# Determination of Surface Water Potential in Southwest Birbhum District, West Bengal

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***Abstract***

*Surface water potential implies the carrying capacity of surface water bodies to sustain water resources for beneficial anthropogenic uses in general and agricultural use in particular. It is the outcome of continuous interaction among climate, vegetation, physiography, soil and drainage network. Being a small geographical unit, climate is more or less homogeneously distributed all over the study area with mean annual temperature 26° C and annual rainfall 1300-1420 mm. More than 93% of the total study area is deforested. Therefore, more or less homogeneous pattern of distribution of these two parameters (climate and vegetation) have lessen their significance in creating spatial variability of surface water potential of the study area. Analysis of surface water potential of Southwest Birbhum district (SWBD) has, therefore, taken into consideration of four relevant parameters, viz, relative relief, ruggedness index, soil available water capacity and drainage density.*

*The present study aims to analyze the methods related to determination of surface water potential, classify SWBD into different surface water potential zones and to analyze the implication of surface water potential zones in the context of SWBD. Based on above four land attributes and field observations the study area has been classified into 8 surface water potential zones e.g. very good (6.79%), good (5.14%), moderately good (9.00%), fair (21.23%), moderately fair (18.08%), poor (28.11%) and very poor (11.65%).*

## Objectives

The main objectives of the present paper are:

- To identify the physical land attributes relevant to determine surface water potential
- To analyse the methods related to assessment of surface water potential
- To classify land into different surface water potential zones
- To analyse the implication of surface water potential in the context of Southwest Birbhum District

## Study area

The study area represents a small tract of Southwest Birbhum District (SWBD), comprising three C.D. blocks, Rajnagar , Khoyrasole and Dubrajpur. The study area is extended from 23°41'4'' N to 24°02'43''N latitudes and from 87° 05'24"E to 87°31'26" E longitudes. The area is bounded by the districts of Dumka and Jamtara of the State of Jharkhand on the west and north. The river Ajay forms the southern boundary of the study area. The eastern

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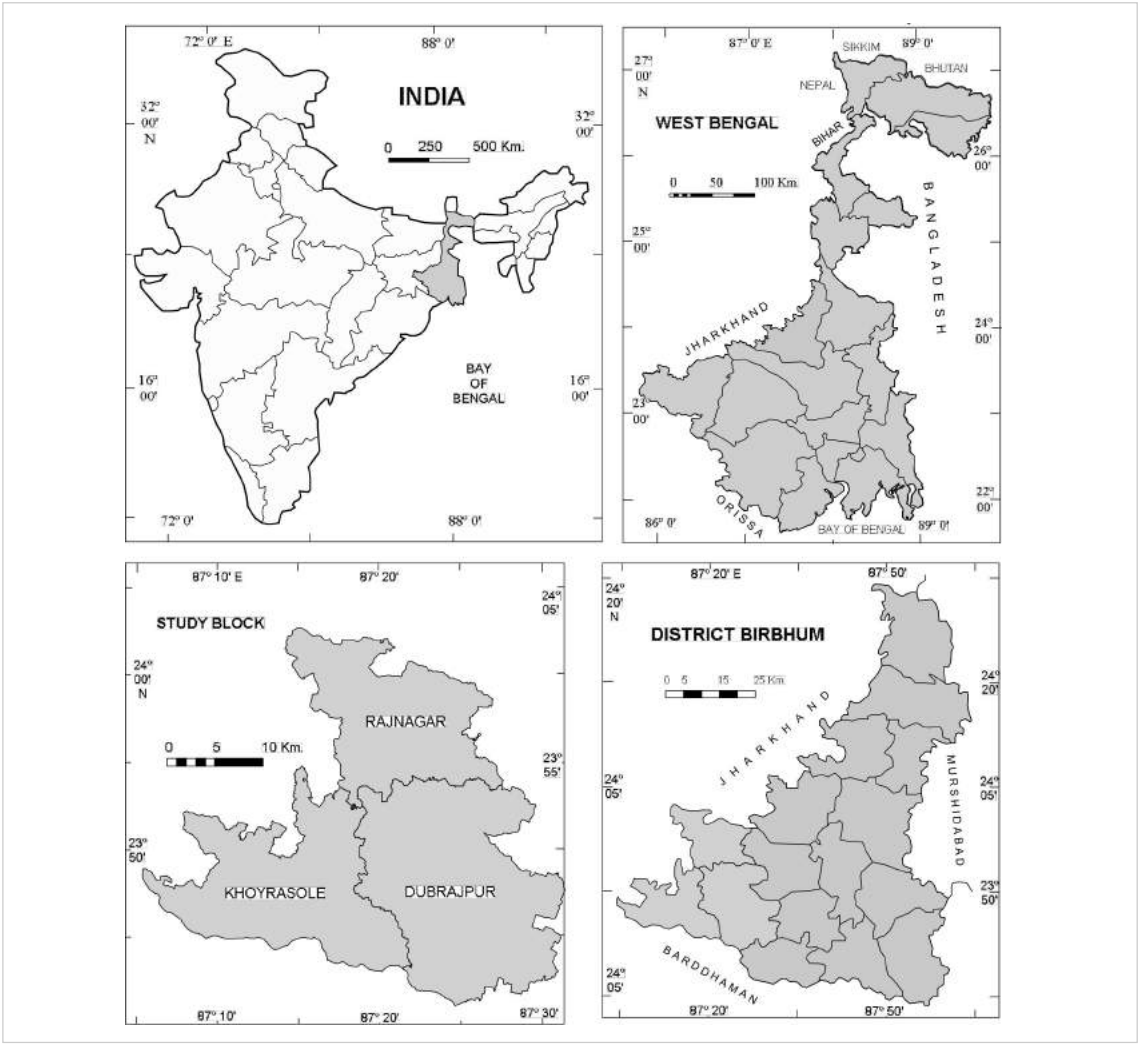


*Fig.1- Location Map*

part is bounded by the two police stations of Birbhum district- Suri and Illambazar. It constitutes 18.40% of total area of the District (Fig. 1)

The study area is predominantly an agricultural area with 62.85% of its total population is engaged in agriculture and allied activities and 67.34% of its total area represents net sown area. Therefore, timely and adequate supply of available water is one of the pre-requisites of smooth agricultural operation in the study area.

## Methods of Assessment of Surface Water Potential

Surface water potential implies the carrying capacity of surface water bodies to sustain water resources for beneficial anthropogenic use in general and agricultural use in particular. It is the outcome of continuous interaction among climate, vegetation, physiography, soil and drainage network. Being a small geographical unit, climate is more or less homogeneously distributed all over the study area with mean

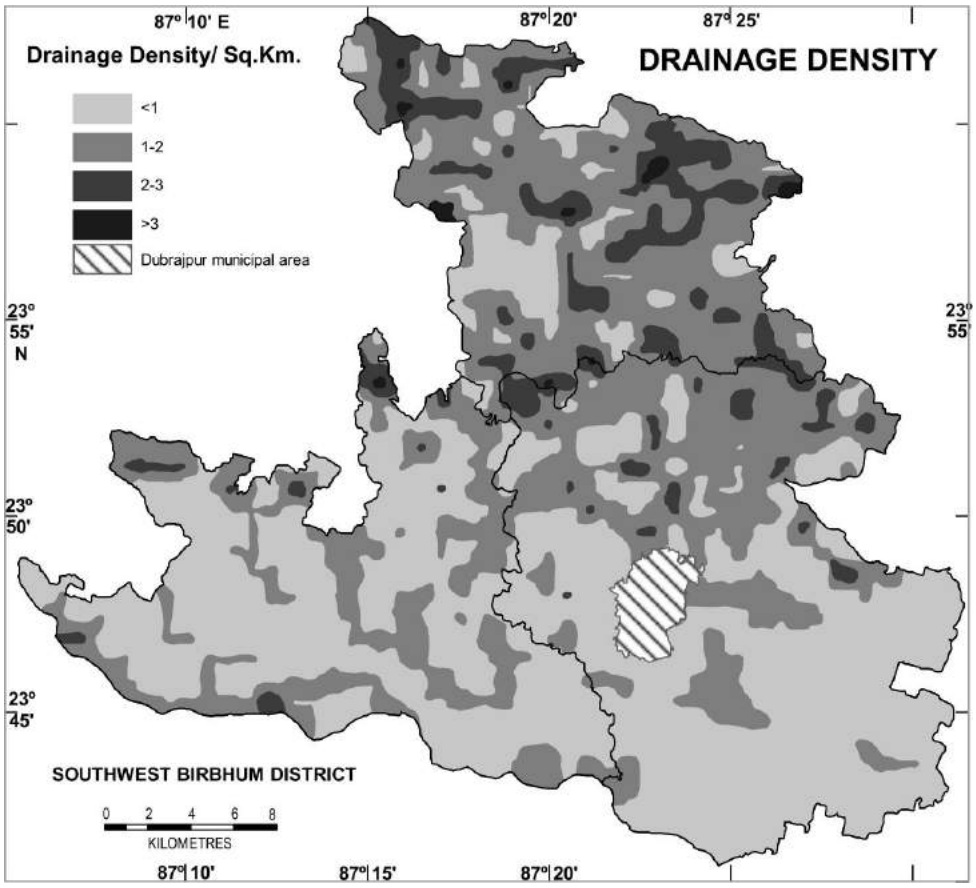


*Fig.2- Drainage Density*

*Source: Raw data obtained from SOI Toposheets(1972) & Complied by the researcher*

annual temperature 26° C and annual rainfall 1300-1420 mm. More than 93% of the total study area is deforested. Therefore, more or less homogeneous pattern of distribution of these two parameters (climate and vegetation) have lessen their significance in creating spatial variability of surface water potential of the study area. Analysis of surface water potential of SWBD has, therefore, taken into consideration of four relevant parameters, *viz*, drainage density, soil available water capacity, ruggedness index and relative relief (Fig. 2 to 5).

All these parameters are not equally important in determining surface water potential of the study area. Therefore, weightage are assigned against these four parameters according to their importance in determining water potentiality (Table 1).

Now, following the methods of Storie Index (Storie, 1954, p.10), each variables have been awarded numerical scores to a maximum of 10. The score is proportionately distributed among the components of each variable according to their quality. The overall score index of each component has been obtained by multiplying the original score by weighted score (Table 2). Now, the cumulative score for the all the 463 land units

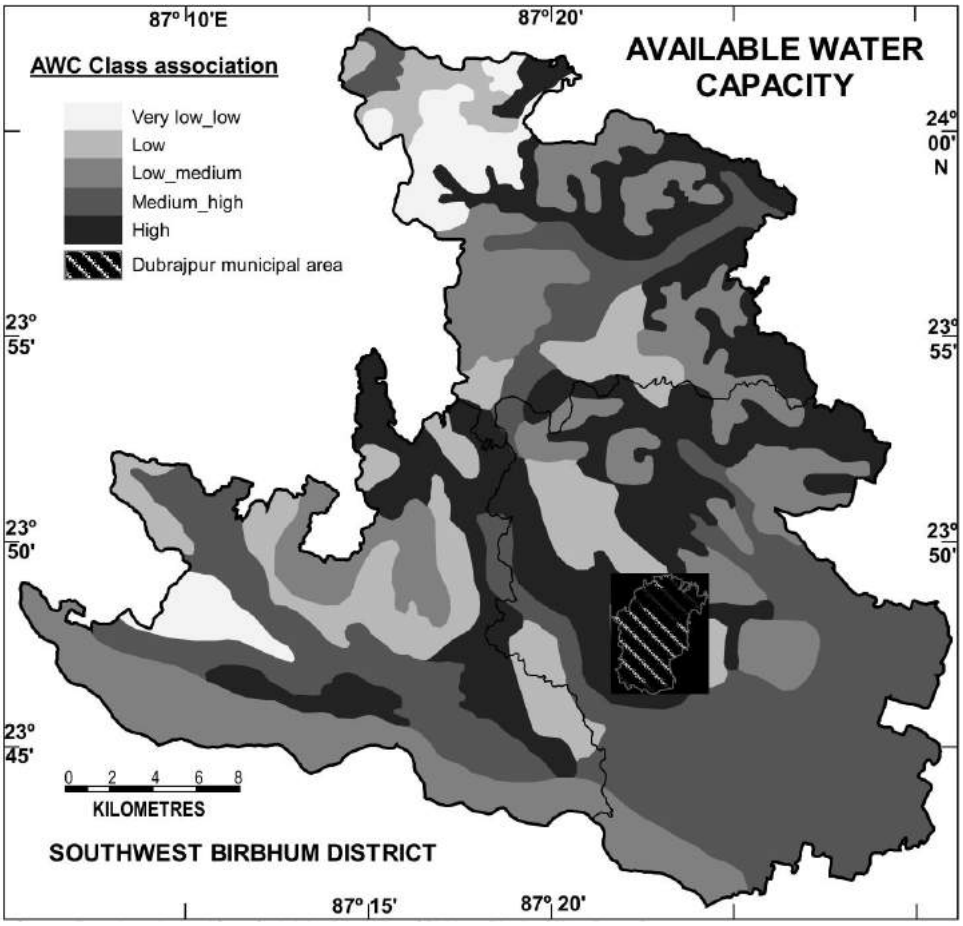


*Fig. 3 - Available Water Capacity, Source: Raw data obtained from Optimising Land Use of Birbhum Dist.(W.B) SRA, NBSS & LUP ad Complied by the researcher.*

(Prasad N. & Ghosh, T, 2013, pp. 6-8) are calculated to obtain the spatial variability of surface water potential of different land units. Finally, on the basis of mean (20.81) and standard deviation (5.00), all the 463 land units have been statistically grouped into seven surface water potential zones (Table 3 & 4).

## Spatial Distribution of Surface Water Potential

### *Very Good*

This water potential zone covers only 57.81 sq. km. (6.79%) of the total study area. This zone is distributed in small isolated patches in the northern, middle and western parts of the study area. A more or less continuous patch is found in the middle eastern part (covering Dubrajpur and Rajnagar block) of the study area. About 52% of this zone is distributed in Rajnagar block, followed by Dubrajpur (37%) and Khoyrasole (11%) blocks (Table 3, 4 & Fig. 6). High relative relief and ruggedness index and consequent high drainage density collectively result in very good surface water potential in this part of the study area.

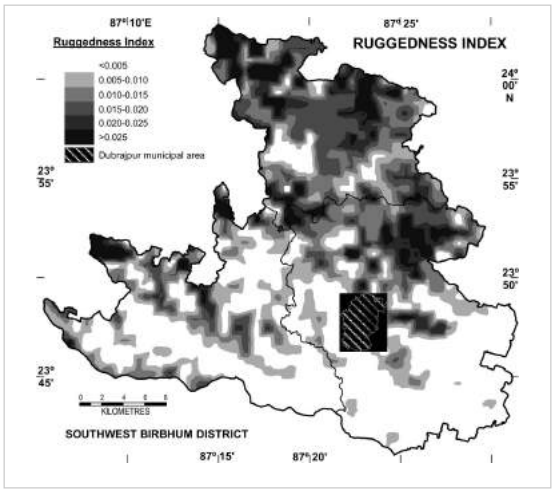


*Fig.4 - Ruggedness Index*

*Source: Raw data obtained from SOI Toposheets (1972) and compiled by the researcher*

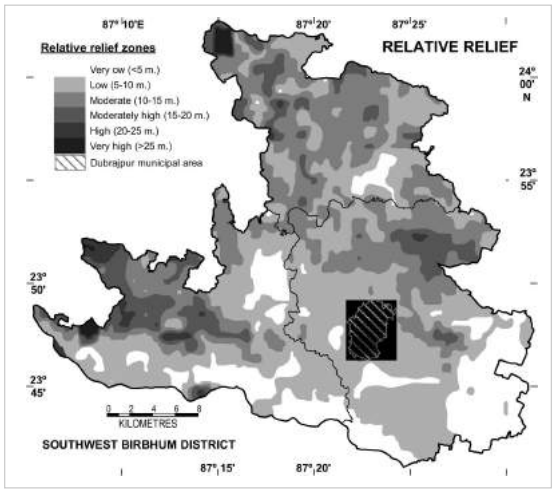


*Fig.5 - Relative Relief Zones*

*Source: Raw data obtained from SOI Toposheets (1972) and compiled by the researcher*

### *Good*

The good water potential zone covers an area of 43.78 sq.km. (5.14%) of total study area and is distributed mainly in the northern, middle, middle eastern and western parts, surrounding the very good water potential zone. About 56% of this water potential zone is distributed in Rajnagar block, followed by Dubrajpur (39%) and Khoyrasole (5%) blocks (Table 3, 4 & Fig. 6).

### *Moderately Good*

This category covers 76.66 sq.km. (9.00%) area of the study area. About 52% of this water potential zone is distributed in Dubrajpur block (middle eastern part of the study area), followed by Rajnagar (32%, mainly in the northern part of the study area) and Khoyrsaole (16%, mainly in the western and southwestern parts of the study area) blocks (Table 3, 4 & Fig. 6).

### *Fair*

A relatively large proportion of study area (180.86 sq.km. & 21.23%) falls under this water potentiality zone. About 42% of Rajnagar block is covered by this water potentiality zone, followed by Khoyrasole (33%) and Dubrajpur (25%) blocks (Table 3, 4 & Fig. 6). The combined influence of moderate relative relief and ruggedness index, low to low-medium AWC and moderate drainage density are responsible for relatively low surface water potential in this part of the study area.

### *Moderately fair*

This water potential zone occupies an area of 154.01 sq.km. (18.08%) and is distributed in the middle portion of the study area. This zone is more or less equally distributed in the three blocks of the study area.

### *Poor*

This zone occupies maximum percentage of area (28.11%, 239.46 sq.km.) of the study area. East-

*Table 1: Ranking of Variables*

| *Rank* | *Variable* | *Weightage* |
|---|---|---|
| 1 | Drainage Density | 3 |
| 2 | Available Water Capacity (AWC) | 3 |
| 3 | Ruggedness Index | 2 |
| 4 | Relative Relief | 1 |

*Table 2: Variables and scores*

*A. Drainage Density (D) - First*

| *Variable (Drainage Density / sq.km.)* | *Symbol* | *Scores assigned on the basis of quality* | *Weightage assigned on the basis of rank* | *Total scores awarded* |
|---|---|---|---|---|
| 1 & below | $D_1$ | 1 | 3 | 3 |
| 1-2 | $D_2$ | 2 | 3 | 6 |
| 2-3 | $D_3$ | 3 | 3 | 9 |
| 3 & above | $D_4$ | 4 | 3 | 12 |
| Total | | 10 | | 30 |

*B. AWC (A) Rank - Second*

| *Variable (Drainage Density / sq.km.)* | *Symbol* | *Scores assigned on the basis of quality* | *Weightage assigned on the basis of rank* | *Total scores awarded* |
|---|---|---|---|---|
| Very low-low | $A_1$ | 0.67 | 3 | 02.01 |
| Low | $A_2$ | 01.33 | 3 | 03.99 |
| Low-medium | $A_3$ | 02.00 | 3 | 06.00 |
| Medium-high | $A_4$ | 02.67 | 3 | 08.01 |
| High | $A_5$ | 03.33 | 3 | 09.99 |
| Total | | 10.00 | | 30.00 |

*C. Ruggedness Index (RI) - Third*

| *Variable (Drainage Density / sq.km.)* | *Symbol* | *Scores assigned on the basis of quality* | *Weightage assigned on the basis of rank* | *Total scores awarded* |
|---|---|---|---|---|
| <0.010 | $RI_1$ | 1.67 | 2 | 3.34 |
| 0.010-0.020 | $RI_2$ | 3.33 | 2 | 6.66 |
| >0.020 | $RI_3$ | 5.00 | 2 | 10.00 |
| Total | | 10.00 | | 20.00 |

*D. Relative Relief (R) - Fourth*

| *Variable (Drainage Density / sq.km.)* | *Symbol* | *Scores assigned on the basis of quality* | *Weightage assigned on the basis of rank* | *Total scores awarded* |
|---|---|---|---|---|
| <10 | $R_1$ | 1.67 | 1 | 1.67 |
| 10-20 | $R_2$ | 3.33 | 1 | 3.33 |
| >20 | $R_3$ | 5.00 | 1 | 5.00 |
| Total | | 10.00 | | 10.00 |

west elongated broad continuous patch of this zone is found in the southern and southeastern parts of the study area. Beside this, few small isolated patches of this zone are also distributed all over the study area. About 70% of this water potential zone is distributed in Dubrajpur block, followed by Khoyrasole (26%) and Rajnagar (4%) blocks (Table 3, 4 & Fig. 6). In the southern and southeastern parts this zone is characterised by medium-high available water capacity. However, the combined influence of very low relative relief, ruggedness index and drainage density reduces the significance of AWC and thus gives rise to a poor water potential zone. In this part, the medium-high AWC of alluvial soil and very low relative relief and ruggedness index facilitate the construction of artificial water storage tank. Thus, the naturally poor surface water potential of this zone can be enhanced by adopting some anthropogenic measures. On the contrary, in the northern and western parts, the low AWC of hard granite-gneissic landscape impedes the construction of artificial reservoir and, thus, represent truly poor surface water potential zone.

***Very poor***

Covering an area of 99.28 sq.km. (11.65%), this zone is distributed in the southwestern and middle

*Table 3: Surface water potential zone*

| *Class* | *Scores* | *Character* | *Area (sq.km.)* | *% to total study area* |
|---|---|---|---|---|
| I | >27.06 | Very good | 57.81 | 6.79 |
| II | 24.56-27.06 | Good | 43.78 | 5.14 |
| III | 22.06-24.56 | Moderately good | 76.66 | 9.00 |
| IV | 19.56-22.06 | Fair | 180.86 | 21.23 |
| V | 17.06-19.56 | Moderately fair | 154.01 | 18.08 |
| VI | 14.56-17.06 | Poor | 239.46 | 28.11 |
| VII | <14.56 | Very poor | 99.28 | 11.65 |
| Total | | | 851.86 | 100.00 |

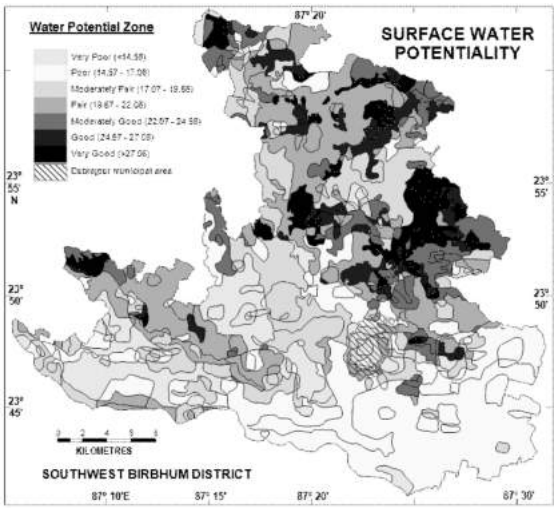


*Fig.6- Surface Water Potentiality*

southern parts of the study area. About 72% of this zone is distributed in Khoyrasole block, followed by Dubrajpur (22%) and Rajnagar (6%) blocks (Table 3, 4 & Fig. 6). Combined influence of very low to low range of all the determinant parameters result in very poor surface water potential zone.

**Concluding Remarks**

In conclusion it can be said that two anthropogenic measures *i.e.* afforestation and rain water harvesting, can make the other two important determining factors of surfaces water potential (*i.e.* vegetation and climate) effective in the study area and thus become significant in changing the existing pattern of surface water potential. However, the materialisation of above two anthropogenic measures is largely depended on the existing geo-physical condition of the study area. If, theoretically, it is taken that all parts of the study area have homogeneous geo-physical properties, then proper implementation of the above two measures will definitely increase the cumulative score of every land units. However, in reality there is a great spatial variability in geo-physical characteristics of the study area. In the southern and southeastern parts, the unconsolidated alluvium formation with nearly level land facilitates the construction of artificial storage tank. The increasing number of surface water bodies will, in turn, help to increase the cumulative score of surface water potential in this part of the study area. Thus, construction of rain water harvesting structure in this part can upgrade the surface water potential from poor to the subsequent upper classes according to the degree of the measures taken. On the contrary, in the northern, middle and western parts, the hard granite-gneissic consolidated formation with undulating land reduces the feasibility of construction of artificial storage tank. At the same time this part is facilitated with high drainage density. Therefore, the capacity of these innumerable ephemeral drainage networks can be enhanced by reducing the river bank erosion through afforestation measures and by de-silting the river beds. Such kind of measure will help to materialise the theoretically high surface water potential in this part of the study area.

| *Land capability class* | *Name of blocks* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Rajnagar* | | | *Khoyrasole* | | | *Dubrajpur* | | |
| | *Area (km.²)* | *% to total block area* | *% to individual capability class* | *Area (km.²)* | *% to total block area* | *% to individual capability class* | *Area (km.²)* | *% to total block area* | *% to individual capability class* |
| Very good | 30.04 | 13.58 | 51.96 | 06.16 | 02.27 | 10.66 | 21.61 | 06.02 | 37.38 |
| Good | 24.38 | 11.02 | 55.69 | 02.40 | 00.88 | 05.48 | 17.00 | 04.73 | 38.83 |
| Moderately good | 24.46 | 11.06 | 31.91 | 12.43 | 4.58 | 16.21 | 39.77 | 11.06 | 51.88 |
| Fair | 75.04 | 33.92 | 41.49 | 60.04 | 22.15 | 33.20 | 45.78 | 12.73 | 25.31 |
| Moderately fair | 52.89 | 23.91 | 34.34 | 55.77 | 20.57 | 36.21 | 45.35 | 12.61 | 29.45 |
| Poor | 08.51 | 03.85 | 03.55 | 62.40 | 23.02 | 26.06 | 168.55 | 46.88 | 70.39 |
| Very poor | 05.88 | 02.66 | 05.92 | 71.92 | 26.53 | 72.44 | 21.48 | 05.97 | 21.64 |
| Total | 221.20 | 100.00 | | 271.12 | 100.00 | | 359.54 | 100 | |

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