CHAPTER 3

PHYSICAL SETTING

3.1 GEOLOGY

The study area Bokaro Steel City is the headquarter of Bokaro district lying in the eastern part of Jharkhand district. Physically it comprises the eastern edge of the Chhotanagpur Plateau where it gradually merges with the plains. The Chota Nagpur Plateau has been formed by continental uplift from forces acting deep inside the Earth. The Gondwana substrates attest to the plateau’s ancient origin. It is part of the Deccan plate, which broke free from the southern continent during the Cretaceous to embark on a 50-million-year journey that was violently interrupted by the northern Eurassian continent. The northeastern part of the Deccan Plateau, where this eco-region sits, was the first area of contact with Eurasia. The Chota Nagpur Plateau consists of three steps.

Most of the Chhotanagpur area consisting of crystalline gneiss and granite is supposed to represent originally solidified crust. The study area is not an exception of that. According to the Geological Quadrangle Map 73 I, this area is not geologically complex. The area consists of biotite, quartz, granite and gneiss, which are metamorphic rocks of Proterozoic age.

Sedimentary of Gondwana age is predominate in the small portion of the NE corner of the study area. Sandstone, shale, coal of Raniganj formation of Damuda group is found here. The Damuda group is a part of the Gondwana Super group of Permian age.

No mineral of economic significance is found in the study area, though it is very near to rich mines specially coal and iron. A number of nonmetallic mineral occurrences are reported here, but none of them comes under in the economic grade.
Hence, it can be said that geologically the place is most suitable for Iron and Steel industry which needs a solid and tough base to hold the heavy industrial structure. Nearby minerals availability saves the transportation cost. Moreover, there are no losses of productive lands as the region is not good enough for agriculture.

3.2 TOPOGRAPHY

The study area is a part of the outer lower Chota Nagpur Plateau. In a single line, it can be said that, the topography is roughly undulating. The area did not undergo any “uplift since Cambrian or Vindhyan times up to Tertiary era” (Enayat Ahmed, 1965 p 24). This is a long period which is regarded by geographers and geologists as more than sufficient time for the reduction of any highland to a plain, very near to the sea level. But hard igneous rocks like granite have resisted erosion with reference to the less hard genesis of the surrounding country. Hence the region is undulating as it is extensively eroded by sheet wash, severe gully erosion and by the valleys of rivulets.

These relief features greatly influence the sitting of a planned city. Surface undulation effects on road alignment. The city sewage system depends on the general slope of the area, which is also a factor considered to build housing units. Therefore, the author feels the necessity to investigate surface elevation, relative relief and average slope of the area.

3.2.1 SURFACE ELEVATION AND FORMS

To get the surface elevation and forms in detail, the author has carried out this task with the help of 1: 20,000 topographical map with contour lines drawn 3 meters apart which is prepared by D. V. C. and used by B. S. L. for ‘The General Plan’ of the city. It has been well supported, confirmed and verified by her intensive field study.

The general configurations of the region vary from 165 meters in the North i.e. the Damodar River valley side to 247 meters in the South West of the area. The contour lines drawn 25 meters apart, divide the study area into four zones (Tb no. - 3.1 & Fig no. - 3.1)
TABLE NO. - 3.1
SURFACE ELEVATION AND FORMS

<table>
<thead>
<tr>
<th>Range Class Sl. No.</th>
<th>Elevation Magnitude</th>
<th>Height above M.S.L.(m)</th>
<th>Area in hect.</th>
<th>Frequency</th>
<th>Form Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>% of Total</td>
<td>Cumulative %</td>
</tr>
<tr>
<td>1.</td>
<td>High</td>
<td>&gt;225</td>
<td>531</td>
<td>11.95</td>
<td>11.95</td>
</tr>
<tr>
<td>2.</td>
<td>Moderately High</td>
<td>200-225</td>
<td>1602</td>
<td>36.05</td>
<td>48.00</td>
</tr>
<tr>
<td>3.</td>
<td>Moderately Low</td>
<td>175-200</td>
<td>1900</td>
<td>42.76</td>
<td>90.76</td>
</tr>
<tr>
<td>4.</td>
<td>Low</td>
<td>&lt;175</td>
<td>410</td>
<td>9.24</td>
<td>100.00</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>4443</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

3.2.1.1 HIGH LAND

The highland, consisting areas above 225 meters occupies 11.95% of the total area. The area lies in western Suburban where no permanent constructions yet have been done. The area is highly undulating in nature and absence of any hill or hillock is remarkable. The area was used as fabrication yard during Steel Plant construction period.

3.2.1.2 MODERATELY UNDULATING LAND

The area lies in between 175 meters to 225 meters contour lines, consists moderately undulating land. It covers 3502 hectare area which is 78.81% of the total study area. It is to be noted that all sectors are built within this region. This area further can be sub-divided into two parts:
(i) Moderately high land and
(ii) Moderately Low Land.

Moderately high land lies between 200 meters to 225 meters contour lines and covers 1602 hect (36.05% of total area). The Eastern part of Western Suburbs, Co-operative Colony, Sector XII, Airstrip, Sector II and III are mainly located in this area. The part of area which lies South of the Airstrip, accommodates large numbers of squatter’s settlements too.
Moderately low land lies between 175 meters to 200 meters and covers 1900 hectare (42.76% of the total area). Sector I, IV, V, VI, VIII, IX and XI are developed in this area. Maximum portion of the planned township has been proposed in this area. The sectors like Sector VII and X which are dropped now, had planned to be built here. This is the most convenient height for construction work. It is very important to note that all the squatter’s settlements are developed on moderately undulating land (Unit II of Table no. - 3.1).

3.2.1.3 LOW LAND

The area lying below 175 meter contour line consists of low land. It covers 410 hectare (only 9.24% of the total study area) lands along the bank of the Damodar River in the Northern most part of the study area. Here agriculture is still being practiced by villagers because some original villages are still remaining in this area. No squatter’s settlements are found here.

3.2.2 RELATIVE RELIEF

Relative Relief is important in order to discriminate the occurrence or local variations in relief which is proved to be one of the useful variables for the purpose of terrain analysis. The values of relative relief with the help of the morphometric attribute “Relative Relief” or amplitude of relief has been adopted. The given map (Fig. 3.2) illustrates the variations in the relative relief of the study area.

The term ‘Relative Relief’ denotes actual differences between the highest and the lowest heights existing in a given area unit, square of a well- definitive size (one sq. km. here). It has been differently termed, as ‘amplitude of relief’ or ‘local relief’ because ‘it ascertains the amplitude of available relief to relate the altitude of the highest and the lowest points of any particular area.’ (Prasad, 1985, p201)

Owing to its close association with slopes the relative relief is more expressive and useful in understanding classes of natural phenomenon including relief dissection and surface ruggedness. When the amplitude of regional relief is greater, the surface roughness will be seen to vary significantly from units to unit under the over thrusting natural set of hydromorphic conditions. Thus, ‘more the local relative relief, the more is the roughness’ (Singh and Dhillon, 1984, p53). Natural variables of relative altitude and slope are interrelated and affect on each other. ‘The relative relief enumerates that the steeper the slope, the higher the surface above its
RELATIVE RELIEF (SMITH METHOD)

Legend
- Study Area
- Relief in Metres:
  - 0.066547714 - 10
  - 10.00000001 - 20
  - 20.00000001 - 30
  - 30.00000001 - 40
  - 40.00000001 - 50
  - 50.00000001 - 60
  - 60.00000001 - 70
  - 70.00000001 - 80
  - 80.00000001 - 90

Source: Map adopted from city Planning & Survey of India but Data Compiled and Computed by Researcher with the help of ArcGIS & Remote Sensing.
base’ (Sahu, S. D., 1997, p165). Therefore the sharpness of relief as visualized by the technique of relative relief cannot be expressed singularly by any graphical representation including surface elevation, profiles and area height relation curves.

A relative relief map (Fig. 3.2) has been prepared after Smith (1935) by determining the difference between the maximum and minimum points of units of 1 sq. km. Isopleths have been drawn at an interval of 5m ranging between 4.27mt – 35.5mt and four major categories of relative relief have been distinguished (Tb 3.2) for a detailed analysis of their distributional pattern and purposeful significance.

**TABLE NO. – 3.2**

**RELATIVE RELIEF**

<table>
<thead>
<tr>
<th>No. of Division</th>
<th>Relative Relief in mt</th>
<th>Zone Categories</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hectare</td>
</tr>
<tr>
<td>1.</td>
<td>&gt; 20.00</td>
<td>Moderately high</td>
<td>624</td>
</tr>
<tr>
<td>2.</td>
<td>15.01-20.00</td>
<td>Moderate</td>
<td>2277</td>
</tr>
<tr>
<td>3.</td>
<td>10.01-15.00</td>
<td>Moderately Low</td>
<td>1412</td>
</tr>
<tr>
<td>4.</td>
<td>&lt;10.00</td>
<td>Low</td>
<td>130</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>4443</strong></td>
</tr>
</tbody>
</table>

**3.2.2.1 MODERATELY HIGH RELATIVE RELIEF ZONE (>20mt)**

The moderately high relative relief zone is quite a rough area comprising only 624 hectare *i.e.* 14.04% of the total area. This area is found in Northern Suburban and in Western Suburban mainly. Township planner has avoided these areas from any permanent constructions till now. These areas are mainly kept as an open space which is environmentally supported and constructionally economical too.

**3.2.2.2 MODERATE RELATIVE RELIEF ZONE (15.01 – 20.00 mt)**

This zone occupies 2277 hectare *i.e.* 51.25% of the total area and supports main part of the planned townships area *i.e.* Sector II, III, Part of Sector IV, VIII, IX and XII and also Co-
operative Colony. The area, through quite undulating, has been widely used mainly due to advantage of its location.

3.2.2.3 MODERATELY LOW RELATIVE RELIEF ZONE (10.01-15.00 mt)

This zone occupies 1412 hectare i.e. 31.78% of the total area and mainly covers area along river sides of the Garga and Damodar. This zone is also widely used in city development and some of the very posh areas have been built up on this zone e.g. Sector I, part of Sector IV, Sector V, VI and BIADA Colony. This area also supports many Squatter’s settlements.

3.2.2.4 LOW RELATIVE RELIEF ZONE (<10.00)

This zone consists of a small area i.e. 130 hectare (2.93% only of the total area) which includes some points along the Garga River. This Zone is not being used by city developers. The southern most areas and the area of Sector VI along with the Garga River are used by Squatter’s settlements.

3.2.3. AVERAGE SLOPE

The slope conditions over the study area have been presented by Wentworth Method. The Map (Fig. 3.3) shows categorical distribution of the degree of land surface inclination.

The Wentworth’s Method is a ‘general’ and ‘random’ devise of average slope determination from a contour map basing upon the formula.

\[
\text{Average Slope} = \frac{\text{Average no. of contour crossing per Contour Unit side of a square grid} \times \text{Interval}}{\text{Length of one side of the grid in unit of contour interval}}
\]

Table 3.3 and Figure 3.3 have been prepared following this method. As the author has selected 1:20,000 map with contour interval 3mt apart, the demerits of Wentworth’s Method does not arise.
### TABLE NO. 3.3

**AVERAGE SLOPE BY WENTWORTH’S METHOD**

<table>
<thead>
<tr>
<th>No. of Division</th>
<th>Slope in Degree</th>
<th>Major Categories</th>
<th>Frequency</th>
<th>Area in Hectare</th>
<th>% of Slope Categories</th>
<th>Cumulative Frequency in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt;8</td>
<td>208</td>
<td></td>
<td>4.68</td>
<td>4.68</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6-8</td>
<td>I Moderately Steep</td>
<td></td>
<td>1403</td>
<td>31.58</td>
<td>36.26</td>
</tr>
<tr>
<td>3</td>
<td>4-6</td>
<td>II Moderate</td>
<td></td>
<td>2426</td>
<td>54.60</td>
<td>90.86</td>
</tr>
<tr>
<td>4</td>
<td>&lt;4</td>
<td>III Gentle</td>
<td></td>
<td>406</td>
<td>9.14</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TOTAL</td>
<td></td>
<td>4443</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

3.2.3.1 AREAS OF MODERATELY STEEP SLOPE (Above 6 Degree)

Areas of moderately steep slope cover 1611 hectare (36.26% of total study area). The Western Suburban areas, along the Garga River in Sector XII, VIII and IX come under this area.

3.2.3.2 AREAS OF MODERATE SLOPE (4 – 6 Degree)

Areas of moderate slope cover 2426 hectare i.e. 54.6% of the total study area. Main planned township has been built up on this area. This category is generally considered as an ideal area for construction because, it is economical and moreover it is favourable in natural run off.

3.2.3.3 AREAS OF GENTLE SLOPE (Below 4 Degree)

Areas of gentle slope below 4 degree consist of only 406 hectare i.e. 9.14% of the total study area. It is found mainly in Nn Suburban areas, along riverside of the Garga in Sector V and in Co-operative Colony.

An overall Average Slope analysis concludes that the whole area is suitable for the development of a city. The area is not very gentle which would have preferable for agriculture or suffers in water stagnant. Moreover, it is not very steep sloped which might have increase the expense of the city construction.

After a thorough discussion on surface elevation, relative relief and average slope of the study area, it has been seen that the area is very much suitable for the city development.
AVERAGE SLOPE BY WENT WORTH'S METHOD (BOKARO STEEL CITY)

Fig-

Legend

River
Study Area

SLOPE IN DEGREE
4.157803535 - 6.049250007
6.049250008 - 7.940696478
7.940696479 - 9.832142949
9.83214295 - 11.72358942
11.72358943 - 13.61503589
13.6150359 - 15.50648236
15.50648237 - 17.39792883
17.39792884 - 19.28937531

Source: Map adopted from city Planning but Data Compiled and Computed by Researcher with the help of ArcGIS & Remote Sensing.
relief measures are not suitable for agriculture activities. Hence the land is economically utilized by industrial development which ultimately changed not only the physical scenario but also the economical condition of the area.

3.3 DRAINAGE

The word ‘drainage’ usually refers to ‘the manner in which precipitation falling within an area or brought from outside is drained off’ (Ahmed, 1965, p 27). Thus, the resulting flow of water is understandably a ubiquitous feature of any landscape surfaced according to the climatic conditions, underlying structure and other physical aspects. It is very common that settlements develop on the bank of the rivers. In Bokaro too, the location of the slums and squatter’s settlements is highly influenced by the rivers, rivulets and brooks.

3.3.1 DRAINAGE PATTERN

To describe broadly, the common drainage pattern, i.e. the layout of rivers of the study area is called dendritic. In a dendritic pattern, the tributaries join the trunk stream at acute angles. ‘The dendritic pattern is regarded as the common and normal drainage pattern. It may indicate homogeneous rocks or horizontal beds or low flat surface without marked slopes. It implies a striking lack of structural control, i.e. as the rock is uniform in hardness the river has no choice like the selection of a region of soft rocks and avoidance of that of hard rocks. It flows indifferently to the rocks.’ (Ahmed, 1965, p 93). In case of Bokaro this statement proves the geology of the area discussed earlier.

3.3.2 SURFACE DRAINAGE

The channeled flows in Bokaro Steel City are in the forms of small streams or nalas, mostly of seasonal and intermittent character.

3.3.2.1 THE DAMODAR RIVER

The Damodar, an important river of the Jharkhand plateau, flows from West to East marking the northern boundary of the City. The area actually lies on the Damodar basin.
DRAINAGE
BOKARO STEEL CITY

Legend
- River
- Drainage
- Study Area

Source: Map adopted from city Planning & Survey of India.
3.3.2.2 THE GARGA RIVER

The Garga River is a small right Bank tributary of the Damodar River. But it has much more importance on Bokaro Steel City.

It originates from Kasmar block of Bokaro district, an elevation of 280 meters above the Mean Sea Level and flows marking the whole Southern and Eastern boundaries of the study area (Fig. 3.4). The topography of the area is mainly dissected by the number of small left bank tributaries of the Garga River. The sources of many of these small streams have been leveled up by artificial interference of the city set up. But main channels are remaining as their original forms and used by the city planners as an outlet of natural storm water.

The river has been thoroughly utilized by the city planners not only by building several bridges for communication network but also for water supply to the city and sewage outlet (Fig. 4.1). The Garga Dam, reservoir and supply of raw water to the water treatment plant have been already discussed in Detailed Project Report. There are many nameless non-perennial tributaries. The only perennial tributary is the Jhari Nala.

3.3.2.3 THE JHARI NALA

The Jhari Nala is the main left bank tributary of the Garga River. It and its tributaries are occupying the whole central part of the city.

The Jhari Nala originates from a point nearby Cooling Pond II at an elevation of 200 meters. It flows towards NE direction in between Sector IX and Sector IV through the Nehru Jaivik Udyan, the city Zoo. Here, a small lake has artificially been created for the flora and the fauna of the zoo and for recreation.

The Jhora Nala, Jhari Nala’s tributary, contributes an important role in the City Park development. It starts from Sector II and flows through the decorated and maintained part of the City Park forming lake for boating and garden and then flows through the Central Green Patches and meets the Jhari Nala behind Sector VI.

3.3.3 DRAINAGE DENSITY

The drainage density, an expression of the total length of an actual number of stream segments per unit area, is a meaningful index of potential sustainability in terms of water availability forming a basic input in human habitation.
DRAINAGE DENSITY OF BOKARO STEEL CITY

Legend
- River
- Drainage
- Study Area

LENGTH OF STREAM IN METRES
- 0 - 112.731
- 112.732 - 231.904
- 231.905 - 344.635
- 344.636 - 467.029
- 467.03 - 821.326

Source: Map adopted from city Planning and Compiled & Computed by Researcher.
The study denotes a spatial variation of natural water resource effecting on distribution of squatter’s settlement. All perennial and non perennial water channels are taken into consideration. (Fig. 3.5)

**TABLE – 3.4**

**DRAINAGE DENSITY**

<table>
<thead>
<tr>
<th>No. of Category</th>
<th>Length of streams in km/sq km</th>
<th>Density Zone and grades</th>
<th>Frequency</th>
<th>% of Density Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area in hectare</td>
<td>%</td>
<td>Cumulative freq. in %</td>
<td>Area in hectare</td>
</tr>
<tr>
<td>1.</td>
<td>&gt; 3.00</td>
<td>I High</td>
<td>27</td>
<td>0.61</td>
</tr>
<tr>
<td>2.</td>
<td>2.01-3.00</td>
<td>II Medium</td>
<td>1199</td>
<td>26.99</td>
</tr>
<tr>
<td>3.</td>
<td>1.01-2.00</td>
<td>III Low</td>
<td>2442</td>
<td>54.96</td>
</tr>
<tr>
<td>4.</td>
<td>&lt; 1.00</td>
<td>II Medium</td>
<td>775</td>
<td>17.44</td>
</tr>
</tbody>
</table>

3.3.3.1 **HIGH DRAINAGE DENSITY**

(> 2 km per sq. km)

The zone of high drainage density, i.e., area with more than 2 km natural water channel per sq km, is mainly found along the bank of Garga and in the middle part of the city, where the Jhari Nala is flowing. It covers 27.6% (1226 hectare) of total area (4443 hectare) and water channels are mainly perennial. This region is also preferred by squatters to develop their settlements. The maximum numbers of squatter settlements are found in this region.

3.3.3.2 **MEDIUM DRAINAGE DENSITY** (1.01 – 2.00 km per sq km)

Medium drainage density, which has 1.01-2.00 km of water channels per sq. km, occupies 54.96% (2442 hectare) of the total area. This area is thickly populated.

Squatter’s settlements, which are developed in this area, do not always depend on natural source of water. As the area is facilitated by water supply artificially, other factors like roadside location, work opportunities etc. help to develop squatter settlements here. There is another important point to be noted that this area is the sources of many non-perennial small tributaries.
of the Garga River. During the city construction headstream of many of these tributaries have been polished off.

3.3.3.3 LOW DRAINAGE DENSITY (< 1.00 km per sq km)

Low drainage density has been graded the area which has natural water channel less than 1.00 km per sq. km. It covers only 17.44% (775 hectare) of the total area. The area is surprisingly absent from the natural growth of any big squatter’s settlement. Small group of hutments are found here and there which are developed due to some local requirements. It encourages to think over that though filtered supply water is abundantly used by the squatters, but development of squatter’s settlements do not solely depend on supply water.

3.3.4 GROUND WATER

Physiographically Bokaro Steel City is characterized by dissected plateau with undulating surface. Lithologically the area consists of hard rock’s like gneisses and granite mainly, which are not endowed with adequate ground water aquifers. However, groundwater circulates in these rocks through opening like joints, cracks, fissures, faults etc. besides the weathered residuum, which is often endowed with considerable porosity.

The ground water level is a combined reflection of the various conditions such as thickness of aquifer, porosity, surface physiography, rainfall, surface run off, basement rocks and its structural characteristics and vegetation cover. Underground water is constantly recharged by rainfall through seepage and river systems. The normal depth of underground water level varies between 2 meters to 5 meters.

During dry season, depth of underground water level falls between 3 meters to more than 7 meters, depending on the nature of basement rocks and thickness of soil. During wet season underground water level raises 1 meter to 3 meters more than normal depth.

Originally the area is not favoured by enough rainfall and natural vegetation. So rich underground water table is not expected. The area is not facilitated by agriculture and human habitation due to lack of water availability.

Squatters mainly depend on surface water like perennial water channels and natural tanks and supply water by network of pipelines which covers almost every corner of the city. In this
city wells are found very less in number. People who practice vegetable gardening, dig wells and keep it is as a stand by source of water. Community wells are found on the old settlements like Dhobi line, Barka Khatal etc. which developed before construction of water pipeline network.

3.4 CLIMATE

Bokaro Steel City lies on the tropical area and away from the sea. Topographically it is a low dissected plateau. Hence, due to associated geographical factors Bokaro Steel City is lucky enough to enjoy five seasons distinctly. Mainly according to temperature and rainfall the year can be divided into five seasons.

3.4.1 THE SUMMER SEASON

Bokaro Steel City experiences the summer season from April to mid June. It is a period of continuous rising of temperature and downfall of humidity. Temperature ranges from 30*C to 40*C. It may rises upto 45*C. The daily range of temperature varies from 8*C to 12*C.

Dust Strom is common in this season especially between 2 p.m to 4 p.m. which is locally named ‘Andhi ‘or ‘Andhar. Sometimes it relieves from suffocation associated with hot dry local wind called ‘Loo’.

3.4.2 THE RAINY SEASON

Generally mid June to last June the South West Monsoon reaches here. July and August are preceded by an acceleration of the monsoon air, through rainfall continues till September. In Bokaro, nature of rainfall is not continuous. Through, because of increase of plantation, the amount of rainfall has increased as well as duration. But last one decade amount of rainfall is declining continuously due to lack of plantation. The annual rainfall varies from 140 c.m to 180 c.m. The rainy season is having through longest duration of months, but there is nothing special about it.

3.4.3 THE AUTUMN SEASON

The Autumn is the season comes in between rainy season and winter in October and November. The temperature starts falling especially at night. Due to clear sky mainly, the night experiences dew fall.
In this period, the South West Monsoon withdraws by retreat, which means a gradual withdrawal of the monsoon wind and associated depressions. A small amount of rainfall occurs by retreating monsoon and air remains humid in the post monsoon which ultimately helps in falling dew from the evening.

3.4.4 THE WINTER

December and January are two months of winter. Here, the winter is cold and dry like any other place of monsoon climatic region away from the sea. Night temperature falls around 8°C when day temperature may rise upto 20°C.

One or two western disturbances may enter in this area and leave it making more cold and humid.

3.4.5 THE SPRING

The spring is distinctly felt in February and March in Bokaro. In this time day temperature may rises upto 25°C with occasional dust rising wind. But night is very much comfortable with 14°C to 18°C temperature and soothing cool breeze which blows from the evening. This season is the driest part of the year.

The degree of comfort with which the climate of the area is associated and which is one of the primary determinants of the working capacity of people, their psychological attitude and social behavior etc. is comfortable and favourable. Relatively uncomfortable period in Bokaro is the month of mid April to May, as the structures and panels of the heavy industry like Iron and Steel warm up upto untouchable condition due to high temperature. Intensive plantation has helped in maintaining temperature little low specially in township as well as increased rainfall.

3.5 SOIL

Soil is the gift of nature of immense value. Though Bokaro as a base of a heavy industry, soil does not concern much. But in the city, to create a healthy environment specially for greenery, soil plays an important role.
3.5.1 RED AND YELLOW SOILS

The entire area is composed of crystalline and metamorphic rocks, granite and gneiss. The soils, derived from them are red and yellow in colour. The soil as a whole is light with a relatively high sand proportion. There are great variation in consistency of depth and fertility of soil. They vary by intermediate stages from the poor, thin and gravelly and light-coloured soils of the uplands to the deep dark-coloured fertile soils of the lower levels. Generally these soils have inadequate content of nitrogen, phosphoric acid and humus, but potash and lime derived from felsper, hornblende and augite of the crystalline rocks are generally sufficient.

3.5.2 LATERITE

Laterite is found in small quantity on higher levels in Western and Northern Suburbans specially. ‘Any rock containing some alumina and iron will be weathered into laterite’. (Ahmed 1965,p 67). The red and yellow soils of this area may be regarded as an initial stage in laterite formation.

3.5.3 DEPOSITED SOIL

This soil is found on the valleys formed by the numerous small tributaries of the Garga River. These depressions, receive all the detritus washed down from the uplands and slopes, are relatively moist, more clayey and dark in colour. Till now these low lands are used in agriculture specially growing vegetables for ready supply in the city, because these spaces are not used for direct city construction. Obviously, before the city built, paddy was used to be cultivated.

3.6 VEGETATION

‘It is estimated that 25 percent of the surface of a country under forests is normally adequate’ (Ahmed 1965,p 68). When the international standard is 33% of the earth should be green.

Though vegetation generally means natural vegetation, but the author has considered it as greenery for this city particularly. Intensive plantation gives same favourable results to environment and ecology as natural vegetation gives.

From the very initial stage of Bokaro, the planners and the management have taken care about intensive plantation which has, as a result changed the ultimate scenario.
NATURAL VEGETATION COVER
(BOKARO STEEL CITY)

Legend
- River
- Study Area
- Natural Vegetation

Source: Adopted from Horticulture Dept, B.S.L.
3.6.1 THE NATURAL VEGETATION

The natural vegetation (Fig. 3.6) of the study area is the tropical dry deciduous which has the following general characteristics.

i) Sal is the main specie available but apart from Sal there are other important species like bamboo, mahua, shisham etc.

ii) Except the right bank of upper stream of Jhari Nala, where a dry Sal forest developed originally, the area is covered by sparse vegetation, i.e., isolated large trees quite apart from each other.

iii) It has a stunted growth, the canopy rarely rising above 15 mt.

iv) The undergrowth is mostly semi-evergreen shrubs which become very thick and green in rainy season.

3.6.2 THE PLANTATION

The Indian saying that “where there is no jungle, there is no happiness” has realized by the management authority from the very early age of Bokaro. The Horticulture Department has been established in 1968 with very small and limited activities. Initially it was involved only in development of gardens in City Park, Administrative Buildings and road side plantation for shades. The mass scale tree-plantation in order to develop green patches was done since 1980 to 2000. After 2000 it became very slow only some places tree-plantation was occurred.

The plantations on both sides of the roads are mainly with Amaltas (Cassia fistula) and in season it bears different colours of flowers especially golden yellow in abundance. The Lake Road, the Steel Road, the Mahatma Gandhi Marg, the Jawaharlal Nehru Marg are good example of road side plantation.

In 1980, a resolution had been taken to develop the greenery of B.S.L. land. Since then 10, 50, 000 trees had been planted inside plant’s boundary wall, but here, only plantation in township area is being considered.

In township, the B. S. L. Horticulture department has selected gardens, parks, picnic spots, sides of new built roads and open spaces for plantation. Total 48 gardens have been
PRESENT GREENERY DUE TO PLANTATION
(BOKARO STEEL CITY)

Legend
- Plantation
- River
- Study Area

Source: Adopted from Horticulture Dept, B.S.L.
developed where 13 gardens are in plant Administrative Offices, 12 gardens are in different B.S.L. schools, 11 in different Health Centres, 4 in different Recreation Clubs, 2 in Water Treatment Plant and 1 garden each in Main Administrative Building, Training and Development Centre, Bokaro General Hospital, Bokaro Hotel, Central Library and Airstrip. Two main parks are developed.

i) Jawaharlal Nehru Javik Udyan with 51 hectares of area in Sector IV and

ii) City Park with 59 hectares area in between Sector I and Sector III. 7 Sector- Centre Parks with children play-equipments are developed in different sectors.

Picnic spots are developed with drinking water facilities in the Garga Dam, in the northern portion of the City Park and in the Botanical Garden of Sector IV F (Fig. 3.7)

TABLE 3.5
PLANTATION BY BOKARO STEEL LIMITED IN BOKARO STEEL CITY
FROM 1980-81 TO 1988-89

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of trees Planted</th>
<th>Area Covered</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980-81</td>
<td>10,000</td>
<td>128 hect area planted by trees approx. 4 mt. apart.</td>
<td>Rs. 20 lakhs.</td>
</tr>
<tr>
<td>1981-82</td>
<td>10,115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982-83</td>
<td>15,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1983-84</td>
<td>1,20,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1984-85</td>
<td>1,23,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985-86</td>
<td>1,00,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986-87</td>
<td>1,00,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1987-88</td>
<td>1,00,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1988-89</td>
<td>1,00,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6,78,115</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Horticulture Department, Bokaro Steel Limited.

Within eight years *i.e.* from 1980-81 to 1988-89 Bokaro Steel Limited Horticulture department planted 6,78,115 numbers of trees on 128 hect of area. Total expenditure within eight years came Rs. 20 Lakh. The most important thing was 95% survival rate which changed the scenario.
The Damodar Valley Corporation, the Forest Department and other NGOs were getting interested in this noble work. Since 1989 to 2000 they initiated giving active participation. But after 2000 this noble work became slow due to lack of interest of Bokaro Steel Limited and other organizations.

**TABLE 3.6**

**PLANTATION IN BOKARO STEEL CITY FROM 1989 ONWARDS**

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of trees planted</th>
<th>Total no. of Plants</th>
<th>Area Covered in hect.</th>
<th>Expenditure in lakh Rs.</th>
<th>Done by</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989-90</td>
<td>2,50,000 1,25,000</td>
<td>3,75,000</td>
<td>118</td>
<td>16.69 1.49</td>
<td>D.V.C. B.S.L.</td>
</tr>
<tr>
<td>1990-91</td>
<td>5,62,823 4,00,000 10,000</td>
<td>9,72,823</td>
<td>253 162 Roadside</td>
<td>39.46 20.44 0.47</td>
<td>D.V.C. Forest Dept. B.S.L.</td>
</tr>
<tr>
<td>1991-92</td>
<td>20,000 4,00,000</td>
<td>4,20,000</td>
<td>Schools 152</td>
<td>0.92 22.45</td>
<td>B.S.L. Forest Dept.</td>
</tr>
<tr>
<td>1992-93</td>
<td>2,00,000 2,00,000 25,000</td>
<td>4,25,000</td>
<td>81 84 11</td>
<td>22.49 12.42 1.00</td>
<td>Forest Dept. D.V.C. B.S.L.</td>
</tr>
<tr>
<td>1993-94</td>
<td>49,446</td>
<td>49,446</td>
<td>20</td>
<td>0.72</td>
<td>B.S.L.</td>
</tr>
<tr>
<td>1994-95</td>
<td>50,000 650 8,000</td>
<td>Replaced 8,650</td>
<td>- 11 4.5</td>
<td>0.80 0.30 2.74</td>
<td>B.S.L. B.S.L. Forest Dept.</td>
</tr>
<tr>
<td>1995-96</td>
<td>8,455 2,537 1,350 90,725</td>
<td>Replaced 94,612</td>
<td>- 2 Roadside 36.29</td>
<td>0.60 0.22 2.04 8.61</td>
<td>B.S.L. B.S.L. B.S.L. Forest Dept.</td>
</tr>
<tr>
<td>1996-97</td>
<td>1,790 58,100</td>
<td>59,890</td>
<td>Roadside 27.33</td>
<td>3.38 6.54</td>
<td>B.S.L. Forest Dept.</td>
</tr>
<tr>
<td>1997-98</td>
<td>35,000 25,840 63,734</td>
<td>Replaced 89,574</td>
<td>- 16 30</td>
<td>0.44 5.52 7.40</td>
<td>B.S.L. N.G.O. Forest Dept.</td>
</tr>
<tr>
<td>1998-99</td>
<td>42,560</td>
<td>42,560</td>
<td>17</td>
<td>0.64</td>
<td>B.S.L.</td>
</tr>
<tr>
<td>1999-2000</td>
<td>1,540 450</td>
<td>1990 Roadside 10</td>
<td>0.59 0.24</td>
<td>B.S.L. Forest Dept.</td>
<td></td>
</tr>
<tr>
<td>2001-02</td>
<td>250</td>
<td>250</td>
<td>11</td>
<td>0.20</td>
<td>B.S.L.</td>
</tr>
<tr>
<td>2002-03</td>
<td>4,650</td>
<td>4,650</td>
<td>Roadside</td>
<td>0.45</td>
<td>B.S.L.</td>
</tr>
<tr>
<td>Year</td>
<td>Replaced</td>
<td>Roadside</td>
<td>Total</td>
<td>+ Roadside</td>
<td>Source: Horticulture Department, Bokaro Steel Limited (B.S.L.)</td>
</tr>
<tr>
<td>-----------</td>
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<td>----------</td>
<td>----------------</td>
<td>------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>2003-04</td>
<td>*1,790</td>
<td>2,768</td>
<td>26,02,626</td>
<td>183.62</td>
<td>A massive tree plantation had been started. In 1989-90, the Damodar Valley Corporation planted 2,50,00 numbers of trees on 116.60 hect of area. In 1990-91, as enthusiasm increased its height with the Government policy. The D.V.C planted 5,62,823 numbers of trees on 250 hectare, The Forest Department joined that year and planted 40,00,000 trees on 160 hect, where the Bokaro Steel Limited Horticulture Department kept their activities limited on plantation of roadside trees. In roadsides of Sector IV F and IV g, Sector V, VI, VIII, IX, XI and XII which are comparatively new built, saplings plantation have been done with drum tree guards or brick gabions. Open spaces are generally selected for block plantation, main purpose of which is afforestation. Areas selected for this purpose are: i) Behind City College, Sector VI, ii) East of Kendriya Vidyalaya- II, Sector IV, iii) Along the aGarga River, Sector VI,</td>
</tr>
<tr>
<td>*2004-05</td>
<td>52,650</td>
<td>12</td>
<td>52,650</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>*2005-06</td>
<td>1,298</td>
<td>2,763</td>
<td>1,298</td>
<td>2,763</td>
<td></td>
</tr>
<tr>
<td>2006-07</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2007-08</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
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<tr>
<td>2008-09</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td></td>
</tr>
<tr>
<td>2009-2010</td>
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<td>-</td>
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<td>-</td>
<td></td>
</tr>
<tr>
<td>2010-11</td>
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<td>-</td>
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<tr>
<td>2011-12</td>
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</tr>
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<td>2012-13</td>
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<tr>
<td>2013-14</td>
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</tr>
<tr>
<td>2014-15</td>
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</tr>
<tr>
<td>2015-16</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>26,02,626</td>
<td>1071.72</td>
<td>1071.72</td>
<td>183.62</td>
<td></td>
</tr>
</tbody>
</table>

*Replaced/Replacement Plantings are not included in the total.
iv) The valley in between Sector IV G and IV F and in between IV G and Petrol Pump opposite Sector V,
v) Behind Bokaro Ispat Library upto Bokaro Hotel and behind Bokaro Hotel upto bank of Garga in Sector V,
vi) Camp I and Mansa Singh Gate,

vii) Ash Pond,

viii) Outside Jawharlal Nehru Park
ix) In between Cooling Pond II and Mahatma Gandhi MArg,
x) Sector XII and Oxidation Pond area
xi) In between Sector IX and Mahatma Gandhi Marg,
xii) North of Bokaro Genral Hospital,
xiii) Open space between Kendriya Vidyalaya-II and Sector XI road.

Total 1136.12 hectare + roadsides (in total 25.57%) have been covered by green and the practice is still going on. The species of trees planted till 1991-92 mainly were Acacia Auriculiformis (Sonajhuri), Cassia Siamea (Chakundi), Pehtophorum roxburghill (Peltophorum), Anthocephalus Cadamba (Kadamb),Tabebuia Rosea (Basant Rani), Sterculia Urens (Keonjhi), Grevillea Robusta (Silver Oak), Albizia Saman (Rain tree), Ficus Glomerata (Gular/Dumar), Eucalyptus Citriodora (Eucalyptus), Mimusops Elengi (Bakul), Nyctanthes Arbor-tristics (Harsingar), Terminalia Arjuna (Arjuna), Azadirachta Indica (Neem), Ficus Benghalensis (Bargad), Polyalthia Longifolia (Ashok), Cassia Fistula (Amaltas) etc.

3.6.2.1 COMMERCIAL PLANTATION

By 1992-93, 840 hectare of open space became green. The management decided to switch over on plantation of commercial trees which decreased the number of tree plantation but definitely increased the quality.
# TABLE NO. – 3.7

## PLANTATION OF COMMERCIAL TREES IN BOKARO STEEL CITY

<table>
<thead>
<tr>
<th>Year</th>
<th>Teak</th>
<th>Sisam</th>
<th>Gumhar</th>
<th>Mehugani</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993-94</td>
<td>1000</td>
<td>10,000</td>
<td>1,000</td>
<td>500</td>
<td>12,500</td>
</tr>
<tr>
<td>1994-95</td>
<td>10,000</td>
<td>10,000</td>
<td>-</td>
<td>500</td>
<td>20,500</td>
</tr>
<tr>
<td>1995-96</td>
<td>20,000</td>
<td>20,000</td>
<td>5,000</td>
<td>500</td>
<td>45,500</td>
</tr>
<tr>
<td>1996-97</td>
<td>20,000</td>
<td>10,000</td>
<td>10,000</td>
<td>-</td>
<td>40,000</td>
</tr>
<tr>
<td>1997-98</td>
<td>2,000</td>
<td>30,000</td>
<td>-</td>
<td>-</td>
<td>5,000</td>
</tr>
<tr>
<td>1998-99</td>
<td>1,000</td>
<td>5,000</td>
<td>-</td>
<td>-</td>
<td>2,000</td>
</tr>
<tr>
<td>1999-2000</td>
<td>500</td>
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<td>-</td>
<td>2,500</td>
</tr>
<tr>
<td>2000-01</td>
<td>200</td>
<td>1,000</td>
<td>-</td>
<td>100</td>
<td>1,300</td>
</tr>
<tr>
<td>2001-02</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100</td>
<td>100</td>
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<tr>
<td>2002-03</td>
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<td>-</td>
<td>--</td>
</tr>
<tr>
<td>2003-04</td>
<td>-</td>
<td>500</td>
<td>-</td>
<td>-</td>
<td>500</td>
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<tr>
<td>2004-05</td>
<td>100</td>
<td>200</td>
<td>100</td>
<td>100</td>
<td>500</td>
</tr>
<tr>
<td>2005-06</td>
<td>-</td>
<td>-</td>
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<td>2006-07</td>
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<td>2007-08</td>
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<td>2008-09</td>
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<td>-</td>
</tr>
<tr>
<td>2009-10</td>
<td>100</td>
<td>300</td>
<td>200</td>
<td>-</td>
<td>600</td>
</tr>
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<td>2010-11</td>
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<td>2011-12</td>
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<tr>
<td>2012-13</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>54900</td>
<td>89000</td>
<td>16300</td>
<td>1800</td>
<td>1,31,000</td>
</tr>
</tbody>
</table>

Source: Horticulture Department, B. S. L.

From 1993-94 to 1997-98, 1, 23, 500 numbers of trees like TEAK, SISAM, GAMHAR, MEHUGANI had been planted. Only teak plantation covered 4.5 hectare of open space behind Sector IV D Rotary Club and behind Sector II Kala-Kendra. Plots with mixed commercial trees were allotted at –
i) Sector XII near Oxidation Pond,

ii) Along Central Avenue, near Nagar Sewa Bhawan,

iii) Jawaharlal Nehru Javik Udyan,

iv) Sector IV F,

v) Area between Kendria Vidyalaya – II and Sector XI road,

vi) In between Ukrid and Scap-bursting yard.

Altogether 24 hectare land is under commercial plantation (Fig. 3.7).

3.6.2.2 OTHER ACTIVITIES AND COST INVOLVED IN PLANTATION

In Bokaro, survival rate is high due to after care and monitoring. Regular hoeing, mulching, deweeding, manuring, watering etc. are done by employees of Horticulture department in 48 gardens. Obviously, this much of care is not possible to give on roadside trees and open space afforestation.

In case of the roadside plantation, saplings are being set with manure and then surrounded by drum tree-guards or brick gabions. These tree-guards protect the saplings not only from falling off and scorching sunrays or cattle but also from vandalism such as removing saplings, plucking flowers.

To protect open space afforestation especially from cattle grazing circular trench gabions is made. Initial manuring is compulsory even in open-space plantation.

Nursery is one important wing of Horticulture Department, which develops seedling, budding, grafting etc. moreover, spraying of insecticides for pest and disease control are other responsibilities of the Horticulture Department.

The whole activities require a great financial assistance. Since 1980-81 to 1988-89, Rs. 20 lakh had been spending only for plantation. It was Rs. 18.18 lakh in 1989-90 and Rs. 60.37 lakh in 1990-91, which was maximum among all the years.

The total expense during 1988-89 to 1997-98 was Rs. 177.14 lakh and 1998-1999 to 2006-2007 was Rs. 30.14 lakh. After 2006-07 there were no plantation done by anyone. 1998-99 to 2006-07 only roadside plantations were done for the beautification of the City.
This included expenditure of sapling, manure, drum tree-guards, circular trench, brick-gabion etc. The expenditure of maintenance of gardens and employees are excluded. The employees are sole liabilities of Bokaro Steel Limited.

Replacement plantation or reforestation of Bokaro Steel Limited is also practiced here. It needs expense when numbers of replaced trees are not included with total number of trees planted.

3.6.2.3 RESULTS OF PLANTATION WITH SPECIAL REFERENCE OF BOKARO STEEL CITY

A steel plant, especially when its capacity is 4 million tons per annum, results in enormous amount of dust and increases the temperature of the surroundings. The artificial dust-catchers are not sufficient and allow good amount of dust to flee outside.

Series of trees serve the purpose of dust filtration nicely. Once the dust fled from Chandrapura Thermal Power Plant (Damodar Valley Corporation) located just other side of the Damodar River, was a great problem for Sector IX and Northern Suburb dwellers. It has been stopped by the intensive plantation along the bank of Damodar River and in the North of Sector IX. The bare rock itself increases the temperature tremendously. In addition of the Blast Furnaces, Coke Oven Plants, Power Plants, Hot Rolling Mills etc., the normal temperature increases by another 5*- 8* C. The intensive plantation makes the place livable maintaining the temperature in a normal level. The dust rising wind is a natural phenomenon in this area especially in the spring and in the summer season. The intensive plantation has decreased the intensity of the dust rising wind. This helps the people to go and work outside in mid-day of the months of March-April-May-June, till the monsoon breaks.

The intensive plantation has increased both the amount of rainfall is a remarkable achievement where duration has increased from 20 minutes/half an hour to one hour or more. It gives soothing look with bright green foliage especially in rainy season.

The intensive plantation also stops the advancement and area occupation by squatters’ dwellers. They do not make their huts inside the circular trench gabions.

It is a very common scene that, squatters’ settlement ends where plantation starts. Hence, by this way the management can protect the authorization of the land. Moreover, in future it may help, the management, as a source of income.
REFERENCE:


2. **Geological Quadrangle Map 73 I**


4. **Topographical Map 73 I / 2 with scale 1:50,000 and 1:20,000.**


