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# Geoinformatics for Industrial Siting – A Case Study of Puruliya District, West Bengal

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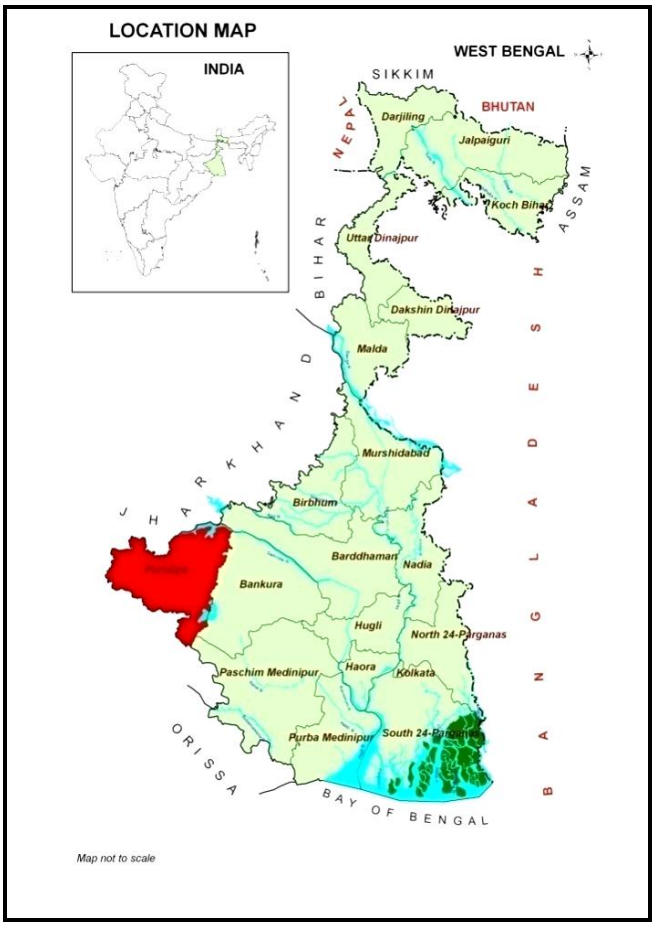
**Abstract** Industrialization is one of the fundamental pre-conditions for the development of civilization. The strength of a country's economy is judged by the level of development of its manufacturing industries. Industries have a major role in the utilization of resources as they transform these resources into more valuable goods, generate more wealth and raise income levels thereby contributing to the economic development of a country. On the flip side, industries release toxic pollutants and wastes that have adverse effects on the environment. The planned development of industries in India has succeeded to the extent that the nation has been able to diversify her industrial base and is able to produce a wide range of products. But industrial expansion and siting has not always been carried out in a sustainable manner. This is more so in case of areas such as forests and settlements that are particularly susceptible to adverse environmental impacts than others. The present paper is a part of the project " Spatial Environmental Planning Programme" (SEPP) sponsored by the Central Pollution Control Board, Ministry of Environment and Forests, Govt. of India. In this paper an attempt has been made to find out suitable locations for industrial siting in Puruliya district, West Bengal. This may be considered as baseline geospatial information for the identification of suitable industrial sites that take into consideration the interrelationship between anthropogenic development and biophysical environment. The present study is based on information derived from various physico-environmental parameters and different theme maps have been used for this purpose. The subtraction method has been used to find out suitable locations for siting of industries following Central Pollution Control Board guidelines. The analysis has been carried out in Arc-GIS software using various geo-processing techniques. Eight industrial siting zones have been identified in Puruliya district that are suitable to a particular type of industry. The analysis reveals that there is a possibility of setting up high air and high water polluting industries (Z4Wh) throughout the district while high air and medium water polluting industries (Z4Wm) can come up along the right bank of the Damodar River in the eastern part of the district.

**Keywords** *Suitable Location for Siting of Industry; Environmental Perspective; Polluting Factor; GIS Technique; Environmental Impact*

## 1. Introduction

West Bengal, one of the most important states in eastern India**,** may rightfully be considered as the gateway to the East and Northeast owing to its strategic location. Its abundant natural resources are supported by a rich cultural, academic and ethnic mix, a vibrant business community and a diversified industrial base. All this stresses on the need to create a more enabling environment for industrial progress in the region.




***Map No. 1***

Site selection for setting up of industries is a very important issue and has been often talked about by experts on this matter. Williams and Massa (1983) and Keeney (1980) have discussed key factors for determining site selection, such as number of possible sites/options, costs and benefits and multiple objectives, impact assessment etc. Badri (1999), Korpela and Tuominen (1996) have used Multi-Criteria Decision-Making (MCDM) techniques to solve various site selection problems. Vlachopoulu et al., (2001) and Siddiqui et al., (1996) opined that integration of various tools is needed so that the weakness of any one tool is offset by the others. Davis (2001) pointed out that the goal in a site selection exercise is to find the best location with desired conditions that satisfy predetermined selection criteria. Gupta A.K. et al., (2010) in their paper “Industrial Siting in Multi-Hazard Environment: Application of GIS and MIS” elaborately discussed all possible criterion for siting industries. Reisi, M. et al., (2011) attempted Multi-Criteria Decision Analysis approach for selecting the best possible location for industry in Asfahan, Iran. Wang Y. et al., (2012) attempted site selection strategy based on Business Area Theory.

## 2. Aim and Objectives

In view of the above, an attempt has been made to find out suitable locations for siting of different industries and also to identify areas that need to be restricted from industrial encroachment on the basis of physical and environmental characteristics of the district, following guidelines laid down by CPCB. The present study is a part of the "Spatial Environment Planning Programme" (SEPP) sponsored by the Central Pollution Control Board (CPCB), Ministry of Environment and Forest, Govt. of India. The outcome of the present study will provide:-

- Readily available information to an entrepreneur in finding out the best suitable location for siting of industry;
- To check additional pollution in the areas already over stressed with pollution;
- To help regulatory bodies to plan pollution control and monitor programmes and infrastructure facilities such as manpower, laboratory facilities, etc. well in advance;
- To protect ecological assets and other sensitive areas;
- To ensure that an industry that has a high polluting factor but has the probability of being set up in a high-risk area, that is otherwise unsuitable from the environmental perspective, will be compelled to adopt cleaner manufacturing technologies so as to significantly reduce generation of wastes and pollutants.

## 3. Study Area

Puruliya is the westernmost district of West Bengal and the fifth largest in terms of geographical area (6259sq.km, BAES, 2012). It extends from 23°42'N to 22°43'N latitude and 85°49'E to 86°55'E longitude. Puruliya is surrounded by Bankura and Paschim Medinipur in the east, Barddhaman districts in the north (*Map No.1*) and shares the state boundary with Jharkhand in the west, north and south. The northern boundary runs through the centre of the Panchet reservoir and the eastern boundary through the centre of the Kangsabati reservoir.

Physiographically, the area constitutes the eastern fringe of the Chotanagpur Plateau and gradually merges with the depositional fluvial terraces of Damodar-Dwarkeswar-Kangsabati Rivers further east. The pedimental landscape of the area is exemplified by rolling/undulating topography with enclosures of erosional remnants of resistant rocks in the form of rocky knobs and residual hills (IMSD, 1997).

The major rivers of this district are the Damodar, Dwarkeswar, Kasai, Kumari and Subarnarekha. Kasai is the most important river of the area draining more than three-fifth of the total district area. The district boundary follows Damodar in the north and Subarnarekha in the west (URC, 2001).

The district has two large-scale industrial units (*Map No.2*), the Santaldih Thermal Power Plant and the Damodar Cement Factory, Madhukunda. Another major unit is the Puruliya Pumped Storage Project at Baghmundi that has a generation capacity of 4 x 225 MW (WBIIDC, 2011).

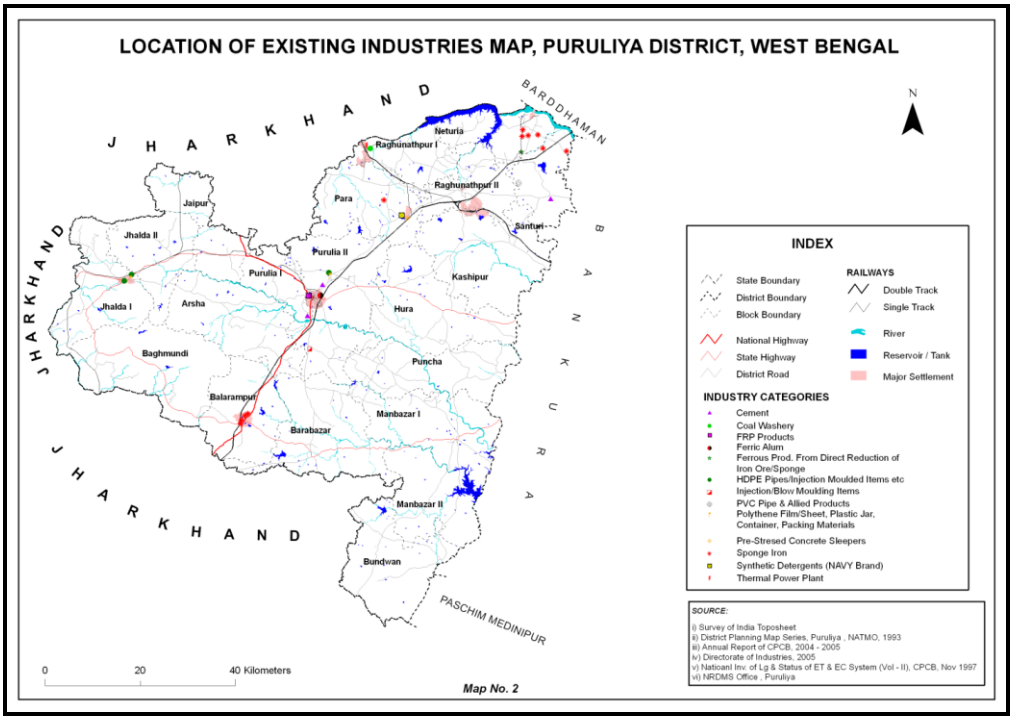
Puruliya has a rich mineral resource base primarily Coal (DSG, 2006). The availability of land and cheap labour and the water supply from the Damodar River particularly in the northeastern portion of the district makes it ideal for industrial location.

## 4. Database

The present study is based on Survey of India degree sheets and Topo sheets, IRS-1D LISS-III Satellite data (both hard copy & digital), Air quality and Surface Water quality data (from West Bengal Pollution Control Board), Ground water quality data (from Central Ground Water Board), other collateral information and limited field verification.

## 5. Methodology

Different thematic layers have been generated for the district viz. Physiography, Hydro-geomorphology, Soil, Landuse, Land Capability, Drainage, Irrigation, Surface water use and flow, Ground water use, Biological Diversity Areas, Sensitive/Incompatible land use, Industry, Mine, Air Quality, Surface Water Quality, Ground Water Quality that have been used as the baseline information for this study. These theme maps have been analyzed in a systematic manner using Geographical Information System (GIS) techniques in Arc-GIS platform and subsequently derivative maps have been prepared for the purpose of industrial siting. The subtraction method has been used to find out suitable location for siting of industries following CPCB guidelines. Some of the main thematic layers used in preparation of ZASI for Puruliya district are: Avoid area, Air Quality, Land use Sensitivity, Air pollution Sensitivity, Surface Water Quality, Surface water flow and use and Surface Water pollution Sensitivity etc.




***Map No. 2***

### 5.1. Step-1: Categorization of Industries

***Table 1:*** *On the Basis of Air and Water Pollution Generating Potential Industries are classified into the Following Categories*

| Industry Category | | Impact Potential* |
|---|---|---|
| Air | Water | |
| A1 | W1 | Very High |
| A2 | W2 | High |
| A3 | W3 | Medium to High |
| A4 | W4 | Low |

**Source:** Guideline of Central Pollution Control Board (CPCB), 2004

*Impact potential considered without pollution control equipment in operation

***Table 2:*** *Based on the Nature of Air and Water Pollution Potential the Following Combinations of Industries are Possible*

| | | | |
|---|---|---|---|
| A1W1 | A1W2 | A1W3 | A1W4 |
| A2W1 | A2W2 | A2W3 | A2W4 |
| A3W1 | A3W2 | A3W3 | A3W4 |
| A4W1 | A4W2 | A4W3 | A4W4 |

A1W1 is high air and water polluting industry and A4W4 is Low air and water polluting industry.

### 5.2. Step-2: Assessment of Pollution Sensitivity

Based on the CPCB guidelines air and water pollution sensitivity areas of this district are:

1) *Biological Diversity area*
2) *Tourism areas with more than 5 lakh visitors/ tourists per year*
3) *Agricultural research stations and 'Critical'/ 'High' air polluted areas*
4) *Public water supply areas from rivers/surface water bodies*
5) *Public water supply areas from ground water (>20,000 population)*
6) *Hilly stretches that act as barriers for dispersion of emissions, areas with frequent invention conditions*

To preserve these sensitive zones/points prescribed buffers have been given around them.

### 5.3. Step-3: Potential Zones for Siting of Industries

***Table 3:*** *Considering above Mentioned Criterion any Area can be grouped under Different Zones for Sitting of Air and Water Polluting Industries. In this Connection the Zones and Prescribed Buffers around Sensitive Area are as Follows*

| **Buffer (km)** | **Zone for Air Polluting Industry** | ***Buffer (km)*** | ***Zone for Water Polluting Industry*** |
|---|---|---|---|
| 2 | Z1: Very high risk zone for air polluting industries | *5/10* | *Wh: High risk zones for water polluting industries* |
| 2 to 5 | Z2: High risk zone for air polluting industries | *5/10 to 7/15* | *Wm: Medium risk zones for water polluting industries* |
| 5 to 7 | Z3: Medium risk zone for air polluting industries | *>7/15* | *Wl: Low risk zones for water polluting industries* |
| **>** 7 | Z4: Low risk zone for air polluting industries | | |

**Source:** Guideline of Central Pollution Control Board (CPCB), 2004

***Table 4:*** *In Ideal Case 12 Combinations of Sites/Zones are Possible*

| | | |
|---|---|---|
| Z1Wh | Z1Wm | Z1Wl |
| Z2Wh | Z2Wm | Z2Wl |
| Z3Wh | Z3Wm | Z3Wl |
| Z4Wh | Z4Wm | Z4Wl |

### 5.4. Step- 4: Site Suitability

In the final stage integration of all thematic layers (both spatial and non-spatial data) has been done in a systematic manner using ArcGIS platform. Different zones have been identified which are suitable/unsuitable for certain categories of air polluting and water polluting industries.

The matrix below gives a clear idea about the type of industry that can be set up in a particular zone.

From the following matrix it is very much understandable which kind of industry can be set up in a particular zone.

| Pollution Sensitivity / Industry Category | Avoid Area | Z1Wh | Z1Wm | Z1Wl | Z2Wh | Z2Wm | Z2Wl | Z3Wh | Z3Wm | Z3Wl | Z4Wh | Z4Wm | Z4Wl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1W1 | R | R | R | R | R | R | R | R | R | R | R | R | B |
| A2W1 | R | R | R | R | R | R | R | R | R | B | R | R | B |
| A3W1 | R | R | R | R | R | R | B | R | R | B | R | R | B |
| A4W1 | R | R | R | B | R | R | B | R | R | B | R | R | B |
| A1W2 | R | R | R | R | R | R | R | R | R | R | R | O | B |
| A2W2 | R | R | R | R | R | O | B | R | O | B | R | O | B |
| A3W2 | R | R | R | R | R | O | B | R | O | B | R | O | B |
| A4W2 | R | R | O | B | R | O | B | R | O | B | R | O | B |
| A1W3 | R | R | R | R | R | R | R | R | R | R | R | B | B |
| A2W3 | R | R | R | R | R | R | R | O | B | B | R | B | G |
| A3W3 | R | R | R | R | R | B | B | R | B | G | R | B | G |
| A4W3 | R | R | B | G | R | B | G | R | B | G | R | B | G |
| A1W4 | R | R | R | R | R | R | R | R | R | R | B | B | B |
| A2W4 | R | R | R | R | R | R | R | B | B | B | G | G | G |
| A3W4 | R | R | R | R | B | B | B | G | G | G | G | G | G |
| A4W4 | R | G | G | G | G | G | G | G | G | G | G | G | G |

**Index**

| | |
|---|---|
| R | Unsuitable. These zones should be avoided as they pose tremendous environmental risks for industries in case of failure of pollution control equipment. |
| O | There is a possibility to find a few suitable sites for a limited number of industries that install state of the art manufacturing process and/or Best Available Treatment technology (BAT) for wastes/effluents/emissions. |
| B | There is a possibility of finding sites for industries that comply with Minimal National Standards (MINAS) by installing Best Possible Treatment technology (BPT) for wastes/effluents/emissions. |
| G | Suitable sites would be found for industries complying with MINAS by installing BPT for wastes/effluents/emissions. |

***Figure 1:*** *Various Zones for Locating Different Pollution Sensitive Industry Category*
**Source:** Guideline of Central Pollution Control Board (CPCB), 2004

## 6. Discussion

From the methodology and data mentioned above, different zones have been identified in Puruliya district that are suitable/unsuitable for certain categories of air polluting and water polluting industries. The final analysis reveals eight zones for industrial siting (Table 5)

***Table 5:*** *Zone Wise Distribution of Area*

| Zone | Area (Sq. km.) | Percentage (%) |
|---|---|---|
| Avoid area | 844.92 | 13.50 |
| Rivers & Waterbodies | 79.02 | 1.26 |
| Settlement | 57.26 | 0.91 |
| Z1Wh | 289.36 | 4.62 |
| Z2Wh | 907.42 | 14.50 |
| Z2Wm | 13.64 | 0.22 |

| | | |
|---|---|---|
| Z3Wh | 651.68 | 10.41 |
| Z3Wm | 24.84 | 0.40 |
| Z4Wh | 3280.54 | 52.41 |
| Z4Wm | 110.32 | 1.76 |
| Total | 6,259 | 100.00 |

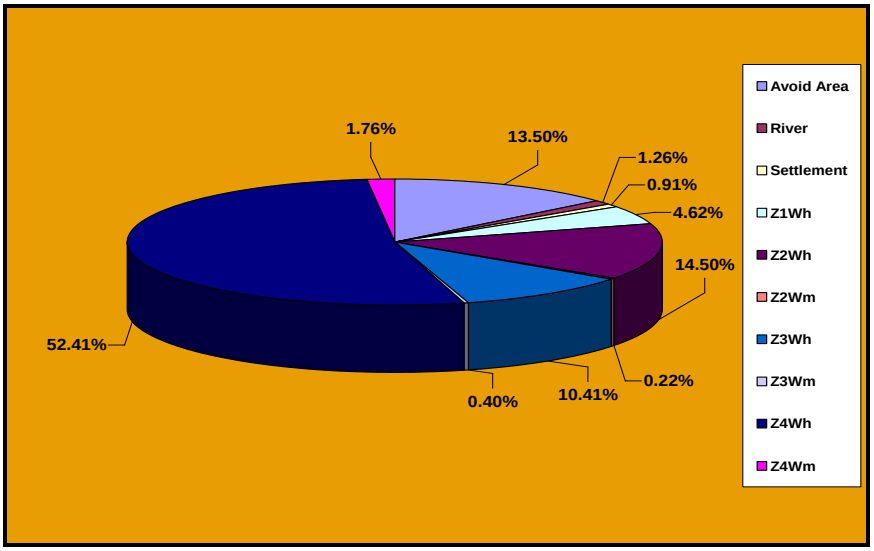
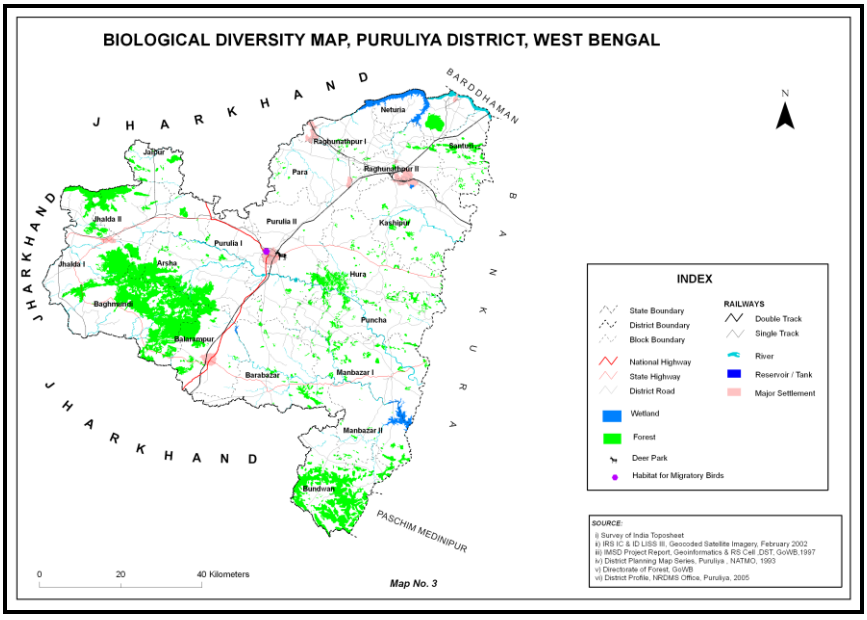



***Figure 2:*** *Percentage Distribution of Zones*

### 6.1. Areas to be Avoided

An Avoid area is the sensitive zone where no polluting industry is allowed. In Puruliya district, the avoid areas are the wild life sanctuaries located at Suruliya in Puruliya-II block, the habitat for migratory birds at Saheb Bandh in Puruliya-II block, Public Water Supply areas, Tourist places such as Ayodhya Pahar in Baghmundi block, Wetlands, Agricultural Research Stations, Reserved Forests and Protected Forests, and locally applicable areas like Chorida in Baghmundi block which is famous for the traditional Chhou Dance (Map No 3 & 4).




***Map No. 3***

### 6.2. Z1Wh

In this zone low air and water polluting industries may be considered. This category is found in patches mainly along northern part of the district covering Raghunathpur-I & II, Neturia, Kashipur blocks and central part of Puruliya-I & II blocks, in the western part of Jhalda–I & II, Baghmundi, Arsha, Balarampur, Barabazar blocks and in the south east covering Manbazar–I & II blocks (Map No.5).

### 6.3. Z2Wh

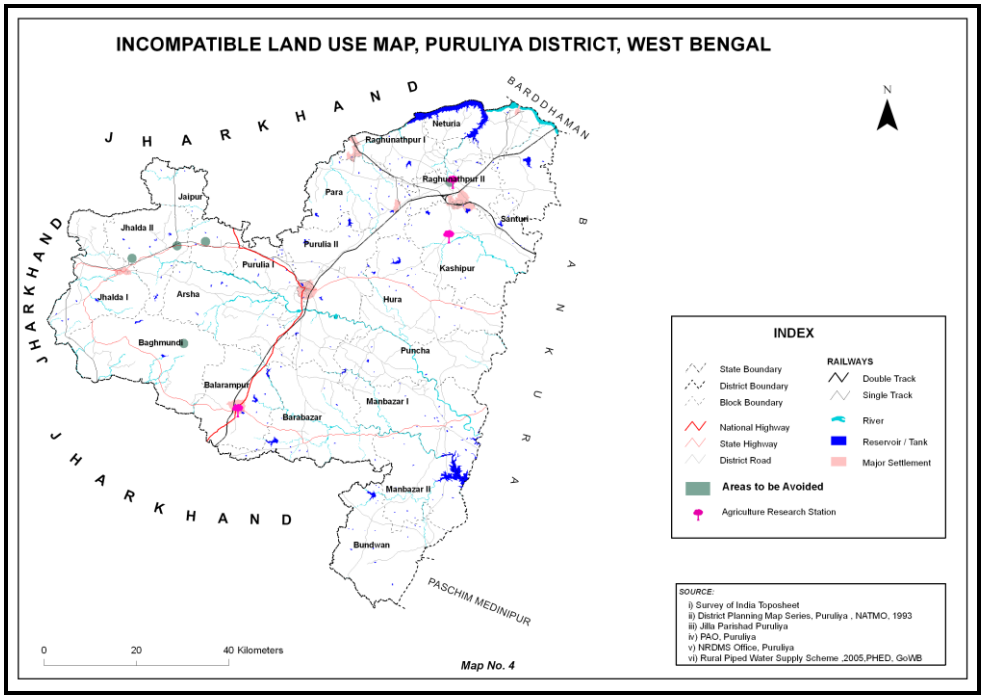
A3W4 categories of industries are permitted here that comply with MINAS by installing BPT for wastes/effluents/emissions. This zone is distributed in small patches all over the district, mainly in northern part of Raghunathpur-I & II, Neturia, Kashipur blocks, central part of Puruliya-I & II blocks, western part of Jhalda–I & II, Baghmundi, Arsha, Balarampur, Barabazar, Jaipur blocks and in the south eastern part covering Manbazar–I & II blocks.

### 6.4. Z2Wm

A limited number of A3W1, A4W1, A2W2, A3W2, and A4W2 industries are possible in this zone by installing state of the art manufacturing process or Best Available Treatment Technology (BAT) for wastes/effluents/emissions and A4W3 categories of industries that comply with MINAS by installing BPT for wastes/effluents/emissions. Small patches of this zone are found in the south eastern and western border of Neturia and Santuri blocks.

### 6.5. Z3Wh

There is a possibility of setting up a limited number of A2W3 industries with BAT for wastes/effluents/emissions and A2W4, A3W4 categories of industries with MINAS by installing BPT for wastes/effluents/emissions in this zone. This zone is mainly found in northern part of Raghunathpur-I & II, Kashipur blocks, central part of Puruliya- I & II blocks, western part of Jhalda–I & II, Baghmundi, Arsha, Balarampur, Barabazar, Jaipur blocks and south eastern part of Manbazar– I & II blocks.




***Map No. 4***

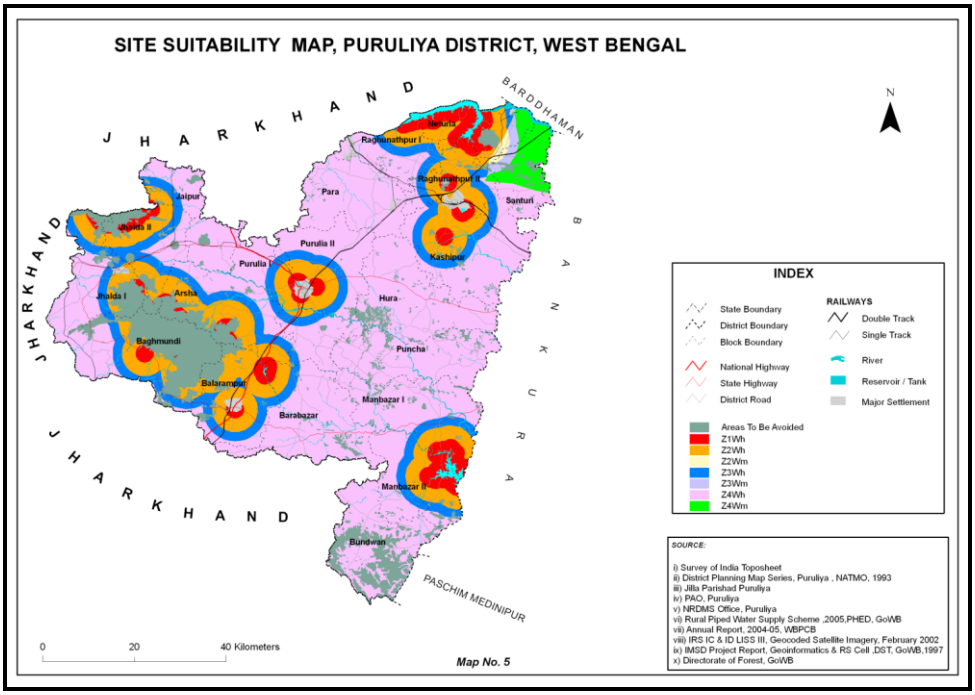
### 6.6. Z3Wm

A limited number of A2W2, A3W2 and A4W2 industries with BAT (Best Avaliable Technology) for wastes/effluents/emissions; A2W3, A2W4, A3W3, A4W3 categories of industries that comply with MINAS by installing BPT (Best Possible Technology) for wastes/effluents/emissions are permissible in this area. Small patch of this zone found along the border of Neturia and Santuri blocks.

### 6.7. Z4Wh

In this zone a few suitable sites for a limited number of A1W3, A2W3, A3W3, A4W3, A1W4, A2W4, A3W4, A4W4 categories of industries may be set up if they comply with MINAS by installing BPT to regulate wastes/effluents/emissions. This criterion is also applicable for A2W4, A3W4, A4W4 categories of industries. The Z4Wh zone covers about 52% of the district area and is found throughout the district (*Photo 1*).

***Photo 1:*** *Open Scrubland, Near Dumarsol Village, Purulia-I Block*




***Map No. 5***

### 6.8. Z4Wm

A limited number of A1W2, A2W2, A3W2, A4W2 categories of industries that implying BAT (Best Avaliable Technology) for wastes/effluents/emissions, A4W3, A1W3, A2W3, A3W3, A4W3, A1W4, A2W4, A3W4 categories of industries that comply with MINAS by installing BPT (Best Possible Technology) for wastes/effluents/emissions are permitted in this zone. This zone is found along the right bank of the Damodar River in eastern part of Neturia block and covers almost entire Santuri block except the southern part.

A4W4 categories of industries are suitable for all zones complying with MINAS provided measures like BPT for wastes/effluents/emissions are in place.

## 7. Conclusion

The study gives an idea that nearly 15% area (i.e. 923.94 sq.km.) of the district belongs to sensitive zone where no polluting industry should be allowed. The Z4Wh zone covers maximum area (52%), where high air polluting and low water polluting industries may be established.

The Z4Wm zone, where high air polluting and medium water polluting industries can come up in the district covers about 2% area (i.e. 110.32 sq.km.). This zone is located in the northeastern part of Puruliya district along the right bank of the Damodar River. The factors that can support industrial growth in this belt are availability of water and mineral resources, infrastructure and labour. Water is available from the Damodar River and the Panchet Hill Dam. Water quality and flow condition in this region is good. The location of this zone in close proximity to Adra town, an important growth centre is another positive factor. Adra is an important railway junction on the Kharagpur - Adra Branch of the South-Eastern Railway thereby providing connectivity to the region. The presence of major industrial and mining belts in the vicinity such as the Asansol-Kulti (Barddhaman district) belt in the north, Bajora (Bankura district) in the east and Jharkhand in the west can provide the much needed industrial inertia to the region under consideration. Among the upcoming industrial ventures in this belt, the proposed Iron and steel factory by the Jai Balaji Group is noteworthy.

The present study on identification of zones for industrial siting is on 1: 250000 scale and based on available data. Hence, the guidelines are to be considered while taking decisions on industrial siting and should not be taken as consent to establish industries. Micro-level detailed studies should be carried out before taking decision on siting an industry and identification of sites for industrial estates. It is necessary to carry out environmental impact assessment (EIA) which will take into consideration the possible positive and negative impact that a proposed project may have on the environment since EIA covers environmental, social and economic aspects. This will enable decision makers to consider the consequent or planing environmental impacts when contemplating a project.

## Acknowledgement

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