RAY: International Journal of Multidisciplinary Studies, E-ISSN: 2456-3064
Volume III, No. 2, October, 2018, pp. 48-60.

Spatial Inequalities in the Pattern of Functional Effectiveness of Murshidabad District: A Multivariate Statistical Analysis

Iftikar Alam
Assistant Professor,
Department of Geography
Chakdaha College,
Nadia, India.
iftikar.emill@gmail.com

Structured Abstract:

Introduction: Human activity is interdependent and interconnected in areas. All the administrative areas occupy space on the earth surface. Location of these administrative areas presents a peculiar arrangement in space. Spatial variation in such phenomena as levels of living, opportunities of employment, economic development and infrastructure development produce an interesting and important geography of functional quality of administrative areas.

Purpose: It is in the light of the above ideas that an attempt has been made to measure the level of functional quality of Community Development Blocks of Murshidabad district based on 17 variables by multivariate statistical technique like factorial analysis. The study also aims to create combined weighted component score to categorise the blocks according to their level of functional quality.

Methodology: In order to analyze the variation in the level of functional quality of C.D. Blocks of Murshidabad district I have used the factor analysis method, the most used multivariate techniques.

Findings: The study shows wide ranging disparities in the level functional quality among the C.D. Blocks.

Keywords: Factor, Variance, Functional Quality, Spatial Variation, Variable, Loading, Varimax Rotation, Eigenvalue, Combined Weighted Component Score.

Paper Type: Case Studies.

Introduction

One of the primary concerns of the geographers is concerned with the areas on the surface of the earth. Hartshorne (1950) and Jones (1954) expressed their views and recognized that political areas formed functional as well as formal region. Any administrative areas can be best understood through the study of their peculiar milieu and the purpose they adopted and function operated within them. Spatial considerations are of prime importance for a reasonable, efficient and effective functioning of any politically organized area (Whitney, 1970). Functional quality of administrative areas involves a complex interaction between political, social, cultural and economic factors. There is a spatial variation in such phenomena as level of living, opportunities of employment and local economic development. Functional quality of blocks reflects the overall development patterns of the blocks. Spatial variation in such level of socio-economic development is a multi- dimensional phenomenon (Thurstone, 1949; Berry, 1960; Thompson, 1962) and can be studied by multivariate statistical techniques like factorial analysis. The goal of factor analysis is to reduce "the dimensionality of the original space and to give an interpretation to the new space, spanned by a reduced number of new dimensions which are supposed to underlie the old ones" (Rietveld & Van Hout, 1993), or to explain the variance in the observed variables in terms of underlying latent factors" (Habing, 2003). Thus, factor analysis offers not only the possibility of gaining a clear view of the data, but also the possibility of using the output in subsequent analyses (Field 2000; Rietveld & Van Hout 1993).

In the light of the above discussion an attempt has been made in this paper to bring out the level of variation in the functional effectiveness of C.D. Blocks of Murshidabad district based on certain selected variables using factor analysis technique. It also makes an attempt to analyze the spatial variation in the functional quality of C.D. Blocks of Murshidabad district.

Study Area

The study area includes the entire C.D. Blocks of Murshidabad district. Murshidabad district is the northern most district of the presidency division in the state of West Bengal. The district of Murshidabad lies between 23°45′30″ and 24°52′30″ North latitudes and 87°57′30″ to 88°46′15″ East longitude. The district belongs to Moribund Delta of the State and divided into two parts by the Bhagirathi River, which is flowing from North to South direction. In 2011, the number of population in the district is 71, 02,430, of which 80.28 percent resided in the rural areas and remaining 19.72 percent resided in urban areas. There are 7 municipal towns and 26 C.D. Blocks in the district at present.

Objective

The main objective of the study is to evaluate the spatial structure of the C.D. Blocks in terms of their functional qualities based on certain selected variables. It also aims to categorise the blocks in terms of levels of functional effectiveness based on combined weighted composite score (CWCS) created by using the method of factorial analysis.

Methodology

In order to analyze the variation in the level of functional quality of C.D. Blocks of Murshidabad district I have used the factor analysis method, the most used multivariate techniques.

There are important methods of factor analysis. In this study, a principal component method of factor analysis has been used. The method of principal component analysis (PCA) is a special case of more general method of factor analysis. Its aim is to construct, out of a set of variables, ([X.sub.i])'s (i=1, 2 …, x), a new set of variables ([P.sub.i]) called principal components, which are linear combination of the X's (Hotelling, 1933). Mathematically it could be presented as follows:

[P.sub.i]= [m. summation over (i=1)] [n. summation over (i=1)] [a.sub.ij] [2.sub.ij]

Where, [a.sub.ij]'s are called loading of the factors (principal component). These are chosen in such a way that the constructed principal components satisfy two conditions: (a) the principal components are uncorrelated (orthogonal) and (b) the first principal component [P.sub.1] absorbs and accounts for the maximum possible proportion of the total variation in the set X's and the second principal component absorbs the next maximum variance and so on.

Using the factor loadings of these principal components, factor score for each C.D. Blocks is computed as fallows.

$$(FS)_{jk} = a_{ij} \times Z_i$$

Where, $FS_{j\,k}$ represents factor scores of k^{th} C.D. Blocks and j^{th} factor.

Z_i is the standardized value of i^{th} variable.

a_{ij} is the factor loading of j^{th} factor and i^{th} variable.

To compute Combined Weighted Component Scores (CWCS), these individual factor scores are adding using following equation.

$$(WCS)\ k = e_j\ (FS\ )_{jk}$$

Where WCS is Weighted Component Scores, e_j is the eigenvalue of the factor j and depicts the proportion of variation in the data set explained by the factor j.

This CWCS in used as an index for rankings of C.D. Blocks on the basis of the general, characteristics of the variable set.

The Variables

The variables are measures calculated from information drawn from various sources like District Census Hand book (2016), Statistical Handbook of West Bengal (2016) and the District Statistical Handbook (2016). In this study, variables from various sectors like population, health, agriculture, literacy, employment, transport and income have been selected. The following list of seventeen variables together with their abbreviated names is provided in **Table 1**.

Factor Analysis and Interpretation of the Result

The factor analysis starts with the correlation matrix of the original set of seventeen variables. As the variables are not standardized, the correlation matrix is used as an input to PCA to extract the factors. Co-efficient of correlation analysis has been attempted to see the degree of relationship among various variables selected to assess the functional quality of C.D. Blocks of Murshidabad district.

Observing the results one can expect that apparent linear relationship between the variables can be explained in terms of four most common factors.

After computing the variances, the next task is to find out first few components which, hopefully, account for a large proportion of the total variance.

Some rules of thumb have been suggested for determining how many factors should be retained (Field, 2000; Rietveld & Van Hout 1993). These rules are as follows:

1. Retain only those factors with an eigenvalue larger than 1 (Guttman-Kaiser rule);
2. Keep the factors which, in total, account for about 70-80% of the variance;
3. Make a scree plot; keep all factors before the breaking point or elbow;

In order to get a realistic result I have applied all the three methods in combination for determining how many factors to be retained for analysis. The components, their eigenvalues and total variance are shown in Table 2.

One of the most commonly used techniques for factor extraction is Kaiser"s criterion, or the eigenvalue rule. Under this rule, only those factors with an eigenvalue (the variances extracted by the factors) of 1.0 or more are retained. Using this criterion, our data reveals four factors. The first four components are extracted as is shown in Table 2 and the other components have been eliminated.

The first principal component accounts for 48.21 of the total variance; the second a further 18.53 %; the third a further 7.79 %; and forth a further 6.38 % making about 81% of the total variance "explained" by four uncorrelated combinations of the original variables. The components can be interpreted in terms of the variables which load "most heavily" onto them (i.e. have the highest component loadings). This means that majority of the variance of the original data has been accounted for by these extracted components. These components are later rotated (Table 3)**.**

For the present study, a graphical method, known as the Catell"s (1966) scree test (in Fig. 1) is also used. These are plots of each of the eigenvalues of the factors. After examining the scree plot (Fig. 1), only four factors are extracted for analysis. It is furthermore always important to check the communalities after factor extraction. If the communalities are low, the extracted factors account for only a little part of the variance, and more factors might be retained in order to provide a better account of the variance.

Perusal of the factor loadings clearly reveals that communality value of all the variables varies between 0.958 and 0.415 (i.e. 95.8 per cent and 41.5 per cent) suggesting that the four factors derived are sufficient to account for most of the variation.

In principal components analysis, the variables are rotated to obtain new variables. Varimax rotation is the most widely used rotation in principal component analysis. This is an orthogonal procedure i.e. it produces uncorrelated factors. This technique tends to eliminate medium-range correlations between the components and the original variables, thus simplifying the decision as to which of the original variables to include in the components extracted (Chatfield & Collins, 1980). The results of PCA using varimax rotation are presented in Table 3. The first decision to be made at this stage is to decide how large a factor loading to be considered "large." This is dependent of the sample size (Field, 2000), the bigger the sample the smaller the loadings can be to be significant.

Stevens (1992) then "recommends interpreting only factor loadings with an absolute value greater than 0.4 (which explain around 16% of variance)". In general, component loadings (Correlation Coefficients) of larger than 0.6, may be taken into consideration in the interpretation (Mahloch, 1974). I have chosen for a value of 0.60 because the sample is not very big.

Factor 1: Agricultural Development and Employment

First four factors accounted for 81 per cent of the total variance in the data. First factor combined at least nine variables of CULTV, SEDST, IRIAR, SMFAR, MAGFAR, ALLAB, HOIWOR, BANKBR, and LITRT. For the first factor, all the variables except HOIWOR show markedly higher positive loadings, while HOIWOR shows strong negative factor loadings. The variables from agricultural sector have relatively high positive loadings on this factor which monitor the level of agricultural development of a block. As far as employment is concerned there is high positive loading of agricultural labourers on this factor. On the other hand, negative load on household industrial workers signifies the fact that with agricultural development the numbers of household industrial workers decreases. There is high positive relationship between literacy and agricultural development. The first factor accounted for 48.21 per cent of the total variation is a reasonable representation of the effect of agricultural development and employment on level of functional quality of C.D. Blocks of Murshidabad district.

Factor 2: Urbanization and Health

As shown in Table 3, at least three variables load heavily on this component. These are URBPOP, NOHOSP and TODOC. This factor emerges out in continuation of factor 1. For the second factor, all the variables show strong positive factor loadings. The second factor accounted for 18.53 per cent of the variance. We may interpret this factor as a measure of urban population and health facilities on functional quality of C.D. Blocks. Certainly, if there is larger urban population and number of hospitals and doctors in the C.D. Blocks is high, then the level of functional quality of the C.D. Blocks will be high.

Factor 3: Educational Development

This factor includes three variables. These are primary enrolment (PRYEN), secondary enrolment (SECONEN) and LENROD. The third factor accounted for 7.79 per cent of the variations. This factor can be termed as factor of educational development. For the third factor, all the variables show strong positive factor loadings. So, there is positive relationship between educational development and functional quality of C.D. Blocks.

Factor 4: Water and Lectricity

This factor includes at least two variables. These are number of mouzas electrified (MOEL) and mouzas having drinking water facilities (MODW). The fourth factor accounted for 7.79 per cent of the variations. High loadings of this measure signify the fact of high positive correlation between development of electricity and water supply facilities and level of functional quality of C.D. Blocks.

Combined Weighted Component Score (CWCS)

This section presents the combined weighted component score (CWCS) of functional effectiveness of C.D. Blocks, derived from weighted component score of overall functional quality for 26 blocks of Murshidabad district. The first, second, third and fourth principal components are taken into account to determine relative weights of selected variables to reflect maximum possible variation in the overall functional quality. Combined weighted component score (CWCS) explained 81 per cent of total variation.

The combined weighted component score thus worked out is considered as composite index of level of functional effectiveness of C.D. Blocks. Blocks are then ranked according to their combined weighted component score (CWCS)). The ranking of the C.D. Blocks based on factor I, II, III, IV and Combined weighted component score (CWCS) are shown in the following Table 4 . Blocks having the highest factor score on the elicited factor loading depict a better performance in terms of functional quality, while blocks with lower factor scores show poor performance or low level of functional quality.

The first factor (Agricultural development and employment) is concerned; the very high developed C.D. Blocks are Samserganj and Suti-II. Contrary to this, Berhampore, Raghunathganj-II, Farakka and Hariharpara are found to have high agricultural development and hence high level functional quality. There are fourteen C.D. Blocks which are most backward and six C.D. Blocks which are moderately developed as far as first factor is concerned.

The list has completely changed when we take factor two (associated to Urbanization and Health) in consideration. In this list Berhampore is the only Block having very high level functional quality (Table 4). There is no C.D. Block in high and moderately developed category. So, remaining twenty five C.D. Blocks are less developed and hence low level of functional effectiveness as far as factor two is concerned.

When we looked at the factor three we find that C.D. Blocks namely Domkal, Nabagram, Bharatpur-I, and Samserganj came in the category of very high level of functional quality. Contrary to this, fourteen C.D. Blocks came in the category of highly developed in terms of educational development. Only eight C.D. Blocks are poorly developed and hence low level functional quality as per educational development is concerned.

On the basis of combined weighted component score (CWCS) C.D. Blocks are finally identified as very high functional quality (20.77 and above), high functional quality (14.89 – 20.77), moderate functional quality (9.01 – 14.89) and poor functional quality (9.01 and below). C.D. Blocks which are found to have very high functional quality are Berhampore and Samserganj. On the other hand, two blocks namely Suti-II and Domkal recorded high functional quality. About 13 C.D. Blocks are in the category of moderate level functional quality group. So, it is clear that about half of the C.D. Blocks have recorded moderate level of functional quality. Contrary to this, about 10 C.D. Blocks of Murshidabd district have recorded poor level of functional quality.

It is clear from the discussion that the blocks having high score on factor two which is concerned with urbanization and health depict very high level of functional quality and high score on factor one have recorded high level functional quality.

Evaluation of the Results and Conclusions

This paper presents the empirical results of factor analysis to examine the level of functional quality or effectiveness of C.D. Blocks of Murshidabad district. This analysis is carried out with limited numbers of variables but can be extended to larger number of variables. From the seventeen factors in Table 2, the first four factors are sufficient to explain more than 81%

of the total variance of the original data set. C.D. Blocks which are found very high developed in terms of functional quality are Berhampore and Samserganj. On the other hand, two blocks namely Suti-II and Domkal recorded high level functional quality. Contrary to this about 10 C.D. Blocks of Murshidabd district have recorded poor level of functional quality.

The analysis reveals that the functional quality in the northern and central region of the district is relatively better than in rest of the district. The picture in other regions is somewhat mixed as considerable variations in levels of functional quality exist within all the regions. It is clear from the discussion that the blocks having high score on factor two which is concerned with urbanization and health depict very high functional quality and high score on factor one also have recorded high functional quality. Remaining twenty two C.D. Blocks have recorded either moderate or poor level of functional quality. So, the policy makers should, therefore, focus their efforts particularly on the laggard blocks.

References

Bery, B. J. L, (1960). *An Inductive Approach to The Regionalization of Economic Development in Ginsburg,N ed., Essays on Geography and Economic Development*, Department of Geography, University of Chicago, Research Paper No.62, 78-108.

Cattell, R. B. (1966). *The Scree Test for the Number of Factors*. Multivariate Behavioral Research, *1*, 245-276.

Chatfield, C., & Collin, A. J. (1980). "*Introduction to Multivariate Analysis*". Published in the USA by Chapmanand Hall in Association with Methuen, Inc. 733 Third Avenue, New York. 10017, ISBN: 0-412-16030-7.

Field, A. (2000). *Discovering Statistics Using SPSS for Windows*. London – Thousand Oaks –New Delhi: Sage publications.

Habing, B. (2003). *Exploratory Factor Analysis*. Retrieved from http://www.stat.sc.edu/~habing/courses/530EFA.pdf (accessed 10 May 2004).

Hartshorne, R. (1950). *The Functional Approach in Political Geography*, Annals of Association of American Geographer. *44*, 315-348

Hotelling, H. (1933). "*Analysis of a Complex of Statistical Variables into Principal Components*." Journal of Educational Psychology *24*, 417-441, 498-520.

Jones, S. B. (1954). *A Unified Field Theory of Political Geography*. Annals of Association of American Geographer. *24*,111-123

Kaiser, H. F. (1958). "*The Varimax Criterion for Analytic Rotation in Factor Analysis*". Psychometrica. *23*(3).

Mahloch, J. L. (1974). "*Multivariate Techniques for Water Quality Analysis*", J. Environ. Eng. Div. Amer. Soc. Civil Eng., 100, No. EE5, 1119-1132.

Rietveld, T., & Van Hout, R. (1993). *Statistical Techniques for the Study of Language and Language Behaviour*. Berlin – New York: Mouton de Gruyter

Stevens, J. P. (1992). *Applied Multivariate Statistics for the Social Sciences (2nd edition).* Hillsdale, NJ: Erlbaum.

Thompson, J. H. (1962). *Towards A Geography of Economic Health: The Case of New York State*. Annals of Association of American Geographer. *52*, 1-20.

Thurstone, L. L. (1949). *Multi Factor Analysis*. University of Chicago Press, Chicago.

Whitney, J. B. R. (1970). *China Area, Administration and nation Building*. Department of Geography, University of Chicago.

Appendix

Table 1: List of Variables

Abbreviation	Variables
1. URBPOP	Percentage of urban population
2.CULTV	Cultivated area in hactare
3. IRIAR	Total irrigated area in hectare
4. SEST	Number of seed store
5. MOEL	Number of mouzas electrified
6. MODW	Number of mouzas having drinking water facilities
7. LENROD	Length of the road in Km
8. SMFAR	Number of small farmer
9 MAGFAR	Number of marginal farmer
10. ALLAB	Number of agricultural labourers
11. HOIWOR	Number of household workers
12. BANKBR	Number of bank branches
13. NOHOSP	Number of hospitals
14. TODOC	Total number of doctors
15. LITRT	Literacy rate in percent
16. PRYEN	Primary enrolment
17. SECONEN	Secondary enrolment

Source: Author's Compiled.

Table 2: Total Variance Explained By the Principal Components

Factors	Eigen value	% of Variance	Cumulative %
Factor 1	8.197	48.218	48.218
Factor 2	3.150	18.531	66.749
Factor 3	1.326	7.799	74.548
Factor 4	1.084	6.376	80.925
Factor 5	0.913	5.372	86.297
Factor 6	0.751	4.418	90.715
Factor 7	0.518	3.047	93.762
Factor 8	0.328	1.929	95.691
Factor 9	0.234	1.375	97.067
Factor 10	0.180	1.058	98.125
Factor 11	0.105	0.620	98.745
Factor 12	0.094	0.553	99.298
Factor 13	0.056	0.327	99.625
Factor 14	0.042	0.246	99.871
Factor 15	0.017	0.098	99.969
Factor 16	0.005	0.028	99.997
Factor 17	0.000	0.003	100.000

Source: Author's Calculated.

Table 3: Varimax Rotated Factor Loadings

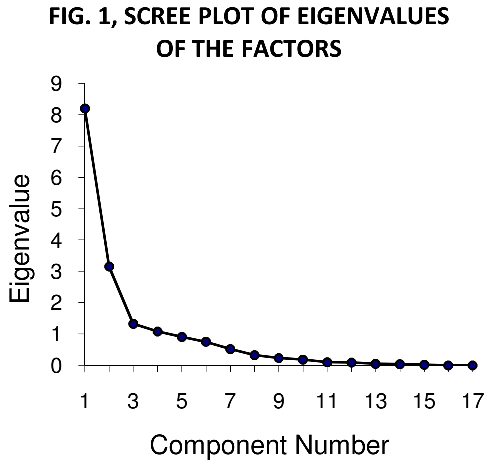
VARIABLES	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
URBPOP	-0.184	0.937	0.172	0.006
CULTV	0.800	0.032	0.124	0.390
SEDST	0.478	0.009	-0.073	0.426
IRIAR	0.864	0.052	0.214	0.073
MOEL	0.386	0.153	0.217	0.846
MODW	0.365	0.165	0.257	0.833
LENROD	0.012	0.068	0.573	0.370
SMFAR	0.823	0.025	0.221	0.344
MAGFAR	0.690	0.201	0.342	0.104
ALLAB	0.833	0.147	0.309	0.225
HOIWOR	-0.817	0.146	0.332	-0.193
BANKBR	0.601	0.467	0.527	0.098
NOHOSP	0.295	0.913	0.147	0.128
TODOC	0.174	0.950	-0.001	0.137
LITRT	0.812	0.291	-0.057	0.310
PRYEN	0.000	0.575	0.708	0.110
SECONEN	0.542	0.016	0.719	0.049

Source: Author's Calculated.

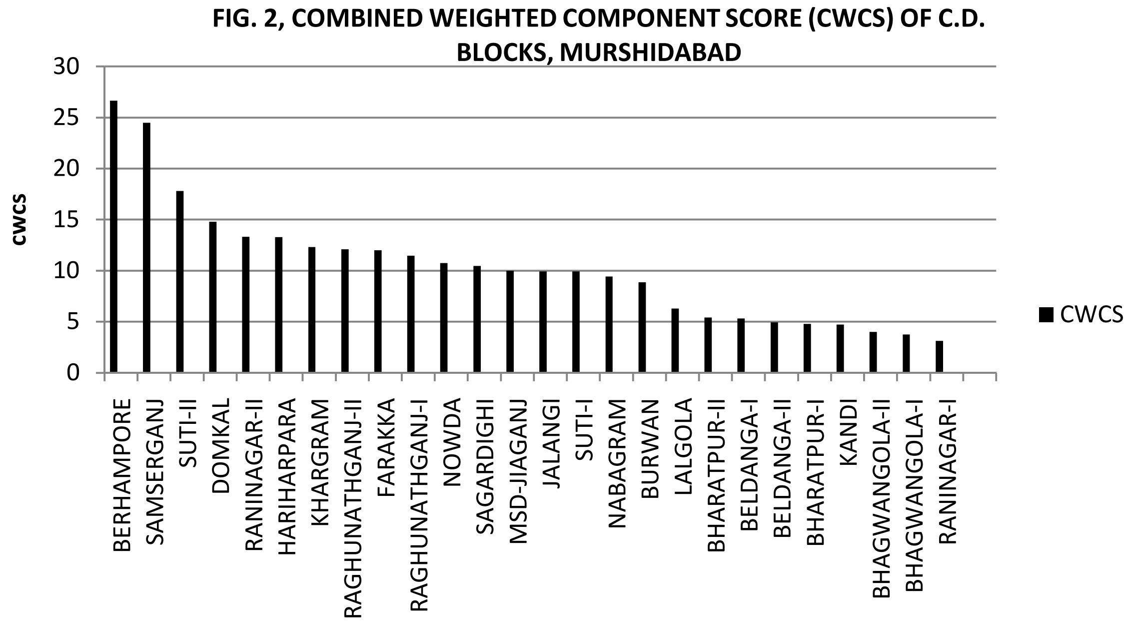
Table 4: Weighted Component Score (WCS) and Combined Weighted Component Score (CWCS) of C.D. Blocks, Murshidabad

NAME OF THE BLOCKS	WCS								CWCS	
	Factor 1	***Rank***	**Factor 2**	***Rank***	**Factor 3**	***Rank***	**Factor 4**	***Rank***	**CWCS**	**Rank**
BERHAMPORE	11.65	*03*	14.05	*01*	0.91	*15*	0.04	*26*	26.65	01
BELDANGA-I	4.15	*17*	0.24	*25*	.095	*25*	0.83	*10*	5.32	20
BELDANGA-II	2.96	*19*	0.98	*18*	0.47	*21*	0.53	*16*	4.94	21
NOWDA	7.81	*11*	0.26	*24*	1.10	*14*	1.59	*06*	10.76	11
HARIHARPARA	10.25	*06*	1.63	*08*	0.66	*19*	0.76	*12*	13.30	06
KANDI	0.54	*25*	1.99	*05*	1.66	*06*	0.53	*17*	4.72	23
KHARGRAM	8.36	*08*	2.01	*04*	1.15	*13*	0.81	*11*	12.33	07
BURWAN	5.27	*13*	0.93	*20*	0.63	*20*	2.05	*03*	8.88	17
BHARATPUR-I	0.46	*26*	1.17	*16*	2.07	*03*	1.10	*07*	4.8	22
BHARATPUR-II	2.68	*21*	0.94	*19*	1.30	*10*	0.49	*18*	5.41	19
FARAKKA	10.52	*05*	0.27	*23*	0.78	*18*	0.45	*21*	12.02	09
SAMSERGANJ	20.32	*01*	1.44	*12*	2.04	*04*	0.67	*13*	24.47	02
SUTI-I	8.05	*10*	0.61	*21*	0.79	*17*	0.48	*19*	9.93	15
SUTI-II	15.06	*02*	1.31	*14*	0.88	*16*	0.54	*15*	17.79	03
RAGHUNATHGANJ-I	8.06	*09*	1.60	*10*	1.35	*09*	0.47	*20*	11.48	10
RAGHUNATHGANJ-II	11.38	*04*	0.06	*26*	0.41	*22*	0.26	*25*	12.11	08
SAGARDIGHI	4.45	*16*	2.18	*03*	1.69	*05*	2.14	*01*	10.46	12
LALGOLA	3.22	*18*	1.20	*15*	1.45	*08*	0.44	*22*	6.31	18
BHAGWANGOLA-I	1.18	*22*	1.06	*17*	1.20	*12*	0.31	*24*	3.75	25
BHAGWANGOLA-II	1.17	*23*	1.87	*07*	0.41	*22*	0.57	*14*	4.02	24
MSD-JIAGANJ	4.72	*15*	1.93	*06*	1.23	*11*	2.12	*02*	10.00	13
NABAGRAM	2.87	*20*	2.74	*02*	2.14	*02*	1.69	*04*	9.44	16
DOMKAL	9.43	*07*	1.62	*09*	2.69	*01*	1.07	*08*	14.81	04
JALANGI	7.59	*12*	1.39	*13*	0.12	*24*	0.84	*09*	9.94	14
RANINAGAR-I	1.03	*24*	0.3	*22*	1.46	*7*	0.34	*23*	3.13	26
RANINAGAR-II	5.05	*14*	1.51	*11*	0.04	*26*	1.68	*05*	13.33	05

Source: Author's Calculated.



Source: Author's Compiled.



Source: Author's Compiled.