RECLAMATION OF A LIMESTONE QUARRY, MAIHAR, SATNA, MADHYA PRADESH.

A DESIGN THESIS

Submitted
In partial fulfillment of the requirements
for the award of the degree of

MASTER OF LANDSCAPE ARCHITECTURE

By

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DECLARATION

I Steffi Sharma, Scholar No. 2015MLA016 hereby declare that the thesis titled **“Reclamation of a limestone quarry, Maihar, Satna, Madhya Pradesh”** submitted by me in partial fulfillment for the award of Master of Landscape Architecture in School of Planning and Architecture Bhopal, India, is a record of bonafide work carried out by me. The matter embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

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This is to certify that the declaration of **Steffi Sharma** is true to the best of my knowledge and that the student has worked for one semester in preparing this thesis.

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I "*Steffi Sharma, 2015mla016, Masters Of Landscape Architecture*" have prepared a report titled "*Reclamation of Limestone Quarry, Maihar, Satna, Madhya Pradesh*" under the guidance of "*Ar. Saurabh Popli*" for the purpose of in partial fulfillment of condition of masters of landscape architecture program at School of Planning and Architecture, Bhopal.

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ABSTRACT

Landscape architecture known as a reconciliation in between human and nature, but few are the areas which are neglected. Anthropogenic activities necessary for the growth of human settlements are degrading the valuable landscapes. Mining is one such activity, started along with agriculture time, it has only increased in each aspect due the increase in demand of the resources. Mining is being done for various resources such as minerals, sand etc. in different forms. One of them is open pit mining also known as quarrying.

Quarrying of limestone is something which cannot be replaced by any other resources as it has a huge demand for the growth of economical section and is harmful not only for the human beings but also for the environment. Quarrying of limestone eaves behind the huge bowl of rock and sand at its own for aging to the worst conditions and acting as main sources of harmful effects to the surroundings.

The thesis aims at proposing a landscape plan for the abandoned limestone mines of Maihar. A holistic landscape conservation plan aims at creating a sustainable landscape in the study region including landscape engineering techniques.

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1.1 Background

Mining is considered one of the most profitable and least environmentally friendly activities. In the following centuries, the average size of mines has increased in India. The various development plans or management plans and guidelines are on paper and are hardly even executed on site. Mining affects the landform by modifying the layers of geology, hydrology, and vegetation and even after the site is abandoned, the surroundings are affected by it in many ways. Nearly none or very few reclamation of mining has been done in India whereas the practice of mining to get the ores is not been decreased a bit.

Constructions worldwide require cement and concrete. The large demand for cement requires equally large supplies of raw materials, mostly limestone. “Limestone comes from calcium rich deposits usually extracted through open cast mining. This creates large quarries which are stripped of all their living material and what remains after the extraction is a large sterile quarry that in most cases does not support any life”.1 “However, mankind cannot afford to give up the underground geological resources which are the basic raw materials for development, since an undamaged nature can provide ecological security to people but cannot bring economic prosperity.”2

A quarry is a surface mining operated area, which produces enormous quantities of gravel, limestone, and other materials for industrial and construction applications[3]. Quarrying is the essential first step in the cement production process because limestone, shale or clay must be extracted from below the ground surface to provide the industry’s raw material. Usually where quarrying takes place, the land is cleared of all vegetation, the landscape is drastically altered and the ecosystem totally disrupted[4].

[1] Chaoji, 2009
[2] Sinha, Pandey and Sinha, 2000).
[3] Duan, et al., 2008)[3].
[4] [4](Bradshaw and Chad wick 1980

1.2 Problem Statement and Study Justification

Quarrying of the limestone deposit at the study site produces huge tonnages of waste material which is dumped at any convenient location. Land around the mines seems too abundant to cause concern. These unconfined disposals of wastes, are major source of pollution to the environment. Substantial research has been conducted on rehabilitation and ecological restoration of mined lands, but most of the research has been focused on large mines where valuable materials including gold, copper and zinc have been extracted. However, little attention has been paid to small quarries which produce low value materials yet all quarries have similar environmental impacts.

Aesthetic impacts of mining are of critical concern to the rehabilitation specialists. Negative landscape impacts or visual intrusion are greatest with large waste dumps in densely settled areas[5] .

Rehabilitation of the mine site using the appropriate vegetation will lead to the better utilization of resources, improved community health, as the amount of dust will have been reduced, and it will help in the establishment of an ecological environment that will stimulate colonization of wildlife for natural plant propagation, consequently this will increase the biodiversity of the system.

1.3 Need of reclamation

Ironically, the wealth created in part by mining, has led to increased concern for the environment by society. The impacts of primary industries (agriculture, forestry, fishing, and mining) on the environment are under increasing scrutiny. With the increasing pressure upon the mining industry upon the limited land base, the need to balance the environmental disruption caused by mining and landscape changes has emerged. Once the mining has stopped on a site, the site is left open for the natural processes. But due to the absence of the vegetation, disturbance in the geology,

[5] Law, 1983.

change in land-use, and natural processes which once made the landscape of that place , affects the other natural processes along with the quality of the landscape. Reclamation of the abandoned mine is required and the aim should be –

- To return the land to productivity with a usable contour and
- To protect the environment in terms of quality of natural features.

Loss of vegetation, impacts on surface and ground water, fauna and human health due to dust and noise and loss of interior forest, species habitat and diversity from edge effects created by mining are among the environmental effects of limestone quarries[6]. These impacts have a cumulative effect with other human activities in the region of occurrence. It is difficult for a limestone quarry to be reclaimed easily due to the coarse substrate, mineral deficiencies and excessive drainage. Leaving over a quarry by itself is not help for the vegetation to grow as re-vegetation, treatment of the soil, Slopes, the waste and several other issues is to be done by human for the reclamation of the site.

All these factors lead to the need of reclamation of a limestone quarry so that harmful effects can be controlled and to return to the nature in a healthy manner can be made.

1.4 Aim

The project aims to reestablish the lost landscape values of the abandoned mine for the case of open cast mining of limestone. The study will focus on the landscape proposals of the abandoned mine which will be applied to the whole mining belt of kaimur hills coming under the Maihar district. Kaimur hills, is the eastern portion of Vindhyan range, about 483 km long extending from Jabalpur to Rohtas district in Bihar.

[6] Martínez-Garza and Howe 2003, Wickham et al. 2007, Darwish et al. 2011

1.5 Objectives of the Study

- To identify the landscape of the study region with various natural layers and problems affecting the landscape.
- To study how mining has changed the landscape in order to understand the complete process.
- To create a balance between the mining sites and its surroundings in terms of health, quality, ecology of the surroundings.
- To develop tools, methods, and strategies to accommodate uncertainty through more thoughtful design and construction.
- To create awareness about the issues in a manner to prevent the site or similar case from further degradation.
- To determine how various landscape engineering techniques can be used to stabilize the existing conditions of the study region.
- To attempt to answer the question: "How well can we predict long term landscape performance?" and develop methods, tools, and strategies to accommodate uncertainty through more thoughtful design and construction and through adoption of other mechanisms.
- To determine the current status of landscape design, mine reclamation, and reclaimed landscape performance and how well these efforts and outcomes support mining companies and the mining industry

1.6 Methodology

Step 1- Site selection

Step 2 -Literature review - To study similar case and derive the inferences for understanding how to deal with the sensitive issues.

Step 3- Site Visit - To identify the potential of site and read the site surroundings

Step 4 Data collection

Step 5 – Analysis of Physical and Cultural Features

Physical features

- Geology
- Topography
- Hydrology
- Soils
- Vegetation

Cultural features

- Land use
- Ownership
- Utilities
- Historical Perspective
- Circulation
- Visual Aspects

Step 6- To give landscape proposals for the abandoned mine which can be applied to the whole mining belt of kaimur hills.

1.7 Scope, Limitation and Assumptions of the Study

The scope of the study is limited to Maihar mines only. The study will focus on the abandoned mine sites, reason for its abandonment its potential foe development, issue, values and concerns related to the selected quarry site**.**

CHAPTER 2: LITERATURE REVIEW

2.1 Quarry rehabilitation

2.2 Mining and its phases

2.3 Open pit mining.

2.4 Impacts of mining

2.1 Mining and its phases

Ming is being done in different phase carrying various process throughout the whole journey of mining. They are as follow:

1. Prospecting - Search for ore (Mineral deposit)
a. Prospecting methods -Direct: physical geologic
Indirect: geophysical, geochemical
b. Locate favorable loci (maps literature old mines)
c. Air: aerial photography, airborne geophysics satellite
d. Surface: ground geophysics geology
e. Spot anomaly, analyze, evaluate

2. Exploration- Defining extent and value of ore
a. Sample (drilling or excavation),
b. Estimate tonnage and grade
c. Valuate deposit present value income cost
d. Feasibility study: make decision to abandon or develop mining property

3. Development - Opening up ore (Prospect) production
a. Acquire mining rights (purchase or lease
b. File environmental impact statement, technology assessment, and permit
c. Construct access roads, transport system
d. Locate surface plant, construct facilities
e. Excavate deposit (strip or sink shaft)

4. Exploitation Large-scale production of ore

a. Factors in choice of method: geologic, geographic, economic, environmental, Societal safety
b. Types of mining methods
    i. Surface: open pit, open cast, etc.
    ii. Underground: room and pillar, block caving, etc.

5. Reclamation & Restoration of site

a. Removal of plant and buildings
b. Reclamation of waste and tailings dumps
c. Monitoring of discharges

Mining is being done in various forms of extract different minerals. The process is divided into two main types, i.e.

1. **Surface mining-** Surface mining is further divided into following types. They are:
    a. **Placer mining**
    b. **Strip mining**
    c. **Mountaintop removal mining**
    d. **Hydraulic mining**
    e. **Open pit mining**
    f. **Dredging**
2. **Under-ground mining-** Underground mining is done in different types as given below:
    a. **Drift mining**
    b. **Slope Mining**
    c. **Shaft mining**
    d. **Hard Rock Mining**
    e. **Bore Hole Mining**

2.2 Open pit mining

The ores in an open pit mine are covered by overburden. Both the ores and overburden are removed in benched=s ranging from height 5m to 30 m .A thin deposit may require one or more benches but a thick deposit needs more number of benches and pit in its production stage resembles like an inverted cone as mining reverses the topography.

Design aspects of an open pit mine

a. Ultimate pit depth- the ultimate depth of mine that it will reach at the end of its life.
b. Bench height- the bench height is the height in which one bench is dug. Usually heights decided as per the esitence of the equipments and depending on the type of machinery being used. As a thumb rule to be followed on all case bench height

should be equal to the economic bucket height of an excavator plus 3 meters in addition.

c. Bench slope- depending upon the geology and amount of overburden, bench slope is decided
d. Overall pit slope- Depends upon the bench height, bench slope and geotechnical slope of rocks beneath the ground. Bench slope is always more than the overall pit slope.
e. Bench width – this is usually decided on the space required by the equipment.
f. Haul road width and slope- It's wider than the bench width, depending upon equipment width and trucks for the movement.
g. Bench length- the bench length generally depends on the geology beneath, how much ore to be extracted.

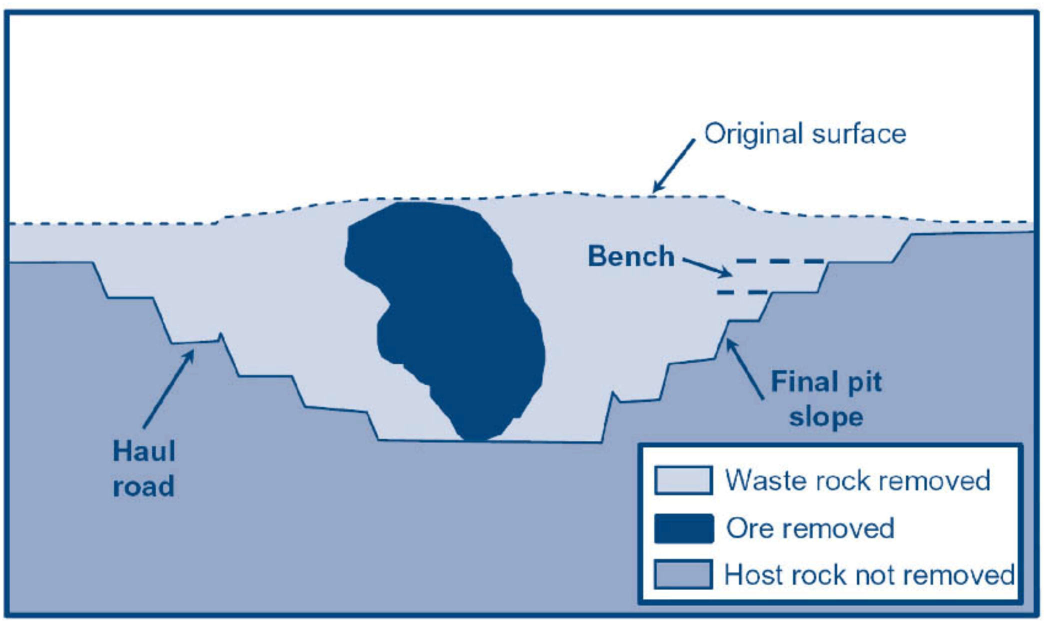

Figure 1: Basic terminology of open pit mining.

2.3 Impacts of mining

Limestone deposits exist throughout the world. These alkaline, sedimentary rocks were laid down mostly as deposits on the beds of ancient seas. A valuable natural resource, limestone has many uses in construction, agriculture and industry. Limestone quarries can be above ground or underground, and can cover large areas. Environmental hazards from mining operations depend in part on the location, characteristics and extent of the mining operations.

The negative impacts of surface mining on environment can be listed as the following:

- Occupation of large farming areas needed for excavation and dumping operations.
- alteration of land morphology,
- disturbance of native fauna and flora,
- modification of surface and ground water balance,
- resettlement of residential areas, roads and railways,
- Release of air, liquid and solid pollutants and noise pollution.

Open cast mining has impacts on different environments. They are:

- **Air Environment**
  - · Impact on Ambient Air Quality
  - · Impact on Ambient Noise
- **Water Environment**
  - Impact on Water resources
  - Impact on Water quality
- **Socio Economics**
  - Impacts on demand-supply
  - Impacts on natural resources
  - Impacts on industry
  - Impacts on infrastructure
  - Impacts on employment
- **Land Environment**
  - Impacts on land use
  - Impacts on soil fertility

- Impacts on agriculture
- Impacts on forests and wildlife

- **Indirect impacts**
  - Impacts on public health and safety
  - · Impacts on cultural resources
  - · Impacts on ecology and biodiversity
  - · Impacts on aesthetics

The major key issues to be dealt in mining are as follows:

- **Soil destruction** is one of the most crucial environmental impacts of opencast mining activities. In the course of removing the desired mineral material, original soil become lost, or buried by wastes. When mining is going and has gone on, particularly top soil must be conserved because it is an essential source of seed and nutrients, and should be preserved for use in reclamation.

- Another adverse impact of opencast mining on land is **soil contamination** with a range of potentially hazardous substances (both chemical and biological) which, if present at sufficiently high levels, may introduce potential problems related to public health and environment. For example, soils can contain high levels of heavy metals such as cadmium and lead, which can severely affect the local population.[7] So, identifying and dealing with contaminated land is important in order to support increased quality of life for communities and conservation of biodiversity[8].

- **Ground Water-** Limestone mining can affect ground water conditions. Limestone deposits often occur in association with karst, a topography where limestone slowly dissolves away underground. The deposits result in sinkholes, caves and areas of rock fractures that form underground drainage areas. When mining occurs in karst, disruption to natural aquifers, or flows of underground water, can result. Often, mining operations remove ground water to expose the quarrying site, which can lower the water table and change how water flows through the rock formations.

[7] A. J. Kibble, P. J. Saunders, Contaminated Land and the Link with Health. In: Hester R.E., Harrison R.M. (ed.) Assessment and Reclamation of Contaminated Land. Cambridge: Royal Society of Chemistry

[8] M. Kibblewhite, Identifying and Dealing with Contaminated Land. In: Hester R.E., Harrison R.M. (ed.) Assessment and Reclamation of Contaminated Land. Cambridge: Royal Society of Chemistry

- **Surface Water-** Streams and rivers can be altered when mines pump excess water from a limestone quarry into downstream natural channels. This increases the danger of flooding, and any pollutants or changes in water quality affects the surface water. In Germany, salty water pumped from limestone quarries into rivers has degraded the water quality, according to the International Mine Water Association. Upstream surface water features, such as marshes, ponds and wetlands, can lose volume as their waters drain into the mine and are pumped out.

- **Sinkholes-** As water and rock are removed from mines, the support they give to underground features is gone. Sinkholes can develop, where the roofs of underground caverns are weakened or collapse. Collapse can be gradual or sudden. Although natural sinkholes develop over time, man-made ones predominate in mine areas. Sinkhole formation can cease after mine dewatering is stopped and the water table is allowed to return to normal levels.

2.4 Quarry reclamation

Opencast mines deface some of our finest landscapes and wreck tranquility, they have a devastating effect on nearby communities and wildlife. To reclaim an open cast quarry is may takes years ad to recover ad reach to an ecological balance. "During this period, these types of lands need human hand for reclamation and recovery. Therefore, post-mining reclamation works are those aiming to regain landscape's fertility, its ecologic, economic and esthetic values"[9].

According to "rearrangement and rehabilitation works on degraded areas due to mining activities are carried out in four main steps: i) post-mining land use planning; ii)rearrangement within the frame of existing land use plan (excavation, dumping, water regime control, removing and laying out of top soil separately etc.); iii) rehabilitation (biological reclamation); and iv)monitoring and maintenance."[10]
Potential future use of the post-mining lands basically depends on the nature of the land, soil conditions, and communal structure of nearby surrounding to be rehabilitated by technical, biological, agricultural means or forestry applications. "The followings are the potential land use types that follow successful land reclamation."[11]

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[9] N. Akpinar, The process of revegetation in the post-mining reclamation. The Mining and Environment Symposium, 56May 2005Ankara; 2005.

[10] N. Akpinar, D. Kara, E. Ünal, Post surface mining land use planning. Turkey XIII. Mining Congress, 1014May 1993stanbul: Chamber of Mining Engineers of Turkey, 1993.

[11] E. Görcelioglu, Landscape Reclamation Techniques. İstanbul: Emek Printing; 2002

- The original land use,
- Afforestation, forestry,
- Agriculture,
- Nature conservation and wildlife,
- Hydrology, Recreation,
- Site improving,
- Special reserve,
- Settlement or industry,
- Solid waste or rubble storage area.

The basic principles of the environmental management policy for reclamation are given:[12]:

- knowledge of the local environmental conditions,
- selection of the proper methods and techniques of land reclamation,
- general land-planning for the areas under reclamation (land use map),
- systematic realization of the environmental protection and restoration programs according to the environmental terms determined by the Ministry,
- Monitoring and evaluation of the environmental restoration results by geographic information systems (GIS).

“Restoration of a landscape disturbed by opencast mining operations is mostly viewed in technical or economic perspectives only. Even though the public focused only on the forestry and agricultural aspects of restoration previously, there has been a recent interest in nature conservation and recreation. In order to restore ecological, hydrological, aesthetic, production, recreational and other functions of the post-mining area, a sustainable land use development plan should be prepared through a holistic approach.”[13]

Three basic goals that any restoration plan should reach are given as: [14]

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[12] C. Kavourides, F. Pavloudakis, P. Filios, Environmental protection and land reclamation works in West Macedonia Lignite Centre in North Greece current practice and future perspectives.

[13] P. Sklenicka, I. Kasparova, Restoration of Visual Values in a Post-Mining Landscape. Journal of Landscape Studies

[14] J. L. Powell, Revegetation Options. In: Hossner L.R. (ed.) Reclamation of Surface-Mined Lands. Florida

- stabilization of newly reclaimed lands against accelerated wind and/or water erosion,
- development of target specific re-vegetation programs,
- Achievable and sustainable land use by enforcing certain minimum performance standards.

“The Society for Ecological Restoration International addresses the same issue by taking 9 ecosystem-related parameters under consideration to measure the restoration success “[15]:

- similar diversity and community structure in comparison with reference sites,
- presence of local species,
- functional groups necessary for long-term stability,
- capacity of the physical environment to sustain viable populations,
- regular functioning,
- integration with the landscape,
- removal of potential threats,
- resilience to natural disturbances,
- Self-sustainability.

[15] M. Hendrychova, Reclamation Success in Post-Mining Landscapes in the Czech Republic: A Review of Pedological and Biological Studies. Journal of Landscape Studies

CHAPTER 3- CASE STUDY

3.1 **Project Basics**

3.2. Background and Content

3.3 Design Intent and Validation

3.4 Key Design Strategies

3.5 Performance Studies

3.1 Project Basics

Location: Cornwall, UK

Latitude/Longitude/Elevation: 50°N 4°W, 213' above sea level

Building type: Biome

Square footage: N/A. outdoors is considered one of the three biomes,

largest biome: 240m long, 55m high, 110m wide

Completion: April 2001

Client: UK Millenium Project for the Eden Trust

Design Team: Nicholas Grimshaw and Partners, Tim Smit, Arup Engineering

3.2. Background and Content

Initially conceived as a UK Millennium Project for the public, the Eden Project has grown to become not only a tourist attraction, research and educational tool, but one for generations to come. From the start, the mission of the Eden Project has been to "promote the understanding and responsible management of the vital relationship between plants, people, and resources, leading towards a sustainable future for all."

The idea for the three biomes was thought up by Tim Smit who had worked on and was largely responsible for the successful restoration of The Lost Gardens of Heligan. This time his focus was to create something new, starting from scratch, that would amaze future generations. This structure aimed to educate visitors about the importance of a sustainable environment through the study and education of plants. To achieve this goal, Tim teamed up with the internationally known sustainable architecture firm of Nicholas Grimshaw and Partners. Together they explored many innovative ideas for the creation of the world's largest biome.

There are essentially three biomes in the Eden Project: the humid–tropics biome, the warm temperate biome, and the moderate temperate biome which is the land surrounding the two enclosed bubble-like structures. The humid–tropics biome, the largest biome at over 240m long, houses tropical plants from all over the world. Trails and various waterfalls enclosed inside the structure allow visitors to totally immerse themselves in a unique environment that would otherwise be impossible. The moderate temperate biome, though smaller still, allows visitors to enjoy and learn about plants and environments from all over the world.

Figure 2 Eden project before reclamation.

3.3 Design Intent and Validation

The strict criteria for such an innovative structure created many design challenges. First, the structure was to be the world’s largest plant enclosure. This involved coming up with a design scheme that could span for great distances without the use of a single internal support. Second, the structure must be as light as possible. This was needed for transportation reasons primarily because all the materials would have to be brought in from other cities, a long distance away. In addition, a lighter structure would put less stress on the soil and allow for smaller footings and less site impact. Last, the demonstration of sustainability.

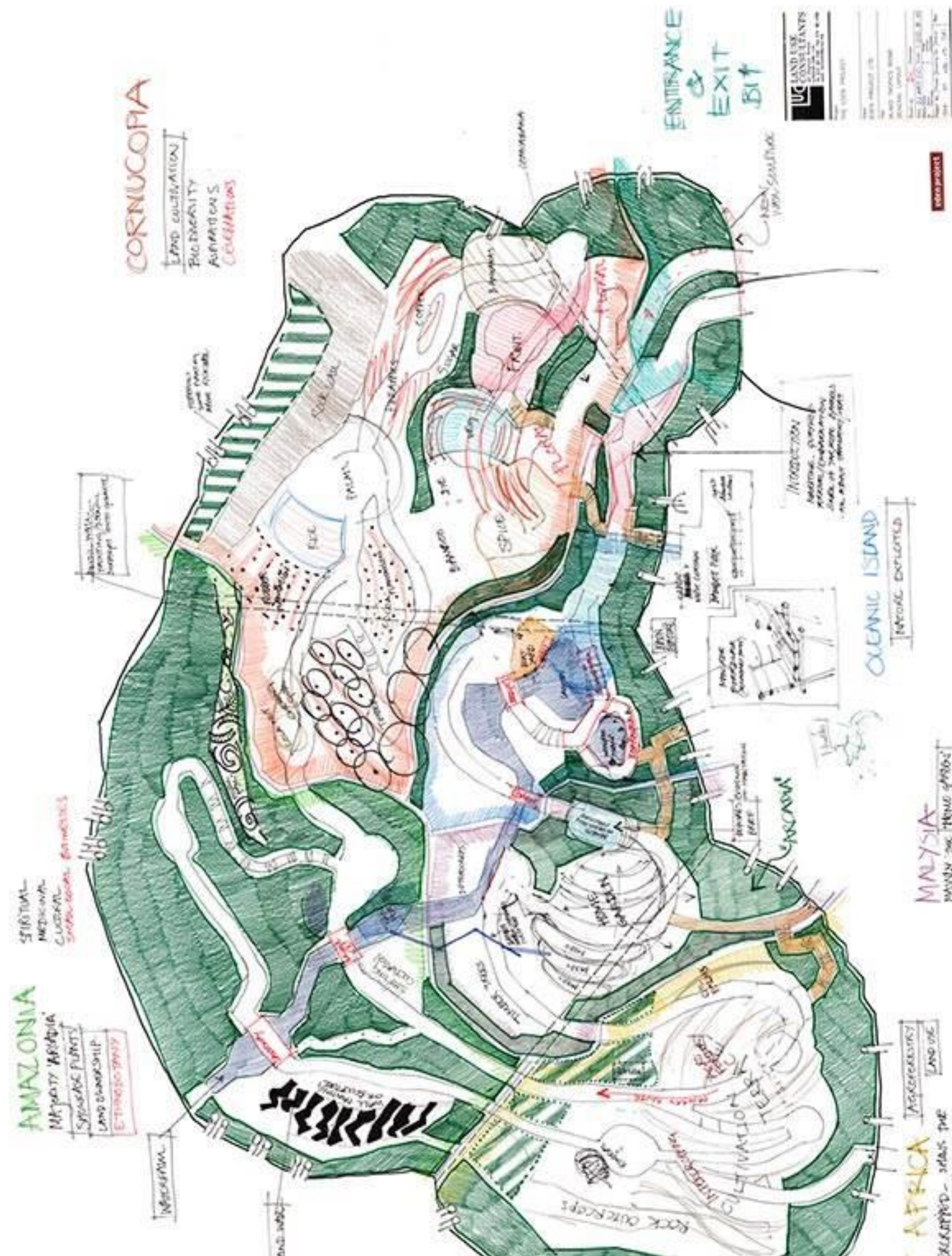

Figure 3 Site plan of eden garden

Grimshaw's solution to this challenge was to look at nature. He got his inspiration from looking at the honeycomb of bees and even the multifaceted eyes of a fly. These creatures used their surroundings most effectively to create a very strong, yet light-weight, solution. In addition, a geodesic dome-like structure would be able to conform to the expanding and contracting contours of the clayey soil.

Figure 4 View of the Eden project

3.4 Key Design Strategies

The Eden Project uses a variety of design strategies to help it complete its goal of sustainability.

The official name for the bubble-like geodesic structure mentioned earlier is a "hex–tri–hex." Though the final structure looks very similar to half a sphere,

Figure 5 Plants developed inside the conservatory of Eden project.

Figure 6 Rainforest biome of Eden project

Figure 7 Recreation Space created in between the biomes

The entire building uses straight planes with straight edges. It incorporates an outer shell of primarily hexagonal pieces, (some pentagons) which attaches to an inner network of triangles for stability. The design is so structurally stable that it does not need any internal supports even in the 240m span of the largest biome. In addition, all the steel tubes that make up the grid-like network could be easily transported to the site in small pieces reducing costs. The structure transfers loads to the ground uniformly around its base which helps to eliminate large footings that otherwise might have been needed to support such a large enclosure. Energy efficiency-wise, the hemisphere shape helps to conserve the heating that is needed especially in the humid–tropics biome. This is because of the fact that a sphere has the largest amount of volume compared to its surface area of any form.

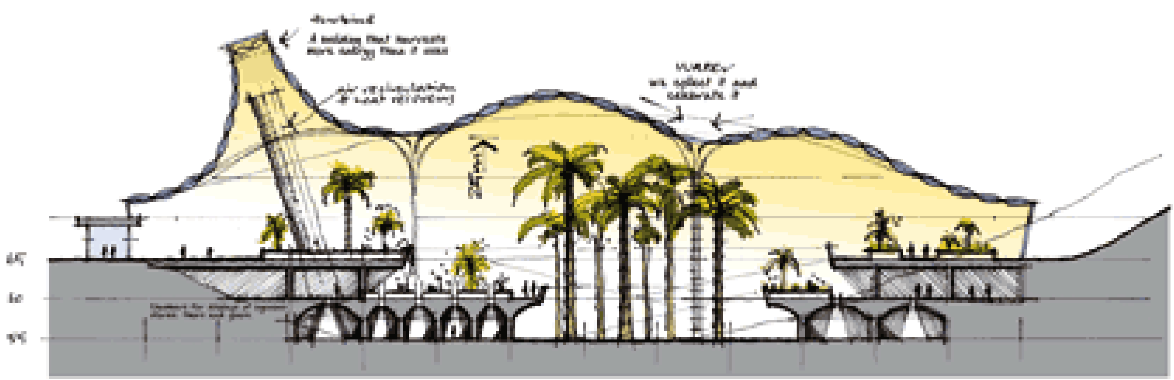

Figure 8 conceptual section of the biomes

Cushions of ETFE (ethyltetraflouroethylene) transparent foil are used for the glazing. This very lightweight material weighs approximately 1% of glass. In addition, its strength and the fact that it is self-cleaning makes it the perfect product to use for this project. Last, it also has excellent ultraviolet transmittance which is essential for the healthy development of the plants grown inside. This also means that it is important to wear sunscreen when hiking through the biome. Since each of the hexagonal pieces of the biome is a different size, Grimshaw worked with others to come up with a specialized 3D computer program that determines the dimensions of each piece. These data are then transferred to a machine that correctly cuts and labels each piece before it is shipped to the construction site.

3.5 Performance Studies

To study the “macrosopic performance” of the biome a dynamic thermal analysis computer program called OASYS was used. This program helped measure the performance of the biomes during the extreme climate conditions of the year, such as a hot summer afternoon or a cold winter morning.

The performance studies reinforced the design strategies that were used in the original designing process. It also allowed for various adjustments to be made to enhance the energy savings within the biome. One of these adjustments was the change of the location and number of some of the nozzles that supply warm air for the biome.

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Case Study by Kenny Bissegger,Spring 2006

CHAPTER 4: SITE ANALYSIS

4.1 Regional study

4.1.1 Geology

4.1.2 Geomorphology

4.1.3 Ground water table

4.1.4 Hydrology

4.1.5 Slope analysis

4.1.6 Vegetation

4.2 Site study

4.2.1 Location

4.2.2 Climate

4.2.3 Wind

4.2.4 Precipitation

4.2.5 Flora fauna

4.1 Regional study

The study region covers the belt of kaimur hills up to length of 72 kms. As mining is being done in this belt because of the composition of the area. The district known as cement district

To understand the natural process of the region layers have been studied as follows:

4.1.1 Geology

The southern part of the Vindhyan Range up to Katangi is called Bhander Range. Beyond this point the escarpment enclosing the land-locked valley of Sirampur and the hill range in continuation is called the Kaimur Range. The most important physio-graphic feature in eastern Madhya Pradesh is the great Kaimur escarpment. This forms the watershed or divide for two of the major rivers of peninsular India, the Son on the south and Tons on the north. Throughout its length of 300 miles and throughout its continuation into Narmada valley, it is not breached at any point by any stream flowing northwards, with a few minor exceptions.

The Kaimur Range runs through the entire length of Maihar and Amarpatan tehsils of Satna district in an easterly direction slightly inclined to the north. At Jhukehi, the strike of the Kaimurs is displaced, producing the only gap in the whole length of the Vindhya series of plateau runs along the Kaimur Range. These fluvial plateau, consists of a series of descending plateau, starting with the Panna Plateau in the west, followed by Bhander Plateau and Rewa Plateau and ending with Rohtas Plateau in the east.

The deposit of these mines, Bhadanpur belongs to Rohtas formation of semri series of Vindhyan Supur group. This formation is made up of main lithic units of Limestone and Shale, which are lying as laminated Sedimentary deposit**.**

Classification of Limestone

The different types of limestone in the area can be easily recognized in the field by their physical characteristics. They may be grouped as below.

- **Algal Limestone**: massive dense, hard and compact, dark grey in color, it is characterized by layers of closely-packed conical stromatolites structure. This is the highest grade limestone in the area and is about 60m thick.
- **High Magnesium Limestone**: which underlie the stromatolites limestone and is characterized by uneven surface caused by weathering. Limestone from this horizon contains 10-15 % MgO, with low $Si0_2/Al_2O_3$. The thickness of this horizon also is about 60m.
- **Banded Limestone**: which underlies the high-magnesia limestone and is characterized by banded structure, with alternate bands of limestone of different solubility. This horizon is the thickest limestone horizon in the area, with an average thickness of over 200m.

The nature of outcrop of these three horizons varies widely. The banded limestone is bedded and has attained a maximum height of 1.5m above the general ground level. The high magnesium limestone occurs as bedded as well as boulder type outcrops with a peculiar nature of weathering. The algal limestone occurs as huge boulders with solution cavities in between.

Super Group	Group	Formation	Dominant Lithology
Deccan Traps			
Gondwana Super Group			
Vindhyan	Bhander Group		
	Rewa Group		
	Kaimur Group		
	Semri Group	Bhagwar	Shale and Porcellanite
		Rohtasgarh	Limestone with Shale partings
		Rampur	Glauconitic sandstone and Shale
		Salkhan	Siliceous and cherty Limestone
		Koldaha	Olive green Shale
		Deonar	Porcellanite
		Kajrahat	Limestone (Algal, Magnesian & Banded)
		Arangi	Shale
		Deoland	Sandstone with basal conglomerate
---------------------unconformity-------------------			
Precambrian	Kaolinitised Metamorphics		

Figure 9 Table showing the geology classification of the region.

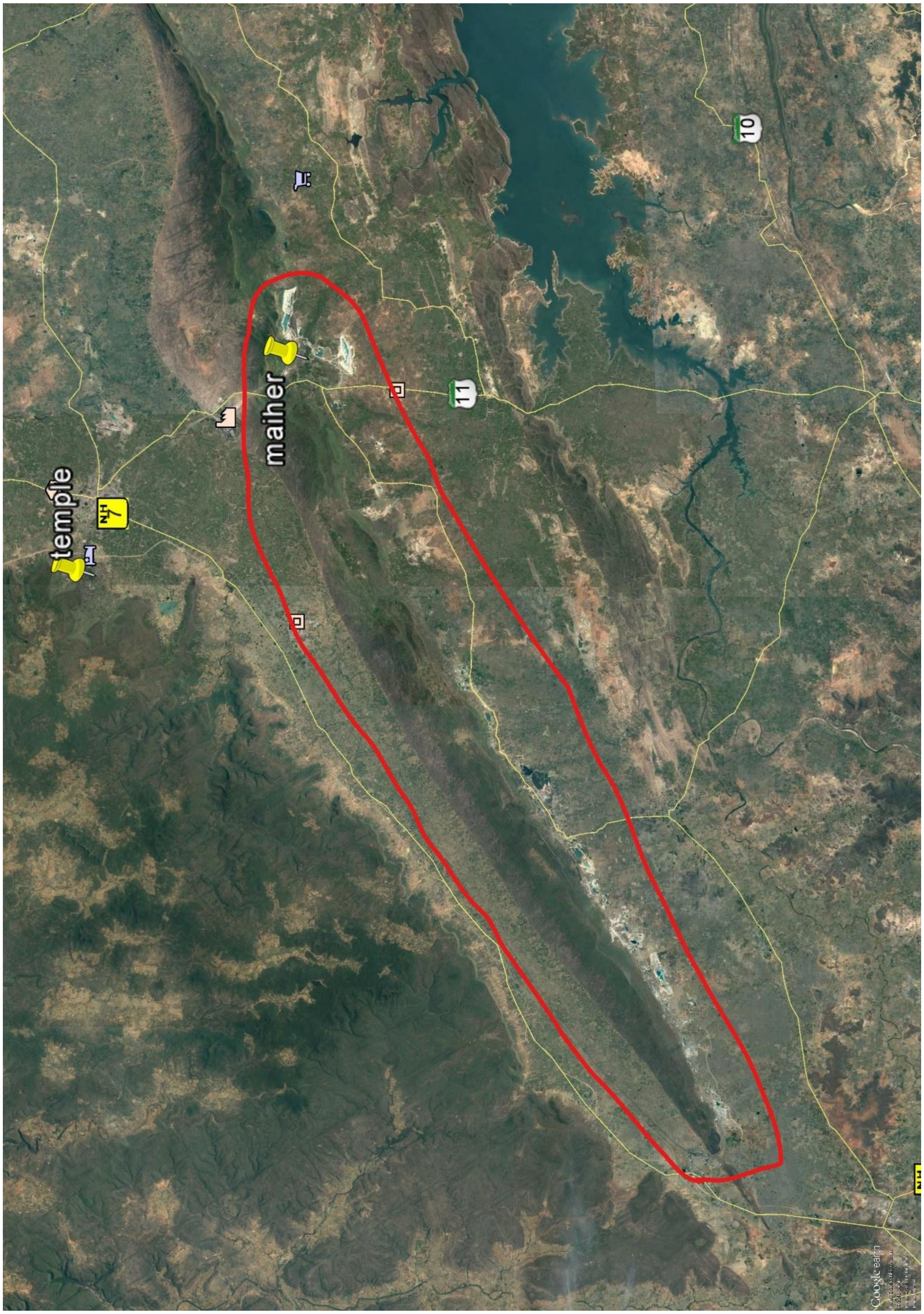

Figure 10 google earth image showing the belt of study region.

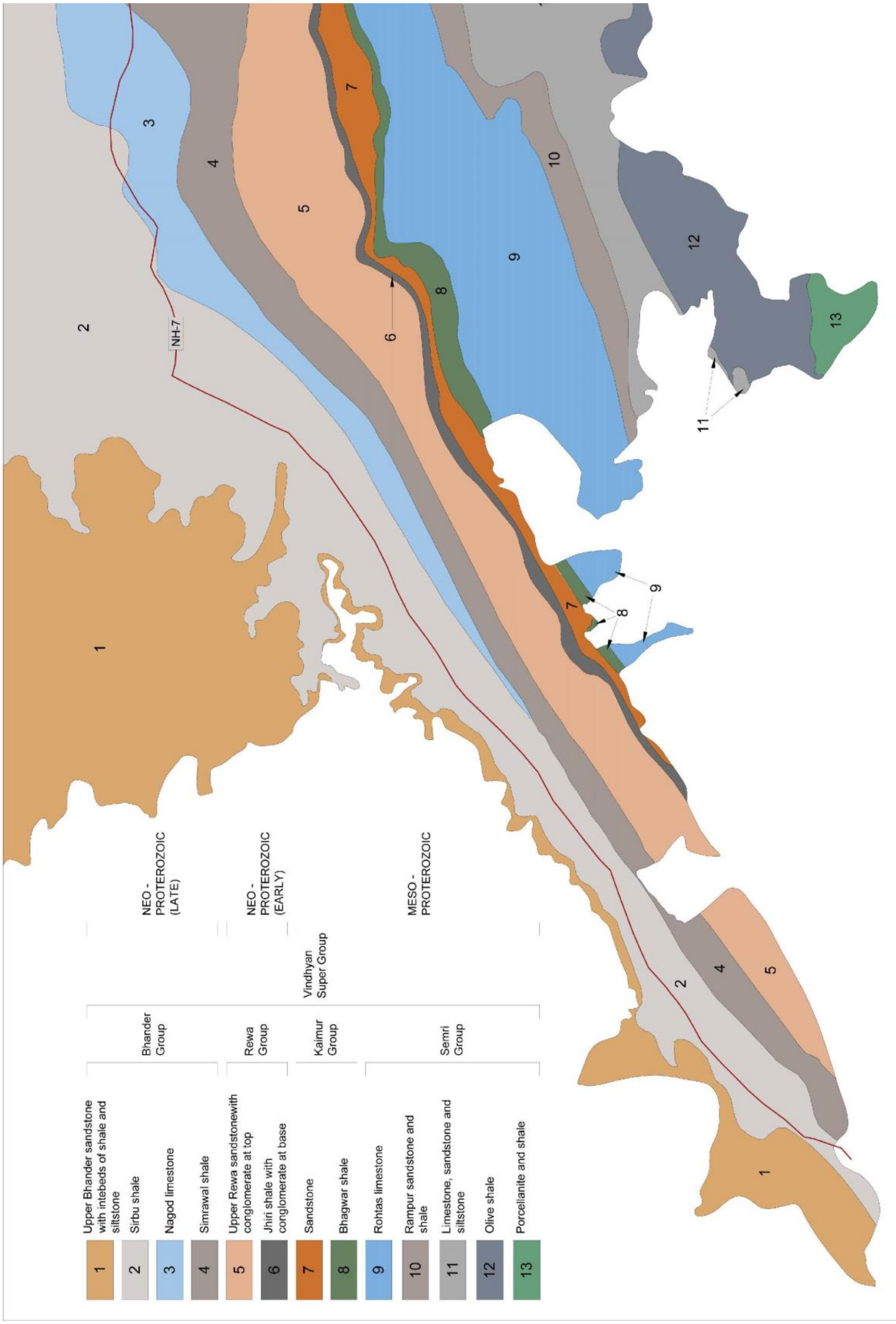

Figure 11 Geology of the study region

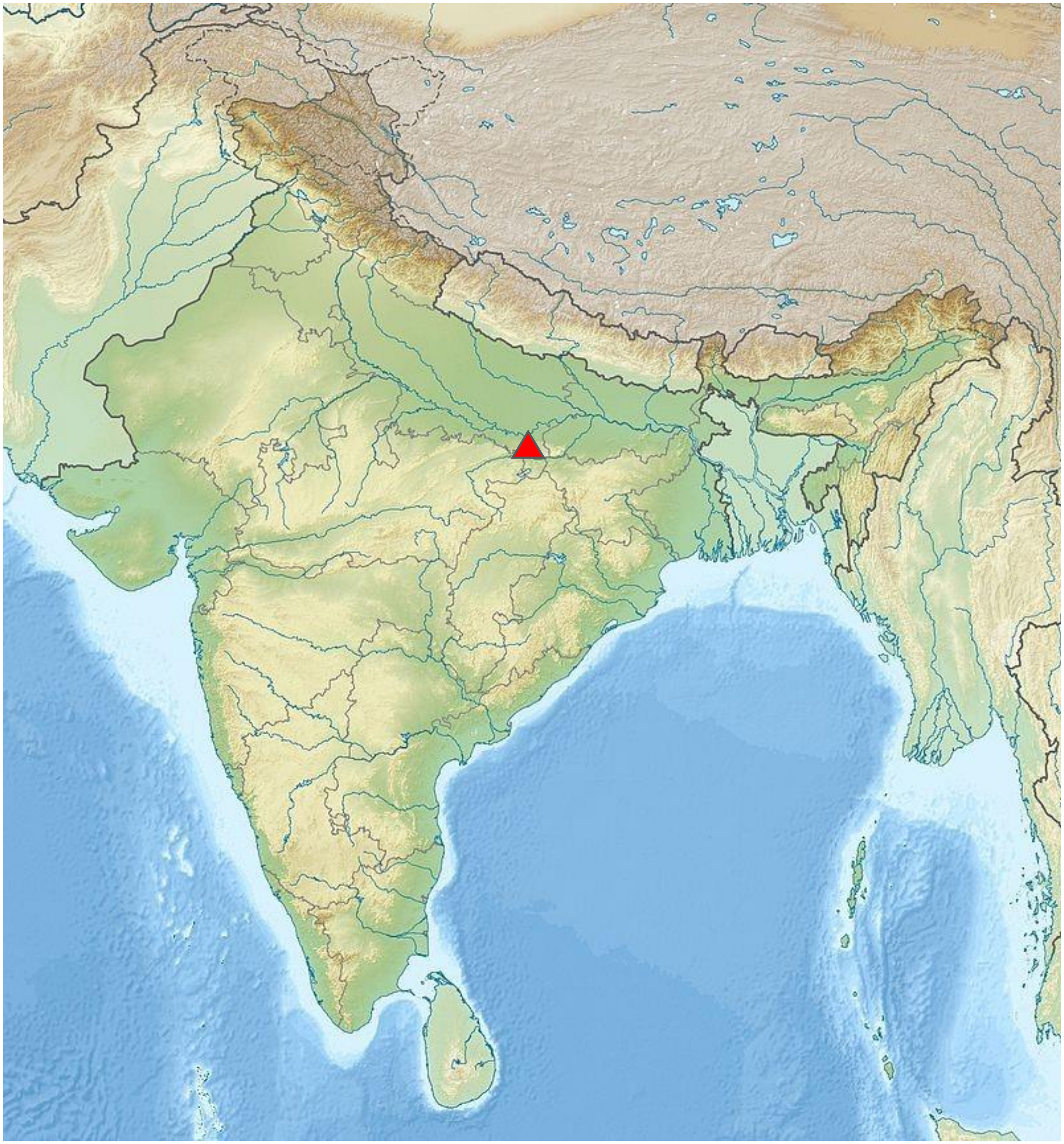

Figure 12 Map of India showing kaimur hills

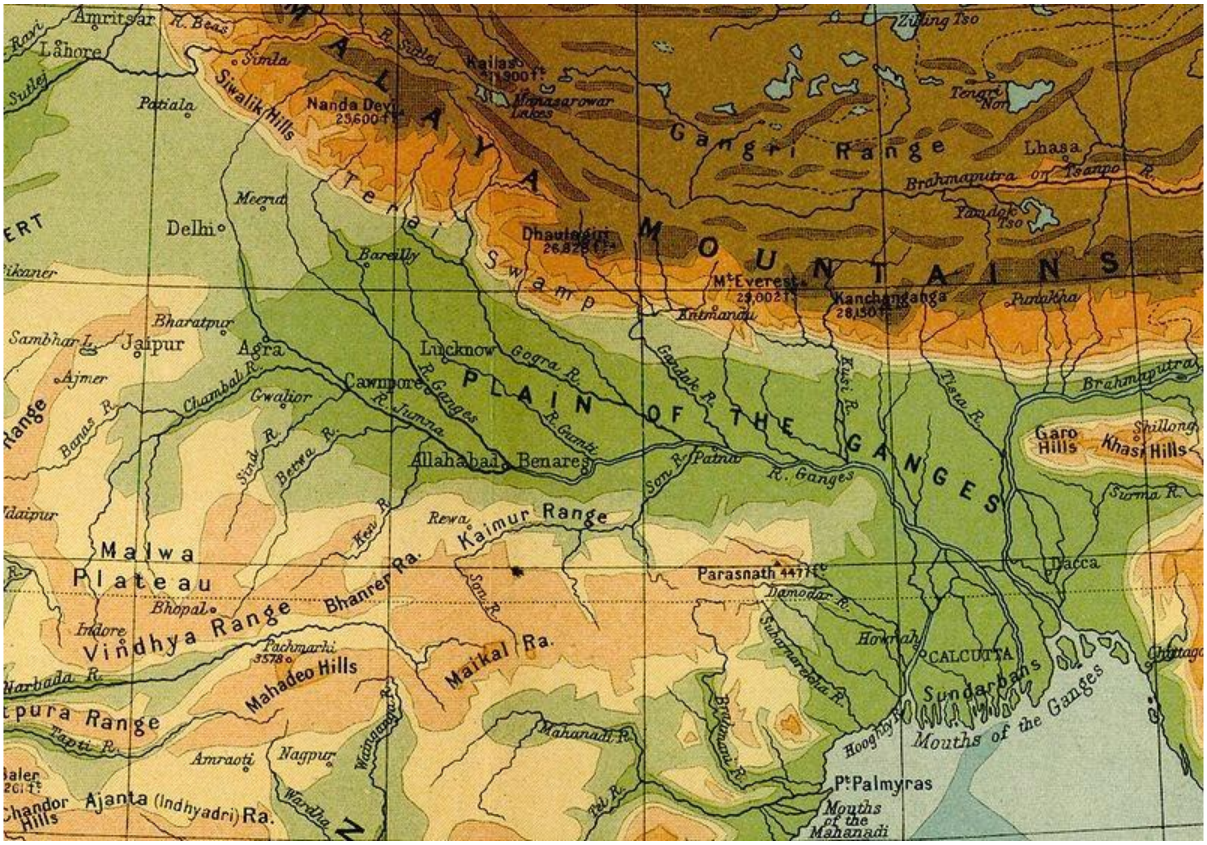

Figure 13 Map of Vindhyan range showing the major divide of tons and son river by kaimur hill range.

4.1.2 Geomorphology

The pediments have very thin cover of soil, but its thickness may increase away from the pediment junction. Depending upon the thickness of the weathered zone, the groundwater potential is moderate to good. It provides the best yield in the region. A lineament may by a fault, fracture, master joint, a long and linear geological formation, the straight course of streams, vegetation served may be the result of faulting and fracturing and hence it is inferred that they are the areas and zones of increased porosity and permeability in hard rock areas.

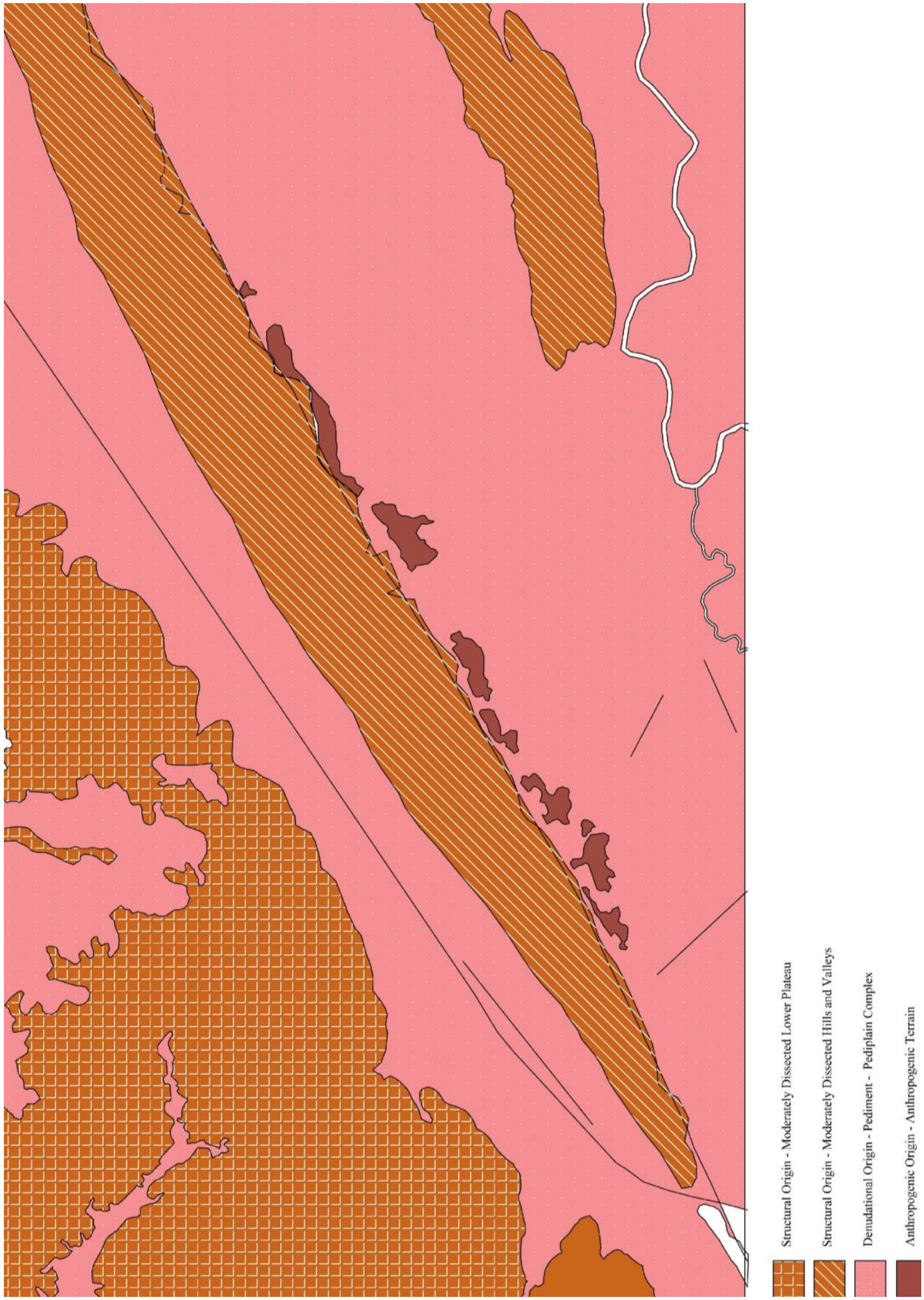

Figure 14 Geomorphology map

4.1.3 Hydrology

The region acts as the main divide for tons river and Son River. The water flows from kaimur range towards Bansagar Lake.

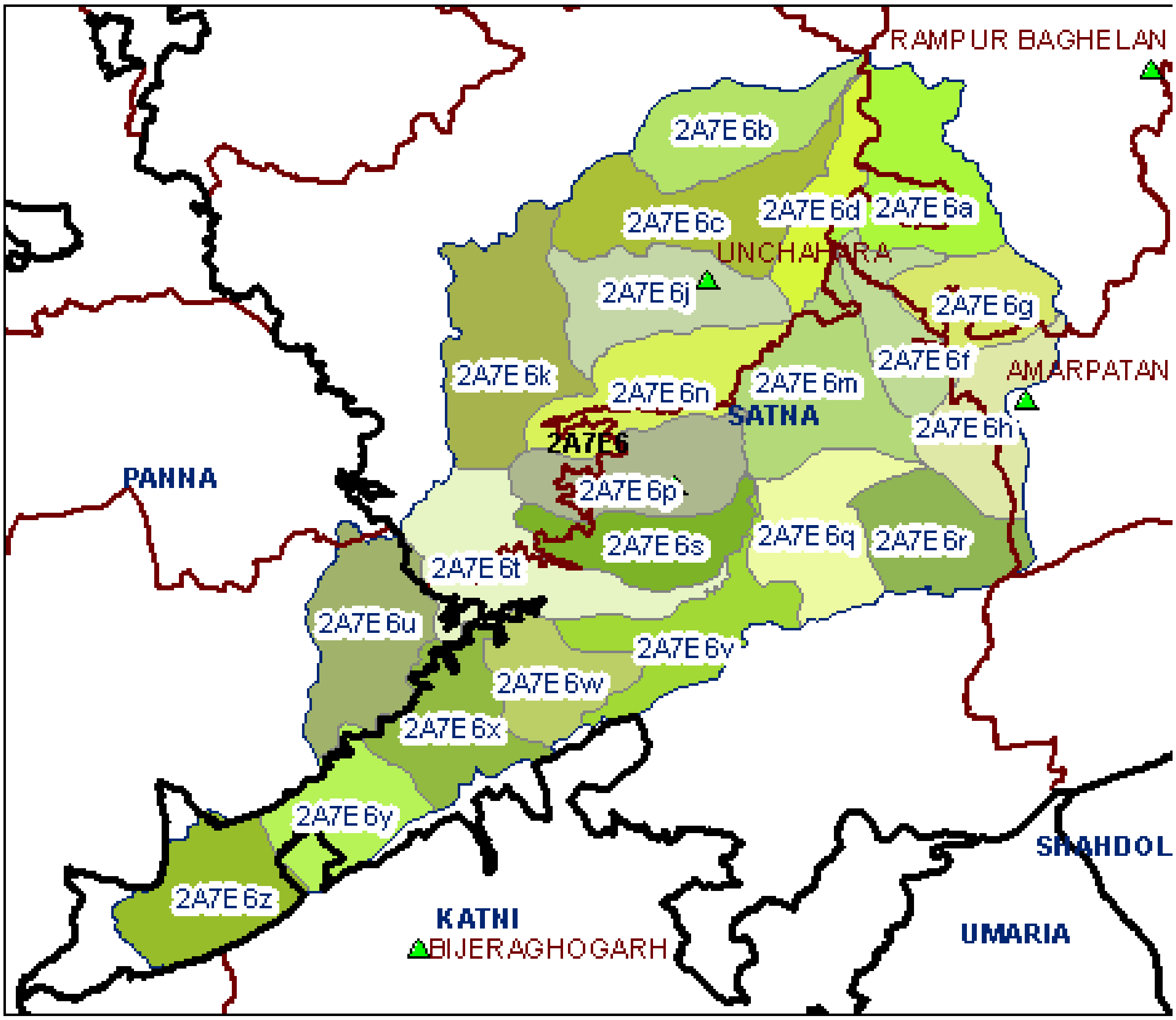

Figure 15 Watershed divide of the district Satna.

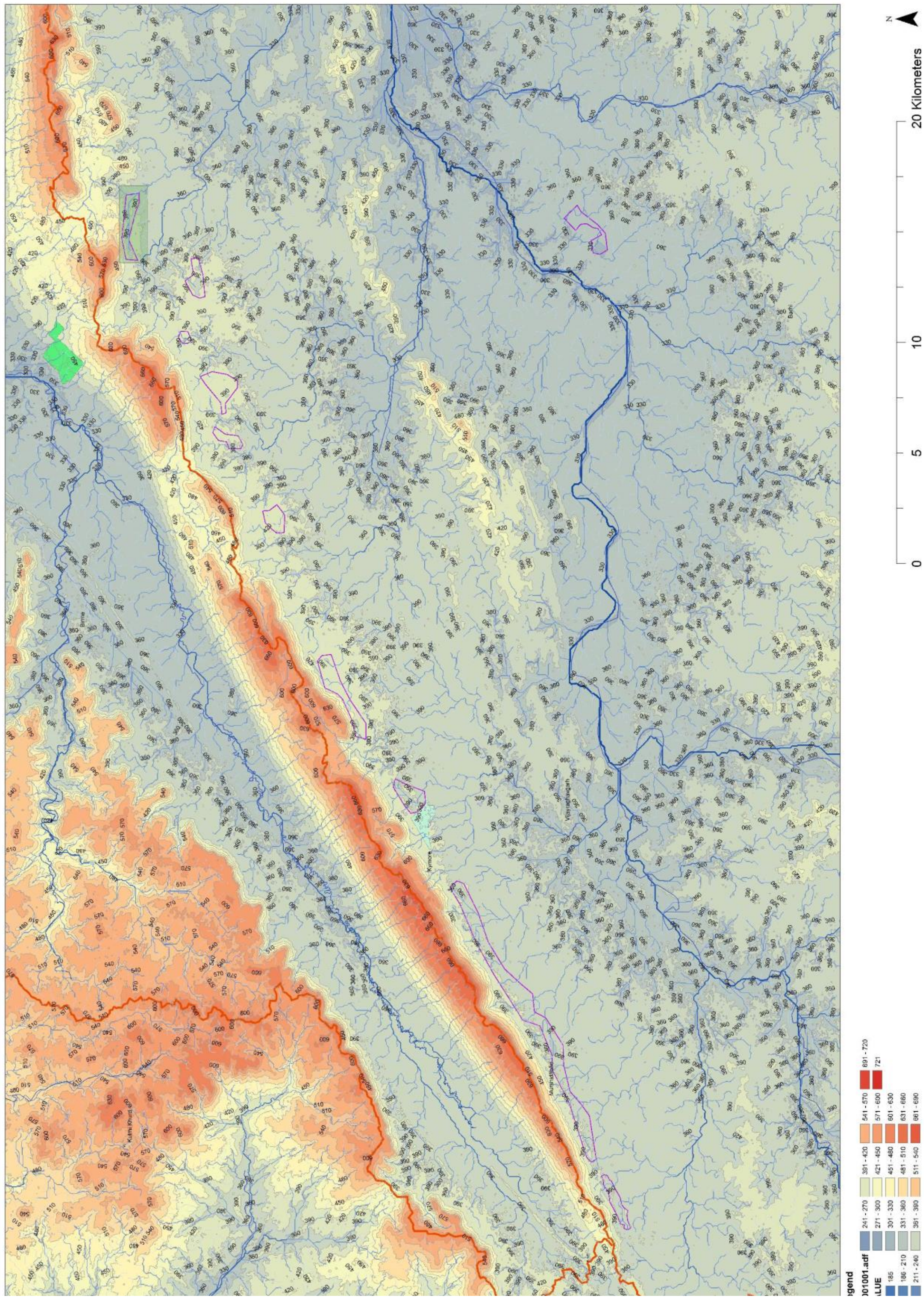

Figure 16 Elevation map with stream order

4.1.4 Ground water table

Falling under the pediment zone**,** A pediment is a very gently sloping (.5°-7°) inclined bedrock surface. It typically slopes down from the base of a steeper retreating desert cliff, or escarpment, but may continue to exist after the mountain has eroded away. It is caused by erosion. It develops when sheets of running water (laminar sheet flows) wash over it in intense rainfall events. A Pedi plain is a concept is an extensive plain formed by the coalescence of pediments.

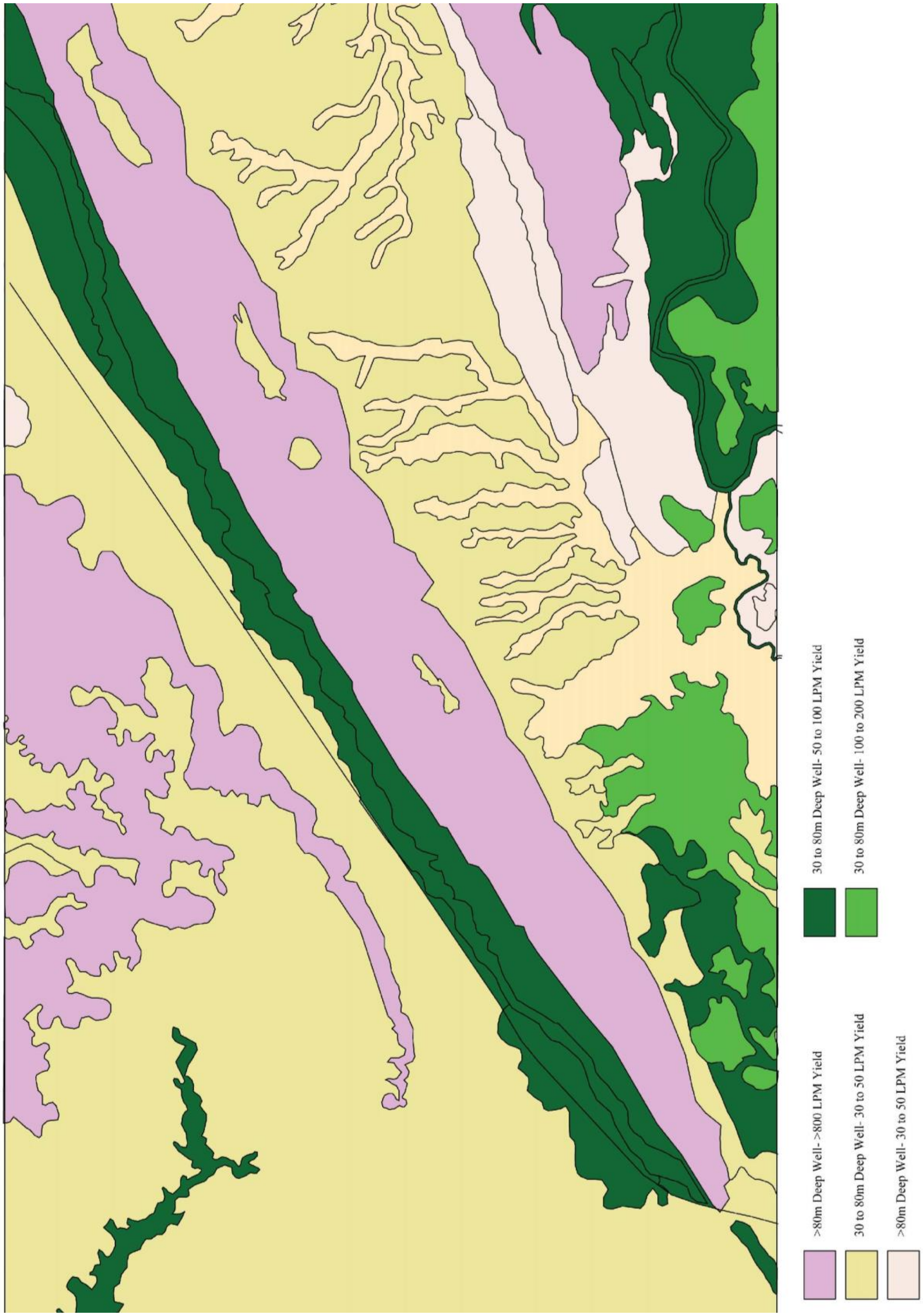

Figure 17 Groundwater map of region

4.1.5 Slope analysis

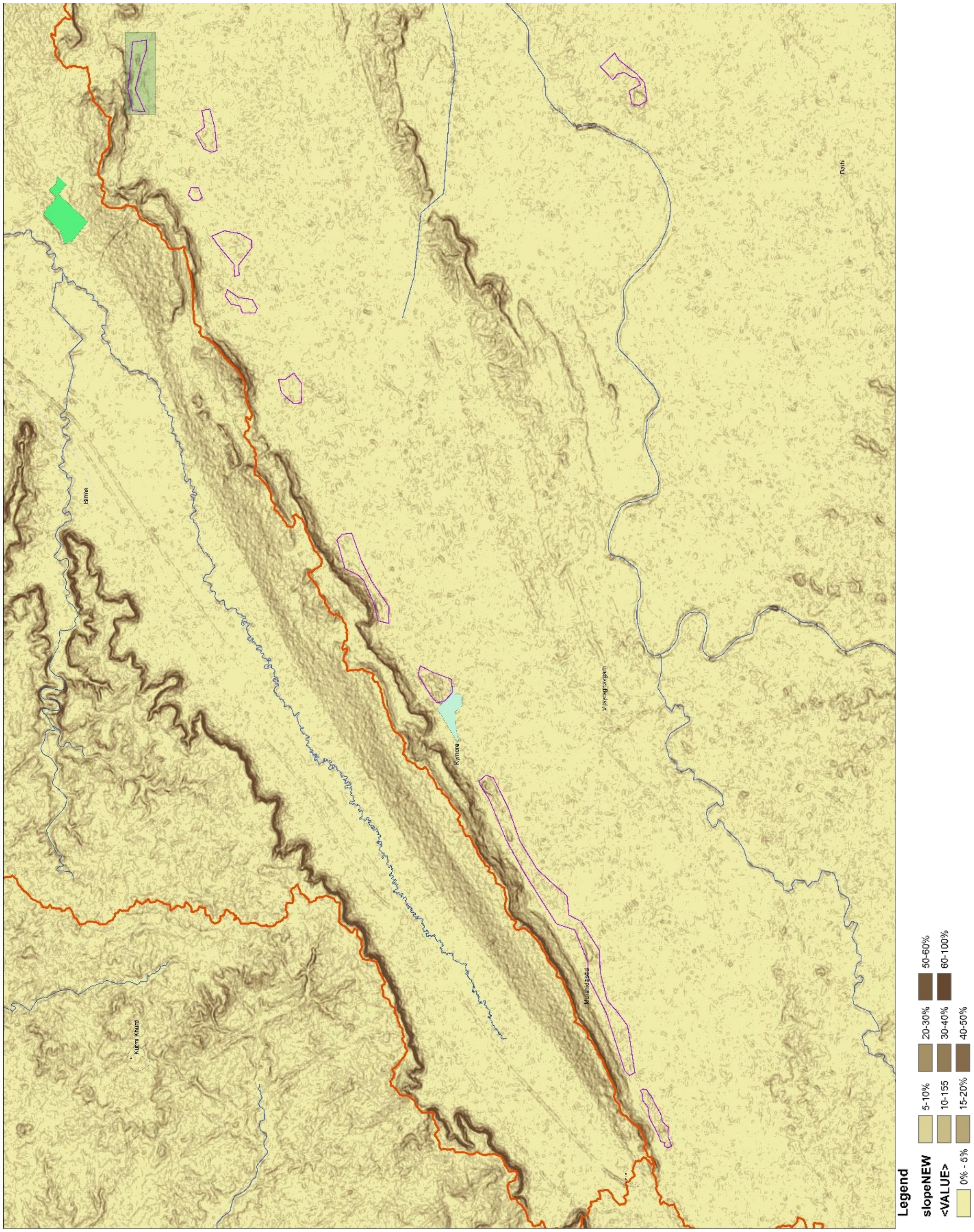

Figure 18 Slope analysis

4.1.6 Vegetation

The vegetation of the whole belt is mapped and in the mined area no existing vegetation is found as before mining the land is cleared.

The common trees observed in the study area and in the reserved forests in the study area are Khair, Babool, Haldu, Bel, Mahaneem, Akol, Kala Shiras, Chichwa, Shafed Shirash, Sitaphal, Khatuwa, Neem, Amta, Keolaar, Asta, Astra, Bosa, Kachnar, Salai, Kasai, Khaja, Achar, Palash, Kumbhi, Tondri, Amaltash, Shisham, Dhobin, Fansi, Tendu, Jamrasi, Amla, Gadha Palash, Kanth Jamun, Kaitha, Bad, Gular, Peepal, Kakkai, Garghati, Papda, Papra, Khamer, Dhaman, Chirol/Papri, Mahuwa, Aam, Sinduri, Karanj, Karanji, Beeja, Menphal, Semal, Sal, Jamun, Imli, etc.

4.2 Site study

4.2.1 Location

The mine selected for the reclamation is situated in Maihar city which is known for its cultural values due to existence of sharda devi temple. Maihar is situated in Satna district of Madhya Pradesh, at a distance of around 50kms. As of the 2001 India census, Maihar had a population of 34,347. Males constitute 52% of the population and females 48%. Maihar reported an average literacy rate of 64%, with male literacy at 72%, and female literacy at 56%. In Maihar, 15% of the population is under 6 years of age. There is a 3.1 mn tn cement factory near Maihar (Maihar Cement Factory) which provides an industrial touch to the holy place. The factory complex and the township are situated at Sarlanagar about 8 km away from Maihar town on the Maihar-Vijayraghavgarh Road. The selected site is mined by Maihar cement mines only and has an area of 300 acres. Maihar falls on the Bandhavgarh khajurao trail famous for its pristine landscape and in between, Maihar offers a pilgrimage to the tourist.

Figure 20 Map of Madhya Pradesh showing tourist spots in the state.

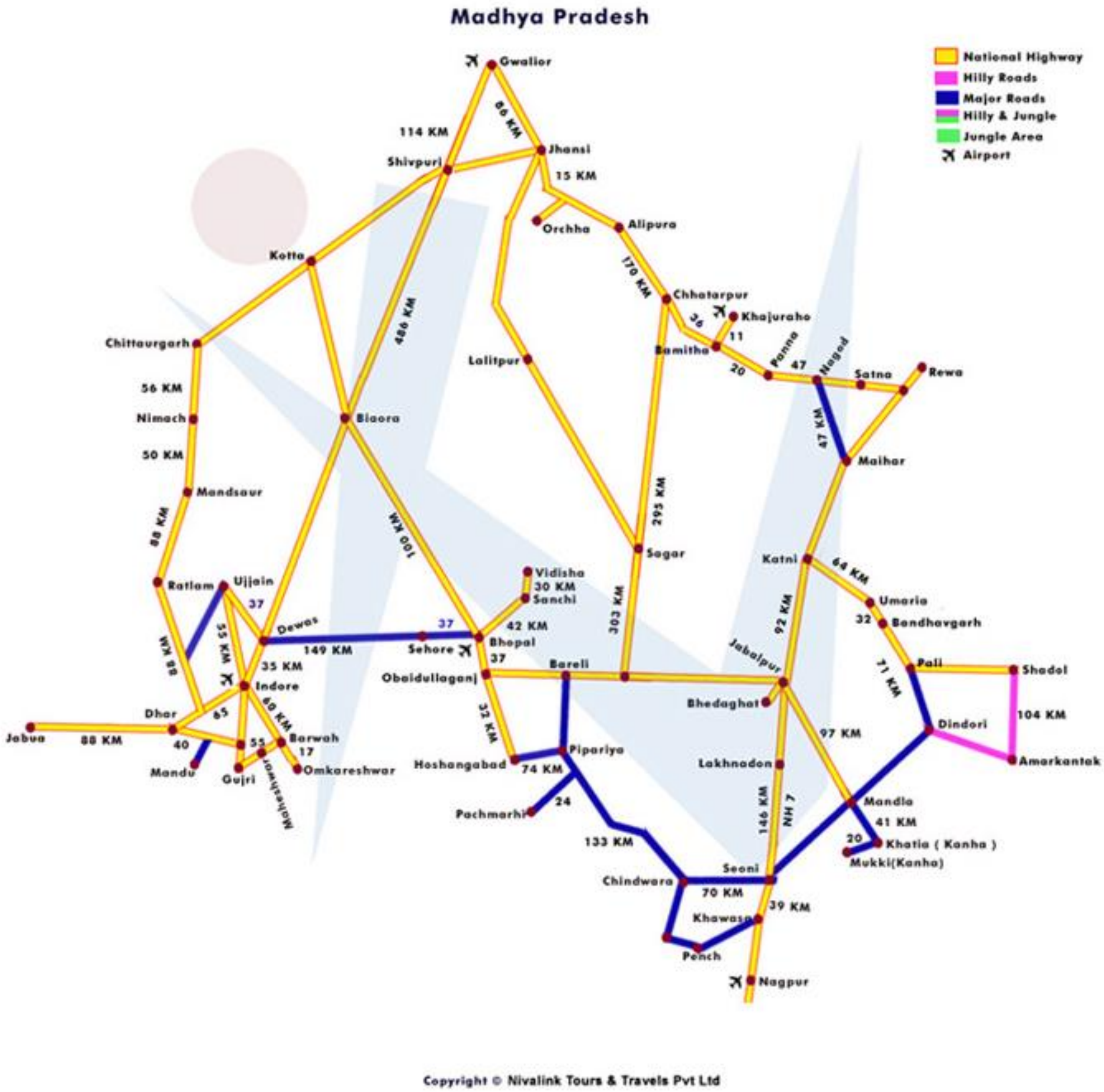

Figure 21 map showing the distance of Maihar city from other tourist spot in Madhya Pradesh.

Location Details of the Project

District and State : Satna District, Madhya Pradesh

Village : Maihar

Lease Area (acres) : 300 acrea

Ownership : Govt. Revenue Land, Non-forest area.

4.2.2 Climate

Temperature

The maximum temperature in the study area during the study period (summer season) is about 45.2°C and the minimum temperature is about 13.6°C.

Rainfall

Average annual rainfall in the region is about 808.8mm. No rainfall was observed during the study period.

Relative Humidity

The maximum relative humidity in during the study period is recorded as 86% and minimum is recorded as 21% during the study period.

4.2.3 Wind

The average wind speed recorded during the study period is about 1.44 m/s respectively. The predominant wind direction was from NW. The data generated for wind speed and wind direction is computed to obtain wind rose diagrams for the study area. The 24 hourly wind rose diagram for the study period is shown in figure below.

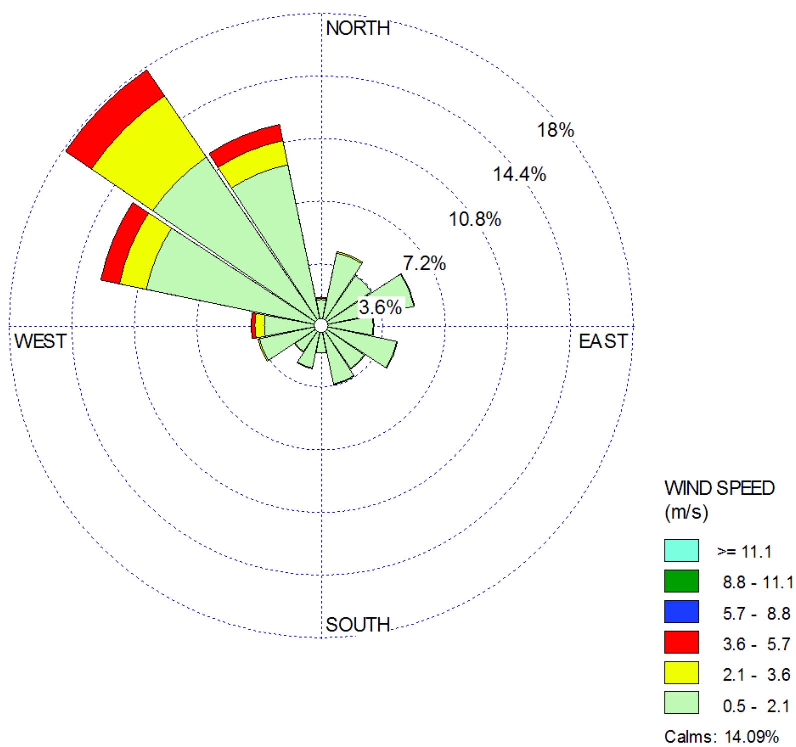

Figure 22 Wind rose diagram for the study region

4.2.4 Soil quality

From the soil quality analysis, it is observed that the soil is having normal to saline pH and low to medium fertility. The soil in the mine lease area shows poor fertility and needs to be topped with fertile soil cover before plantation. Also, the soils in agriculture lands in the nearby villages need to add fertilizers to improve its fertility.

4.2.5 Flora fauna

Flora

There is no forest in the mine lease area. There are four forests in the study area viz.,Hardua Reserve Forest (5.1 km NW), Karreha Reserve Forest (7.5 km N), Bara Reserve Forest (9.0 km NE) and Open Mixed Jungle (6.7 km SE). The forest in this area is broadly categorized as 5B-Clb - Southern Tropical Dry Deciduous Dry Teak Forest and 5B-C2C - Northern Tropical Dry Mixed Deciduous Forest [16].

The common trees observed in the study area and in the reserved forests in the study area are Khair, Babool, Haldu, Bel, Mahaneem, Akol, Kala Shiras, Chichwa, Shafed Shirash, Sitaphal, Khatuwa, Neem, Amta, Keolaar, Asta, Astra, Bosa, Kachnar, Salai, Kasai, Khaja, Achar, Palash, Kumbhi, Tondri, Amaltash, Shisham, Dhobin, Fansi, Tendu, Jamrasi, Amla, Gadha Palash, Kanth Jamun, Kaitha, Bad, Gular, Peepal, Kakkai, Garghati, Papda, Papra, Khamer, Dhaman, Chirol/Papri, Mahuwa, Aam, Sinduri, Karanj, Karanji, Beeja, Menphal, Semal, Sal, Jamun, Imli, etc

Fauna

The mine lease area is scantily vegetated and the area is devoid of thick faunal existence. The wild animals observed in the study area includes Three-stripped Palm Squirrel, Common Indian Hare, Hanuman Langur, Jackal, Spotted Deer, Field Rat, Indian Field Mouse, Common house rat, Indian wild dog, Jungle cat, Wild boar, Common mongoose, Rhesus macaque, Indian fox, Indian Porcupine and Sambar.

4.2.6 Historic mapping

The below give maps shows the increasing pattern of the mining in past 20 years:

[16] Champion and Seth's Classification, 1964).

1980

1985

1990

1995

2000

2005

2010

2015

2017

4.2.7 Visual Analysis

CHAPTER 5: DESIGN DEVELOPMENT

5.1 Zoning

5.2 Concept and design

5.1 Zoning

The site is divided in two pits naming pit A and pit B in which pit A is abandoned and pit b is still under the mining process. So the area to be reclaimed was pit A with a total area of 148 acres.

As per the existing site conditions the zoning is done is such manner so that less of topography is disturbed and more of the land is subjected to change with time and regain its ecology back. The different zones proposed in the site was recreation zone, restricted forest zone, semi-private zone and research zone.

For recreation zone the existing waste dumps with few plantation were designed so that they can act as mounds and a mountain bike trek was proposed. The tailing pond was developed as a wetland with a buffer for the plants to grow back.

The main pathway connecting the whole site was developed in such a manner that the whole journey of a mine from a forest land to an abandoned mine is explained with the help of planting scheme .

5.2 Concept and Design .

The foremost idea was to put the abandoned area to some use, so in order to achieve that productive landscape, agroforestry and agro tourism was proposed.

Agroforestry- Agroforestry is the intentional integration of trees and shrubs into crop and animal farming systems to create environmental, economic, and social benefits. It is a land use management system in which trees or shrubs are grown around or among crops or pastureland. It combines shrubs and trees in agricultural and forestry technologies to create more diverse, productive, profitable, healthy, ecologically sound, and sustainable land-use systems.

Agro tourism- The concept of agro tourism is a direct expansion of ecotourism, which encourages visitors to experience agricultural life at first hand. Agro tourism is gathering strong support from small communities as rural people have realized the benefits of sustainable development brought about by similar forms of nature travels.

Visitors have the opportunity to work in the fields alongside real farmers and wade knee-deep in the sea with fishermen hauling in their nets.

Productive landscapes-

Productive landscapes mean landscapes that have meaning, purpose, beauty, and utility within their context. Well-managed forests and landscapes present opportunities for productive activities that are crucial for sustainable livelihoods, food security, national development and the provision of environmental services. Intensified agriculture, small-scale agro-industrial plantations, small scale logging from farm lands, restoration of forests, biodiversity conservation and biomass storage are functions that can be combined in such productive landscapes. Productive landscape is breaking the barriers and furthermore emphasizing the existing potentials in the space. From problems of the urban sprawl and ineffective outskirts we want to create a landscape that will integrate the local people, therefore increase interest agriculture and bring social welfare to the society.

CLIFF EDGE WALKWAY

The cliff edge walkway divides the whole site into two zones. The walkway is designed in such a manner that it gives the view of whole site and in order to play with views, plantation is done, at points the open vistas are provided whereas dense plantation is also done to hide the views. Also cliff edge walkway gives the idea about the geology of the area as the edges are kept as earlier in the existing form.

BUFFER ZONE (6 ACRE)

A buffer zone is provided for the growth of wetland/ riparian zone. An area created for the nesting of flora and fauna.

WATER BODY (12 ACRES)

The water is already collected in the two lower benches throughout the year not exceeding the highest level of 369 meters. It is retained so that it can be utilized for the site and helps flourishing the bio- diversity.

PRODUCTIVE LANDSCAPE

As the area is a dump area already reclaimed by the authority has few fruit trees planted and soil content is good then the whole of the site, so by productive landscape condition can be.

AGROFORESTRY (10 ACRES)

An adventurous system over conventional agricultural methods and forest production methods though increased productivity, economic benefits, social outcomes and ecological means.

FARMLANDS- AGROTOURISM (ACRES)

The existing zone converted into farmlands including sightseeing tours of the techniques practiced there and showcase of cultural techniques of farming.

AFFORESTATION (20 ACRES)

Since the grading has been done already and these two terraces are on the highest levels, so plantation is done to increase the tree cover of the site.

TERRACES

Terraces are designed to enjoy the view of the whole site from the highest point.

PAUSE POINT

Pause point is given at the very beginning of cliff edge walkway to give a glimpse of landscape designed. Buffer plantation on the terraces to prevent dust and merge the site with nearby reserved forest.

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