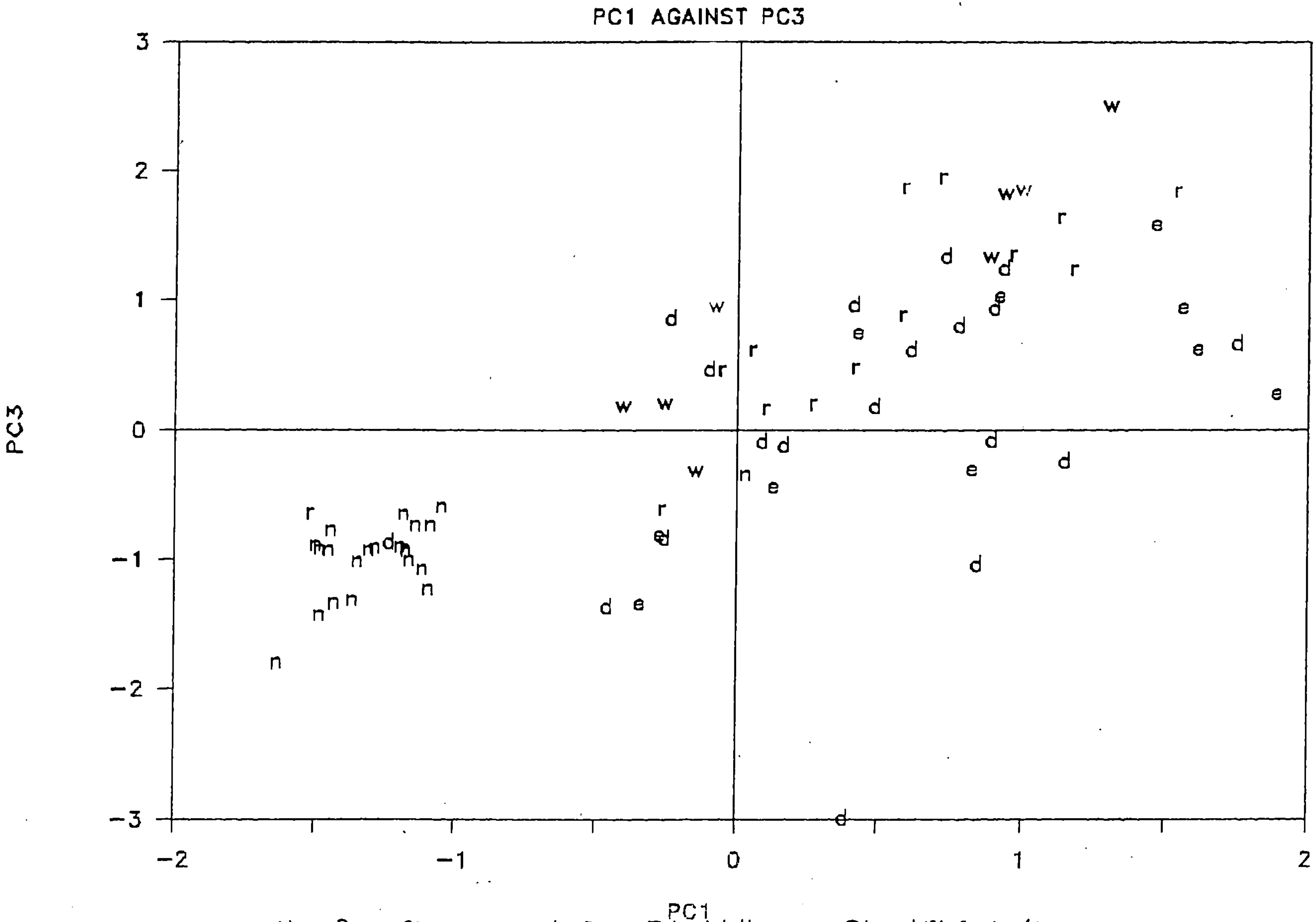
4.5 A Summary

The methodology used for multivariate analysis clearly identifies the strengths and weaknesses of each scheme, insofar as input-use parameters are concerned. Of STW(e), it can be said that the scheme makes intensive use of fertilizers and seeds. It might be construed from this that its performance in terms of acreage sown might be better. With reference to the present area of analysis this implication seems to be underscored by the fact that as far as energy costs are concerned,STW(e) scores considerably better than RLI(d),



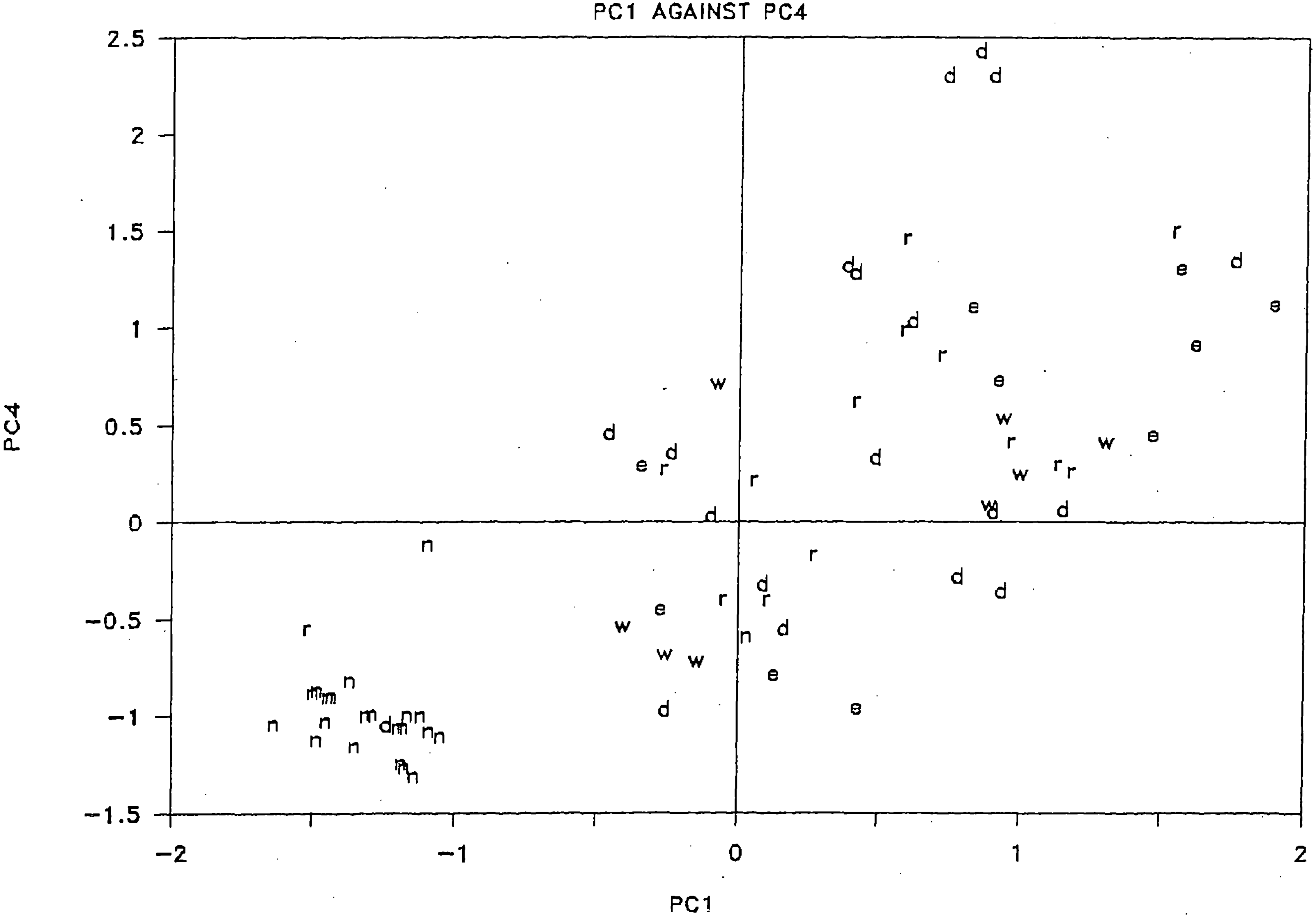
n – Non Beneficiary ; W – Deep Tube Well ; r – River Lift Irrigation ;
d – Shallow Tube Well (Disel) ; e – Shallow Tube Well (Electrified).

Fig-1



n- Non Beneficiary ; W- Deep Tube Well ; r- River Lift Irrigation ;
d- Shallow Tube Well (Disel) ; e- Shallow Tube Well (Electrified).

Fig- 2



n- Non Beneficiary ; W- Deep Tube Well ; r- River Lift Irrigation
d- Shallow Tube Well (Disel) ; e- Shallow Tube Well (Electrified)

Fig-3

although their unit cost of irrigation is nearly similar. This pattern for energy cost is observed over all PCs.

STW(d) has greater intensities of input-use in pesticides and other miscellaneous inputs, and energy, where,however it has to bear the burden of significantly higher unit irrigation cost. Although high energy cost might also carry acreage implications, this conclusion is defeated by the fact that for STW(d) the score on *SEEDCOST* is low, as also for fertilizer costs/manure costs. Thus the high quantum of *ENERGYCOST* is mostly because of higher diesel cost in irrigation. Other schemes fare better as far as other input variables concerned.

Of the larger schemes, DTW(e) is intensive in its use of seeds, manure, pesticides, and to some extent, labour. Its main attribute is however labour use. RLI(d) is the other large scheme. Patterns for RLI(d) are similar to that of DTW(e) except when it comes to fertilizer-use, where RLI(d) shows higher intensities.

As a whole the energized sector, i.e. ALL(e) occupies a significantly better position compared to the diesel sector as a whole, because of the combined strengths of STW(e) and DTW(e) over a larger base of impact variables. This gives rise to the thought that this overall better performance may be explained by the price and substitution effects of lower energy costs for the energized sector.

Insofar as the diesel sector is concerned, investment on input use is high, particularly for STW(d); however, a large chunk of this investment goes to defray energy cost. For the energized sector on the other hand, lowered energy cost frees some of this investment for use on other agricultural inputs that lead to better performances for this sector. A case can thus be cogently established for electrification of existing diesel irrigation schemes, keeping in mind, especially, that with global scarcities of fossil fuels, diesel costs are prone to rise further.

Understanding of the broad patterns of impact-differentials evinced in the PC analysis is aided by looking at the PC-plots that accompany the chapter. Three plots have been generated for PC1 scores on PC2, PC3 and PC4 scores to offer a bivariate visual comparison of PC-SCORS over all 74 sample respondents. Vis-a-vis the control-group, i.e. the non-beneficiaries or those without recourse to any means of irrigation other than the traditional, it is seen that cultivators who have gone in for tubewell irrigation have made substantial forward progress in the use of agricultural inputs in general. This is abundantly clear from the PC-plots. The clustering therein is particularly interesting. While NB presents a more or less homogenous cluster with little outlier behaviour, the schemes themselves dissemble category-wise into much more scattered clusters. Outlier behaviour is most pronounced for the diesel schemes possibly on account of the more uncertain circumstances in which they operate.

4.6 Tentative Findings

In the analysis of scheme-wise differences in the use of agricultural inputs in the light of variations in investment behaviour of sample respondents, cost data have been used as a surrogate for data on physical input-use to circumvent problems of comparison that would have arisen because of the heterogeneity of the latter. Standardization procedures were necessary to reconcile different scales of measurement into a common measure of variance. The intrinsic economic relationship explored by the PC-analysis was the conceptually basic one of input substitutability/complementarity. Theoretical inferences that can be drawn are of course contextual, and peculiar to the case being studied.

Sufficient evidence is found to establish that there are explicit differences in the input-mix pertaining to each irrigation scheme. Energy-costs of irrigation appear to play a significant part in the determination of this input-mix, this being evident from the findings that relate scheme-performances to scheme-category. It may be useful to indicate some of the underlying reasons accounting for this. In the course of the survey, it was noticed that seasonal preferences are exercised by the various categories of respondents. Boro and rabi are alternative seasons to a large extent, and boro cultivators tend to skip the pre-kharif season altogether. Mobility,too, appears to be an important factor - whereas the larger schemes are tethered to their respective spouts, leaving such land that is not in close proximity to the spout unirrigated, the smaller schemes have certain advantages in this respect. STW(d), particularly, is a case in point, as the same pump can be shifted at the cultivator's will to other spouts within his holding. STW(d) cultivators are thus observed to be very enterprising, although they are burdened by much higher energy costs. STW(e) cultivators, on the other hand, balance their somewhat restricted mobility by an intelligent choice of cropping season. A more detailed analysis of these seasonal differences are, however, beyond the scope of this paper, confined as it is to annual scenarios.

Certain methodological conclusions also follow. The use of multivariate methods of analysis is demonstrated to be a quick and effective way of pinpointing major determinants of the overall impact of irrigation. Regression analysis of the same would have been limited by serious multicollinearity problems that would have rendered OLS inapplicable. Sufficient indication of the extent to which multicollinearity is present in the data is found in the covariant behaviour of the impact in the correlation matrix in Table 4.1. As the problem confronted by the study is not one of estimation but requires ranking of the differential impact, no information loss is embodied in its choice of methodology. More precision, when called for, can always be obtained by using recursive procedures to expostulate the results from Principal Components analysis to Factor Analysis. However, in the limiting case where the number of cost-variables is equal to the number of Factors, the Principal Components analysis corresponds to Factor Analysis results for the purpose of the present study, the ranking suffices to reach definite coclusions on differential scheme-performance and to the extension was beyond its scope.

4.7 Other Results

Although the standardisation of sample data was necessary for conducting PC analysis, one of the problems of such standardisation procedures is that the information content of the data series themselves is considerably reduced in order that better understanding is achieved of the intrinsic positions of various irrigation schemes in relation to the head of information covered by the questionnaire. An analysis of actual data is therefore also presented below .

It will be pertinent to mention the methodology followed in tabulation. Actual data were with reference to the four agricultural seasons and were collected over various crop-categories. Since the interest of the study is in analysis of the comparative position of various schemes, the different crops were subsumed into four crop categories :

a) crops where qualitative modernisation of agricultural technology is involved i.e. crops involving HYV seeds, called 'Main' crop, for convenience,
b) crops where no qualitative changes in agricultural technology are involved i.e. crops whose identity remains intact between pre-irrigation and post-irrigation periods, called 'Traditional' crops for convenience,
c) crops of a subsidiary nature, often cash-crops, called 'Subsidiary' crops for convenience, that are further subdivided into,
   i) subsidiary crops no.1, denoted by 'Sub I' and
   ii) subsidiary crop no.2, denoted by 'Sub II'.

The above categorisation renders inter-seasonal comparison and aggregation of physical quantities possible, which would otherwise be a problem because of the peculiarities of the crop sown every season. It must be noted here that the classification does not however adhere to normal distinctions between food and non-food crops, with, for example, foodcrops being the main crop during the kharif season whereas during the rabi season the status of main crop being given basically to vegetables.

After tabulating all seasonal information under such crop categories the task of aggregation of seasonal into annual data becomes easy. Tables presented in the next few pages present various categories of information, with annual figures being arrived at by the above procedure. Seasonal information give some indication of differences in cropping, etc. Figures are in difference terms, representing variation between pre-irrigation and post-irrigation periods.

Table 4.7

Inter-Seasonal Profile of the Impact of Irrigation: by Crops

(Figures in Annual Incremental Terms)

	Acre		Labour Absopn.M		Labour Absopn.F		SeedCost		Manure Cost		Fertiliser Cost		Pest Cost		Other Cost	
	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnScd	AnnAvg	AnnSt
Main	5.70	4.74	157.30	109.00	26.19	21.71	948.38	1006.86	1804.73	1296.94	969.68	681.41	520.43	400.64	1162.86	778.
Trad	-2.90	2.61	-41.80	44.65	2.46	9.27	-78.78	285.66	-270.27	529.64	49.51	149.07	28.27	85.58	-186.35	323.
SubI	-0.04	0.91	5.00	42.98	7.18	14.70	74.89	350.06	115.95	518.42	107.72	197.80	102.01	166.07	97.43	337.
SubII	-0.64	1.00	-23.45	37.83	-0.93	5.54	-16.61	34.54	-49.59	142.69	-1.78	42.78	4.46	44.14	-100.35	188.

BORO

	Acre		Labour Absopn.M		Labour Absopn.F		SeedCost		Manure Cost		Fertiliser Cost		Pest Cost		Other Cost	
	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnS
Main	0.98	1.36	29.73	39.68	6.07	8.37	45.88	60.06	393.24	533.81	160.68	217.06	44.26	63.99	175.68	226.
Trad	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SubI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SubII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

(continued in next page)

PRE-KHARIF

	Acre		Labour Absopn.M		Labour Absopn.F		SeedCost		Manure Cost		Fertiliser Cost		Pest Cost		Other Cost	
	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd
Main	0.82	1.17	22.23	28.71	1.77	4.57	32.16	42.13	98.99	170.87	61.23	83.99	7.70	32.67	-66.96	168.86
Trad	-0.41	1.07	-13.85	29.43	1.46	4.61	-7.16	43.47	-39.86	143.57	19.80	64.19	14.86	50.83	19.53	126.11
SubI	0.05	0.56	3.70	23.54	0.36	9.07	5.55	26.06	5.61	93.82	11.42	43.66	4.46	44.14	-108.35	188.32
SubII	-0.64	1.00	-23.45	37.83	-0.93	5.54	-16.61	34.54	-49.59	142.69	-1.78	42.78	125.68	167.46	337.23	445.79

KHARIF

	Acre		Labour Absopn.M		Labour Absopn.F		SeedCost		Manure Cost		Fertiliser Cost		Pest Cost		Other Cost	
	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd
Main	2.51	2.58	28.11	33.60	6.74	7.59	43.51	41.29	89.19	300.93	193.51	177.50	57.53	67.59	286.89	268.26
Trad	-2.39	2.14	-20.88	26.53	1.20	7.54	-9.59	50.73	-175.00	470.25	46.68	108.36	26.85	73.92	-69.05	234.15
SubI	0.09	0.35	2.93	13.77	2.77	6.21	9.12	26.09	41.89	155.53	30.76	70.08	14.45	39.25	56.08	156.88
SubII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

RABI

	Acre		Labour Absopn.M		Labour Absopn.F		SeedCost		Manure Cost		Fertiliser Cost		Pest Cost		Other Cost	
	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd	AnnAvg	AnnStd
Main	1.39	1.17	77.23	52.88	11.61	11.44	826.82	961.18	1223.31	899.81	554.26	396.92	390.74	321.28	574.62	402.89
Trad	-0.10	0.24	-7.07	16.86	-0.20	1.73	-62.03	277.01	-55.41	155.96	-16.96	50.93	-6.28	26.90	-50.34	123.06
SubI	-0.17	0.65	-1.64	36.39	4.04	9.56	60.22	350.25	68.45	486.87	65.54	179.19	72.70	144.20	21.82	278.58
SubII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Source : Sample Survey

Table 4.7 presents the complete inter-seasonal profile of differential impact of the introduction of irrigation, in per capita (or average) terms. Standard deviations are indicated alongside so that an idea of the dispersion of the data is also available. Multiple cropping exists in all seasons except boro where the single crop is boro rice which is entirely irrigation-dependent and hence was not sown in the pre-irrigation period. A second subsidiary crop or sub II is only sown in the pre-kharif season, with kharif and rabi seasons being limited to three crops. Negative figures are for negative impact and thus represent shift variables generated by shift in cropping patterns resultant to irrigation. Such shifts are most pronounced for the trad crop and, to a lesser extent, for the sub II crop, indicating a shift, at least on the part of sizeable number of cultivators, to the rabi-boro combination.

Study of the table shows highest impact for the main crop in terms of acre sown, with traditional subsidiary cropping all being marked by negative shifts in annual terms. Changes in use of other inputs follow thereon, although positive impacts are generally obtained for the sub I crop indicating, perhaps, that some of the irrigation potential is shifted to at least one cash crop.

In terms of labour utilisation, variant patterns are found between male and female labour, which will be analysed in depth later on. However, female labour seems to have stepped into the shoes of male labour especially in the trad and sub I crops - male labour being applied in a larger measure to the main crop.

Table 4.8

Seasonwise Net Impact

	Acre	LabAbspM	LabAbspF	SeedCost	ManurCost	FertCost	PestCost	OthCost
BORO	0.98	29.73	6.07	45.88	393.24	160.68	44.26	175.68
PREKHF	-0.18	-11.36	2.66	13.95	15.14	90.66	54.93	-30.11
KHF	0.20	10.16	10.72	43.04	-43.92	270.95	98.82	273.92
RABI	1.12	1419.88	15.45	825.01	1236.35	602.84	457.16	546.11
ANNUAL	2.12	1448.41	34.89	927.88	1600.81	1125.12	655.18	390.98

Source : Sample Survey

Manure-, fertilizer- and pesticide-use, on the other hand, generally show positive impact which, combined with acreage shifts mentioned above, indicates better application of the same to all crops. Table 4.8 is derived from Table 4.7 in net terms, i.e. after subsuming the negative shifts into the net averages.

Table 4.9

Comparative Features of Pre- and Post-Irrigation Profiles

	CROP POST			CROP PRE					DIFFERENCE (in Annual Terms)		
	POSTAVG	POSTSTD	POSTSUM	PREAVG	PRESTD	PRESUM	SUMDIFF	NETSUM	ANNUALAVG	ANNUALSTD	ANNUALSUM
MainAcre	6.52	5.15	482.7	0.82	1.65	61	421.7	156.74	5.71	4.74	422.34
TradAcre	2.12	2.55	156.73	5.02	2.20	371.3	-214.57		-2.82	2.70	-208.50
SubIAcre	0.58	0.87	43.01	0.62	0.93	46.15	-3.14		-0.02	0.93	-1.70
SubIIAcre	0.11	0.38	8.16	0.75	0.90	55.41	-47.25		-0.59	1.00	-43.89
MainLabAbspM	176.49	117.26	13060	19.19	30.22	1420	11640	7182	155.38	108.87	11497.77
TradLabAbspM	42.12	40.50	3117	83.92	33.33	6210	-3093		-39.60	45.24	-2930.19
SubILabAbspM	36.58	47.69	2707	31.58	42.46	2337	370		5.87	43.52	434.54
SubIILabAbspM	5.34	18.07	395	28.78	31.75	2130	-1735		-22.13	38.22	-1637.96
MainLabAbspF	27.11	21.96	2006	0.92	3.20	68	1938	2582	25.48	20.98	1885.22
TradLabAbspF	7.89	8.84	584	5.43	6.55	402	182		2.57	9.28	190.00
SubILabAbspF	9.49	12.26	702	2.31	8.77	171	531		7.26	14.67	537.45
SubIILabAbspF	0.89	3.34	66	1.82	4.04	135	-69		-0.93	5.54	-69.00
MainSeedCost	984.12	1002.44	72825	35.74	118.09	2645	70180	68663	933.54	998.28	69081.89
TradSeedCost	76.49	73.46	5660	155.27	270.33	11490	-5830		-75.74	286.07	-5604.81
SubISeedCost	98.86	348.89	7316	23.97	41.63	1774	5542		75.66	349.96	5599.02
SubIISeedCost	6.35	21.58	470	22.96	25.24	1699	-1229		-15.58	34.72	-1152.93
MainManurCst	1936.49	1371.07	143300	131.76	222.67	9750	133550	118460	1785.36	1301.59	132116.42
TradManurCst	339.86	395.65	25150	610.14	345.46	45150	-20000		-255.50	533.38	-18906.77
SubIManurCst	400.00	643.54	29600	284.05	430.94	21020	8580		121.00	519.09	8953.76
SubIIManurCst	24.32	97.00	1800	73.92	96.17	5470	-3670		-46.46	143.55	-3437.76
MainFertCst	1007.45	707.00	74551	37.77	67.56	2795	71756	83259	960.15	683.40	71050.77
TradFertCst	123.99	125.53	9175	74.47	71.01	5511	3664		51.92	148.51	3841.98
SubIFertCst	179.80	249.07	13305	72.08	126.59	5334	7971		109.26	197.40	8085.43
SubIIFertCst	8.99	34.68	665	10.77	22.48	797	-132		-0.74	42.41	-54.89
MainPestCst	526.20	404.67	38939	5.77	18.22	427	38512	48483	509.84	396.18	37728.09
TradPestCst	37.96	79.41	2809	9.69	28.79	717	2092		28.27	85.58	2092.01
SubIPestCst	116.27	178.19	8604	14.26	31.95	1055	7549		104.17	165.77	7708.64
SubIIPestCst	9.32	36.84	690	4.86	22.38	360	330		4.46	44.14	330.01
MainOthCst	1293.68	818.59	95732	130.81	188.97	9680	86052	71454	1147.01	778.25	84878.84
TradOthCst	340.68	320.85	25210	527.03	202.14	39000	-13790		-173.35	325.65	-12828.06
SubIOthCst	315.20	381.06	23325	217.77	282.55	16115	7210		103.59	340.11	7665.89
SubIIOthCst	28.18	95.30	2085	136.53	152.22	10103	-8018		-101.04	188.33	-7477.05

Source : Sample Survey.

Table 4.9 provides for comparison of a tabular listing of annual actual figures for pre-irrigation and post-irrigation periods. The information covers annual-sum and annual-averages to provide both aggregate and per capita profiles, with the annual standard deviation figure providing an indication of the dispersion thereon. Analysis of the shifts of Table 4.7 may be made by comparing pre-and post-irrigation situations in Table 4.9 The sum figures are an assessment of the total input in non-relative terms i.e. independent of differential impact. The difficulties relating to units and scales of measurements, alluded to earlier in the chapter, can be seen therein and it is clear why standardisation of the data was necessary prior to Principal Component analysis. The figures, of course, pertain to the sample as a whole with no distinction between scheme categories.

Table 4.10

Schemewise Annual Impact

(Figures in Average terms)

	NB	RLI	STW(d)	STW(e)	DTW(e)	STW(e)+DTW(e)	ANNUAL
MainAcre	0.40	6.97	7.22	10.02	9.07	9.53	5.71
TradAcre	-0.59	-2.95	-3.95	-4.82	-3.37	-4.19	-2.82
SubIAcre	-0.10	-0.03	0.30	-0.51	-0.01	-0.29	-0.02
SubIIAcre	-0.37	-0.65	-0.58	-1.24	-0.27	-0.83	-0.59
MainLabAbspM	23.41	206.07	204.25	231.00	210.53	222.93	155.38
TradLabAbspM	-12.82	-48.86	-53.60	-61.50	-35.40	-49.57	-39.60
SubILabAbspM	-6.64	8.50	9.30	2.60	30.22	15.31	5.87
SubIILabAbspM	-20.50	-24.64	-19.20	-42.00	-4.06	-25.44	-22.13
MainLabAbspF	4.23	33.29	30.20	39.50	41.16	40.12	25.48
TradLabAbspF	10.68	1.43	-1.95	-1.90	-0.56	-1.44	2.57
SubILabAbspF	-2.32	10.00	14.15	11.40	6.83	9.19	7.26
SubIILabAbspF	-1.91	-0.93	0.35	-2.10	0.79	-1.17	-0.93
MainSeedCost	6.36	1291.07	1227.50	1475.50	1447.48	1462.05	933.54
TradSeedCost	42.27	-139.14	-175.15	-68.20	-51.91	-60.21	-75.74
SubISeedCost	-7.05	281.21	73.05	33.80	10.48	19.78	75.66
SubIISeedCost	-13.27	-18.57	-13.10	-36.20	4.07	-18.83	-15.58
MainManurCst	164.77	2637.50	2207.50	2550.00	2774.17	2634.25	1785.36
TradManurCst	-25.91	-144.29	-493.00	-432.50	-281.19	-358.71	-255.50
SubIManurCst	-51.14	300.00	223.50	-16.00	198.42	78.26	121.00
SubIIManurCst	-52.73	-44.64	-49.25	-82.50	33.92	-37.10	-46.46
MainFertCst	79.32	1328.93	1237.30	1585.50	1253.22	1441.93	960.15
TradFertCst	182.50	12.50	-18.50	-19.80	29.73	1.22	51.92
SubIFertCst	19.09	140.71	177.50	117.60	129.45	119.19	109.26
SubIIFertCst	1.82	-1.21	-3.75	-17.00	25.77	-0.16	-0.74
MainPestCst	25.00	733.93	752.45	677.30	628.52	658.56	509.84
TradPestCst	74.32	12.14	12.95	-6.20	15.00	1.56	28.27
SubIPestCst	9.09	157.14	153.45	88.50	172.39	124.42	104.17
SubIIPestCst	3.41	5.00	13.75	-18.00	15.00	-5.00	4.46
MainOthCst	167.05	1497.86	1548.25	1665.00	1575.83	1626.05	1147.01
TradOthCst	86.14	-255.00	-268.50	-408.00	-214.88	-321.28	-173.35
SubIOthCst	-18.64	168.93	202.75	30.50	159.97	91.99	103.59
SubIIOthCst	-87.27	-128.57	-78.75	-222.30	8.73	-121.22	-101.04

Source : Sample Survey

Such distinction is made in the subsequent tables which are in difference terms. Table 4.10 repeats schematic averages on the structure of Table 4.7, above, against the annual averages. It can be seen from the table that whereas all irrigation schemes record positive average impact as far as additional acreage and male labour absorption are concerned, these figures are negative for non-beneficiaries indicating leasing-out of their land and labour to the scheme-holders. The point is taken up in the analysis of labour impact in the subsequent chapter. Although average land-use has declined for non-beneficiaries, it is seen that the average impact on their use of other agricultural inputs is positive. These appears to show that, in proximity with scheme- beneficiaries, the non-beneficiaries also absorb, in part, the technological changes resulting from irrigation insofar as these are independent of irrigation itself. However such absorption occurs along the intensive margin leading to higher input commitments to a reduced quantum of land. For scheme- beneficiaries, the impact is along both intensive and extensive margins, as the additional acreage figures indicate. Thus not all the incremental input-use is committed to incremental land; some part of this is applied to the some acreage that was previously cultivated in the pre-irrigation situation. The impact of irrigation, both direct, and indirect (on non-beneficiaries), has been to enhance overall agricultural input-use per unit of cultivated land.

However, differences between schemes are found to exist, which are evident in the table. It can again be noted that additional input-use does not bear any hard and fast relation to incremental acreage since, although a wide difference of upto 2.41 acres per capita separates DTW(e), with the highest incremental land, from STW(d), with the lowest, differences in input-use are not so marked, strengthening the hypothesis that the impact of irrigation is along intensive as well as extensive margins.

Table 4.11 presents the annual impact figures of the Table 4.10 in cost terms. Column-totals represent per capita incremental cost outlays and standard deviations thereof. Percentage outlays are also indicated by the bracketed figures. A large variation is seen between per capita cost outlays for scheme-beneficiaries versus non-beneficiaries, with each scheme-holder investing Rs. 11,000+ as against to a mere Rs. 660 for each non-beneficiary. Among the beneficiaries highest outlay is made by STW(d), although as much as 17.78 % of this is by way of energy costs. Energy costs for RLI(d) and DTW(e) are much lower. Separately indicated in the table are also the adjusted figures for input costs exclusive of energy cost, where it is seen that STW(d) outlays declined considerably. For the electrified sector as a whole, outlays are substantially in excess of those for the diesel sector.

Table 4.11

The Annual Impact : Per Capita Incremental Cost & Percentage Outlays

	NB		RLI(d)		STW(d)		STW(e)		DTW(e)		STW(e)+DTW(e)		ANNUAL	
	Avg	STD	Avg	STD	Avg	STD	Avg	STD	Avg	STD	Avg	STD	Avg	STD
Total Acre	-0.66	0.90	3.34	2.33	2.99	2.06	3.45	2.38	5.20	3.67	4.23	3.15	2.27	2.94
%	(-0.10)		(0.03)		(0.03)		(0.03)		(0.04)		(0.04)		(0.03)	
TotalLabourCost	55.68	677.75	2735.82	1590.19	2834.35	1363.21	2816.49	1385.45	3457.54	1456.00	3101.40	1452.60	2054.58	1826.76
%	(8.43)		(24.69)		(24.37)		(25.33)		(29.57)		(27.27)		(25.05)	
TotalSeedCost	28.32	235.83	1414.57	1109.31	1112.30	994.97	1404.90	971.24	1400.15	924.40	1402.79	950.71	917.08	1042.16
%	(4.29)		(12.77)		(9.56)		(12.63)		(11.98)		(12.33)		(11.19)	
TotalManureCost	35.00	589.39	2748.57	1146.09	1888.75	1205.92	2019.00	1169.76	2688.83	1080.42	2316.70	1178.89	1604.40	1485.96
%	(5.30)		(24.80)		(16.24)		(18.16)		(23.00)		(20.37)		(19.56)	
TotalFertiliserCost	282.73	201.92	1480.93	524.15	1392.55	506.18	1666.30	462.53	1432.04	437.98	1562.18	466.54	1120.58	697.84
%	(42.78)		(13.36)		(11.97)		(14.98)		(12.25)		(13.73)		(13.66)	
TotalPestCost	111.82	167.37	908.21	298.80	932.60	503.89	741.60	276.67	826.97	325.77	779.54	302.48	646.74	490.39
%	(16.92)		(8.20)		(8.02)		(6.67)		(7.07)		(6.85)		(7.88)	
TotalOtherCost	147.27	312.35	1283.21	381.14	1403.75	588.49	1065.20	686.72	1538.45	456.75	1275.53	640.32	976.21	736.98
%	(22.29)		(11.58)		(12.07)		(9.58)		(13.16)		(11.21)		(11.90)	
EnergyCost	0.00	0.00	510.09	376.03	2067.88	1892.81	1406.53	560.49	347.43	192.52	935.82	684.08	883.02	1321.78
%			(4.60)		(17.78)		(12.65)		(2.97)		(8.23)		(10.76)	
TotalCost	660.82	1522.21	11081.41	4322.43	11632.18	4676.05	11120.02	3556.88	11691.41	4082.72	11373.97	3810.18	8203.42	6145.53
%	100		100		100		100		100		100		100	
NetLabourCostMale	-109.16	617.96	2231.48	1524.66	2305.24	1219.92	2219.40	1243.02	2863.30	1233.68	2505.58	1279.53	1622.22	1622.06
%	(-16.52)		(20.14)		(19.82)		(19.96)		(24.49)		(22.03)		(19.77)	
NetLabourCostFemale	164.85	162.92	504.34	247.64	529.11	312.58	597.08	275.14	594.24	358.15	595.82	314.75	432.36	318.25
%	(24.95)		(4.55)		(4.55)		(5.37)		(5.08)		(5.24)		(5.27)	

Source : Sample Survey.

A study of deviation figures brings new facts lights. For example, a markedly high standard deviation is encountered for STW(d) as far as energy costs are concerned. For the other schemes deviations are much less although RLI(d) figures do indicate wider dispersions. This would bear out the observation on greater outlier behaviour in the diesel sector compared to the electrified sector made in the Principal Component analysis. For indexing purposes, another ratio has also been provided, namely the incremental cost:incremental acreage ratio. It is seen here that these ratios are higher for the diesel sector then for the electrified sectors, thus revealing that there is a difference is margins amongst this two sectors : whereas the electrified sector invests along the extensive margin, that diesel sector is more concerned with the intensive margin. It must be remembered, however, that these ratios are obtained on incremental rather than total acreage and therefore tell only a part of the story. Taking into account greater dispersion for the diesel sector, these ratios would also be subject to greater variation for RLI(d) and STW(d) schemes whereas the Allscheme ratio has been adjusted to exclude (zero) energy costs for non-beneficiaries and to subsume their (negative) incremental acreage. Comparing over all schemes STW(e) lays greatest emphasis on fertiliser use, a finding common to the earlier PC analysis, and furthermore, its high seedcost outlay will also point to greater acreage sown relative to STW(d). Percentage distribution indicate schemewise focus over the input-use components.

A question might be raised as to why schemewise differences should exist and as to how they surface. For an answer to such questions, the annual picture is not sufficient. It had earlier been remarked during the PC analysis that scheme-holders optimise their annual investment activity by an intelligent choice of cropping season that somehow reflects on their inherent cost structure, particularly that of energy cost. Table 4.12 pertain to a demonstration of this behaviours through presentation of seasonal factors in cost terms.

Table 4.12

Seasonwise & Schemewise Investment Pattern

(in average cost terms)

BORO	NB	RLI	STW(d)	STW(e)	DTW(e)	STW(e)+DTW(e)	AllScheme
Acre	0.00	0.73	0.86	2.96	1.91	2.49	0.98
LabAbspM	0.00	27.86	27.25	82.00	55.63	70.28	29.73
LabAbspF	0.00	4.64	5.75	16.50	13.00	14.94	6.07
SeedCost	0.00	45.00	42.50	114.50	96.25	106.39	45.88
ManurCost	0.00	364.29	370.00	1140.00	650.00	922.22	393.24
FertCost	0.00	135.71	147.50	511.50	240.63	391.11	160.68
PestCost	0.00	38.57	41.00	124.00	84.38	106.39	44.26
OthCost	0.00	164.29	171.25	452.50	343.75	404.17	175.60

Pre-Kharif	NB	RLI	STW(d)	STW(e)	DTW(e)	STW(e)+DTW(e)	AllScheme
Acre	-0.16	0.33	0.23	-1.70	-0.20	-1.07	-0.18
LabAbspM	-23.23	-9.36	7.55	-37.00	2.50	-19.44	-11.36
LabAbspF	0.23	1.29	5.00	2.00	6.75	4.11	2.66
SeedCost	9.45	8.36	35.75	-23.40	28.25	-0.44	13.95
ManurCost	-13.18	75.36	44.50	-121.00	84.38	-29.72	15.14
FertCost	77.27	88.79	125.05	57.00	86.88	70.28	90.66
PestCost	15.68	59.64	106.50	11.50	80.00	41.94	54.93
OthCost	-62.50	-49.29	74.25	-207.80	53.75	-91.56	-30.11

Kharif	NB	RLI	STW(d)	STW(e)	DTW(e)	STW(e)+DTW(e)	AllScheme
Acre	-0.56	0.52	0.77	0.94	0.29	0.65	0.20
LabAbspM	-1.05	17.86	33.29	-4.90	-1.88	-3.56	10.16
LabAbspF	8.00	12.29	13.32	11.60	10.50	11.11	10.72
SeedCost	35.23	45.36	75.97	34.50	0.63	19.44	43.04
ManurCost	-9.09	123.21	-58.13	-235.00	-31.25	-144.44	-43.92
FertCost	167.05	325.36	332.19	333.80	242.13	293.06	270.95
PestCost	80.23	91.07	124.90	93.60	119.38	105.06	98.82
OthCost	149.53	331.43	501.55	179.50	111.88	149.44	273.92

(continued in next page)

	Rabi NB	RLI	STW(d)	STW(e)	DTW(E)	STW(e)+DTW(e)	AllScheme
Acre	0.06	1.77	1.47	1.25	1.85	1.52	1.12
LabAbspM	7.73	104.71	76.50	90.00	125.63	105.83	68.53
LabAbspF	2.45	25.57	19.75	16.00	21.20	18.67	15.45
SeedCost	-16.36	1315.86	962.00	1279.30	1367.50	1318.50	825.01
ManurCost	57.27	2185.71	1583.00	1235.00	1952.50	1553.89	1236.35
FertCost	38.41	931.07	792.75	764.00	904.38	826.39	602.84
PestCost	15.91	718.93	666.00	512.50	621.25	560.83	457.16
OthCost	60.23	836.79	675.75	641.00	931.88	769.83	546.11

Source : Sample Survey.

Before discussion of the seasonal variations, it is useful to point out that the lowest irrigation impact on whole would be recorded for the kharif season because this season coincides with the primarily rain-fed cultivation season of pre-irrigation times. Highest impact, on the other hand, would be felt during the dry months of the rabi and boro seasons. This, in fact, is borne out in the data.

Table 4.12 for the boro season shows a clear demarcation between preferences of the diesel as against the electrified sector. In acreage terms, the electrified schemes cover the largest component of their incremental acreage during this season. Correspondingly, input-use and by implication, cost outlays thereon are also markedly high for the electrified schemes. Boro cultivation did not exist prior to irrigation and comprises, entirely, the cultivation of highly resource-intensive and highly-productive boro rice that is all of the HYV type. Marketing of boro rice takes place in a sellers' market with commensurately higher prices, unlike kharif rice that often reaches the market under glut conditions. STW(d) and DTW(e) farmers therefore seek maximum returns for their scheme-investment by devoting exclusive attention on boro rice. Because of the water-intensive nature of rice cultivation a significant utilisation of irrigation capacity must be made during this season, with the number of times the crop has to be irrigated being as high as 15 to 20 times per cropping season. This obviously gives the electrified sector a cost advantage relative to STW(d) for whom the energy cost of such irrigation would prove to be prohibitive, with its per acre energy cost at Rs.63. Regarding RLI(d), the explanation is more complex and is not entirely carried by the figures. Boro rice, being non-traditional and practically unheard of in earlier times, requires the will to experiment on the part of cultivator. RLI(d) scheme-holders who otherwise have favourable cost structures, have been shown to lack that element progressivism during the PC analysis. Hence in their case, the problem is probably transitional - before committing themselves to the characteristically high outlays required boro rice, they have chosen to adopt caution while waiting for a demonstration of the benefits from such cultivation. Although a similar explanation might also have been offered for the obvious reluctance of STW(d) cultivators, this is evidently not so from the fact that they are generally progressive and that, inspite of the high irrigation cost they do participate in boro cultivation to a larger extent than RLI(d).

Coming to table 4.12 which relates to the now-outmoded pre-kharif season, it is seen that the diesel schemes are the only significant participants in cultivation during this season. Cropping during pre-kharif season is much less water-intensive with only 2-6 irrigations being required. STW(d) thus finds justifications for incrementing cultivation activity during this season, when it can use to good effect the lingering soil fertility produced by heavy input application during the rabi season. The electrified schemes are already heavily committed to the boro season which overlaps into the pre-kharif season. The negative average over all schemes also points to the general marginalisation of pre-kharif cropping, although higher application of inputs such as fertiliser, manure and pesticides are still reported.

Table 4.13 represents scheme profiles during the kharif season, where irrigation has lowest impact. Nevertheless greatest acreage increments are reported by the small schemes. Certain explanatory details must be noted before entering the data in the table. Analysis of the kharif data by crop i.e. 'main' versus 'trad' versus 'sub I', showed that although the general impact of irrigation has been to generate a shift from traditional indigenous cropping to HYV, schemewise shift patterns have differed. STW(d) is a case in point: the data for kharif with cropwise break-up showed a greater tendency on the part of STW(d) towards retention of indigenous acreage. This is borne out in Table 4.13 in the seed quantity, manure and fertiliser figures. Whereas seed requirements for HYV are lower, STW(d) shows enhancement in incremental seed quantities in contrast to all other schemes where this increment is negative. The drop in manure-use is also less marked for STW(d) while it is very high for the electrified schemes. Fertiliser-use, in incremental terms, is also relatively low for STW(d) compared to STW(e). Since labour requirements per acre are higher for the 'trad' crop, the increment in male labour absorption is substantially high for STW(d). This applies, although in a slightly restricted sense, to RLI(d) where also the shift from indigenous to HYV crops is weaker then for the electrified sector. Thus in the table, increments in male labour absorption are positive for the diesel sector and negative for STW(e) and DTW(e) - this despite the fact that acreage responses for the electrified sector are markedly strong. Further confirmation of this was found in the standard deviation for male labour absorption : in the case of diesel schemes much higher standard deviations attend to the average incremental figures than in the case of the electrified sector, particularly STW(e). On the average male labour increment for STW(d) of 33.29 man-days, the standard deviation is of the order 30, indicating highly-dispersed responses. This point had earlier been touched upon in the comments on outlier behaviour, in the PC analysis. Standard deviation figures are available in the section pertaining to labour impact, in the next chapter.

The rabi season, figures for which are tabulated in Table 8.4, is a season of uniformly high cultivator activity as far as all irrigation schemes are concerned. However, the larger schemes i.e. DTW(e) and RLI(d) report relatively higher acreage increments. Additional acreage, between STW(d) and STW(e), is lower for the latter. Labour man-day creation is more complex, with non-uniform variations between male versus female labour absorption. For instance, male labour absorption is higher for STW(e) than for STW(d), but in the case of female labour an opposite pattern prevails. So also between RLI(d) and DTW(e), DTW(e) also shows the highest incremental acreage, overall, in the rabi season, but comparison with RLI(d) places the latter in a better position as far as most inputs are concerned. The bulk of annual manuring is done during the rabi season where the crop consists entirely of vegetables except for some rare instances of wheat. Cooch Behar of course is not traditionally either a wheat-producing or a wheat-consuming area. The choice of the appropriate vegetable-crop by different scheme-holders is thus guided by considerations of risk, marketability and price volatility etc. There has been a tendency for cultivators in the district to diversify from potatoes to green vegetables concomitant to the growth of the urban markets. The disease-proneness of the potato crop is an added risk factor therein, although a steadier price is guaranteed.

From the table, the highest cropping shift to green vegetables is revealed by the diesel schemes, thus explaining lower seed requirement. The electrified schemes show lesser shifts and still concentrate heavily on potatoes. For added clarity, the table also includes an entry for average seed costs which resolves this point of confusion, and considerably reduces the apparent dissimilarities between diesel and electrified schemes into a more compatible set of cost figures.

4.8 Conclusions

The study of average seasonal responses throws light on differential behaviour of scheme-beneficiaries which explain their relative standings in the PC-scores. Since each irrigation scheme is subject to its own ordered constraints relating to investment capacities, a primary determinant of which is the energy cost embodied in the scheme, cultivators seek optimise annual performance and thus earnings, by recourse to specialised cropping patterns and to seasonal choice. On the whole, the performance of the electrified sector, particularly of STW(e), is significantly better; this is borne out in both the PC-analysis and the analysis of averages. In the diesel sector, STW(d) is an active participant throughout the agricultural year, faced though it is by the burden of heavy energy cost. RLI(d) is less progressive on the whole, which is why it has not been able match up to the progress achieved by STW(e), with the comparable energy cost, or the other schemes. In general progressive electrificaton of the diesel schemes would first of all produce significant positive impact on the performances of the cultivators who are presently STW(d) beneficiaries, eventually followed, through demonstration, by the present RLI(d) beneficiaries. Also, an accelerated programmes of rural electrification would see highly productive use being made of electricity as an energy source for irrigation, at the same time bringing more and more of the present non-beneficiary group into progressive agriculture.

Although overall features of the research study are by and large covered in the present chapter insofar as they pertain to broad agrarian impact of electricity use, certain interesting features that broaden the study framework into well-defined extensions are the subjects of the subsequent chapter. These pertain to labour impact, land-use dynamics and specialised energy impact. These extensions are broadly independent of the PC analysis that forms the core of the present chapter.