# MULTIVARIATE ANALYSIS OF SOME DRAINAGE BASINS OF SINGANAMA AREA, HOSHANGABAD DISTRICT, MADHYA PRADESH

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ABSTRACT : Third order darinage basin data for three distinct stratigraphic formation are factor anlysed. The factor analysis has helped in discetning the pattern of relationship amongst the parameters, their variances and identification of important parameters, from the multidimensional framework.

## Introduction

The morphometric data (Verma, 1972) for 18 parameters and 134 third order drainage basins have been used in this paper. Fiftyone, thirty-seven and eighteen drainage basins have been sampled from the three distinct stratigraphic formations, namely the Pachmarhi, the Bagra and Denwa formations and the Recent Alluvium respectively, included in the Survey of India topographic sheet no. 55 J/6; they have also been referred as regions III, II and I respectively. These three sets of data have been factor analysed. The results of the factor analysis have been reproduced in three tables (II to IV);. each divided into two parts. The part A consists of number of factor extracted, their variance in percentage. Part B is the rotated factor matrix which has been used to finally screen out the parameter interms of their relative importance. Anderson (1958), Blackith & Reyment (1971), Mather (1976), and Smith (1975) provided necessary help for the application of factor analysis to this problem. A factor analysis programme was prepared with the help sub-routines like EIGEN, CORRE, and LOAD, taken from the IBM 360/44 computer of Delhi University. The loadings of factor on variables have been interpreted and the variation,

regularity, interdependency and the pattern in the data has been delineated. The entires in the rotated factor matrix are the loadings. By comparing the factor loadings for all factors and variables, those particular variables involved in an independent factor can be defined, and those variables most closely related to a factor can be delineated. The column headed $h^2$ displays the communality of each variable. This is the proportion of a variables total variance that is accounted for by the factors and is the sum of the squared loadings for a variable. The per cent. of variance in a variable XJ accounted for by the factor is $h^2j \times 100$.

## Table I

| | |
|---|---|
| FRQn | Frequency of nth order stream |
| LNTn | Length of nth order stream |
| BLNT | Basin Length |
| AREA | Area of the basin |
| RELF | Relief of the basin |
| BFRn | Bifurcation ratio of FRQn/FRQn+1 |
| LNRn | Ratio of length of n/n+1 in order of stream |
| SFRQ | Stream frequency |
| DDEN | Drainage Density |
| DTXT | Drainage Texture |
| BSHP | Basin shape |
| BSLP | Basin slope |
| RGNO | Ruggedness number. |

## Region I

A total of 5 factors were extracted accounting 53.3, 17.6, 10.1, 9.8 and 9.1 per cent. of variance respectively. Most of the variables show very high values of communalities excepting RELF and LNR1; communality of LNR1 being the lowest. These two variables have a higher amount of unique variance. Very high communality (above 0.90) are shown by FRQ2, LNT2, AREA, BFR2, SFRQ, DDEN and DTXT. These variables have very low unique variance and are practically wholly explanable through other variables.

### Variance of a variable accounted for by all the factors

Factors 1 and 2 account for 77.06 per cent. of variance in FRQ1. Factor 1 accounts for 92.16 per cent. of variance in FRQ2. 73.43 per cent. of variance is accounted for by the first 3 factors in LNT1. 86.12 per cent. and 71.25 per cent. of variance are accounted for by the first two factors in LNT2 and LNT3 respectively. In BLNT 75.39 per cent. of variance is accounted for by factors 1, 2 and 5. 88.45 per cent. of variance in AREA is accounted for by first two factors. 52.88 per cent. of variance in RFLF is accounted for by factors 2 and 4. In BER1 68.89 per cent. of variance in BFR2 is accounted for by factors 2 alone: similarly, 92.16 per cent. of variance in BFR2 is accounted for by factors 1 alone. All other factors account for a very low variance. The highest amongst them is accounted for by factor 2 (28.09 per cent.). 79.34 per cent. of variance in LNR2 is accounted for by factors 1, 3 and 4. The first three factors account for 91.09 per cent. of variance in SFRQ. Factor 2 alone accounts for 44.89 per cent. of variance in DDEN. Factors 2 and 3 together account for 78.25 per cent. of variance in DTXT. 81.0 per cent. of variance in BSHP is accounted for by factor 5. Factors 3 and 5 together account for 64.23 per cent. of variance in BSLP. 73.96 per cent. of variance in RGNO is accounted for by factor 4 alone.

### Factor 1

The loadings of first factor show that it has a positive correlation with FRQ2, LNT1, AREA and BFR2. Factor 1 accounts for a variance of 92.16, 38.44, 44.89 and 92.16 per cent. respectively.

### Factor 2

Factor 2 has high loadings on FRQ1, LNT2, BFR1, LNR1, SFRQ, DDEN and DTXT, accounting a variance of 42.25, 54.76, 68.89, 28.09, 39.69, 44.89 and 42.25 per cent. respectively. Factor 2 has positive correlation with first three variables and negative with the remaining four.

### Factor 3

Loadings of 3rd factor show that it has a positive correlation with LNR2, accounting a variance of 44.89 per cent.

### Factor 4

It has high positive correlation with RELF and RGNO accounting 38.44 and 73.96 per cent. respectively.

### Factor 5

Loadings of 5th factor show that it has a positive correlation with BLNT and a negative correlation with B3HP and BSLP accounting 34.81, 81.0 and 97.21 per cent. of variance respectively.

## Region II

A total of 5 factors were extracted accounting 49.6, 18.1, 13.6, 10.0 and 8.7 per cent. respectively. Most of the parameters show communality values above 80 per cent. excepting BFR1, LNR1, LNR2 and BSHP; and communality for LNR2 being the lowest.

### Variance of a variable accounted for by all the factors

Factor 1 accounts for 88.36 per cent. of variance in FRQ1 and the same factor accounts for 86.49 per cent. of variance in FRQ2. Factor 1 and 4 together account for 87.38 per cent. of variance in LNT1 and factors 1 and 3 accounting for 89.96 per cent. of variance in LNT1. 81.0 per cent. of

variance is accounted for by factor 1 in LNT3. Variance in BLNT is solely accounted for by factor 1, the figure 59.29 per cent. 73.96 per cent. of variance is accounted for by factors 1 in AREA. 62.41 per cent. of variance in RELF is accounted by factor 5. Factors 1 and 3 together account for 39 04 per cent. in BFR1. Factor 1 alone accounts for 86 49 per cent. of variance in BFR2. 46.24 and 18.49 per cent of variance is accounted for by factor 3 for LNR1 and LNR2 respectively. 82.33 per cent. of variance in SFRG is being accounted by factors 2 and 4; of this factors 2 and 4; factor 2 accounting for 59.29 per cent. of variance. 77.44 per cent. of variance in DDEN is accounted for by factor 2 alone and 94.09 per cent. of variance in DTXT being accounted for by factor 2 alone. Factors 2 and 4 together are accounting for 37.16 per cent. of variance in B3HP. Factor 1 and 4 together account for 42.5 per cent. of variance in BSLP and factor 2 and 5 account for 70.93 per cent. of variance in RGNO.

## Factor 1

Loadings of first factor show that it has high positive correlation with FRQ1, FRQ2, LNT1, LNT, LNT3, BLNT, AREA and BFR2. This factor accounts for more than 50 per cent. of variance in the said variables.

## Factor 2

SFRQ, DDEN and DTXT are found to have high positive correlation with factor 2. This factor accounts for 59.29, 77.44 and 94.09 per cent. of variance in SFRQ, DDEN and DIXT respectively.

## Factor 3

BFR1, LNR1 and LNR2 are found to have high correlation with this factor; the correlation of LNR1 being of negative in nature. This factor accounts for 39.04, 46.24 and 18.49 per cent. of variance in BFR1, LNR1 and LNR2 resepctively.

## Factor 4

This factor in general has low correlation with all the variables. With BSHP it has

negative correlation explaining nearly 19.0 per cent. variance in it.

## Factor 5

RELF, BSLP and RGNO have high positive correlation with an factor, explaining 62.41, 53.29 and 53.29 per cent. of variance respectively.

## Region III

Seven independent factors have been extracted with variance of 41.8, 16.9, 13.8, 9.1, 7.9, 6.7 and 3.8 per cent. respectively. All the variables show very high communality values excepting LNR1 and LNR2 which show communality of 59.0 and 42.0 per cent. respectively.

## Variance of a variable accounted by all the factors

95.36 per cent. of variance in FRQ1 is accounted for by factors 1 and 5 of which factor 1 alone accounts for 64.0 per cent. Factor 1 alone accounts for nearly 96.0 per cent. of variance in FRQ2. 73.45 per cent. of variance is accounted for by factors 1 and 5 in LNT1. 72·32 per cent. of variance in LNT2 is accounted for by factors 1 and 6. 65.16 per cent. of variance in LNT3 is accounted for by factors 1 and 4. In BLNT 82.42 per cent. of variance is accounted for by factor 1 and 4. 54.76 per cent. of variance in AREA is accounted for by factor 1 alone. 92.16 per cent. of variance in RELF is accounted for by factor 5 alone variance in BFR2 is accounted for by factor 1 alone; the figure being 96.04 per cent. 51.84 per cent. of variance in LNR1 is accounted for by factor 6 and 31.36 per cent. of variance in LNR2 is accounted for by the same factor. Factor 2 accounts for 54.76 per cent. of variance in SFRQ. 75.69 per cent. of variance in DDEN is accounted for by factor 2 alone, and 92.16 per cent. of variance in DTXT is accounted for by the same factor. Factor 4 accounts for 72.25 per cent. of variance in BSHP; and factor 3 accounts for 64.0 and 94.09 per cent. of variance in BSLP and RGNO respectively.

## Factor 1

FRQ1, FRQ2, LNT1, LNT2, LNT3, AREA and BFR 2 show high positive correlation with factor 1 and factor 1 having found to account for 64.0, 96.04, 50.41, 40.96, 36.0, 54.76 and 96.04 per cent. of variance in the above mentioned variables respectively.

## Factor 2

SFRQ, DDEN and DTXT show high positive correlation with factor 2 having 54.76, 75.69 and 92.16 per cent. of explanable variance in SFRQ$_2$ DDEN and DTXT respectively.

## Factor 3

RELF, BSLP and RGNO show high positive correlation with this factor. This factor explains 92.16, 64.0 and 94.09 per cent. of variance in RELF, BSLP and RGNO respectively.

## Factor 4

BLNT shows high posstive correlation with factor 4. This factor explains 47.61 per cent. of variance in BLNT. BSHP shows high negative correlation with this factor having 72.25 per cent. of variance in it being explained by this factor.

## Factor 5

BFR1 is the only variable which shows high positive correlation with this factor, having 77.44 per cent. of explanable variance due to this factor.

## Factor 6

LNR1 shows negative correlation with the factor and LNR2 shows high positive correlation with this factor. This factor alone explains 51.84 and 31.36 per cent. of variance in LNR1 and LNR2 respectively.

## Factor 7

None of the variables has very high correlation with this factor, and hence this factor has been dropped from the analysis.

### REGION I                                 TABLE II A

| FACTOR | EIGEN VALUE | PCT OF VAR | CUM PCT |
|---|---|---|---|
| 1 | 9.00 | 53.3 | 53.3 |
| 2 | 2.96 | 17.6 | 70.9 |
| 3 | 1.70 | 10.1 | 81.0 |
| 4 | 1.65 | 9.8 | 90.9 |
| 5. | 1.54 | 9.1 | 100.0 |

| VARIABLES | ROTATED FACTOR MATRIX FACTORS | | | | | II B |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | h² |
| 1 | 0.59 | 0.65 | −0.01 | 0.02 | 0.25 | 0.83 |
| 2 | 0.96 | 0.02 | 0.04 | −0.03 | 0.14 | 0.96 |
| 3 | 0.62 | 0.47 | 0.36 | 0·19 | 0.20 | 0.84 |
| 4 | 0.56 | 0.74 | 0.21 | 0.15 | 0.15 | 0.97 |
| 5 | 0.68 | 0.50 | −0.01 | 0.26 | 0.06 | 0.80 |
| 6 | 0.47 | 0.43 | −0.05 | 0.04 | 0.59 | 0.77 |
| 7 | 0.67 | 0.66 | 0.20 | 0.01 | −0.05 | 0.93 |
| 8 | 0.20 | 0.38 | 0.16 | 0.62 | −0.14 | 0.62 |
| 9 | −0.05 | 0.83 | −0.06 | 0.05 | 0.17 | 0.73 |

|    | 1 | 2 | 3 | 4 | 5 | h² |
|----|------|-------|-------|-------|-------|------|
| 10 | 0.96 | 0.02 | 0.04 | −0.03 | 0.14 | 0.96 |
| 11 | −0.13 | −0.53 | −0.04 | 0.15 | −0.05 | 0.34 |
| 12 | −0.42 | 0.06 | −0.67 | −0.41 | 0.07 | 0.82 |
| 13 | −0.36 | −0.63 | −0.62 | 0.10 | 0.11 | 0.95 |
| 14 | −0.32 | −0.67 | −0.29 | 0.43 | 0.28 | 0.91 |
| 15 | −0.33 | −0.65 | −0.60 | 0.24 | 0.12 | 0.97 |
| 16 | −0.16 | −0.01 | 0.08 | −0.13 | −0.90 | 0.86 |
| 17 | −0.15 | −0.32 | −0.52 | 0.30 | −0.61 | 0.87 |
| 18 | −0.02 | −0.18 | −0.05 | 0.86 | 0.16 | 0.80 |

## REGION II                         TABLE III A

| FACTOR | EIGEN VALUE | PCT OF VAR | CUM PCT |
|--------|-------------|------------|---------|
| 1  | 8.27 | 49.6 | 49.6 |
| 2. | 3.01 | 18.1 | 67.7 |
| 3. | 2.26 | 13.6 | 81.3 |
| 4  | 1.67 | 10.0 | 91.3 |
| 5  | 1.44 | 8.7 | 100.0 |

## ROTATED FACTOR MATRIX FACTORS        III B

|     | 1 | 2 | 3 | 4 | 5 | h² |
|-----|------|-------|-------|-------|-------|------|
| 1   | 0.94 | 0.01 | 0.20 | 0.03 | 0.15 | 0.96 |
| 2.  | 0.93 | −0.04 | −0.07 | −0.10 | −0.02 | 0.89 |
| 3   | 0.83 | 0.04 | 0.10 | 0.43 | 0.16 | 0.92 |
| 4   | 0.70 | −0.01 | 0.64 | 0.12 | 0.12 | 0.94 |
| 5   | 0.90 | −0.01 | −0.08 | 0.18 | 0.14 | 0.86 |
| 6   | 0.77 | −0.04 | 0.29 | 0.46 | 0.12 | 0.92 |
| 7   | 0.86 | −0.32 | 0.18 | 0.21 | 0.06 | 0.94 |
| 8   | 0.33 | −0.18 | 0.17 | 0.18 | 0.79 | 0.84 |
| 9   | 0.40 | 0.10 | 0.48 | 0.23 | 0.25 | 0.52 |
| 10  | 0.93 | −0.04 | −0.07 | −0.10 | −0.02 | 0.89 |
| 11  | −0.03 | 0.10 | −0.68 | 0.30 | 0.07 | 0.57 |
| 12. | −0.29 | −0.07 | −0.43 | −0.10 | 0.05 | 0.29 |
| 13  | −0.23 | 0.77 | −0.17 | −0.48 | −0.13 | 0.93 |
| 14  | 0.02 | 0.88 | 0.02 | 0.39 | 0.06 | 0.94 |
| 15. | −0.17 | 0.97 | −0.09 | −0.01 | −0.06 | 0.98 |
| 16  | −0.24 | −0.40 | −0.18 | −0.46 | −0.04 | 0.47 |
| 17  | −0.49 | −0.16 | −0.15 | −0.43 | 0.73 | 1.00 |
| 18  | 0.36 | 0.42 | 0.17 | 0.32 | 0.73 | 0.99 |

**REGION III**                        **TABLE IV A**

| | EIGEN VALUE | PCT OF VAR | CUM PCT |
|---|---|---|---|
| 1 | 7.28 | 41.8 | 41.8 |
| 2 | 2.94 | 16.9 | 58.8 |
| 3 | 2.40 | 13.8 | 72.8 |
| 4 | 1.58 | 9.1 | 81.7 |
| 5 | 1.37 | 7.9 | 89.5 |
| 6 | 1.16 | 6.7 | 96.2 |
| 7 | 0.66 | 3.8 | 100.0 |

**ROTATED FACTOR MATRIX**             **IV B**

| VARIABLES | 1 | 2 | 3 | 4 | 5 | 6 | 7 | $h^2$ |
|---|---|---|---|---|---|---|---|---|
| 1 | -0.87 | -0.14 | 0.17 | 0.20 | 0.01 | 0.32 | -0.12 | 0 98 |
| 2 | -0.72 | -0.13 | 0.43 | 0.29 | 0.37 | -0.15 | 0.04 | 0.98 |
| 3. | -0.85 | -0.05 | 0.14 | -0.04 | -0.03 | 0.32 | 0.30 | 0.96 |
| 4 | -0.85 | 0.11 | -0.09 | 0.37 | -0.14 | -0.08 | 0.01 | 0.92 |
| 5 | -0.74 | -0.03 | 0.35 | -0.34 | -0.01 | -0.01 | 0.15 | 0.82 |
| 6 | -0.90 | 0.09 | 0.11 | -0.28 | -0.11 | -0.24 | -0.10 | 1.00 |
| 7 | -0.96 | -0.11 | -0.06 | 0.01 | 0.05 | 0.14 | 0.02 | 0.97 |
| 8 | -0.12 | -0.93 | -0.14 | 0.04 | -0.17 | 0.22 | -0.04 | 0.99 |
| 9 | -0.45 | -0.08 | -0.16 | -0.01 | -0.43 | 0.56 | -0.22 | 0.81 |
| 10 | -0.72 | -0.13 | 0.43 | 0.29 | 0.37 | -0.15 | 0.04 | 0.98 |
| 11 | 0.24 | -0.34 | 0.22 | -0.48 | 0.07 | 0.35 | -0.02 | 0.59 |
| 12 | 0.14 | 0.28 | -0.31 | 0.45 | -0.09 | -0.08 | 0.08 | 0.43 |
| 13 | 0.70 | 0.01 | 0.49 | 0.36 | -0.01 | 0.18 | -0.13 | 0.91 |
| 14 | 0.17 | 0.19 | 0.73 | 0.03 | -0.51 | -0.03 | 0.22 | 0.92 |
| 15 | 0.58 | 0.10 | 0.69 | 0.31 | -0.26 | 0-11 | -0.01 | 1.00 |
| 16 | 0.25 | -0.33 | -0.31 | 0.41 | 0.31 | 0.43 | 0.15 | 0.75 |
| 17 | 0.32 | -0.85 | -0.11 | 0.15 | -0.06 | 0.01 | 0.04 | 0.87 |
| 18 | -0.02 | -0.87 | 0.09 | 0.04 | -0.36 | -0.25 | 0.07 | 0.98 |

## Conclusions

RELF and LNR1 in ' region I, BFR1, LNR1, LNR2, BSHP in region II and LNR1, LNR2 in region III are found to have very high unique variance. Unique variance is that part of the variance which is not explained by other variables in the system. For the unique variance of relief, length ratio and basin shape the explanation is to be sought from some other component of drainage basin which has not been included in this study.

From the factor analysis of morphometric data for the three regions the following cluster of variable have emerged.

### REGION I

FACTOR 1   FRQ2, LNT1, AREA, BFR2.

       2   FRQ1, LNT2, BFR1, LNR1, SFRQ, DDEN, DTXT.

       3   LNR2

4 RELF, RGNO
5 BLNT, BSHP, BSLP

REGION II

FACTOR 1 FRQ1, FRQ2, LNT1, LNT2, LNT3, BLNT, AREA, BFR2
2 SFRQ, DDEN, DTXT
3 BFR1, LNR1, LNR2
4 BSHP
5 RELF, BSLP, RGNO.

REGION III

FACTOR

1 FRQ1, FRQ2, LNT1, LNT2, LNT3, AREA, BFR2
2 SFRQ, DDEN, DTXT
3 RELF, BSLP, RGNO
4 BLNT, BSHP

5 BFR1
6 LNR1, LNR2.

From these groupings of variables in three different regions it may be concluded that the drainage basin parameters such as FRQ1, FRQ2, LNT1, LNT2, LNT3, AREA, BFR2, SFRQ, DDEN and DTXT are the most important ones so far as the variance in drainage basins are concerned since these parameters collectively explain a major part of total variance in a drainage basin. The remaining parameters are, however, found to cluster differently in the three regions; they also contribute less significantly to the total variance in a drainage basin.

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