Research Paper

Wasteland Landuse Planning Approaches in a GIS Environment Using Space Syntax Analysis

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Abstract

The Greater Bangalore region has a rich geological and ecological history that has supported extensive enterprise, industries, agriculture, and now IT sector driven urbanisation. While the region is transforming into a smart city, there is tremendous potential to organise spatial information within Greater Bangalore limits that could be used as a basis of context specific land use planning decisions. Space Syntax theories allow for rigorous analysis of data through modeling revealing intricacies of social-space relationship. This paper aims to identify approaches that guide study of wasteland morphology and its feasibility to transition into urban land uses. The research focuses on the study of urban wastelands (anthropogenic types) using the application of GIS in the context of Urban Bangalore, a metropolitan region in South India. It further looks specifically at mining wastelands, the spatial flows- migration, transportation; infrastructure and demographic characteristics through space syntax analysis to understand better the potential of the wasteland for future development. This methodology is proposed as a basis of land use planning decisions specific to the select typology of urban lands.

Keywords

Land use Planning, Geographic Information system, Space Syntax Analysis

1. Introduction

Bangalore, the capital city of the state of Karnataka, in India has witnessed rapid urbanisation in the past three decades owing to policies inviting global MNCs and expanding investment in education infrastructure. This requires developing land as a valuable resource, particularly wastelands. This paper aims to look at the mining land adaptive reuse for an urbanising context- the case of Greater Bangalore. The mined lands are systematically degraded due to anthropogenic actions and their future development has limited potential; to an extent that the government has categorised these lands as wastelands under the land use category of Mining and Industrial area. This paper is an attempt to research the possibilities for adaptive reuse of mining wastelands of Bangalore using Space Syntax and GIS. The paper uses the space syntax theory and analysis as the base to predict the growth model for greater Bangalore to understand the development projections for existing mining lands. This model can serve as an objective basis of proposing land use transition from wastelands, with a systematic method, to facilitate adaptive reuse for mining lands. The development projections and strategies for the Greater Bangalore region with Hoskote satellite town have been discussed in the paper.

2. Land use Planning Approaches

2.1 Background

The genesis of systematic planning is tied to the *Blueprint Planning Movement* during the period of renaissance where the physical planning was carried out by experts like architects and civil engineers. Haussmann's reconstruction of Paris in 1850-1860 was a significant planning exercise in historical context. In 1953 Charles Lindblom observed that planning is a continuous process and that policy making should be part of the process of planning. Dennis O Harry (1963) observed that existing planning approaches were relatable and scientific. These include-

2.1.1 Social City movement (Garden city) 1850-1928 proposed the polycentric development model where the city would be developed with 1000 acres for a population of 32000 and surrounded with 5000 acres of farms and institutions which would benefit from the surroundings. After reaching the limit a new city would be created with intercity rail with polycentric settlements forming a Social City.
2.1.2 City Beautiful Movement (1909) proposed by Daniel Burnham, aimed at restoring the visual and aesthetic value in city context.
2.1.3 Regional planning movement (1864-1932) proposed by Patrick Geddes, emphasised on - region had to be surveyed before planning a settlement.
2.1.4 Rational approach (1890-1960's) emphasised on improving the built environment based on spatial factors. It relied on quantitative assessments, predictive modeling, design, alternatives and monitoring progress.
2.1.5 Systems Theory Approach (1960s) gained popularity wherein cities were studied as systems with coherent entities, composed of interconnected and interdependent parts. This approach has 5 stages defining the issues, identification of alternatives, evaluation of alternatives, implementation and monitoring.
2.1.6 Incremental approach (1950-60s), described by Lindblom as 'muddling through', emerged from the critique of rational theory. It required decisions incrementally, small consequences bound by reality, adjusting the objectives in the planning process.
2.1.7 Mixed Scanning Model (1968) proposed by Etzioni planning undertaken at - two levels- the tactical and strategic. It can be regarded as a - functional planning- studying the environment at multiple levels and then uses strategies to resolve the issues.
2.1.8 Transactive approach is a distinctive model, centred around public participation. The public is sought out to build awareness, understand and actively engage for policy formulation.
2.1.9 Radical Planning (1973) was developed by Grabow and Heskin as a new paradigm based on system change, decentralization, decolonization, democratization, self empowerment and reaching out. This model actively considered societal needs and environmental balance for development.

These approaches reveal that planning as a process was developed by contribution of - theorists, archaeologists, geographers, urban designers, all of them trying to understand the spatial organization and social needs of an urban life. In the 1970s the *"Social logic of Space" by Bill Hillier* made the outline of a new theory, a method of investigating the relationship between the society and space. This had profound bearing on studying the order of spatial patterns and understanding the morphological relations in global patterns (Yamu, van Nes and Garau, 2021).

To analyse the spatial relationship in this theory a quantitative and more objective method was developed - the 'Space Syntax' method by Bill Hillier. This could be applied to urban studies at all levels. There are four stages: firstly to find the issues in the concepts of spatial units. using Spatial Syntax (SS) for analysing the cities and its routes by placing and grouping. Thirdly, the SS method is set to observe the relationship between the land uses, transportation, movement pattern, migration pattern. Fourth it gives us an opportunity on how the city has been developed spatially with respect to the social, economic and cognitive factors. This method could be applied from small scale projects like individual buildings, to road networks to cities and metro cities to understand the urban structure and it dependence on social relations (JPER, 2015).

Space Syntax analysis can be used to understand the development prospects of existing mining regions, to bring a more objective basis of proposing land use and its transition. The mining wastelands situation from a policy perspective is discussed in the following section.

3. Mining Wastelands - Case of Greater Bangalore, India

3.1 Background

Mining resources and infrastructure are the economic backbone of nations. There are rich reserves of geological conditions that make a growth and development of the mining sector in India. The history of mineral extraction dates back in the Harappa civilization. The first recorded mining was in 1774 when the East India Company mined coal in Raniganj. The Kolar Gold Mines, Karnataka, in 1880 are among the most known reserves. India is fourth among the mining exporters of minerals in the world in terms of volume of production. Mining sector contributes nearly 2.4% to India's GDP (Reichl and Schatz, 2020) (Katharina Buchholz, 2020).

The assessment of wastelands in India started from the year 1984. The National Remote Sensing Centre (NRSC) has completed five cycles of wastelands monitoring 2000, 2003, 2005-06, 2008-09 and 2015-16 for the country. Applications of wastelands databases have been used at various Government levels. Identification of Potential Land for Renewable Energy Projects". Site suitability analysis for rehabilitation, disaster support, siting of Industries, likewise. India with a total land area of 3.3 Million Sq. Km. of which 5,57,665.51 Sq. Km. is the total wasteland area in the country available in the year 2015-16 (NRSC, 2019). Karnataka which covers a land area of 1.92 lakh Sq Km. had 77,990.0 Sq Km. of identified degraded and wasteland which makes it 41% of wasteland category in the state (Geology, 2008).

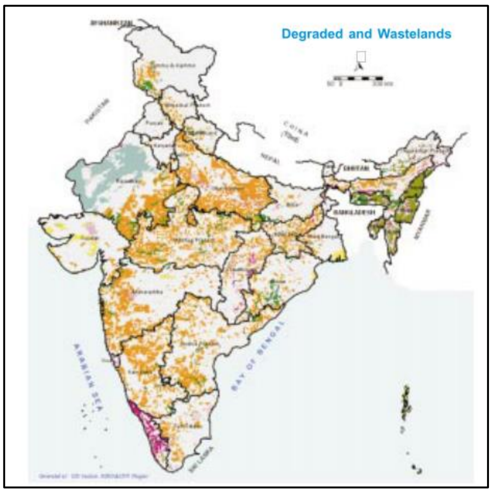

Figure 1: Degraded and Wasteland :NBSS & LUP Source : (Trivedi, 2010)

3.2 Mineral scenario in Karnataka

Karnataka, the southern state in India, in particular has a very rich asset of natural resources and mineral wealth, due to its deccan plateau geology. The SOER (2015) State of Environmental Report 2015 of Karnataka gives detailed data on the mining, quarrying and the effect of land degradation in the state. Mining impacts the existing landscape altering - topography, geology, and the substrata, the hydrology and its drainage pattern, the topsoil, vegetation, the existing habitat. It also significantly degrades the air quality, the runoff discharge may be toxic waste water, joining the nearby streams and water bodies. This has potential health and environmental hazards, and can even affect the agricultural crop and the nearby water bodies.

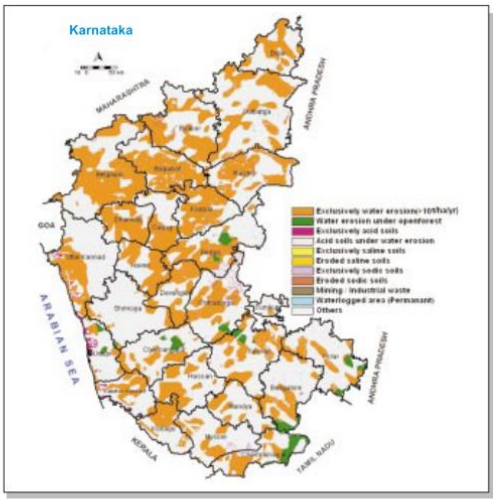

Figure 2: Degraded and Wasteland: NBSS & LUP Source: (Trivedi, 2010)

The mining activity leaves behind open pits and heaps of waste that eventually pollute the environment. Mining is a serious concern of noise if it is placed closer to the wildlife and human habitat. Apart from disturbing the land in various ways it also requires a huge land area for the execution of the mining activity. It requires areas for extraction, exploration, dumping of overburden, dumping of the raw materials, and waste, water collection and retention ponds, infrastructure for the processing stage, office block, accommodation block and residences for the workers, other amenities like the hospitals, schools, roads and basic facilities as required for a small township.

Figure 3: Mining Wasteland in Bangalore Source: (Times of India, 2019)

Karnataka alone has around 1.95 lakh SqM. of mining land with coal bauxite, asbestos, copper gold etc. The progressive mineral policy was formed in 2000 (FICCI- Mines and Metals Department, 2013). However, the scope of the paper deals with adaptive reuse of mining waste lands, and for that it is pertinent to discuss the policy framework around these lands typology.

3.3 Mining and Industrial Wastelands

Mining wastelands are those areas where waste debris is accumulated after extraction of required minerals. Generally, these lands are confined to the environment of the mining area (NRSC, 2019). It concludes that 1991, 2000, 2016 years are mapped regarding land degradation and noticed a 10.5 % increase in the degradation. In 1991- vegetal and water erosion was the cause of land degradation. In 2000 quarry and mining activities were the cause of degradation.

3.4 Mineral Policy and Regulation in India

The Indian Bureau of Mines(IBM) is responsible for the regulations of mines in the nation. It carries the inspection of mines, approves of mining plans, mining closure plans and conducts a survey of the environment on the closure of the mine and its impact. This statutory body prepares the mineral maps, inventory resources, publishes the technical and statistical information relating to the mining activity in the country. All the ongoing mines should file and report the update with IBM (Ministry of Mines, 2011). Mines and Minerals development and regulation Act 1957 (MMDR), Rules made under the minerals like coal, gas and petroleum, Geological Survey of India (GSI) explore the exploration of minerals and mine resource assessment in the country. Indian Bureau of Mines(IBM) and responsible for the mine regulations in India.

The National Mineral Policy was laid in 2008. Out of the 3318 reporting mines in India, there are around 178 mines in Karnataka. India is self-sufficient in the availability of raw minerals for the rising demand. National Mineral Policy 2008, has focused on the area of liberalisation of private sector involvement and broadened the vision of regulating the framework in terms of transparency, sectoral best practices.Mining is a high risk oriented activity and the closure of this activity would be very systematically planned and executed for the restoration purpose. The ICMM and IUCN are based on eight principles which incorporates the Assessment on key mining regions, managing the impacts of mine by regulatory management systems, addressing the land, resettlements and social impacts, community engagement and other socio- economic impact, community engagement, social sensitivities and social impacts, mining closure and post closure and reporting and updating the statutory bodies (Kanataka Mineral Policy 2008) (MOEF 2015). Mineral Administration- Mining lease will be coordinated with the Survey of India toposheets. All the maps will be digitised. The IBM and department of environment will regularly check if there is any encroachment and irregularities in the leased area (Ministry of Mines, 2011).

4 Mining Landuse Planning in GIS Environment

4.1 GIS Application on Mining Wastelands

Remote sensing is a highly reliable tool to develop multi-temporal mapping of geographic regions and can be integrated with GIS to enable progressive monitoring of such identified regions. It allows for adding distinctive quantitative data in layers that helps assessment of spatial factors related to development, hazards, risks, natural assets, prospects and so on. From 1986, GIS was used to map wastelands in India, when the Planning Commission of India defined degraded lands as the lands deteriorating with poor management of soil and water (DoLR, 2010). However, the use of GIS is not fully explored when it comes to planning prospective land uses for existing mining lands. This may be because, there is a need to apply GIS based technology in consonance with existing planning theories, that can bridge the gap for objectivity in land resource allocation for development, and not driven by policy focused action.

5. Methodology

As mining wastelands need a strategic reuse plan for the deformed lands.However, the principal question is what is this reuse strategic plan based on. Since land is a vital resource, how can this decision be made more value free, more objective, so as to optimally contribute to the regional development plan. A research gap - the assessment tool for landuse transition for a post mining wasteland area to have an adaptive reuse has been addressed in this paper. To achieve this a literature study was undertaken to understand different planning approaches, of which space syntax Theory and method is studied in detail. A study of mining wastelands in India and Bangalore Urban and peri urban areas to understand regulatory framework was undertaken.

Greater Bangalore urban region was identified as the study context and the Hoskote satellite town was identified to understand planning factors for adaptive reuse of mining lands. Spatial maps for study context were developed based on data collected from- Bangalore Development Authority (BDA), Bruhat Bengaluru Mahanagara Palike (BBMP), National wasteland development Board (NWDB), Department of Land resources, National Remote sensing data (NRSC), Open street map (OSM) and Google Earth Pro.

QGIS and DepthmapX were used for generating spatial syntax analysis. As Space Syntax Analysis/ tools has fulfilled the criterias like analytical approach to spatial design, this could be linked to the user and space, applied at different scales and this can show the future development possibilities.

The spatial syntax analysis indicates the principal activities cluster likely to come up in study context- peri urban region, which can assist in determining the consonant landuse for existing mining wasteland. The findings and results have been discussed in detail.

6. Space Syntax Analysis: Case of Bangalore

6.1 Space Syntax theory and parameters

Human activities are a spatial phenomenon where the activities give rise to urban patterns, their spatial characters, the physical elements which could be identified as a city with its behavioural patterns. These social and economic activities shape the culture of the city. Spatial syntax is a spatial configuration approach using the logic of graph theory. Space Syntax is a theory emerged under the Urban Network Tradition. The theory is focused on street structure and spatial configuration. This theory results in mathematical relationships between spaces. The theory was pioneered in1970s by Bill Hiller in Bartlett, UCL (Bill Hillier and Julienne Hanson, 1984).

There are two steps in this theory: first the analysis of two regions in comparison with the spatial and social parameters and the second step is the correlation from the socio-economic data available which decides on how and why the city is growing in a certain way with its social activities and the other way round. For the analysis of a city there are two main approaches: the normative and descriptive approaches. The paper is focusing on the descriptive approach where it studies on how the city would function in the future (Nes and Yamu, 2021).

In morphological analysis there are 3 basic principles

-Buildings - open spaces form the fundamental physical elements that define the urban form.
-Urban forms- different levels namely building, street, block and neighbourhood, city and region.
-Continuous transformation- urban understanding historically (Nes and Yamu, 2021).

The research area taken is Bangalore Urban (District -1) and Bangalore Rural (District-2). Bangalore Urban is a metropolitan city that has a rich geological and ecological history that has supported extensive enterprise, industries, agriculture, and now IT sector driven urbanisation(Figure 3). Bangalore Rural has 4 Taluks: Nelamangala, Doddaballapur, Devanahalli and Hoskote. As we are concentrating more on the mining and industrial land use we are taking Hoskote as the connecting district (Figure 3).

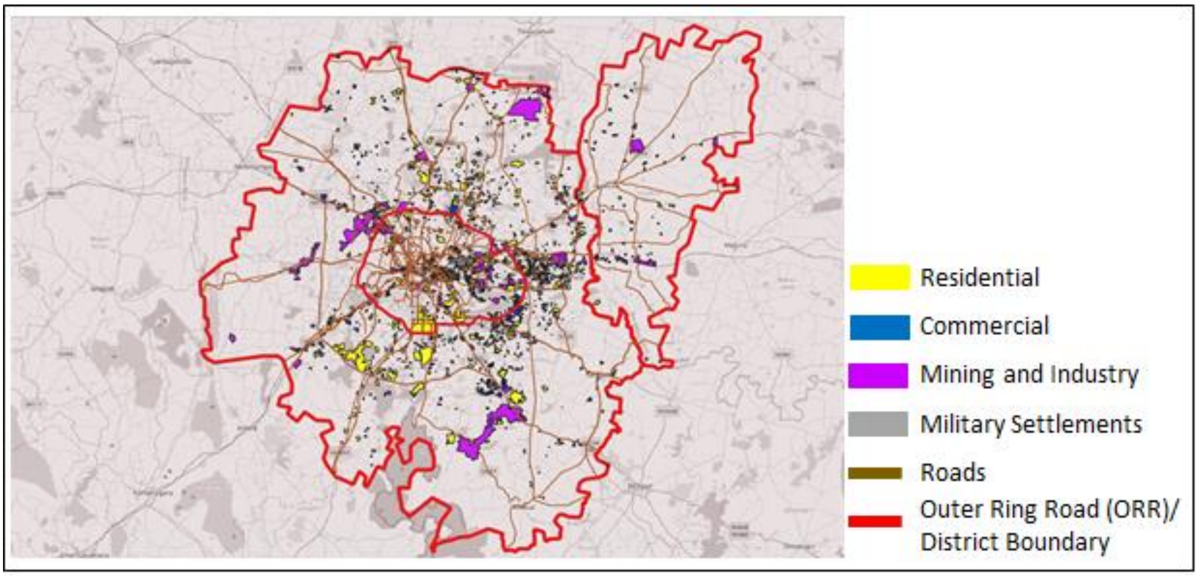

Figure 3: Landuse map of Bangalore Urban and Hoskote Taluk (Bangalore Rural)

6.2 Site Specific Space Syntax Application

The method generates a model of topological relationship with the street network structure. Figure 4, explains the core area (Black Dotted Line) Ulsoor Lake in the CBD within the limits of outer ring road (ORR), the second ring (Blue dotted line) showing the development beyond the ORR, Whitefield Area. There is a good network of transport and metro lines available, Infrastructure development till the Bangalore Urban district boundary. The third circle (Purple dotted line) shows the Mining and Industrial development of many Industries along the road network. By using QGIS software, the landuse basemap considering

Residential, Commercial, Mining and Industrial, Parks and Roads are mapped in QGIS software.

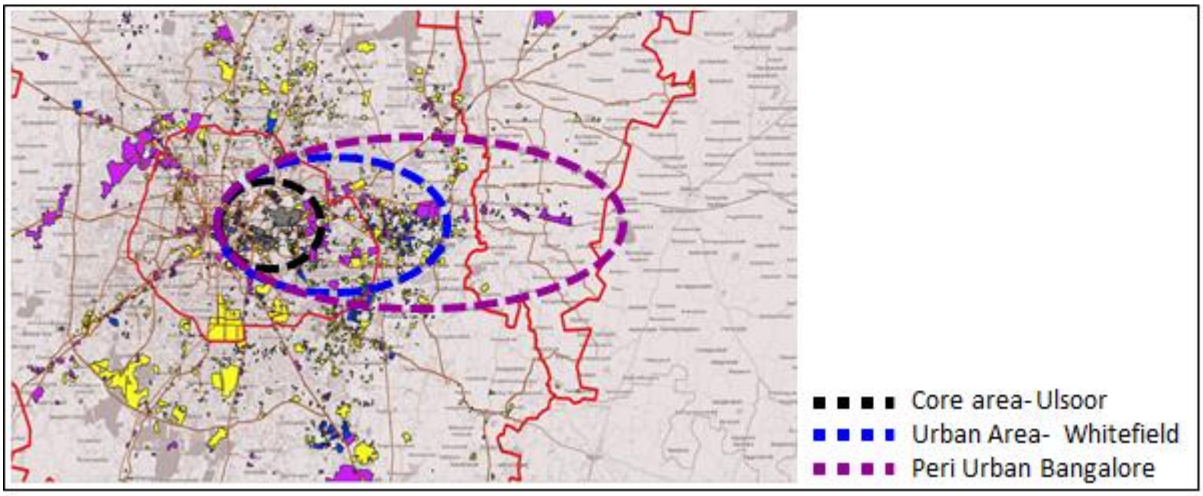

Figure 4:Study Area: Landuse map of Bangalore Urban and Hoskote Taluk(Bangalore Rural)

7. Space Syntax Analysis : Results and Discussions

The landuse plan indicates that the movement of growth from the urban centre to the peripheral area is post 2000. Observing the road network pattern this area of Whitefield is going to develop towards the Hoskote region and the land preparedness toward the future needs has to be catered. Figure 5 shows the density map of development in the region.

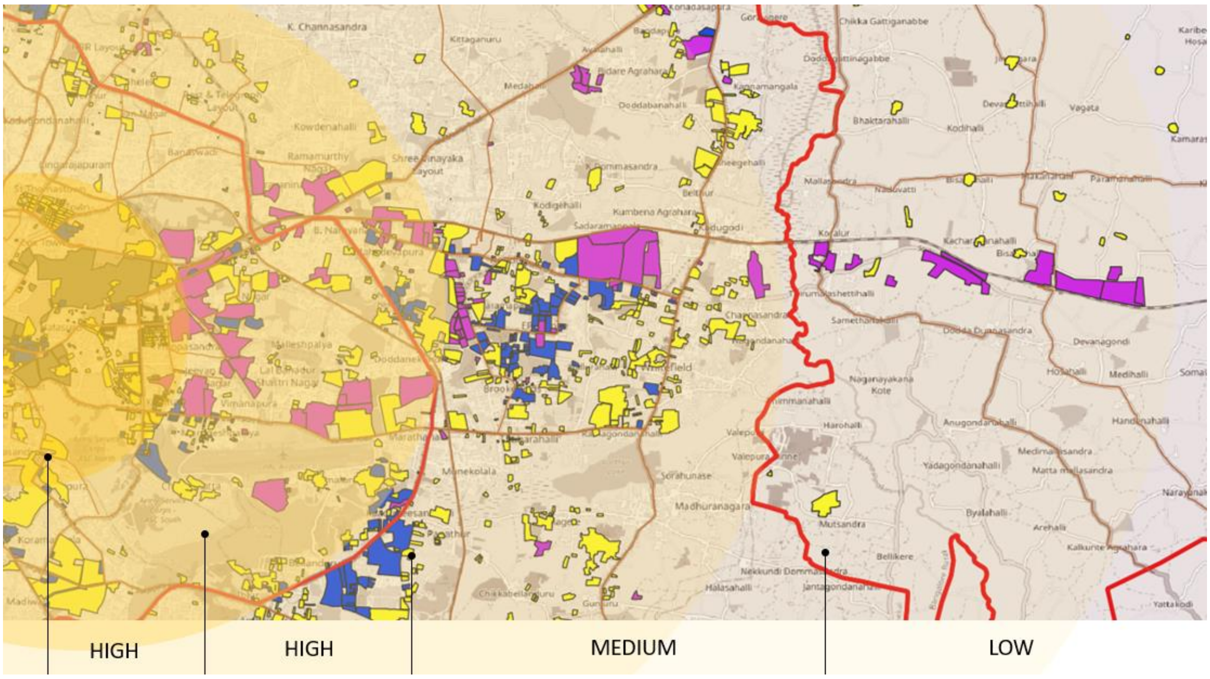

Figure 5: Spatial Density map of Development in Bangalore Urban and Hoskote Taluk (Bangalore Rural)

This spatial arrangement is taken for further analysis to the DepthmapX Software to analyse the relationship of development and network with spatial landuse component. The Depthmap method gives an understanding of the economic processes and the natural movement of the spatial structure of the city.

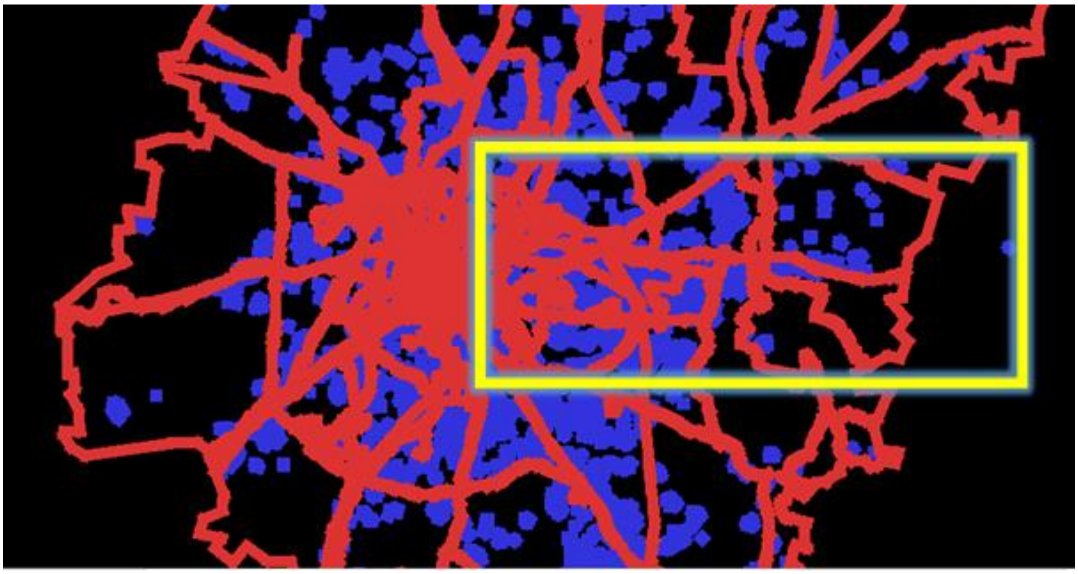

Figure 6: Depthmap Axial Analysis

Table 1: Attribute Summary For Axial Line Method

Attribute	Minimum	Average	Maximum
Angular Connectivity	0	0.90764	8.46
Axial Line Ref	0	331821.6	63066
Connectivity	1	2.18449	7
Segment Length	1.309	73.1712	6294.46

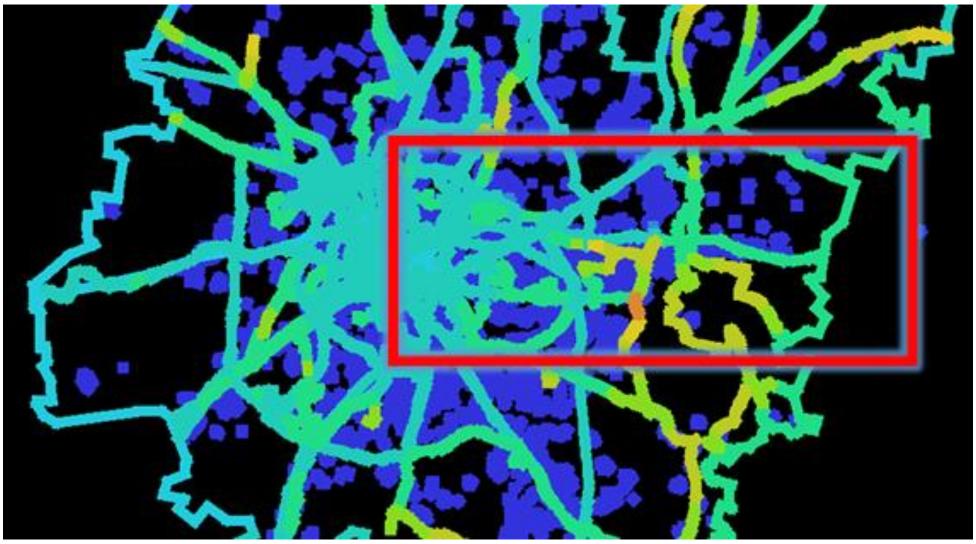

Figure 7: Depthmap Axial Analysis showing the development pattern along the Mining and Industrial Landuse

Table 2: Attribute Summary For Axial Line Method

Attribute	Minimum	Average	Maximum
Choice	0	4.15445	1.99158
Choice(Norm)	0	0.207961	1.33333
Connectivity	1	2.09536	12
Drawing layer	0	5.14109	15
Integration	0.0201	0.324846	3.49023
Line Length	0.0282442	75.2286	6294.46
Mean depth	1	130.118	618.351
Node Count	3	17195.9	32920

7. Conclusion

It is understood that mining wasteland gives the scope for extensive evaluation and preparation for the landuse transition to take place after extracting extensively for 20-30 years on the same piece of land. Landusues like residential, Commercial, Infrastructure facilities like Transit hubs, Bus depots, Parks, Urban Forestry, Manmade Landscapes, etc. can come in this region within the vicinity of 10KM from the Bangalore Urban. It is recommended that mining wastelands should be transitioned or prepared for the future proposed landuse with an objective planning strategies. Spatial syntax analysis in GIS environment allows for an objective development projection for the near future. This could be a strong foundation for the strategic framework that reinforces the urban development component. In this research paper the spatial syntax analysis of context area of Greater Bangalore and Hoskote reveals likely cluster of mining related industries which might attract Commercial, Infrastructure, Intermodal Transit Hubs and Urban Landscapes. To be specific, landuse immediate to existng mining and industrial wastelands spatial syntax is proposed to be extended to smaller scale of 2.0 -5.0 Km for future research.

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