A Methodology for the Regeneration of Indian Steel Cities: Case Study Durgapur, West Bengal

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I, Parikhit Biswas, registered on 13.04.2018, do hereby declare that thesis entitled "**A METHODOLOGY FOR THE REGENERATION OF INDIAN STEEL CITIES: CASE STUDY DURGAPUR, WEST BENGAL**" contains literature survey and original research work done by the undersigned candidate as part of the Doctoral studies.

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List of Abbreviations

Abbreviation	Full form
ADDA	Asansol Durgapur Development Authority
ADPA	Asansol Durgapur Planning Area
AHP	Analytic Hierarchy Process
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
ANN	Artificial Neural Network
BCG	Boston Consulting Group
BOGL	Bharat Ophthalmic Glass Limited
DEM	Digital Elevation Modelling
DMC	Durgapur Municipal Corporation
HFCL	Hindustan Fertilizer Corporation Limited
ICCIH	International Committee for the Conservation of the Industrial Heritage
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
LUDCP	Land Use and Development Control Plan
LULC	Land use Land cover
MAMC	Mining and Allied Machinery Corporation
MDG	Millennium Development Goal
MLPNN	Multi Layer Perceptron Neural Network
MOLUSCE	Modules for Land Use Change
NRSC	National Remote Sensing Centre
PESTLE	Political, Economic, Social, Technological, Legal, And Environmental
PMBOK	Project Management Body of Knowledge
PWC	PricewaterhouseCoopers
SAIL	Steel Authority of India Limited
SWOT	Strength, Weakness, Opportunity And Threat
SDG	Sustainable Development Goal
URDPFI	Urban and Regional Development Plans Formulation and Implementation Guidelines
VRIO	Value, Rarity, Imitability, Organization

Abstract

The Government of India started founding a set of steel industries during the second five-year plan after independence in an endeavour to become self-sufficient in this basic resource essential in nation building. The steel industry imparted employment, infrastructural stability and profit till the introduction of General Agreement on Tariffs and Trade (GATT) agreement 1994 and World Trade Organisation (WTO) agreement in 1995 with the introduction of global trade liberalisation that led the steel industry face global challenge and go for technological upgrade for its sustenance that curbed the profit and employability of Indian steel industry in a big way. Thus, the resources at these steel cities, namely the residential facilities, schools, medical facilities, markets, banks, post offices, feeder and ancillary industries, etc., were suddenly proved surplus. People lost their job with many industries shutting down and other cutting down employment, following the market pressure. In this context, it is necessary to plan a resurgence of this steel cities by generating additional jobs and utilise the existing facilities. In this research the case of Durgapur, once called the Ruhr of India, has been chosen as a case study for its 'regeneration'.

The city of Durgapur evolved as a steel city to support the employees of the two steel plants established over there, the Durgapur Steel Plant (DSP) and the Alloy Steel Plant (ASP), along with other similar steel cities in India which came up during the 1950s and 1960s. Initially its main economic basis was the steel industry, which since the 1995 World Trade Organization (WTO) agreement shifted heavily towards a tertiary sector-based economy due to global liberalisation, corresponding technological advancement due to increased competition and resulting drop in manpower requirement. The city's dependence on steel sector has resulted in reduction in employment following upgraded technology, reduced investment in the maintenance of civic amenities with receded demand for them and gradual dilapidation of the under-utilized facilities like quarters, markets, schools, etc. Some industries, ancillary to the steel sector, namely, Mining and Allied Machinery Corporation (MAMC), Bharat Ophthalmic Glass Limited (BOGL), etc., had been shut down, worsening the state of employment in Durgapur. Absence of supplementary industry to generate employment and any strategy to use the dwindling surplus infrastructures are essential.

In this thesis, it is proposed to formulate a strategy that would help in identifying a set of alternative industries that are compatible with flavour of Durgapur while strengthening her economic basis. Initially this research reviews the prevailing policies on the steel industries globally. It is observed that though the steel sector is still indispensable and will continue to do so, employment in this sector has shrunk a lot due to technological upgrade.

To cater for additional employment, since the city has a capability of support more residents than present, a quest has been made here to identify a series of additional industries through the Porter's Five forces framework. With the help of expert's opinion, Porter's framework evaluates the competitiveness of the probable supplementary industries in the prevailing market condition. It is found that IT sector have the best competitive advantage, followed by the non-metal sector. The growth of the city is assessed by simulating its future land use land cover (LULC) through QGIS application. It is found that the city is expanding both along the north-west and south-east directions following the historic Grand Trunk (G. T.) road, presently a part of the Asian Highway-1 (AH-1). Despite having administrative restrictions, the industrial civic portion is also showing sporadic growth. The city growth simulation can help in determining strategic locations for additional industrial sites and infrastructure facilities for the residents. To gauge the magnitude of necessary infrastructure, population count has been taken as the indicator of the city's growth. In this step, city population is expressed as the dependent variable and city growth factors are deemed independent variables. The growth factors are obtained from past

literature study, which have been further refined and reduced as per experts opinion, measurability and applicability. The relation between the city's population and growth variables provides a relation, which will further determine the requirements to support the population.

Finally, an industry-specific proposal has been developed, following the industry-wise growth trends of the Tata house of industries at Jamshedpur, accepted as a benchmark standard in this research, to set the competitive positions of various industries, and define the growth trajectory of Durgapur. Population projections indicate that by 2031, Durgapur is expected to reach a population of 8.5 lakh. The necessary urban infrastructure requirements have been determined on the basis of this projected population. Additionally, a dedicated section has been included to outline potential solutions for improving civic facilities within the industrial township.

In the next step of proposal formulation, population influx due to added proposed industries has been computed. The increased population provides a base for the required infrastructure. Referring to the Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines Volume 1, 2015, a brief unit wise requirement of infrastructure is obtained. URDPFI provides the data about the number of population a unit infrastructure serves along with its required area for set up. Total area requirement is computed by multiplying the unit area with the total infrastructure units. The obtained industries and infrastructure are placed strategically following the simulated scenario of Durgapur. A proposal is also provided for the dilapidated quarters and amenities within the steel township area, where the dilapidated buildings are put to use for a suitable purpose, i.e., small-scale industry, old age home, children care centre, nursing home, coaching centre, etc., according to respective demands. To effectively implement the development scheme, a project management framework is also framed following the PMBOK (Project Management Body of Knowledge) guidelines. Finally, a strategy is proposed in the conclusion.

Chapter 1: Introduction

1.1 Background

After independence, the Government of India took an initiative to set up steel industries under the second five-year plan (1956-61), in a quest of being self-sufficient (Ghosh, 2012). Thus, steel factories and their supporting steel cities were established under the patronage of Government of India in different locations of India, namely, Rourkela, Durgapur, Burnpur, Bhilai, Salem and Visakhapatnam. They supplemented the Tata Iron and Steel Company (TISCO) established in 1907 at Jamshedpur, founded by Jamsetji Nusserwanji Tata under private endeavour alongside IISCO, Burnpur, West Bengal, a public enterprise, established in 1918, and Bhadravati, founded by N. K. Wodeyar, king of Mysore, in 1923. However, later it was taken up by the Steel Authority of India Limited (SAIL), Government of India.

Durgapur, the second industrial city of West Bengal after Burnpur, began her journey as a steel city in 1959[1]. Durgapur Steel plant is located in Faridpur-Durgapur Block, in Paschim Bardhaman district, West Bengal, India, between 23°31'38" N to 23°33'45" N latitude and 87°14'22" E to 87°16'19" E longitude and spread over 600 hectares (ha). Once recognised as the Ruhr of India, Durgapur too shows signs of wilting and has been selected as a case study for this research so as to rejuvenate its overall health, technically known as 'regeneration' of a city. Durgapur has a better strategic location being much closer to Kolkata (168 km) than Burnpur (221 km). Being a post-independence steel city, the city resembles other steel cities of India under SAIL, engaged in monitoring the State-owned steel plants since 1973.

Table 1.1: Growth of steel industry in Durgapur in terms of steel production, profit and employment

	1971	1981	1991	2001	2011	2021
Crude steel production (Million tonne per annum)	0.68	0.72	0.75	1.8	3.2	3.4
Profit (INR-crore)	26	35	81	114	148	365
Employment	41255	38978	32117	29223	15498	12931

Source: Steel News, Census of India- 1971, 1981, 1991, 2001 and 2011, Trade union document

Since its inception, vide Table 1.1, Durgapur has fared well in crude steel production and profit generation. However, the employment has shown a steep slump since the 1990s, when the renewed

[1] https://www.sail.co.in/en/plants/about-durgapur-steel-plant Collected on 19.02.2025.

General Agreement on Tariffs Trade (GATT, 1947[2]) agreement in the form of World Trade Organization (WTO, 1995[3]) agreement, enforced global competition and resulted in imposing technical upgradation that drastically curbed the work force requirement to cut down the production cost.

Durgapur has two steel plants, the Durgapur Steel Plant, DSP, and the Alloy Steel Plant, ASP, the former extracting steel while the later manufacturing alloy steel products acting as an ancillary industry to DSP. Since inception, the steel plants were the sole economic backbone of Indian steel cities. Gradually other industries like Mining and Allied Machinery Corporation (MAMC), Bharat Ophthalmic Glass Limited (BOGL), Hindustan Fertilizer Corporation Limited (HFCL), DTPS, Durgapur Projects Limited (DPL), and Phillips Carbon, etc., grew up in Durgapur.

However, since 1995, when India accepted the WTO agreement and went for technological upgrade to remain globally competitive, steel industries in India gradually started becoming less employable. As per the PricewaterhouseCoopers report (PWC, 2019), in 1991 Government of India liberalises the steel sector by removing iron and steel industries from the reserve list, which allowed the international access. The economic liberalization and technological advancements in the steel industry reduced the manufacturing cost, and made the industry less labour intensive (PWC, 2019).

In Durgapur, the number of employments in Steel Authority of India Limited (SAIL) units reduced to 12931 by 2020 from 41255 in 1970. Chakraborty (Chakraborty D. , 2024) pointed out that a list of factories and establishments were also shut down failing to bear the competitive pressure, leaving a scar on the face of Durgapur. Since the 1995 WTO agreement, the contribution of steel industries in employment has started shrinking at the national level, while MAMC, BOGL, etc. started losing their relevance under market pressure and lack of timely technical upgrade. Mining and Allied Machinery Corporation (MAMC), Bharat Ophthalmic Glass Limited (BOGL) and Hindustan Fertilizer Corporation Limited (HFCL) are some of the prominent industries of Durgapur, that were shut down during that period from 1998 to 2005, leaving their industrial land and civic infrastructure in an unutilized state. The legal ownership of these lands still resides with the respective industrial corporations, creating resistance to further development. From the administrative aspect, the Steel Authority of India Limited (SAIL) and Durgapur Municipal Corporation (DMC) have their separate jurisdiction areas. The development proposals from Asansol Durgapur Development Authority (ADDA) is not applicable in SAIL or other industry administered areas.

[2] https://www.wto.org/english/docs_e/legal_e/gatt47_e.htm Collected on 24.08.2024
[3] https://www.wto.org/english/res_e/booksp_e/agrmntseries1_wto_e.pdf Collected on 05.03.2024

Most of the deterioration is observed on the lands earmarked for the industries and their civic counterparts due to lack of maintenance from the respective industries since requirement for infrastructural support has shrunk along with increased market pressure. During establishment, SAIL had constructed approximately 32000 staff quarters along with necessary civic amenities for its employees during the 1960s. The other relative smaller Ancillary to Steel Industry (ASI) industries, namely, MAMC also constructed similar kind of civic facilities. Now, with the reduction in employment in SAIL and MAMC facing closure, there lies a big share of unutilized civic facilities lying without proper maintenance, there being no requirement in near future (Figure 1.1). The closed industries showed even greater problem, as there is no such authority to even take care of their facilities. Both the plant and the corresponding civic facility are left unattended. Degradation is noticed primarily in the Steel Township, unlike and the rest of the city, where the properties are privately owned and maintained.

		
Abandoned school	Rarely used market	Abandoned housing
		
Abandoned health care centre	Abandoned Industrial Training Institute	Abandoned housing

Figure 1.1: Sample pictures showing the dilapidation at different locations of Durgapur
Source: Primary survey

Since Durgapur is one of the most prominent industrial hubs in West Bengal, once recognised as the Ruhr of India, where employment facilities are shrinking fast with abundance of surplus facilities, it is chosen as the study area.

Observing the development pattern of Durgapur, the following problems have been initially highlighted which requires a regeneration approach.

a) The city lacks guidance in identifying appropriate potential industries those could improve the economic basis of Durgapur future.
b) The growth direction of Durgapur and its magnitude needs assessment. The nonexistence of any city growth assessment creates a barrier in planning future development.
c) Large amount of industrial civic amenities remains unutilised. Alternative possible usage for this portion has to be figured out.

1.2 Literature Review on Regeneration Strategies and Schemes

The review in thus section is split into two halves: the first part explores various strategies implemented globally, while the second examines strategies specifically adopted in India.

1.2.1. Regeneration: Strategies taken Throughout the World

As per Raco (Raco, 2003) and Mizzau et al. (Mizzau, Montanari, & Rinaldini, 2025), in urban planning, regeneration involves promoting growth and development of a city by redeveloping underutilized areas. Ramlee et al. (Ramlee, Omar, Yunus, & Samadi, 2015) explain that the goal of urban regeneration is to maximize benefits through partnerships between public and private sectors and prioritizing strategic management for multi-sector development. Adding to the fact, in 2012 Ahsan et al. (Ahsan, Asad, & Alam, 2012) commented that the promotion of urban regeneration involves active engagement of local government, decentralization of welfare schemes, increased involvement from private enterprises, and leveraging regional heritage for marketing purposes. Kong (2000) and Garcia (2004) also identified that urban regeneration not only aims to enhance the quality of life, but also raises inquiries about its overall societal benefits and equitable distribution. To promote comprehensive societal progress, the United Nations (UN) has adopted the Millennium Development Goal (MDG) in 2000, which concluded in 2015, and initiated the ongoing Sustainable Development Goal (SDG) in 2015. The SDG encompasses 17 objectives that address a wide range of issues, such as poverty reduction, hunger eradication, inequality mitigation, and environmental stewardship, among others.

Depending upon the characteristics of the problem, different regeneration strategies have been adopted at different locations. Report from World Bank group (2016) and UNHABITAT (2016) showed successful examples like in Bilbao, Buenos Aires, and Santiago where projects like the Guggenheim Museum at Bilbao, public participation schemes at Buenos Aires, and subsidized housing at Santiago led to significant economic and social transformation (World bank Group, 2016; UNESCO, 2016). Other successful initiatives include the Cheonggyecheon project in Seoul, which addressed downtown degradation caused by overcrowding through mixed-use development

promotion. Tel Aviv and Rotterdam utilized gentrification to tackle congestion and crime rates while addressing economic development (World Bank Group, 2016; UNESCO, 2016).

However, there are also instances such as in Istanbul, where gentrification faced criticism for issues related to job security and ethnic cleansing concerns raised by UNESCO. Pittsburgh, Pennsylvania's successful revitalization involved increasing employment opportunities through alternative employment opportunities (World Bank Group, 2016; UNESCO, 2016).

Mulion et al. (Mullin, Armstrong, & Kavanagh, 1986) have studied a regeneration strategy where, a mill town has been transformed to a service oriented center of minicomputers in Maynard, Massachusetts, with the help of industrial transition.

Sandhu (2000) explained how Alexandria displays successful rejuvenation through improved infrastructure, with a focus on reducing unemployment rates. He pointed out that assessing actual housing needs of the target population is essential for resource distribution by the government.

Domenico and Domenico (2007) and Sasaki (2010) describes that the impact of culture on urban revitalization has been observed in the cases of Kanazawa and Dundee, both leveraging their unique cultural and regional advantages for successful rejuvenation.

Spanns (2010) shows that urban regeneration in Madrid has focused on enhancing housing and infrastructure, leading to improved social mobilization. The approach involved creating a multicultural economic centre that served cultural and recreational purposes, to address limited space for expansion due to population growth.

Syrette and North (2010) shows that, issue of city degradation has been countered by an economic revival strategy in England by encouraging entrepreneurial activity and providing employment opportunities in deprived neighborhoods for revival.

Christudason (2011) shows that Singapore has observed an increasing need for housing, due to population growth and urban expansion. The government has supported urban development projects, led by private companies, including reforms enabling collective sale of land plots. This is similar to Ontario's approach to address land scarcity, through legal support.

Huang and Hsu (2011) shows that in Taiwan, the involvement of public participation and engaging local heritage are useful in economic revival of the heritage city.

Thomson (2012) mentioned that most urban renewal projects relied on citizen’s participation and adherence to government regulations. At the same time, these projects faced challenges due to unequal resource distribution. An effective urban renewal strategy includes restoration efforts,

financial subsidies, infrastructural support, and careful selection of sites for demolition and construction, and inclusive development across all society segments.

Ahsan et al. (Ahsan, Asad, & Alam, 2012) and Weerasinghe et al. (Weerasinghe, Sandanayake, & Bandusena, 2014) illustrates that, the regeneration efforts in Bangladesh focused on improving city infrastructure so as to address population pressure. In the Khulna Bazar area, the focus has been on creating a better urban environment, to stimulate economic growth, with attention given to shops, storage spaces, waterfront locations, and road networks.

Douet (2013) identified that the industrial heritage locations can be rejuvenated by following the principle of International Committee for the Conservation of the Industrial Heritage (ICCIH) with adaptive reuse and conservation. The identity of heritage locations and their contribution are found to be a key factor to proceed for re-using along with documenting its present condition.

Lawal (2014) observed that the use of socio-economic and morphometric factors have been useful in simulating land use, which identifies the extent and dynamics of land use in the region.

Hadjri et al. (2015) demonstrated that urban regeneration in the UK focuses on inner-city areas, and emphasizes mixed development, led by private sectors. The 'Urban Task Force' (a special organisation to tackle city degradation[4]) recommended high-density mixed-use development, but this approach resulted in varying effects across cities, including a decline in living standards. In 2003, the Sustainable Communities Plan aimed to address this issue by redeveloping industrial regions (Hadjri, et al., 2015). He also pointed out that, in Hungary, the urban environment has continuously evolved, and played a significant role in shaping the local cultural landscape, especially in Budapest. The city's administration has consistently influenced its perception and contributed to its gentrification process.

Ardiwijaya et al. (Ardiwijaya, Sumardi, Suganda, & Temenggung, 2015) showed that in Bandung Metropolitan Area, Indonesia, management of vacant lands and abandoned buildings, and judicious use of land management scheme can lead to increased revenue generation and form a sustainable urban environment.

Antyufeev & Ptichnikova (2017) mentions that Serbia has prioritized urban regeneration with a focus on housing projects, in response to post-World War II industrialization and housing shortage. On the other hand, Russia is revitalizing its urban areas near waterbodies by creating socially inclusive recreational spaces in Krymskaya Embankment, Moscow, and the right side of the Volga

[4] https://www.udg.org.uk/publications/articles/urban-task-force-report-25-anniversary-survey-and-summary

River in Volgograd. Additionally, Volgograd transformed its industrial region into a vibrant sports and cultural centre through The Red October Regeneration Plan project implementation.

Guo et al. (Guo, Tong, & Mei, 2020) demonstrates that the judicious utilization of city growth parameters during industrial redevelopment have proved useful in addressing issues related to green development efficiency, negative environmental conditions, industrial restructuring, and deteriorating infrastructure in North-east China.

Subasinghe (2021) shows that in Colombo metropolitan area, Sri Lanka, apart from traditional parameters to measure urban expansion, urban and non-urban landscape and non-traditional approaches, which include the context of neighborhoods, are more useful in understanding urban expansion of neighborhood.

Slade et al. (Slade, Inch, & Crookes, 2021) figured out that in Westfield, physical infrastructure have helped the community-based regeneration.

Lee et al. (Lee, Shin, & Jang, 2022) mentioned that Taebaek, Korea, an abandoned mine city, is regenerated by transforming the city into a cultural sports city. The strategy involved conserving the industrial heritage sites, and simultaneously developing sports facility. It used the existing geological terrain as a bicycle-racing track. Amalgamating sports and culture resulted in forming a city of leisure also.

Wang (2022) showed that spatial technologies is found to prioritize and construct green infrastructure in a region.

According to Lewis et al. (Lewis, Yarker, Hammond, Kavanagh, & Phillipson, 2022), at Collyhurst, UK, regeneration have been done with the help of providing better social infrastructure.

Cai et al. (Cai, Kwak, Cvetkovic, Deal, & Mörtberg, 2023) explain that spatial simulation helps in providing solutions for smart city planning. Based on the simulated urban scenario, decision-makers can provide space-making solutions, which proves useful in better smart city planning.

Mullion et al. (Mullin, Armstrong, & Kavanagh, 1986), Syrett and North (2010), Huang and Hsu (2011) and Subasinghe (2021) and many other authors showed examples where a new set of industries has been introduced to replace a degraded industries for economic revival of a city. However, in most cases, the choice of a new industry or strategy has been followed by a spontaneous reaction, as per the recommendation of a group of experts. The recommendation is proved a success or failure on a case-to-case basis. A methodology to identify a supplementary industry is missing.

It is observed that the process of tackling urban or city-level degradation has been majorly done through reviving the city's economy, providing regional identity, and aligning society with ongoing change. The procedure of managing city degradation can be managed from multiple aspects, namely - ecological, social, and economic, etc. Among all them, economic revival has been the most crucial and relevant, being a prerequisite for other improvements.

1.2.2. Regeneration Strategies in India

In India, some Government schemes have been initiated for regeneration of a sick city.

Ahluwalia (2017) mentions the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and Smart City Mission. The purpose JNNURM was to modernize urban infrastructure, improve governance, and promote sustainable urban development in Indian cities through financial assistance. AMRUT focuses on providing basic urban services like water supply, sanitation, and public transport to improve the quality of life in smaller cities and towns. The Smart City Mission, launched in 2015, aims to develop cities with modern infrastructure, efficient governance, and smart solutions for better urban living. It focuses on improving basic services, technology integration, and sustainable development to enhance the quality of life of the citizens.

There are some specialised programmes targeted at particular blight areas of a society , namely, the Nirmal Bharat Abhiyan (NBA), Swach Bharat Mission (SBM), Heritage City Development and Augmentation Yojana (HRIDAY), Basic services to urban poor (BSUP), Integrated Housing and Slum Development Program (IHSDP), etc. BSUP and IHSDP works towards eliminating homelessness and providing necessary infrastructure and services to urban poor (Source: https://mohua.gov.in/).

There are examples where a system has been reframed and initiated with new name and objective. A PricewaterhouseCoopers (PWC, 2016) Public Finance Newsletter highlights that Total Sanitation Campaign (1992) have been renamed as Nirmal Bharat Abhiyan in 2012 with modified objective.

There are scheme, which are specifically targeted to upgrade the employment condition. The Swarna Jayanti Shahari Rozgar Yojana (SJSRY) is one such example. The Nehru Rojgar Yojna (NRY) and Prime Minister's Integrated Urban Poverty Eradication Programme (PMI UPEP) also address the issue of unemployment.

Some schemes particularly address the issue of providing shelter and housing, like the Valmiki-Ambedkar Awas Yojona (VAMBAY) and Indira Awas Yojna (IAY), etc.

Along with these national level schemes, there are state level schemes, which achieved prideful international mentions. The Kanyashree Prakalpa of the government of West Bengal received United Nations Public Service Awards (UNSPA) in 2017 for women empowerment.

There are examples where state government have addressed the improvement of a particular section of industry. Uttar Pradesh Sant Ravidas Education Assistance Scheme aims for the financial assistance for the education of their construction workers. For the betterment of widows in the state, the Kerala State Government initiated 'Abhayakiranam' and 'SAHAYA HASTHAM' schemes to provide them financial assistance and opportunities for self-employment. In a different angle for women empowerment, the Punjab Government have a scheme named 'Shagun' where financial help is provided for the marriage of girls under BPL category and minority caste. The 'Balaram' scheme of Orissa was launched to provide financial assistance to COVID-19 affected farmers.

Parlewar and Fukukawa (2006) identified that local heritage and regional asset can be used to regenerate the historical town of Pauni.

The Sabarmati Riverfront Urban Renewal Project in Ahmedabad focuses on riverfront development by reclaiming land, improving flood management, and creating public spaces[5]. It includes promenades, parks, and recreational zones to enhance urban life and tourism. The project also emphasizes environmental sustainability by improving water quality and restoring the river's ecosystem.

Similarly (Rethinking the future, Accessed on June 2024) the Slum Networking Project in Indore is an urban renewal initiative aimed at upgrading slum areas by improving basic infrastructure like water supply, sanitation, and drainage. It follows a community-driven approach, integrating slums with the city by enhancing living conditions and providing secure land tenure. The project focuses on long-term sustainability by involving residents, reducing health risks, and promoting better urban planning.

The Bhendi Bazaar Redevelopment Project aims to transform a congested area of Mumbai by replacing 250 old buildings with modern infrastructure. It provides better housing, commercial spaces, and public amenities while preserving the area's cultural identity (Rethinking the future, Accessed on June 2024).

It is observed that in the Indian context, comprehensive city-level regeneration initiatives are relatively rare. Most schemes are designed to address specific urban challenges that can be

[5] https://www.re-thinkingthefuture.com/city-and-architecture/a10060-urban-renewal-projects-successes-and-failures/#google_vignette

implemented across various locations, while some interventions are limited to neighbourhood-scale improvements.

1.2.3. Research Gap

Though introducing supplementary industries is understood to be the most coveted strategy for regeneration, no specific regeneration strategy exists for the Indian steel cities whereby such industries can be systematically identified. No specific procedure has been proposed either for land use optimization that would be helpful in the rejuvenating a city. To the best of this author's knowledge, a culmination of strategic actions to rejuvenate an Indian industrial town is either lacking or scanty in the published literatures.

In addition, land use simulation and consecutive land utilization would further help in utilizing the most available resources while planning the industrial transition. However, using land use simulations to direct the growth direction of the city and using them to prioritize city infrastructure have been missed in previous studies.

1.3 Aim

The research is aimed at formulating a methodology for regenerating and improving the deteriorating conditions of India's Steel city with Durgapur, addressed as the Ruhr of India, being selected as case study.

1.4 Objectives

In this research, an attempt has been made to generate a methodology, which will regenerate the degrading condition of Durgapur. To meet the research, the following objectives has been formulated.

a) To identify the best supplementary employment opportunities for Durgapur in the prevalent competitive market environment.
b) To recognise the growth pattern and direction of Durgapur for the horizon year 2031. The existing civic facilities offered by the existing and closed industries need to be taken care of immediately, and hence a 6-year horizon has been set on an emergency basis, to match with the census year. This would help to reassess the situations by comparing with the census report of 2031.
c) To evolve suitable strategies and recommendations for the betterment of Durgapur, which will simultaneously retain the industrial identity of Durgapur.

1.5 Research Questions

Considering the research issue of the study followings are the research questions.

a) Which Indian steel city is performing better than the rest, and why?
b) Which kind of economic profile of the city will help to rejuvenate Durgapur?
c) What are the factors influencing the growth of Durgapur? How these factors will determine and define the infrastructural demand for regenerative scheme?
d) What are directions of city growth, and how the spaces are sprawling in the city?

1.6 A Review on the Best-Performing Steel City in India

In terms of their size and production capacity, steel cities in India can be classified primarily into three categories. First type includes Rourkela, Bhillai, Durgapur, Bokaro, Burnpur, Jamshedpur which are integrated steel plants and bulk producer, second type includes special steel plants in the form of Alloy Steel Plant (Durgapur), Salem, and Bhadravati with relatively smaller yield, and there is a third category, the ferroalloy plant at Chandrapur, Maharastra, producing manganese-based ferroalloys. Unlike Salem and Bhadravati, which have had a diverse economy for many years, other state-owned steel cities have emerged primarily during the growth of the steel industry post-independence with steel plants being the major source of employment.

By observing the growth patterns in various Indian steel cities, it can be inferred that a monopolistic economy presents a major challenge for these urban centres. All these steel cities have experienced growth in their service sectors and have evolved into educational hubs for their respective regions. In addition to this, there has been an increase in medical and pharmaceutical businesses, IT sector development, and other service industries. Notably, each of these cities is home to either a National Institute of Technology (NIT) or an Indian Institute of Technology (IIT), as well as a medical college which is an institute of national repute. Durgapur itself boasts of two private medical colleges. However, despite such business opportunities flourishing, some core areas within these cities are facing degradation issues, such as closed institutions and abandoned civic facilities.

On the contrary, Jamshedpur stands out as a city that has effectively maintained its urban infrastructure while evolving its economic characteristics. It is the sole steel-producing city in India that emphasizes on both pre- and post-steel processing products. In addition to manufacturing finished products, Jamshedpur also produces consumable automobile goods, resulting in a substantial profit margin. Jamshedpur produces various chemicals and gases required for the steel industry. Most of the necessary raw materials for steel production, excluding coal and iron ore, are manufactured locally in Jamshedpur. They own their coal and iron mines too. Unique entities like JAMIPOL (Jamshedpur Injection Powder Ltd.) and Linde India, producing industrial gases, operate

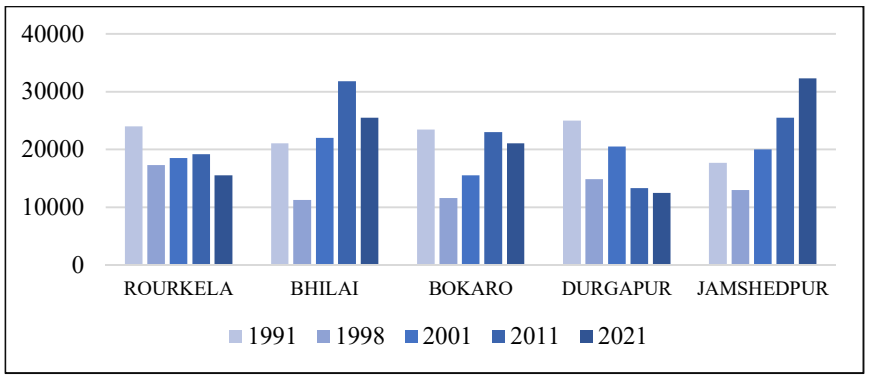

Figure 1.2: Employment in Rourkela, Bhilai, Bokaro, Durgapur, and Jamshedpur steel plants

Source: Census of India 1991, 2001 and 2011, Public Relation Office, Durgapur

within this area as well, producing supportive chemicals and related products for the steel industry thereby minimizing cost and transportation. The slag from the steel industry has been used to produce Portland slag cement (PSC) and Portland pozzolana cement (PPC) at Jojobera, Jamshedpur. The Jamshedpur Utilities and Service Company (JUSCO) proved urban infrastructure services for managing their township.

Table 1.2: Evolution of employment percentage in Jamshedpur

	Percentage distribution in total employment (main worker)		
Year / Industry	2001	2011	2021
Steel	20	15	8
Allied to Steel Industry (ASI)	8	12	13
Non-metal industry	4	15	10
Small Sized Enterprise (SSE)	37	18	21
Institution-Healthcare	3	4	6.14
Institution-Educational	4	3	8.5
Information technology(IT)	0	2	2.8
Shopping mall	0	1	3.78
Medium Sized Enterprise (MSE)	15	18	17
Balance	12	12	10
Total	100	100	100

Source: Census of India 2001 and 2011, JUSCO and Jharkhand Public Commission office.

The comprehensive integration of pre- and post-steel products not only enhances economic effectiveness but also creates additional job opportunities. Alongside these engagement, there has been a deliberate effort to foster growth within the service sector with companies like Tata Consultancy Services (TCS) leading this change. Adityapur industrial area, a satellite town to Jamshedpur, 8 km apart, is the largest industrial belt in Eastern India, mainly hosting small and medium scale industries, with a few large-scale industries. Tata Motors in Jamshedpur, manufactures automobiles and related accessories, which is a post-metal processing industry.

In contrast, other steel cities primarily focus on producing only final steel products such as rails, axles, wheels, joists, angles and channels, etc. However, the limitation of these types of products is their lack of direct usability by common citizens or consumers; they must be purchased again by other industries including railways, civil, military, automobiles, and construction sectors. SAIL steel industries depend on the raw materials such as iron ore, coal and other minerals like limestone from Bolani mines in Orissa, Jharia and Ranigunj in Jharkhand and West Bengal, and the Chota Nagpur Plateau, respectively. This entails significant costs of transportation and licensing fees associated with specific mines. Even in terms of crude steel production capacity, TATA Steel in Jamshedpur have produced approx. 35 MTPA (million tonne per annum)[6], whereas SAIL have only produced 19.2 MTPA[7] in total during the assessment year 2024. To examine further, the development pattern of its economic development have been studied. It is noteworthy that although the Tata group owns the steel plant in Jamshedpur, import decisions are made by the Tata Steel, Jamshedpur unit, to maximize favourable conditions for the company. The Tata Steel have their own mines too at different locations[8]. Vis-a-vis, procurement decisions for the SAIL administered steel plants are centralized, and various governmental sectors are involved in the supply chain, including railways and coal administration, creating administrative operational and management snags and snarls.

Even for city maintenance, the Jamshedpur Utilities and Services Company Limited (JUSCO) had been established as an inclusive unit within Tata Steel, and is solely responsible for the town maintenance. Since the entire township is privately owned, there are no conflicts regarding administration and maintenance and JUSCO takes care of all aspects of city development within its authority. There is no need to seek approval from higher authorities; JUSCO acts as the sole authority for city development issues. It figures out the requirements and implements them within the city. Therefore, it can be inferred that apart from specific localized concerns in each city, the SAIL steel cities face two primary challenges. These include economic distribution and its impact on employment opportunities, and secondly determining responsibility for urban development.

Tiwary (2021) has praised the economic policy of Jamshedpur, where the distribution of industries in city's profile is regarded as an effective one. In terms of 'quality of life', Jamshedpur occupies the second position, after Chandigarh, as per AC Nielsen ORG-Marg (The Pioneer, 08-06-2013).

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[6] https://www.tatasteel.com/newsroom/press-releases/india/2024/tata-steel-2qfy2025-production-and-delivery-volumes-provisional/

[7] https://www.sail.co.in/en/sail-news/sail-achieves-highest-ever-annual-production-and-sales-fy24

[8] https://www.tatasteel.com/tata-steel-brochure-2020-21/inside-tata-steel.html#inside-bg3 Collected on 06.11.2024

In terms of applying urban governance, generating city revenue and addressing challenges related to city infrastructure, Jamshedpur appeared to be an ideal city (The mint, 21-12-2023). The strategy of industrial distribution, organisational structure to manage the whole city, and its overall management policy have placed Jamshedpur as the best steel city in India.

1.7 Review of Tools and Techniques Used in the Study

The literature review indicates the necessity of conducting three types of analyses, each requiring an appropriate methodological tool. First, an assessment of the competitiveness of existing industries must be carried out. Second, an evaluation of the spatial growth patterns is essential for understanding the dynamics of urban expansion. Finally, a numerical projection of Durgapur's future growth is required to estimate forthcoming demands and facilitate strategic planning.

1.7.1. Identification of a Model to Choose the Efficient Supplementary Industries

The competitive environment in a city varies from one industry to other; it is a complex procedure having deep impact on a company's strategic planning while setting up a business unit. Thomas (2016) has listed a set of 66 strategic planning tools used in various fields of strategic management. There are methods like SWOT (strength, weakness, opportunity and threat) analysis, and PESTLE (political, economic, social, technological, legal, and environmental) analysis, Boston Consulting Group (BCG) Matrix, Porter's Framework, Value-Rarity-Imitability- Organization (VRIO) analysis, McKinsey 7S Framework, Ansoff Matrix, Balanced Scorecard, and so on and so forth which are used to assess the internal[9] and external environments[10] of an industry. Internal environment of an industry is assessed when an industry has already set established in a location; however, external environment is assessed when it tries to set its foot in a new environment. Porter's Five forces framework (Porter, 1979) is one of the most widely accepted analytical mechanism to find competitive situation of an industry (Stonehouse and Snowdon, 2007; Mohammadrezaei,

[9] The "internal environment" of an industry encompasses all the elements within a business or organization that have a direct impact on its functioning, such as its culture, management hierarchy, workforce, technology, financial assets, and internal operations (Ramzaeva, Kravchenko, & Gorbunova, 2021)

[10] A company's "external environment" encompasses all the elements outside the organization that can affect its operations and performance, such as economic conditions, political factors, social movements, technological developments, legal requirements, and competitive forces. Although these aspects are mostly not under the company's control, they still play a significant role in shaping its decision-making and strategic planning (Ramzaeva, Kravchenko, & Gorbunova, 2021)

Nayebzadeh, and Roknabadi, 2016). Mohammadrezaei et al. (Mohammadrezaei, Nayebzadeh, & Roknabadi, 2016) studied the competitive position of Kian Isatis Pars Company through analytic hierarchy process (AHP) and Porter's framework had also adopted this approach. Stonehouse and Snowdon (2007) also mentioned the efficiency of the Porter model and confirmed that the five forces framework helps to assess the attractiveness and competitive position of the industry. Further, Butarbutar et al. (Butarbutar, Purnamasari, & Safitri, 2023) have mentioned that, Porter's model mainly emphasizes assessing competitiveness, whereas the BCG matrix is useful for analysing the internal portfolio. In a similar vein, Abbasi (2017) and Goyal (2021) opined that, compared to Value Chain Analysis which aims to provide customer value, does not concentrate on determining competitiveness. To conclude, the analytical approach of the Porter's Five Forces Framework could provide an efficient tool in assessing all supplementary industries in the present external environmental situation. However, its needs to be given a numerical attire before it can become a perfect numerical tool for practical implementation, which is discussed in the next section.

1.7.1.1. Identifying the Criteria and Sub-Criteria

Michael E. Porter (1979) proposed the model, which helps to formulate the strategy of industries, based on the five competitive forces: threat of entry of new industry, threat of suppliers, threat of buyers, threat of substitute products, and intensity of rivalry among existing industries. Lee et al. (Lee, Kim, & Park, 2012) applied the method of analytic network process (ANP), a generalized version of the analytic hierarchy process (AHP), to measure the forces of Porter's model numerically. AHP is a process developed by Saaty (1987), which judges the relative importance and determine the weightage of each criterion.

Porter formed the framework for industries through the five forces to determine the competition level and orient business strategy. These five forces (or criteria, in case of AHP) help to assess the position of industries in a microenvironment. These forces determine the core competencies of industries (Porter, 1979). During the compilation of criteria, experts from respective industries are interviewed to assess the impact of each of the five forces of Porter's model. While selecting the criteria from the original Porter's five-force framework, it has been tried to retain all the mentioned criteria from the original research work of Porter. Table 1.3 shows the five forces (criteria) of Porter's model along with their sub-criteria from the studies of Porter (1979) and Tseng (2010) and Wu et al. (Wu, Tseng, & Chiu, 2012) and along with brief explanation.

Table 1.3: Assessment criteria for industry's business competence through Porter's five forces analysis and its sub-criteria

Target	Five Forces (Criteria)	Sub criteria of the forces
Business competence	The threat of potential new entrants (A)	**Economies of scale** (A1): Large companies produce more at a lower unit cost, making it harder for smaller businesses to compete or enter.
		Product differentiation (A2): Companies try to create unique products or brands to stand out so that customers would love them and be ready to pay more and remain loyal.
		Capital requirement (A3): Higher initial investment to initiate a business could be prohibitive to the new entrants.
		Switching cost (A4): The difficulty/cost a customer incurs while changing brands/suppliers. If switching is costly, customers avoid it.
		Access to distribution channel (A5): Companies need good connections with retailers and online platforms to sell their products. If bigger brands would control these platforms, new entrants struggle.
		Government's policy (A6): Laws, regulations, and taxes can help or hurt businesses. Strict policies can delimit competition, while government patronage can help new companies grow.
	Bargaining Power of suppliers (B) (Deemed a threat to the new entrants)	**Number of suppliers** (B1): If there are many suppliers, businesses have more choices and can negotiate for better prices. If only a few suppliers exist, terms are dictated by the suppliers.
		Uniqueness (B2): If a supplier deals with some unique product that doesn't have an easy substitute, it is dominant. If a supplier serves a particular industry, the buyer dominates.
		Cost of switching (B3): Lower switching costs mean companies can easily find better deals elsewhere, and, vice-versa.
		Threat of forward integration (B4): If suppliers have the ability and decide to move forward into the buyer's industry that would challenge their former buyers.
	Bargaining Power of buyers (C)	**Number of buyers** (C1): If the number of buyers is fewer while the suppliers are many, buyers can bargain on price and quality of goods.
		Product differentiation (C2): If the products are undifferentiated, buyers can easily switch to other competitors, increasing their bargaining power.
		Buyer's changing frequency (C3): If buyers frequently change suppliers, businesses must compete more aggressively to retain customers. If buyers rarely switch, companies can enjoy stable long-term sales.
		Number of buyers (C1): If the number of buyers is fewer while the suppliers are many, buyers can bargain on price and quality of goods.
		Switching cost (C4): Low cost of changing suppliers can empower buyers to bargain
		Price sensitivity (C5): If buyers are price-sensitive, businesses must offer competitive prices to attract them. If buyers prioritize quality, brand, or service, businesses can charge premium prices.
		Threat of backward integration (C6): If buyers start producing the products they used to purchase earlier, they become competitors and dominate over the sellers.
		Importance of the product to buyer (C7): If a product is crucial, buyers will purchase it regardless of price, e.g., medicine. If it's optional, businesses must work harder to convince buyers to spend

Table 1.3 (Continued): Assessment criteria for industry's business competence through Porter's five forces analysis and its sub-criteria

Target	Five Forces (Criteria)	Sub criteria of the forces
Business competence	The threat of substitutes (D)	**Number of substitutes** (D1): If many alternatives exist for a product, customers can easily switch, increasing competition. If substitutes are few or unavailable, sellers have stronger pricing power.
		Obvious advantage of the substitute (D2): If a substitute product offers better quality, lower price, or greater convenience, customers are likely to switch, e.g., streaming services replacing DVDs.
		Switching cost (D3): Lower switching costs encourage buyers to explore for better alternatives.
		Profit level of substitute industries (D4): If substitute industries are highly profitable, they may attract more competition and investment. The original industry is then forced to innovate or lower prices.
	The intensity of competitive rivalry (E)	**Number of rivals** (E1): If many companies compete in the same market, they would fight harder to capture the market. Fewer competitors means more pricing power and customer loyalty.
		Exit barrier (E2): If it is costly for a company to leave an industry due to debts/contracts/specialized assets, they compete aggressively to stay afloat. Lower exit barriers helps struggling businesses to leave.
		Growth potential (E3): Being lucrative and growing, fast-growing industries attract new competitors. Slow-growing or shrinking industries compete harder for existence.
		Product differentiation (E4): If rivals sell very similar products, lower price attracts market and companies try to add unique features, or quality, to create loyal customers.
		Diversity among rivals (E5): If competitors vary in size, strategy, and resources, competition becomes unpredictable. When all rivals operate similarly, market behaviour is more stable.
		Threat of horizontal integration (E6): When two or more competitors merge, they become a stronger force, reducing competition. This can lead to fewer choices for customers but higher efficiency for businesses.

Source: Porter, 1979; Tseng, 2010; Wu, Tseng, & Chiu, 2012

1.7.2. The Idea and Procedure of Land Use Land Cover (LULC) Simulation

Land transformation triggered by human intervention changed land use land cover (LULC) all over the world that mainly happens due to the mechanism of human activity and its urge to use natural resources for its development (Mallick, Kant, & Bharath, 2008). This is the main driving factor for the change of natural land to urban and sub-urban land (Satya, Sashi, & Deva, 2020; Mubako, Nnko, Peter, & Msongaleli, 2022). Urbanization is one of the major factors of land conversion. Due to the involvement of land conversion with the environment and current environmental degradation throughout the world, it has attracted the attention of a wide range of researchers (Mohammad, Goswami, Chauhan, & Nayak, 2022; Nasar, et al., 2023). The change of LULC through spatiotemporal data, its correlation with demography, and the usefulness of satellite imagery in the procedure have been discussed by various authors (Satya, Sashi, & Deva, 2020; Chettry & Surawar,

2021; Devi, Deka, Aneesh, Reji, & M, 2022). The procedure of LULC change and its detection uses natural, demographic, and infrastructural issues as a determining factor. Various methods including Markov and Cellular automata (CA) (Eastman & Toledano, 2017) models have proven useful (Al-sharif & Pradhan, 2014) in determining future land use. In the process, land use maps of a series of years are taken and analysed based on the logic of input. Among various available options, MOLUSCE[11] (Modules for Land Use Change) is one of the easy, free, and popular tool, that have been used by various authors to simulate future land use by detecting spatiotemporal changes through Markov, CA, and ANN (Guidigan, Sanou, Ragatoa, Fafa, & Mishra, 2019; Yatoo, Sahu, Kalubarme, & Kansara, 2022; Rabby, Li, Abedin, & Sabrina, 2022; Hakim Y, Baja, Rampisela, & Arif, 2019; Kamaraj & Rangarajan, 2022).

Several attempts have been made to illustrate the method of urban simulation. Reis investigated LULC in Rize, Turkey, where he studied the impact of terrain through GIS. It was found that settlements are more susceptible to development in less sloped areas (Reis, 2008). Yesserie tried to estimate the future LULC from the rate of change of LULC for each class of LULC (Yesserie, 2009). Ashraf highlighted that hydrology, terrain slope, and various distance matrices from settlement have an impact on urbanization (Ashraf, 2013). Muhammad used distance from the road, slope, and digital elevation modelling (DEM) as predictors to simulate future land use (Muhammad, Zhang, Abbas, Guo, & Gwiazdzinski, 2022). Apart from the mentioned studies, there are also several research that have used the QGIS-MOLUSCE duo to simulate future land use (Alshari & Gawali, 2022; Roy & Rahman, 2023; Kamaraj & Rangarajan, 2022; Gao, Cheng, Iqbal, & Yao, 2022). Despite a number of researches dealing with land use simulation in different regions, there is no such study on the steel cities of India that delineates its spatial growth potential.

1.7.3. Identification of Growth Variables for Durgapur

The growth variables or driving forces of a city are described as the variables, which have a significant impact on the city growth or the procedure of urbanization. It is also observed that these forces accelerate the process of urbanization if increased in a potential value (N, Jenamani, & Mahanty, 2017; Sridhar, 2010).

To identify the variables of city growth, similar studies have been referred to trace out the possible variables. Table 1.4 shows the variables and their sources. The variables, which have been found in

[11] https://plugins.qgis.org/plugins/molusce/

a particular literature is marked as '✓'. The last column shows the variables selected for the present study, with brief explanation thereafter about how they are accounted in this research.

Table 1.4: Primary selection of variables

Source / Variables	LUDCP, City Development Plan (CDP)	(N, Jenamani, & Mahanty, 2017)	UN-HABITAT Document (2017)	(Mata, Deichmann, Henderson, Lall, & Wang, 2007)	(Liao & Wei, 2012)	Initially selected variables in this research
Population density						✓
Population size	✓	✓	✓	✓	✓	✓
Distance from CBD	✓	✓	✓	✓		✓
Infrastructure	✓		✓	✓	✓	✓
Ground coverage		✓		✓		✓
Greeneries			✓	✓	✓	✓
Employment	✓	✓	✓	✓		✓
Market potential		✓	✓	✓		✓
Governance			✓	✓		
Policy	✓			✓		
Migration	✓		✓			
Geographic location		✓	✓		✓	

Population Size: It is the population of the study area at the start of a census year. It is considered as dependent variable, in multiple similar type studies (Aguayo, Wiegand, Azocar, Wiegand, & Vega, 2007; Sridhar, 2010; N, Jenamani, & Mahanty, 2017)

The following are possible explanatory (or, independent) variables.

Population Density: It is described as the population per unit area (sq km). It will be used to distribute the population load in the study area as per future proposals.

Distance from CBD: It is the distance of the study area from the CBD. This data is applicable for the analysis of wards but not for the entire city. In the case of the whole city, it is to be taken as the nearest major city.

Infrastructure: This is the measurement of the availability of various city infrastructure and amenities in the study area including transportation networks, water supply, healthcare, education, electricity, etc. Infrastructure describes the quality of living of the citizens and is directly related to the availability of roads. In this study, the percentage of roads within the study area has been considered as a representative indicator of this variable (Navarro & Domeque, 2010).

Ground Coverage: This variable expresses the total percentage of built-up space in the study area. This provides a picture of the load on administration.

Greeneries: It is the ratio of forest, orchard, agricultural, and grassland concerning the **total area** in the study area expressed as a percentage. This is a quasi-representation of a healthy environment.

Employment: It is measured by the percentage of employed people in the study area. This expresses the human resource utilization in the city.

Market Potential: This factor provides a measure of the capability of the city to attract the market. Val et al. (Val, Tirado-Fabregat, & Marsal, 2013) suggested that this can be expressed by the gross development product (GDP) of the city per unit to-and-fro transport cost to the nearest capital. In this study, the revenue generation of the city has been passively accounted through the expenses incurred by city administration, obtained from year-wise financial documents of Durgapur municipality, since the expenses have direct bearing with fund generated. Numerical figures and prices have been transformed on the basis of a common base year, 2021, through the inflation comparison[12] method.

This research is aimed at suggesting governance policies, and hence governance and policies have been disregarded. Migration and geographic location are suitable for intercity analysis, where two or more locations will be analysed. Since 'population' and 'population density' are correlated factors, population density has not been considered for developing the regression model. Further, since the model is proposed to predict the population in Durgapur as a whole, the variable 'distance from CBD' is deemed redundant.

1.8 Methodology

For regeneration of the study area, initially various strategies adopted worldwide have been studied. Next, different schemes and cases from India are reviewed. It is found that, in most of the cases, supplementing some industries have helped to bridge the degradation. Along with appending additional industries, it is found that different government back-up schemes are available to tackle certain specific issues in India.

To initiate this research, the state of land use, economic status and the share of dilapidated quarters in the study area are reviewed in Chapter 2 along with its administration and demography etc. to

[12] Due to inflation, price of a commodity or service changes over time. To match the price of a certain commodity or service over a period of time, it is adjusted as per inflation rate.
(**Source**: https://www.investopedia.com/terms/i/inflation.asp).

understand the study area, Durgapur. The industries within the study area have been divided into eight conventional clusters for further analysis (Table 2.8).

In Chapter 3, the most competitive industry in Durgapur is identified by Porter's five forces framework (Porter, 1979). First, the forces under the five forces framework are provided with their due weights as in context of the prevailing situation at the study area using the inputs from experts and implementing AHP (Table 3.3). Thereafter, all contending industries are provided their ranks against the forces of the framework by experts (Table 3.4). These weights are used to arrive at the final relative rankings of the different contending industries within the prevalent market challenges (Table 3.6).

To assign strategic locations of an industry that is expected to fare well along with its supporting infrastructure, land use simulation is done in Chapter 4. With the help of QGIS 3.30.2, land use map of Durgapur for the year 2000, 2010 and 2020 are prepared. To validate, a simulated map of Durgapur is prepared for the year 2020, through QGIS-MOLUSCE by extrapolating the maps of 2000 and 2010. This simulated map is compared with actual 2020 land use map. Upon reaching satisfactory level, simulated map for the year 2031 is prepared. This chapter provides the direction of city's growth in the next five years, and locations where growth is being concentrated are identified. A tenure of 6 years has been selected since beyond this period, most of the vacant residential facilities might become sick beyond repair since they are not properly maintained any more, while a Census report is expected for 2031, which might help in reassessing the situation.

To determine the required infrastructure and other supporting requirements, namely, ground coverage, greeneries and built-up space, etc., models depicting the relationship of city's population with the explanatory variables are established in Chapter 5. The variables have already been collected in Chapter 1 from different sources (Table 1.4).

Finally, the supplementary industries and the city's growth simulation are merged to prepare a proposal in Chapter 6. A proposal is prepared where a new set of employment distribution has been proposed. The proposal is developed in light of Jamshedpur, since it is one of the best performing steel cities.

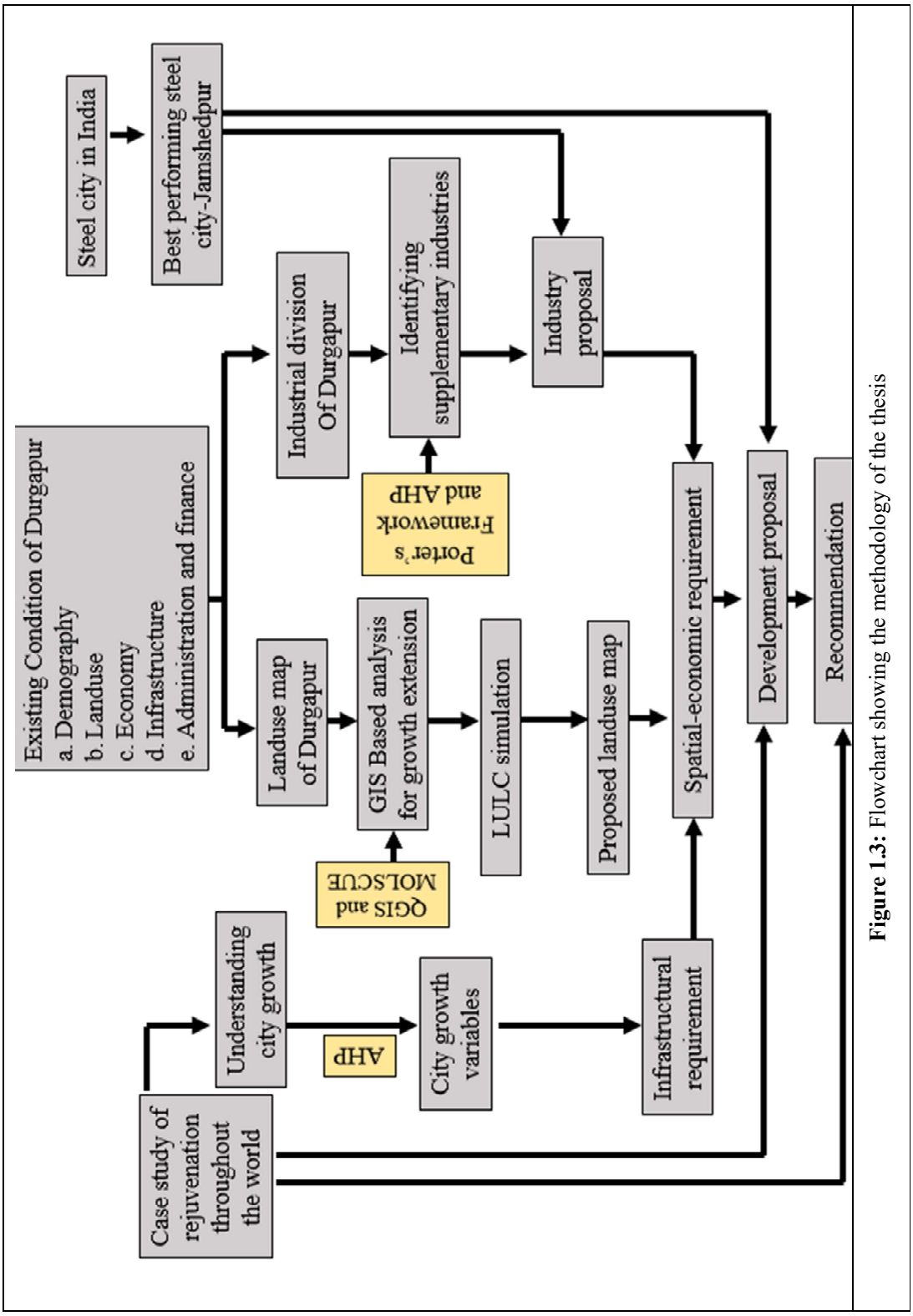


Figure 1.3: Flowchart showing the methodology of the thesis

Based on the distribution of proposed industries, increment in total population is computed. Simultaneously, the required infrastructure to support this population is also projected through the models formulated in Chapter 5. Further, different possible solutions are suggested for the industrial township area in particular; where all residential facilities are managed by the employer and privately owned facilities are nearly non-existent.

A list of strategies and recommendations are also suggested in Chapter 7 based on strategies adopted taken throughout the world, and condition of Durgapur.

1.9 Scope and Limitations

The study focused on developing strategies to rejuvenate Indian steel cities, with the primary focus on its spatial-economic aspects. It also focused on developing its infrastructural capability to accommodate the proposed intervention, keeping the fabric of the steel town intact as much as possible. In doing so, the following aspects have been identified as limitations of the thesis.

e) Environmental quality has not been considered as an explanatory variable in any numerical model. However, while proposing the land use upgrade, the land usage has been kept conducive, maintaining recommended shares of each land use.
f) The assessment and attached development proposal have been confined to Durgapur Municipal Corporation (DMC) area only. Any regional-level analysis has not been considered.
g) The study is focused on developing a strategy to rejuvenate Durgapur at the city level. However, in doing so, any micro-level approach has not been taken up.
h) The study has not considered the impact of governance and government schemes and policies in the regeneration process.

Chapter 2: Review of the Study Area – Durgapur

2.1 Introduction

Durgapur was established in 1854 when the Eastern Railway of British India extended its track to Raniganj coalfields, leading to the creation of a small railway station (Ghosh, 2012). It evolved into an industrial town in the 1950s and earned the nickname "Ruhr of India" due to its industrial character. In this study the area under Durgapur Municipal Corporation (DMC) have been referred as Durgapur. The boundary of Durgapur, under Durgapur Municipal Corporation (DMC) is shown in Figure 2.1. Following the chapters in URDPFI 2015, for understanding a city, the following features have been chosen to introduce the study area, Durgapur.

2.2 Location

Durgapur is located about 170 Km away from Kolkata beside the Damodar river (Figure 2.1). The city is situated between 87° 13' E to 87° 22' E longitude and 23° 28' N to 23° 26' N latitude.

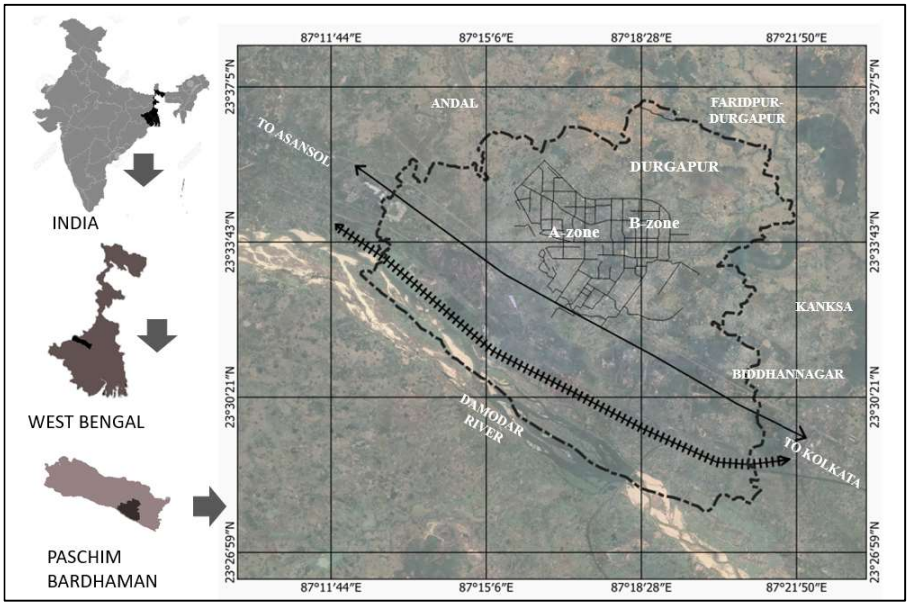


Figure 2.1: Location of Durgapur

Durgapur, formerly a part of 'Jungal Mahal', is located in the Durgapur sub-division of Paschim Bardhhaman District of West Bengal, India. It shares its administrative boundary with Faridpur-Durgapur, Andal, Kanksa, and Pandabeswar community development blocks. Despite being one of India's largest steel cities, it is surrounded by forest and urban areas and has good connectivity through NH-2, Howrah-Dhanbad railway link, and Andal Airport. The terrain comprises remains of the renowned Jungal Mahal, characterized by barren rocky undulating land. The Damodar and

Ajoy River naturally flows southward, due to the slope of this region. The area near Durgapur has historically been affected by flood for many years.

Physically, Durgapur is broadly divided into two zones. Firstly, the area under SAIL and secondly, the rest of the area. The area under SAIL is monitored by SAIL, which includes the steel industry and civil township (Steel Township) under SAIL. Apart from the area under SAIL, the rest of the area is monitored and administered by DMC.

2.3 Administration

As per the Land Use and Development Control Plan (LUDCP) of Durgapur (Asansol Durgapur Development Authority (ADDA), 2023), the city's administration is governed by the West Bengal Municipal Act of 1993 under the three-tiered decentralization system established by the 73rd and 74th Constitutional Amendment Act and is part of the Asansol Durgapur Development Authority (ADDA). Durgapur has undergone significant expansion from its initial establishment in 1962 to its upgrade to Municipal Corporation status in 1996. The Durgapur Municipal Corporation (DMC) consists of 43 wards organized into five borough units. The Steel Authority of India Limited has a separate maintenance department in Durgapur to oversee the steel township.

2.4 Demography

The region is primarily an urban locality with some rural portions in its northern side. The city's population has been consistently increasing, leading to a rise in the population density. There has been a noticeable rise in population density in wards 5, 13 and 14 as well as across all wards.

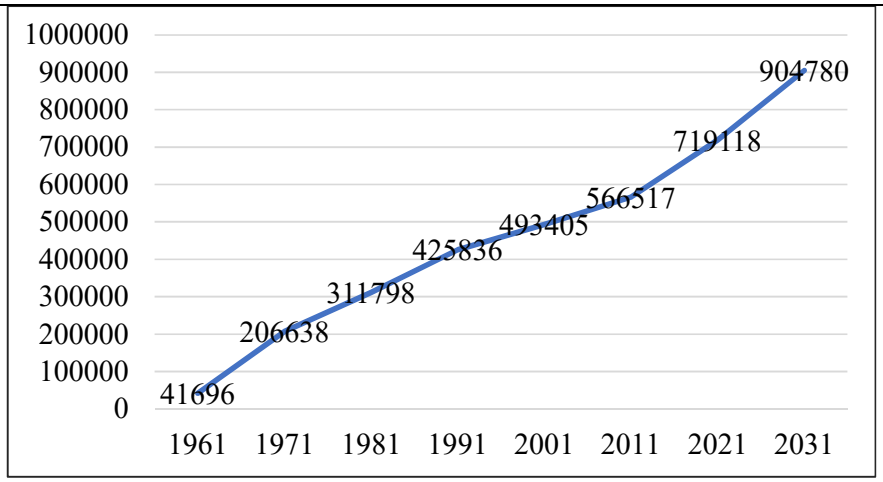


Figure 2.2: Population growth projection of Durgapur
Source: Census of India 1961, 1971, 1981, 1991, 2001 and 2011, Population projection

Furthermore, demographic features including literacy rate, sex ratio, and number of households have been examined along with survey data relating to age-sex structure, level of education, etc., providing insight into the socio-economic characteristics of the population.

To figure out the population for 2021 and 2031, population projection through Arithmetic projection, geometric projection and linear projection is taken and their value is averaged. (Table 2.1).

Table 2.1: Population projection for 2021 and 2031 in Durgapur

	Existing data						Projected year	
Year	1961	1971	1981	1991	2001	2011	2021	2031
Arithmetic projection	41696	206638	311798	425836	493405	566517	671481	776445
Geometric projection	41696	206638	311798	425836	493405	566517	818216	1181743
Linear projection	41696	206638	311798	425836	493405	566517	667657	756150
Summation							**2157355**	**2714339**
Average							**719118**	**904780**

Source: Census of India 1961-2011,
https://oldsite.pup.ac.in/e-content/science/stat/MScStatistics5.pdf,
https://www.measureevaluation.org/resources/training/online-courses-and-resources/non-certificate-courses-and-mini-tutorials/population-analysis-for-planners/lesson-6.html

Table 2.2: Literacy, sex ratio, and no of households in Durgapur

Year	Population density (Pop/ sq km)	Literacy (%)	Sex ratio	Number of households
1961	271	64.03	338	10401
1971	1342	56.77	764	48680
1981	2025	66.76	822	69584
1991	2765	70.07	825	93966
2001	3204	74.01	871	109925
2011	3679	80.01	926	163916
Source: Census of India 1991, 2001 and 2011; Tah, 2016				

Demographical values suggests that in Durgapur, literacy rate, number of households and sex ratio increased and performing better (Table 2.2, Figure 2.3, Figure 2.4 and Figure 2.5). It is found that literacy rate of Durgapur have increased significantly from 60% in 1961 to 81% in 2011 (Table 2.2).

The 'City centre' area of Durgapur acts as the Central Business District (CBD) of the city (Asansol Durgapur Development Authority (ADDA), 2023). It is observed that the number of privately owned households have significantly increased in this portion (Figure 2.5). The City Centre area initially did not had company quarters, and many areas were vacant. Hence, a majority of housings and apartments appeared in City Centre. Ambuja Housing is one of such planned development. Benachity is another area that does not fall under SAIL administration, making it a more attractive

option for housing. It is also an aged old market area in this region, which have served even before the establishment of the steel industry. This phenomenon is evident through the rising population density observed in these regions (Figure 2.3).

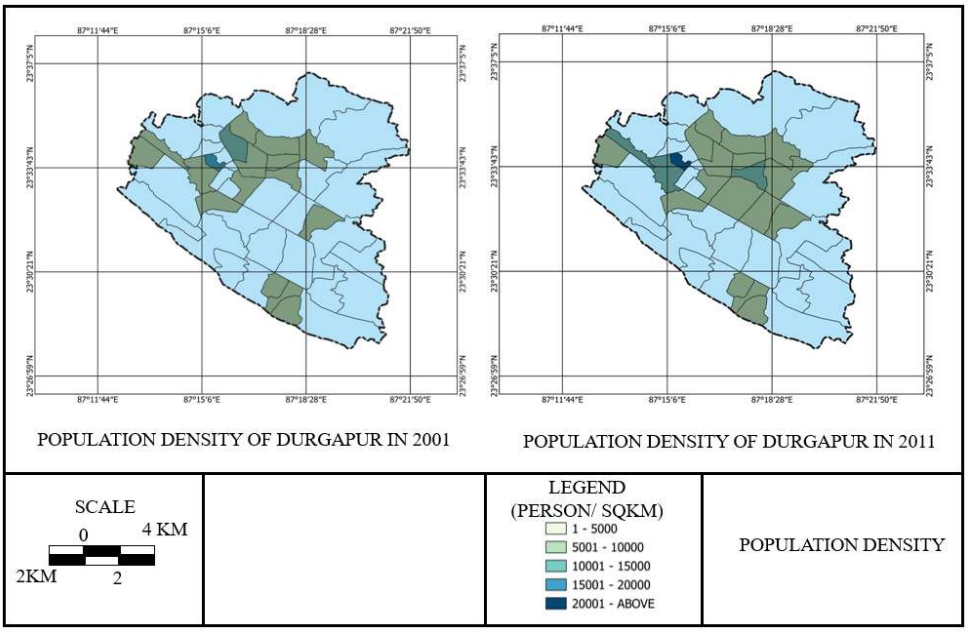


Figure 2.3: Ward wise comparison of population density in Durgapur between 2001 and 2011
Source: Census of India 2001 and 2011

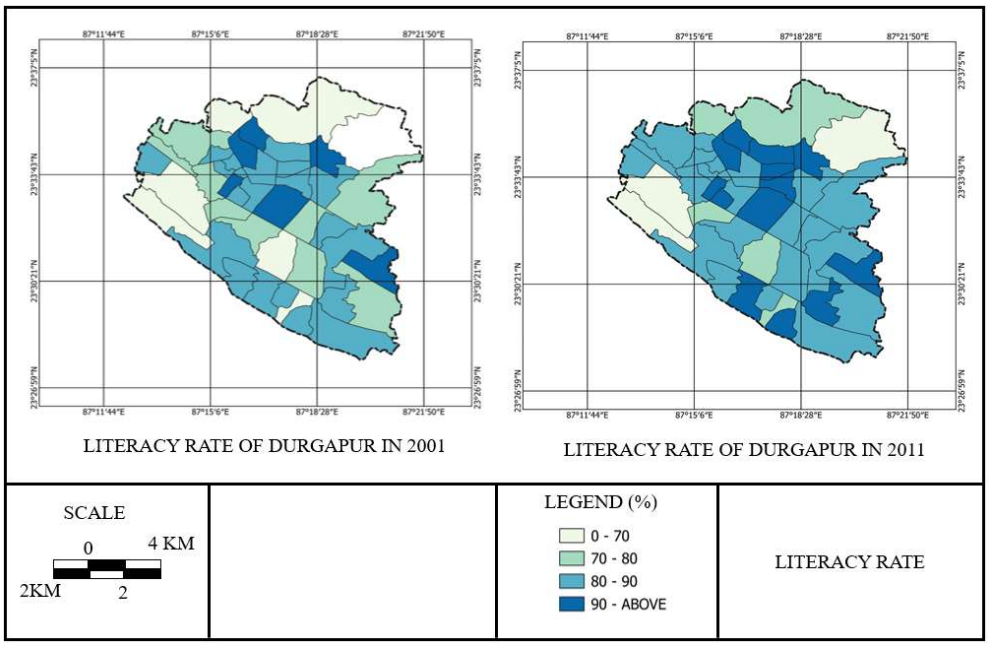


Figure 2.4: Ward wise comparison of the literacy rate of Durgapur between 2001 and 2011
Source: Census of India 2001 and 2011

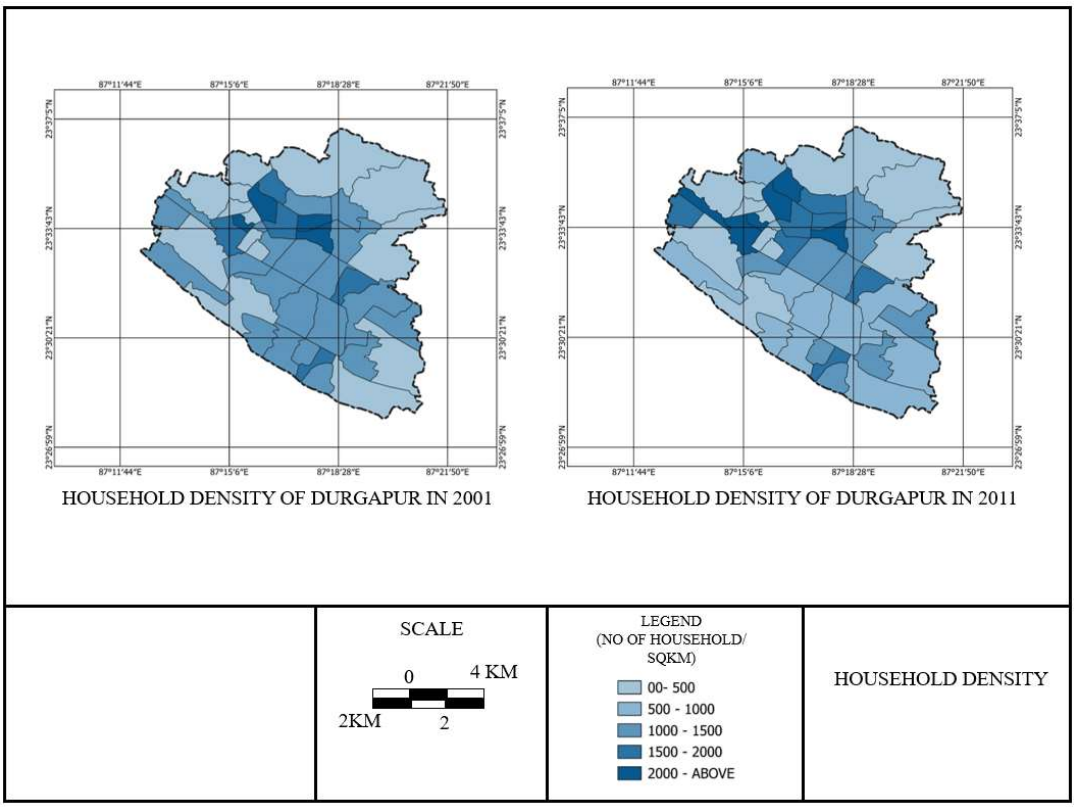


Figure 2.5: Ward wise comparison of the household density of Durgapur between 2001 and 2011
Source: Census of India 2001 and 2011

2.5 Land Use

LUDCP of Durgapur (Asansol and Durgapur Development Authority, 2010; Ghosh, 2012) informed that during the inception period, in 1951, Durgapur was part of the Jungle Mahal, an extended forest area (Figure 2.6). The map in Figure 2.6 is shown within the boundary of DMC for clearer understanding. There was no such clear map with demarcation during that time. So, primary survey has been a major instrument in determining the land use of Durgapur in 1960.

After the foundation of the Durgapur Steel Plant (DSP) in 1955, Durgapur was categorized as a notified area in 1964 (Figure 2.7). Alam (Alam, 2004) informed that Durgapur Area Notified Authority started its operation on 1st Oct 1962, with 40 mouzas (Figure 2.8). This is the time when the boundary of Durgapur was finalised. Later it was further divided into 43 wards. Here below is the evolution of land use in Durgapur from 1960. During the creation of land use maps, QGIS 3.30.2 and ArcGIS 10.8 (Student version) have been used.

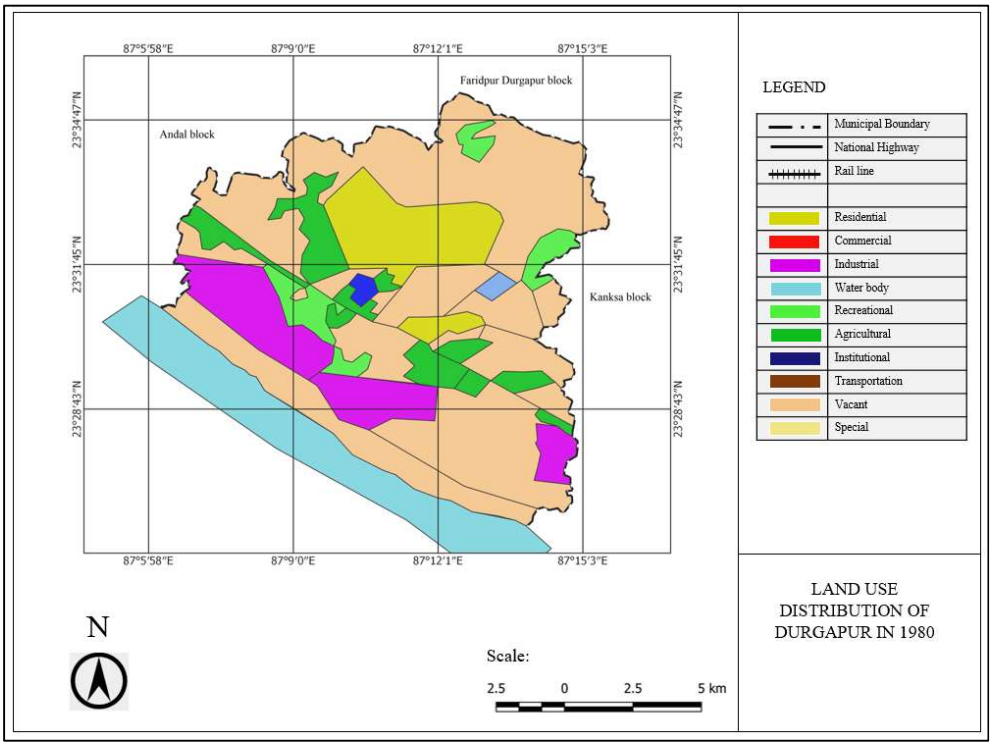


Figure 2.6: Land use of Durgapur, 1980

Source: Biswas, 2008; Survey; Unpublished draft DMC report

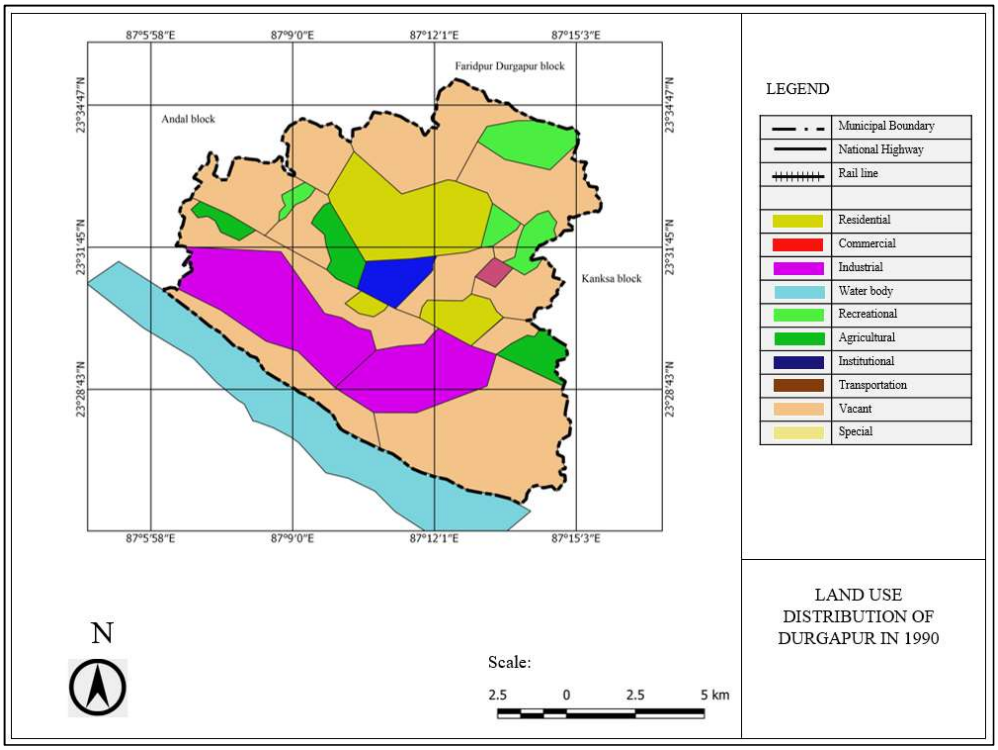


Figure 2.7: Land use map of Durgapur, 1990

Source: Biswas, 2008; Survey; Unpublished draft DMC report

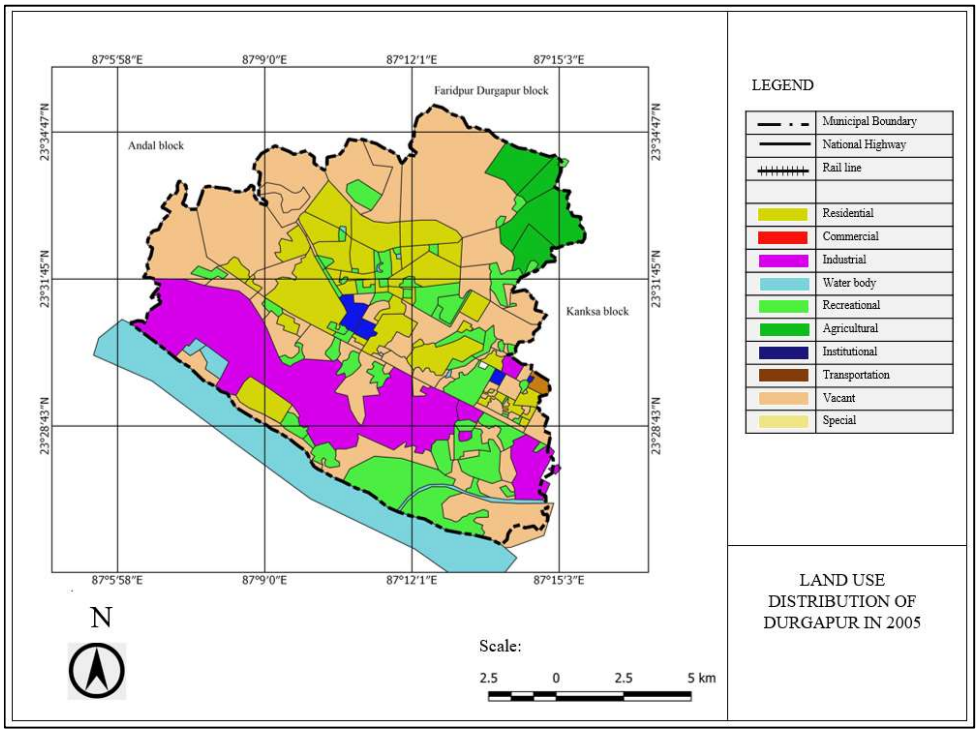


Figure 2.8: Land use map of Durgapur, 2005
Source: Biswas, 2008; Survey; Unpublished draft DMC report

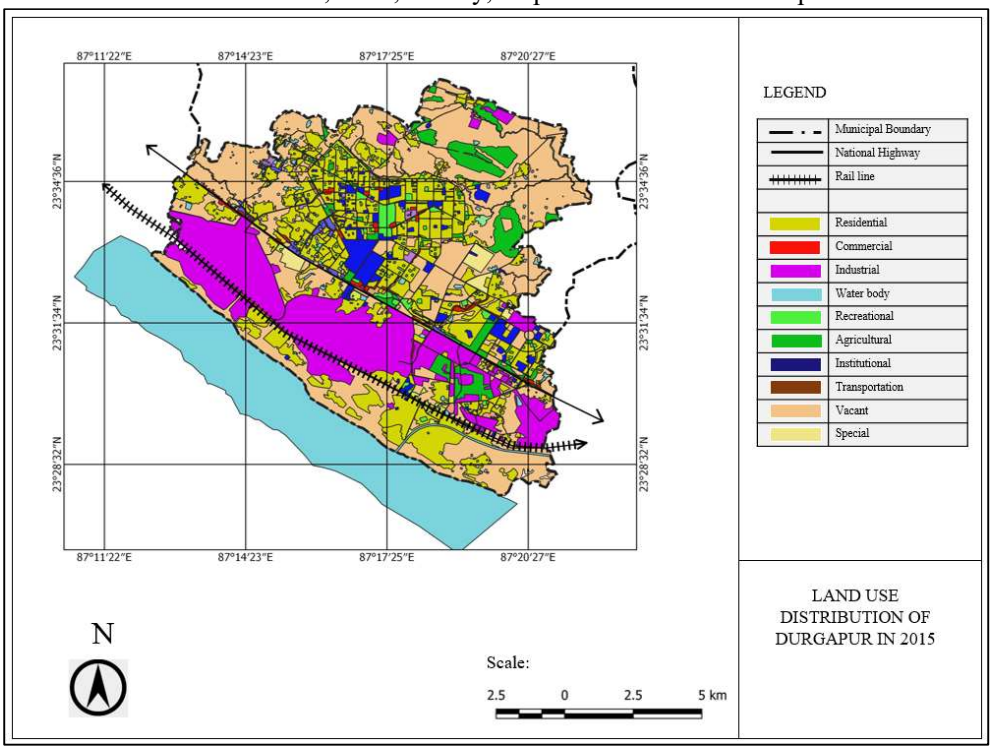


Figure 2.9: Land use map of Durgapur, 2015
Source: Biswas, 2008; Survey; Unpublished draft DMC report

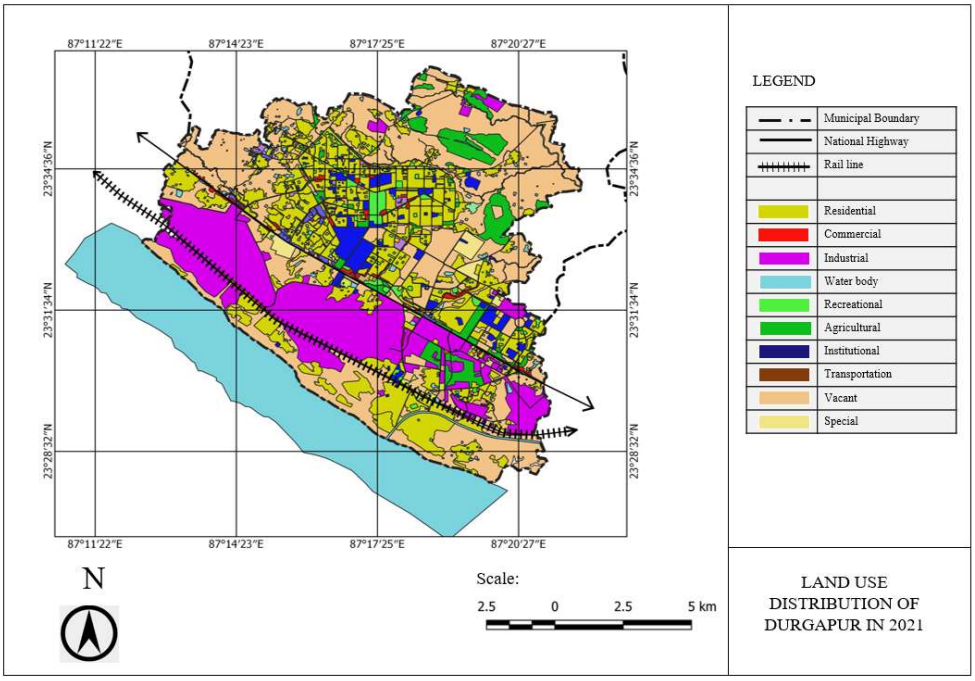


Figure 2.10: Land use map of Durgapur, 2021
Source: Survey; Unpublished draft DMC report

Table 2.3: Change of land use in Durgapur (in %)

	Year				
Land use class	**1980**	**1990**	**2005**	**2015**	**2021**
Residential	9.0	10.2	13.0	16.0	19.0
Commercial	0.2	0.5	0.5	4.0	3.0
Industrial	11.0	19.0	17.9	17.0	16.0
Institutional	0.6	1.5	1.5	1.5	3.0
Transportation	7.0	7.0	9.0	10.0	12.0
Recreational	3.0	2.0	3.0	5.0	6.0
Greeneries	18.0	17.0	16.0	14.0	16.0
Agriculture	13.0	9.0	5.5	5.0	4.0
Water body	9.0	8.0	6.0	4.0	4.0
Special[13]	0.6	0.5	0.5	1.5	2.0
Vacant	29.0	26.0	28.0	25.0	25.0
Total	100	100	100	100	100

In this study the area under Durgapur Municipal Corporation (DMC) have been referred as Durgapur. The boundary of Durgapur, under Durgapur Municipal Corporation (DMC) is shown in Figure 2.1. The identification of land use percentage for each year have been conducted within only

[13] It is the land primarily being used by Armed forces and Ministry of Defense

municipality boundary. The evolution of land use in Durgapur since 1980 to 2021 has been shown in Figs. 2.7-2.10.

During the inception, Durgapur was primarily consisting of Steel Township and some villages in surrounding. With the steel plant, various other ancillary industries appeared in this region. Unstructured settlements appeared in this region, outside of the steel township area. This phenomenon is observed by increasing residential land use. Residential land use increased to 19% in 2021 from 9% in 1980 (Figs. 2.7-2.9 and Table 2.3).

With the increasing population pressure, the commercial and transportation land use also increased to 3% and 12% in 2021 from 0.2% and 7% in 1980. Most of these land use has been converted from agriculture and vacant land. Agricultural land use decreased to 4% in 2021 from 13% in 1980. Greeneries also decreased within this period, but at a slower rate. Greeneries reduced to only 16% in 2021 from 18% in 1980. As per URDPFI 2015, Durgapur falls under the category of 'Large City'.

Table 2.4: Comparison of land use of Durgapur with URDPFI 2015

Land use	URDPFI Recommendation for Large city	Land use division in Durgapur-2021
Residential	**35-40**	**19**
Commercial	4-5	3
Industrial	10-12	16
Public and semi public	12-14	3
Recreational	18-20	6
Transportation	12-14	12
Agriculture	Balance	

URDPFI does not have a detailed land use division for institutional, water body, vacant and greeneries. Here, institutional building has been considered as public and semi-public space because of their nature of use. Table 2.4 shows that residential, recreational, and institutional facility in Durgapur is lagging far behind the prescribed land use division in URDPFI. It shows that mentioned facility might be increased over time to support the development scheme.

Industrial land in Durgapur have its own layout based on the requirement of industry itself. Apart from that, the two broad categories are civic area under SAIL and area under DMC. The area under DMC is directed by LUDCP, CDP, and building bye-laws (Asansol and Durgapur Development Authority, 2010). LUDCP and CDP designate land use for particular purposes with the provisional division of plots, whereas building by-laws regulates the amount of built up space in a region.

In the DMC-regulated area, the layout is decided by individual plot holders on a mutual decision like any other city in India. On the other hand, the Steel Township has a planned layout where the

whole city layout along with facilities has been decided during its planning and foundation stage which is mainly following the grid-iron pattern with formation of sector and related neighbourhood. Mazereeuw (Mazereeuw, Ojha, & Barve, 2017) told that Steel Township was formed in line with the concept of a factory town.

2.6 Industrial Township

The metal industry of Durgapur is primarily categorized as Steel and Ancillary to Steel Industry (ASI) sectors. SAIL and Mining and Allied Machinery Corporation (MAMC) are the two major names, which have remarkable provisions of residential facility (Figure 2.11) for their employees in Durgapur. The steel township of Durgapur, which is controlled by SAIL, is still active in terms of operation, while the MAMC Township is currently inactive, as the industry has been shut down in 2002.

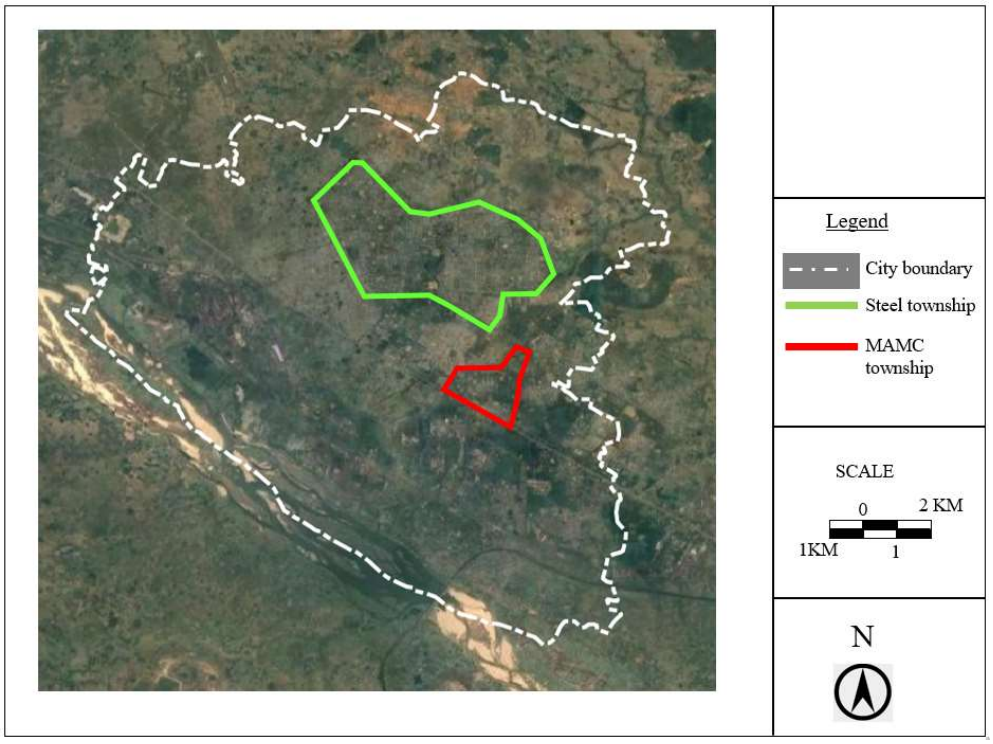


Figure 2.11: Location of industrial civic facility in Durgapur

Steel Township is divided into three major zones, namely A-Zone, B-Zone, and C-Zone. These zones are further divided into some clusters of staff quarters. Presently some of these quarters are being used, while some quarters are not being used or maintained, which led to their dilapidation. Figure 2.12 and Figure 2.13 shows the condition of a cluster in terms of their working condition.

The MAMC Township, being a much smaller civic facility compared to Steel Township, does not have any zone-wise division. A set of residential quarters along with some basic civic facilities are clubbed and positioned in an area of approximately 4.2 sq. km.

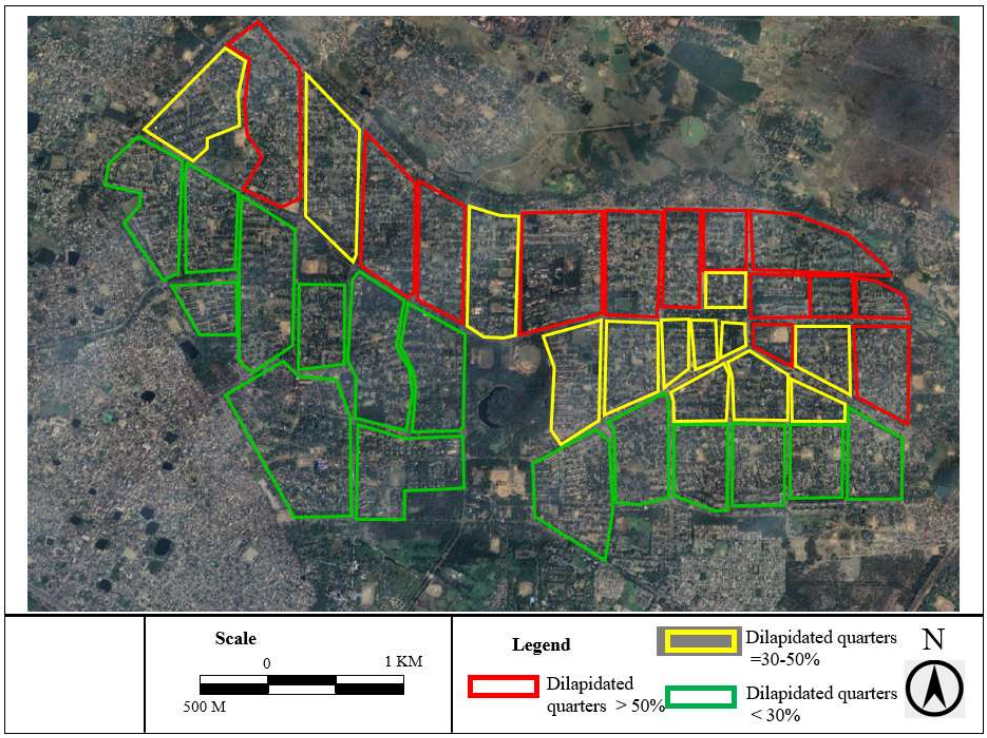


Figure 2.12: Health condition of residential facility in the Steel Township of Durgapur

Figure 2.13: Health condition of residential facility at MAMC Township in Durgapur

It is observed that the steel township consists of a range of quarters, where some clusters have more than 50% dilapidated quarters and some have less than 30% (Figure 2.12).

Table 2.5: Land use division of industrial civic facility (Steel Township and MAMC) in Durgapur

Land use class	The steel township	The MAMC township
Residential	27	42
Commercial	6	2
Recreational	4	6
Institutional	3	5
Transportation	11	7
Water body	4	4
Vacant	31	22
Greeneries	14	12
Total	**100**	**100**

Whereas, MAMC township is in abandoned condition primarily. Still, some residents are using the company quarter in MAMC. However, most of the quarters are in dilapidated condition. In the steel township, it is observed that most of the dilapidated structures are present in the periphery. The clusters near the CBD is in less vacant and dilapidated state.

The SAIL steel township have a residential facility of 27% whereas MAMC township have this facility of 42%. Whereas steel township have allotted more facility for commercial, transportation than MAMC township (Table 2.5). It suggests that steel township is more dedicated towards facilitating civic amenities towards its workers.

2.7 Evolution of Employment Pattern

Initially a forest and agricultural land, Durgapur has witnessed a rapid economic shift from secondary to tertiary over the last three decades (1990-2020). Due to the lack of documented data on the segregation of economic activity and their change over time, it becomes a little confusing about the exact figures. Initially the percentage of workers is summarised within the tenure of 1961-2011 from census. The number of the main worker and marginal worker along with agricultural and household industry workers are summarised (Table 2.7), which also provides information on tertiary workers.

The workforce participation ratio in 1961 was recorded at 62.48% and experienced a significant decline to approximately 30% by 2011. This is attributed to the shift of workers from the primary sector to the secondary and tertiary sectors. During 1960-70, the Durgapur Notified Area Authority mainly comprised urban occupations, particularly in the Steel Plant Township and Coke Oven Township, which accounted for about 98% of the total main workforce (Ghosh, 2012).

Table 2.6: Evolution of main workers in Durgapur

	1961	**1971**	**1981**	**1991**	**2001**	**2011**	**2021**
Total Population	41696	206638	311798	425836	493405	566517	719118
% of employment with a total population	62.48	30.91	26.96	27.53	31.11	35.12	40
Total main workers	26052	63871	84061	117232	153498	198961	287647
Other workers (Excluding cultivator and agricultural)		58582	79497	107173	147266	188833	273365

Source: Census of India 1961-2011 and primary survey

Table 2.7: Division of main workers in Durgapur

Category	Total main workers (%)-1971	Total main workers (%)-1991	Total main workers (%)-2001	Total main workers(%)-2011
Cultivators	2.38	2.62	1.03	1.13
Agricultural labourers	4.78	5.02	1.5	1.7
Household industry workers	1.12	0.94	1.53	2.27
Others	91.72	91.42	95.94	94.91

Source: Ghosh, 2012

The change in economic dependence towards the tertiary sector between 1971 and 2011 reflects a transition in the city's economy.

LUDCP 2010 report on Asansol Durgapur Planning Area (ADPA) revealed an economic concentration towards education, medical services, and hospitality sector (Asansol and Durgapur Development Authority, 2010). Despite its industrial background, ADPA also retains agricultural land and forests to meet both local demands and export.

To identify the number of employment in 2020, various government officials from different industrial sectors, trade union reports Municipal Corporation, and development authority have been interviewed, which provides an insight into the growth of employment in each industry. The evolution of main worker have been computed in Table 2.6. The data for 2021 have been extrapolated with the assistance of Government officials.

Information on employment in the steel industry is obtained from the report of Ministry of Steel and labour union feedback. The remaining data on employment is obtained from municipal records and primary surveys. Changes in patterns of employment are reflected through an analysis that reflects Durgapur's workforce categorisation associated with different industries.

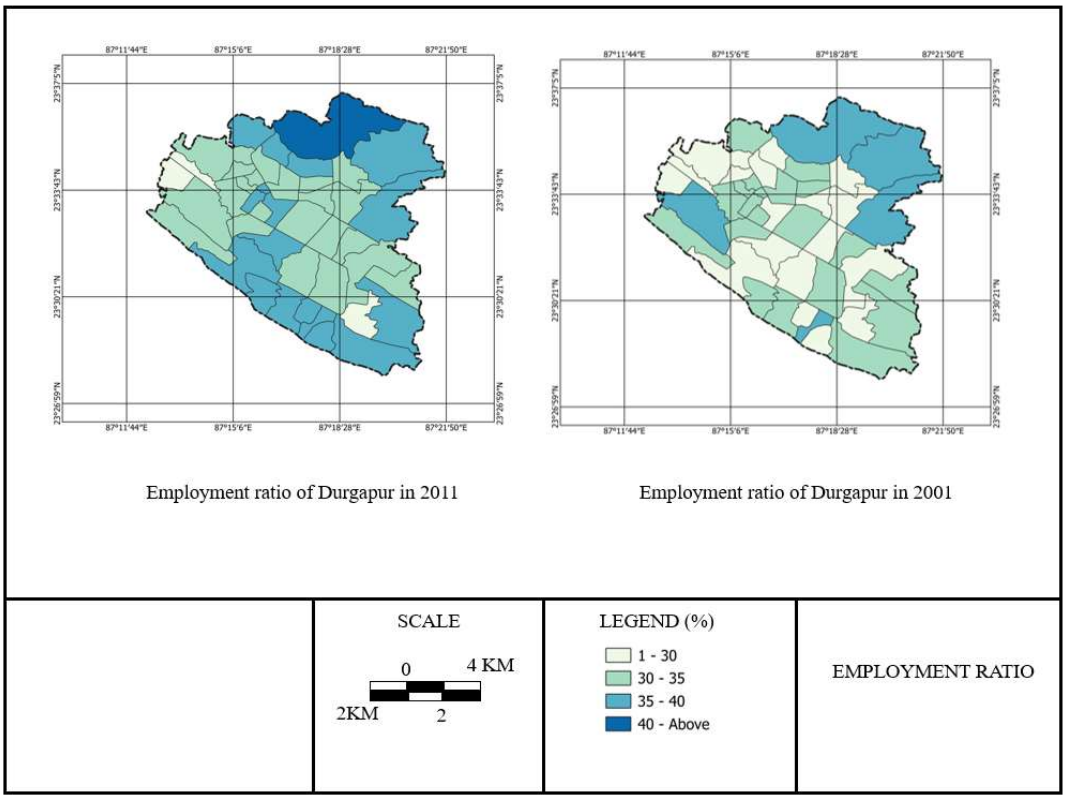


Figure 2.14: Ward wise comparison of employment in Durgapur during 2001-2011
Source: Census, 2011 and 2021

The industries have been initially clustered into nine groups as shown in Table 2.7. It may be noted that the word 'industry' has rather loosely being used here to indicate all enterprises that are capable of generating employment and earn revenue. Thus, the enterprises like manufacturing industries, service industries, schools, offices, colleges, and coaching centres, etc., are all included within the premises of the term 'industry' unless specified otherwise.

The information on profit and loss for each such category have been acquired by interviewing an expert representing an industry (Table 2.9).

Tables 2.8 and 2.9 show nine categories of industries, which is later reduced to eight, since the experts suggested that the shopping malls and the Medium Sized Enterprise (MSE) are operating on almost the same principles and their profit range are almost similar. So, in remaining chapters shopping mall and MSE are represented as MSE only. These categories of industries have been used as identifier in forthcoming chapters.

Table 2.8: Categorisation of industry in Durgapur

Industry	Initial clusters	Profit/ Loss (2019)	Represented by	Average Number of employees	Average area of land cover	Representative companies
Large scale industry	1. Steel	147+13= 160 crore	DSP, ASP	9487	20 sqkm	DSP, ASP
	2. Allied to Steel industry (ASI)	15 crores	1. Automobile 2. Cement 3. Carbon black	500	20000 sqm (square meter)	Shyam Steel Industries Ltd., KIC Metalics Ltd., Haldia Steel Pvt. Ltd.
Medium scale industry	3. Non-metal industry	30 Lakhs	1. Milk and dairy product 2. Paper and print 3. Soft drink 4. Poultry	300	2500 sqm	Wood, Furniture, Chemical factory, Jwellery, Packaging, Ceramics, Water and beverage, Tube, Polymers, Brickfield, Warehouse, Diary
Small scale industry	4. Small Sized Enterprise (SSE)	15 lakhs	Car showroom, Book shop, Hotel, Grocery shop, Consultancy office, Nursery	5	12 sqm	Local shop- Unorganised sector
Organisation	5. Institution-Healthcare	25 crores (Average of Mission and Gouri devi hospital)	Hospital	500, 80	15000 sqm	Mission Hospital, Sanaka Hospital, Healthworld, IQ City, The Nation Hospital, Vivekananda Hospital
	6. Institution-Educational	6 crores (Average of BC Roy college and SETGOI)	College, coaching centre	300	90000 sqm	BC ROY Engineering College, BECT, Sanaka, DSMS, NSHM, DAV model school, FIITJEE, PATHFINDER, Triumphant Institute of Management Education, Akash Institute, Career Launcher
	7. Information Technology	2 Crore (Average of Iglobal Impact and Go IGI, Webmedia)	IT office	100	1500 sqm	Iglobal Impact Ites, Go IGI, Ganesha Intelliware LLP, Webmedia, Digiholic Infotech Pvt. Ltd. Relyon Softech Ltd.
	8. Shopping Mall	5-20 Crores (Junction Mall)	Shopping mall	1500	1856 sqm	Dreamplex, Junction mall, Fortune plaza
	9. Medium Sized Enterprise (MSE)	1 -15 Crore (PC Chandra jewellers,)	Jewellery shop, Restaurant, Electronic	20	30 sqm	PC Chandra jewellers, Senco gold, Car shop, Grocery departmental store, Electronics, restaurants, Food stall

Source: Primary survey, 2025

Table 2.9: Evolution of various employment sectors in Durgapur

Industry type	**Sample**	**1971**	**1981**	**1991**	**2001**	**2011**	**2020**
Total worker (Secondary and tertiary sector)		58582	79497	107173	147266	188833	273365
		Presented in % of Total worker					
Large scale industry (A)	1. Steel	70.42	49.03	29.97	19.84	8.21	4.73
	2. Allied to Steel Industry	13.41	8.47	8.06	7.98	6.54	9.10
Medium scale industry (B)	3. Non-metal industry	4.64	12.26	4.70	3.99	4.26	2.37
Small scale industry (C)	4. SSE	1.48	13.63	35.0	37.19	40.97	33.42
Organisation (D)	5. Institution-Healthcare	2.64	3.24	3.82	4.58	4.62	4.57
	6. Institution-educational	3.05	2.94	2.96	3.61	3.39	4.83
	7. IT	0.00	0.00	0.00	0.24	2.14	1.96
	8. Shopping mall	0.00	0.00	0.00	0.00	0.98	1.52
	9. MSE	0.65	2.59	8.86	13.28	24.63	26.07
Balance (E)		3.70	7.83	6.62	9.29	4.26	11.44
Total (A+B+C+D+E)		100	100	100	100	100	100

Source: Census of India 1971, 1981, 1991, 2001, 2011; Trade union report; Unpublished Municipality report

During the establishment of Durgapur in 1961, there was a strong presence of steel and ASI industries as well as agriculture. As the city, evolved, additional sectors such as non-metal industries and multiple small-scale industries grew. The growth of the economy and increased demand in the service sector led to a rise in employment opportunities in 1971, with 2720 jobs being created in the non-metal sector. This expansion also had an impact on educational institutions and hospitals, as they experienced an increase in employment too.

From 1981 onwards, there was significant growth in the metal sector, which tapered off after 1991. Throughout this period from 1961 to 1991, the steel industry served as the main economic pillar of the city, after which tertiary sector in the city grew rapidly.

The shift of employment dependency (Table 2.9) from the steel industry to sectors like institutional, medical, and information technology along with increase in total employment indicates an increase in skilled human capital.

A significant number of private schools, colleges, hospitals, and small offices have emerged in various locations across Durgapur. Notable institutions such as Sanaka College and Hospital, IQ City Hospital and Medical College, Dr. B.C. Roy Engineering College, and DPS School have established their presence in the city. Their establishment has attracted residents to these areas, leading to increased employment opportunities and a rise in population density in Bidhhannagar, Fuljhore, Malandighi and some other locations. This, in turn, has contributed to urban growth, which has facilitated the expansion of infrastructure, including road networks, water supply, drainage systems, sanitation, sewerage networks, electrification, market, bank etc. The city's evolving economic profile is reflected in the increasing number of office and business registrations, alongside the expansion of residential and commercial land use (Table 2.3).

2.8 Infrastructure

Physical infrastructure directly establishes a visible foundation for development and social infrastructure that supports societal progress (MUD, 2015). This study analysed GIS maps, data from Durgapur Municipal Corporation, and township maintenance data from SAIL to determine the amount of infrastructure in the city.

Table 2.10: Percentage of road in Durgapur

	1971	**1981**	**1991**	**2001**	**2011**	**2020**
Road (Percentage of land)	4	5	8	9	11	12
Electricity (Percentage of households covered)	38	44	52	69	76	88
Water connection (Percentage of household covered)	40	46	54	68	74	83

Source: Unpublished draft DMC report

2.9 Social infrastructure

Due to job curtailment in SAIL following technological advancement and reduced profitability following the WTO agreement of 1995, a number of industry-sponsored schools have been closed down in the city in last ten years. However, a number of private schools have also emerged in the city that have catered the increasing demand simultaneously. Considering the housing sector, Census of 2011 reported 130944 households in Durgapur. As per the Town Administration Department of SAIL at Durgapur, the Steel Township, with 34877 quarters in its stock, is administered and maintained by SAIL. Among these approximately 57% is being used officially.

The primary survey indicates that there are some quarters that are illegally being occupied (10%). It is estimated that approximately 33% of the quarters remain vacant. Since these quarters have remained vacant for quite a long time and there has been no maintenance, the vacant quarters are degrading fast. Steel Township in Durgapur was built to provide housing facilities to its employees.

Individual employees have been allotted a single quarter for their families. Based on their designation, the area and type of the quarters used to vary as, Officers Bungalow (1200 Sq. ft.), Category-1 (800 Sq. ft.), Category-II (650 Sq. ft.), and Category-III (450 Sq. ft.) type quarters. Since the number of quarters have been surplus presently, SAIL have sold some of the quarters to their superannuated employees at a discounted price, which has a symbiotic effect.

Chapter 3: Methodology to Identify Appropriate Supplementary Industries for Durgapur

3.1 Introduction

In order to meet the first objective of this research, useful supplementary industries must be identified under the existing market condition in the study area. The methodology adopted to this end is achieved by coupling Porter's (1979) Five Forces Framework, an analytical tool, with Analytical Hierarchical Process, AHP (Saaty, 1987), both being introduced in Chapter 1, to form a more practical numerical tool for a powerful quantitative analysis. This chapter focuses on determining the weights assigned to the sub-criteria of the five forces proposed by Porter- threat to new entrant, bargaining power of buyers and sellers, threats by substitute products/ services, and that by existing competitors, to quantify the intensity of their influences through AHP. Ultimately, the competitive position of various contending industries will be figured out.

The job have been conducted in three steps. During the analysis, two different set of experts will be selected to eliminate chances of bias. The sample size for expert's opinion survey have been guided by similar researches (Bruce, Langley, & Tjale, 2008; Mohammadrezaei, Nayebzadeh, and Roknabadi, 2016; Sadeghpour, Far, Khah , & Amiri, 2017). In the first step, three experts from the field of commerce and management has been chosen, who are assigned to decide the value of each sub-forces and rate them (Table 3.1, Table 3.2 and Table 3.3). In the second step, thirty-two experts have been interviewed from the aforementioned eight category of industries (Table 2.8). These experts specify a numerical weight for each sub forces specific to the class of industry they represent, which is then averaged (Table 3.4 and Table 3.5). In the third step, the picked up value of rating is multiplied with each sub forces, and aggregated (Table 3.4, Table 3.5 and Table 3.6). The aggregated value is the competitive position of that respective industry.

3.2 Step-1: Defining the Rating and Values of Sub-Criteria

The list of sub-criteria under Porter's five forces framework has been listed in Chapter-1 (Table 1.3). The values for the sub-criteria have been suggested by expert on a scale of 0-5 (Table 3.1) following the unipolar Likert scale, where '0' has been added to denote 'absolute absence of any relationship'.

To assign the value of intensity (high/low) while providing the ratings, experts in set 1 are instructed to use their logic of competition that an industry will face during its establishment and operation in context of the prevailing market conditions, trying to judge the situation from a neutral standpoint, leaving back her/his emotions/affiliation. For the same situation, there may be a juxtaposed assessment if an assessor thinks from the viewpoint of an existing business unit or a unit to be established, i.e., for 'Economies of scale (A1)', it determines the amount of investment to enter the industry, capital, manpower, strategic planning, efforts, all as a whole. Now if the amount is high for a business establishment, then for an existing business unit the condition will be less competitive as any new business unit will be discouraged. However, for a unit that is willing to establish its branch in the region, it will be a competitive environment. Thus, experts are persuaded to focus on the level of competition a new business setup is likely to encounter. So, in Table 3.1 expert provides competition to be 'High' or 'Low' based on the amount of that particular Sub-criteria. Here 'High' or 'Low' refers to the magnitude of the sub-criteria, whereas the scale '0-5' refers to the level of competition.

Referring to sub-criteria A1, if a particular industry requires a huge support during its establishment, there will be less competitive for that industry, as many of the new entrants cannot afford it. In addition, if it does not requires any major support (manpower, land etc.), it will be easier for new competitor to enter the market. Therefore, for A1, High support is aligned with less competition (Value 0), and Low support is aligned with more competition (value 5).

Similarly, regarding A6, if there is limited government regulation, it becomes easier for business set up, and hence low competition (Value 0). On the other hand, if there is restricted government regulation, it becomes tough for new entrants to set up business, and thus high competition (value 5).

For sub-criteria B2 (Uniqueness) (Table 1.3 and Table 3.1) if supplier produces more types of items (High), the entrant cannot bargain or negotiate much, and thus more competitive environment (Value 5).

For cub-criteria C6 (Threat of backward integration), if the buyer in that industry have chance to go backward in production chain (High), it can produce its required raw materials on its own, and thus more competitive environment (value 5).

For sub-criteria E5 (Diversity among rivals**)**, if there is more diversity among rivals (High), it will be easier of an entrant to enter the market, and hence low competition (value 0). Table 3.1 provides the guidelines for the experts in step-2.

Table 3.1: Value for each sub-criterion and rationale for determining the scale

Forces (criteria)	Sub-Criteria	Experts estimate	Logic framed according to expert's opinion
Threat of entry (A)	A1	High- 0 1 2 3 4 5 - Low	If an industry requires huge amount support (land area, manpower, distribution channel etc.), it become tough for an ordinary newcomer. Thus, there will be less competition. Therefore, more value in these sub-criteria denotes low competition.
	A2	Low- 0 1 2 3 4 5 - High	If there are more differentiated products for a particular industry, it will be tougher to compete that company, as it has already been penetrated in more market segments. More no of brand item signifies more value, thus more competition
	A3	High- 0 1 2 3 4 5 - Low	More capital requirement signifies more value, thus low competition
	A4	High- 0 1 2 3 4 5 - Low	More advantage in the location shows more value and so low competition
	A5	High- 0 1 2 3 4 5 - Low	More cost to access distribution channel directs to more value and thus low competition
	A6	Limited- 0 1 2 3 4 5 - Restricted	More restricted government law to oblige directs to more competition
Power of supplier (B)	B1	High- 0 1 2 3 4 5 - Low	Fewer suppliers signify more value and thus more competition
	B2	Low- 0 1 2 3 4 5 - High	If the supplier produces more items, then the supplier will have the upper hand so more value and more competition
	B3	Low- 0 1 2 3 4 5 - High	More shifting cost results in more reluctant to change and so more value and more competition
	B4	Low- 0 1 2 3 4 5 - High	More chance of forward integration results in more value and so more competition
Power of buyer (C)	C1	High- 0 1 2 3 4 5 - Low	Less buyer suggests more value and more competition
	C2	High- 0 1 2 3 4 5 - Low	More buyer often changes its choice directs less value and less competition
	C3	Low- 0 1 2 3 4 5 - High	If the product is not very important for the buyers' side, so more change and thus more value and more competition
	C4	High- 0 1 2 3 4 5 - Low	If buyers switching costs is low then there will be more competition
	C5	Low- 0 1 2 3 4 5 - High	If the buyer can bargain better, then there will be more competition
	C6	Low- 0 1 2 3 4 5 - High	The more the chance of backward integration, the more will be the competition
	C7	Low- 0 1 2 3 4 5 - High	The more important product will have more competition

Table 3.1 (Continued): Value for each sub-criterion and rationale for determining the scale

Forces (criteria)	Sub-Criteria	Experts estimate	Logic framed according to expert's opinion
Threat of substitute (D)	D1	Low- 0 1 2 3 4 5 - High	A greater number of substitute products leads to a more competitive condition
	D2	Low- 0 1 2 3 4 5 - High	If the substitute product is more profitable then there will be more competition.
	D3	Low- 0 1 2 3 4 5 - High	If the buyer needs to pay more to switch then there will be more competition.
	D4	Low- 0 1 2 3 4 5 - High	If there is more profit for the substitute product then there will be more competition
Intensity of rivalry (E)	E1	Low- 0 1 2 3 4 5 - High	Greater number of rivals leads to more competition
	E2	Low- 0 1 2 3 4 5 - High	If the exit cost is high then there will be more competition
	E3	Low- 0 1 2 3 4 5 - High	If the industry growth is high then more competition
	E4	High- 0 1 2 3 4 5 - Low	If rivals have less differentiated products, then there will be more competition
	E5	High- 0 1 2 3 4 5 - Low	If the rival is less diverse in different industries, then there will be more competition
	E6	High- 0 1 2 3 4 5 - Low	The less chance of horizontal integration of two companies or merging, there will be more competition.

The weightage of each sub-criteria is determined through AHP by two experts. This has been done in two levels through pairwise comparison (Appendix-3.A). In the first step, the weightage of each force is determined one expert (Table 3.2). In the second step, the weightage of each sub-criteria/sub-force is determined by another expert (Table 3.3). Details of the procedure of AHP have been shown in Appendix-3 at the end of this chapter. Finally, the weight of sub-criteria was aligned as per the weightage of forces. The whole process is done through group consultation with two experts to avoid individual biases.

Table 3.2: Forces of the business competence and their weightage as opined by expert

Serial No	Forces (criteria)	Weightage of each force (Appendix-3.A)
A	Threat of entry	0.061
B	Power of supplier	0.095
C	Power of buyer	0.460
D	Threat of substitute	0.167
E	Intensity of rivalry	0.216
Total		1

The sub-forces are re-weighted as per the weightage of each force. The final weightage of each sub-criteria (Table 3.3) is listed below.

Table 3.3: Weightages of sub-criteria along with final weightage

Force No	Forces (W_a) (ref. Appendix-3.A)	Sub criteria	Weightage (W_b) (ref. Appendix-3.B)	Final weightage ($W_c = W_a \times W_b$)
A	Threat of entry (Weightage-0.061)	Economies of scale (A1)	0.05	0.003
		Product differentiation(A2)	0.07	0.004
		Capital requirement (A3)	0.38	0.023
		Shifting cost (A4)	0.12	0.007
		Access to distribution channel (A5)	0.16	0.009
		Government's policy (A6)	0.23	0.014
		Subtotal		**0.061**
B	Power of supplier (Weightage-0.095)	Number of supplier (B1)	0.07	0.007
		Supplier's concentration (B2)	0.45	0.043
		Shifting cost to change a supplier (B3)	0.20	0.019
		Threat of forward integration (B4)	0.28	0.027
		Subtotal		**0.095**
C	Power of buyer (Weightage-0.460)	Number of buyer (C1)	0.09	0.040
		Buyer's concentration (C2)	0.07	0.031
		Buyer's sophistication (C3)	0.05	0.024
		Switching cost (C4)	0.10	0.044
		Price sensitivity (C5)	0.13	0.060
		Threat of backward integration (C6)	0.32	0.148
		Importance of the product to buyer (C7)	0.25	0.115
		Subtotal		**0.460**
D	Threat of substitute (Weightage-0.167)	Number of substitute (D1)	0.07	0.012
		Obvious advantage of substitute (D2)	0.15	0.024
		Buyer's switching cost (D3)	0.52	0.086
		Profitability level of substitute industries (D4)	0.26	0.044
		Subtotal		**0.167**
E	Intensity of rivalry (Weightage-0.216)	Number of rival (E1)	0.06	0.013
		Exit barrier (E2)	0.10	0.021
		Industry growth (E3)	0.30	0.064
		Product differentiation (E4)	0.08	0.017
		Diversity of rival (E5)	0.30	0.065
		Threat of horizontal integration (E6)	0.17	0.037
		Subtotal		**0.216**
		Total (Subtotal of A+B+C+D+E)		**1**

3.3 Step-2: Assigning Rating for each Sub-Criteria against Each Industry

Four experts from eight industry clusters (Table 2.8), total thirty-two experts, have been interviewed to obtain the scale rating as per their stand for those criteria. It is already discussed in chapter-2 that 'Shopping mall' and 'MSE' have considered as 'MSE', making the total industry category as eight. The provided scale is averaged and multiplied by the weightage of that sub-force (Table 3.4 and Table **3.5**). It produces the value as per the weightage of each sub-criteria. Summation of these sub-criteria produces the competitive position of the industry. During the collection of final value,

experts were asked to concentrate on the amount of difficulty a business unit will face during its setup and operation in an industry line.

Table 3.4: Rating of sub-criteria and the final value of business competence against each criterion for Steel, Ancillary to Steel (ASI), Non-metal and Information technology (IT) Sectors in Durgapur

		STEEL		ASI		NON-METAL		IT	
Sub criteria W_c		**Rating R**	**Final value $R \times W_c$**	**Rating R**	**Final value $R \times W_c$**	**Rating R**	**Final value $R \times W_c$**	**Rating R**	**Final value $R \times W_c$**
A1	0.003	2.5	0.009	1.75	0.006	4.25	0.02	4.75	0.017
A2	0.004	4	0.017	4.25	0.018	1.75	0.01	4.25	0.018
A3	0.023	0.5	0.012	4.25	0.101	2	0.05	4.25	0.101
A4	0.007	0.5	0.004	3.25	0.023	2.25	0.02	4	0.028
A5	0.009	1	0.009	3	0.028	2.75	0.03	3.5	0.033
A6	0.014	5	0.069	5	0.069	2	0.03	2.5	0.035
Sub total			**0.12**		**0.245**		**0.139**		**0.232**
B1	0.007	4	0.020	2.75	0.014	1.75	0.01	1.5	0.007
B2	0.043	1.5	0.062	3	0.123	2.75	0.11	0.25	0.010
B3	0.019	5	0.084	4.75	0.080	2	0.03	1.25	0.021
B4	0.027	1.5	0.032	2	0.042	3.75	0.08	3.75	0.080
Sub total			**0.197**		**0.259**		**0.239**		**0.118**
C1	0.040	4.75	0.195	3.25	0.134	1.75	0.07	2	0.082
C2	0.031	4.75	0.158	2.5	0.083	2.25	0.07	4.5	0.150
C3	0.024	1.25	0.025	2	0.040	3	0.06	2.25	0.044
C4	0.044	1.5	0.065	3	0.130	1.75	0.08	4	0.173
C5	0.060	1.25	0.077	1.5	0.093	3.25	0.20	0.5	0.031
C6	0.148	0	0.000	0.5	0.081	2	0.32	4.75	0.768
C7	0.115	4.25	0.488	4	0.459	1.75	0.20	2.75	0.316
Sub total			**1.009**		**1.02**		**1.008**		**1.565**
D1	0.012	0	0.000	0.25	0.003	3.25	0.04	4.25	0.050
D2	0.024	1.25	0.024	2.25	0.043	3	0.06	2.5	0.048
D3	0.086	0	0.000	2	0.181	1.75	0.16	3.25	0.293
D4	0.044	0	0.000	1.75	0.073	3	0.13	1	0.042
Sub total			**0.024**		**0.30**		**0.379**		**0.433**
E1	0.013	0	0.000	3.25	0.037	3.5	0.04	4.75	0.055
E2	0.021	4.75	0.109	4	0.092	3	0.07	1.25	0.029
E3	0.064	1.75	0.115	2.25	0.148	1.75	0.12	4.75	0.313
E4	0.017	3.25	0.054	1.5	0.025	2.25	0.04	3	0.050
E5	0.065	0.5	0.031	1	0.062	3	0.19	4.5	0.279
E6	0.037	4.5	0.161	4	0.143	3.75	0.13	4.75	0.170
Sub total			**0.471**		**0.508**		**0.582**		**0.896**
Total			**1.821**		**2.332**		**2.344**		**3.244**

Table 3.5: Rating and final value of business competence against each sub-criteria for Small Scale Enterprise (SSE), Medium Scale Enterprise (MSE), Educational, and Healthcare Sector in Durgapur

		SSE		MSE		EDUCATIONAL		HEALTHCARE	
Sub criteria W_c		**Rating R**	**Final value $R \times W_c$**	**Rating R**	**Final value $R \times W_c$**	**Rating R**	**Final value $R \times W_c$**	**Rating R**	**Final value $R \times W_c$**
A1	0.003	4.25	0.015	2.25	0.008	2.25	0.008	3.25	0.011
A2	0.004	4.75	0.020	3.25	0.014	3.25	0.014	2.5	0.011
A3	0.023	5	0.118	2.25	0.053	1.75	0.041	0.5	0.012
A4	0.007	4.75	0.034	3	0.021	0.5	0.004	0.5	0.004
A5	0.009	0.5	0.005	2	0.019	4.75	0.045	2.25	0.021
A6	0.014	0.5	0.007	1.75	0.024	3.25	0.045	4.75	0.065
Sub total			**0.199**		**0.139**		**0.157**		**0.124**
B1	0.007	4.25	0.021	2.75	0.014	0.75	0.004	4.5	0.022
B2	0.043	4	0.165	2	0.082	2.75	0.113	0.5	0.021
B3	0.019	1	0.017	2.25	0.038	3	0.050	3.25	0.055
B4	0.027	2.25	0.048	3.75	0.080	0.25	0.005	0.25	0.005
Sub total			**0.25**		**0.213**		**0.173**		**0.103**
C1	0.040	1.25	0.051	3	0.123	1.25	0.051	1.5	0.062
C2	0.031	1	0.033	1.75	0.058	3.75	0.125	3.25	0.108
C3	0.024	1.25	0.025	2.25	0.044	2.25	0.044	1.75	0.035
C4	0.044	0.25	0.011	1	0.043	2.75	0.119	0	0.000
C5	0.060	3.25	0.201	2.25	0.139	0.25	0.015	0.75	0.046
C6	0.148	3.25	0.526	0.25	0.040	0	0.000	0.25	0.040
C7	0.115	4.5	0.517	2.5	0.287	4.75	0.546	4.5	0.517
Sub total			**1.364**		**0.736**		**0.901**		**0.808**
D1	0.012	0.25	0.003	2	0.023	4.75	0.056	3.75	0.044
D2	0.024	0	0.000	2	0.039	3.25	0.063	3.25	0.063
D3	0.086	0.25	0.023	0.5	0.045	0.5	0.045	1.75	0.158
D4	0.044	0	0.000	1.5	0.063	0.25	0.010	1.25	0.052
Sub total			**0.026**		**0.170**		**0.174**		**0.317**
E1	0.013	4.75	0.055	2.75	0.032	3.75	0.043	3.25	0.037
E2	0.021	0.25	0.006	0	0.000	2.75	0.063	3.25	0.075
E3	0.064	1.25	0.082	4.25	0.280	4.75	0.313	4.5	0.297
E4	0.017	1	0.017	4	0.067	2	0.034	0.5	0.008
E5	0.065	2.25	0.139	2.75	0.170	3.75	0.232	2.5	0.155
E6	0.037	0.75	0.027	0.75	0.027	1.5	0.054	0.25	0.009
Sub total			**0.326**		**0.576**		**0.739**		**0.581**
Total			**2.164**		**1.835**		**2.143**		**1.933**

3.4 Step-3: Aggregating the Obtained Value for Each Industry Sector

The obtained value for each sub-criterion are aggregated in Table 3.6, which provides the value of competitive position.

Table 3.6: Sum of business competence for each industry sector obtained from Tables 3.4 and 3.5

Industry sector	Business Competence
Steel	1.821
Ancillary to Steel Sector (ASI)	2.332
Non-metal	2.344
IT	3.244
SSE	2.164
MSE	1.835
Educational	2.143
Healthcare	1.933

Studies show that industry category, Medium sized enterprise (MSE) and 'Steel' sector is having the lowest values of 1.835 and 1.821, respectively. In addition, it shows that the Information Technology (IT) industry shows the highest score with 3.244 followed by the 'Non-metal' industry with a score of 2.344 as the second highest score. 'Educational', 'Healthcare', and 'Ancilliary to Steel Industry (ASI)' show scores of 2.143, 1.933, and 2.332, respectively. Based on Porter's framework, these scores highlight the competitive positions of these industries in the present market conditions of Durgapur. The score obtained by IT industry is almost double that of the 'Steel' and 'MSE' industries proving their suitability and employability. However, it does not imply that the 'IT' industry will face almost double the competition as 'Steel'. It only implies that the 'IT' industry will face more competition if compared with the 'Steel' industry.

Analysing each force provides a better insight about the competitive scenario in Durgapur, i.e., for the force 'Threat for new entry' 'A1', the non-metal sector is experiencing more value than the 'IT' sector, though the total value for the 'IT' sector is more. It implies that there is more chance that a new business entity will easily enter the market for 'Non-metal' sector than the 'IT' sector. Similarly, for the force of 'Power of supplier', all sectors are having more competition than of 'IT' sector. For this force 'IT' sector has a value of 0.118, which is the lowest. It implies that it is easier to supply the necessary raw materials for the 'IT' sector than any other is. Therefore, it needs not to worry about its in-supply line. While it is facing more competition in the force of buyer's power, threat of substitutes, and rivalry. It implies that it is easier for a substitute in the IT industry to attract buyers and to be its competitive rival. On the same line, the steel industry and MSE is the second last competitive industry in the region. However, there is no competition against substitute products. It implies that though a new competitor can enter the market it is tough to produce a substitute product. On a similar type of analysis, education and healthcare are the third and fourth competitive

industries with a value of 2.143 and 1.993 respectively. However, these two sectors have the second and third highest value in the force of 'Intensity of rivalry'. In addition, in the force 'Threat of entry', these industries are getting low values among other industries. It implies that education and healthcare industries can easily penetrate the market and so there is a high risk of rival units. In this way, Porter's framework provides a platform, which not only reveals the competitive position of industries in a market but also explores the forces, which need to be taken care of by individual industries for better performance. Study reveals that the IT industry is obtaining the highest score to be called the most competitive industry in the city. In addition, the steel industry is getting the lowest score. It implies that the IT industry will face the most competition and the steel industry will face the least competition.

3.5 Dual Nature of Competence

The level of competence refers to the amount of competition a business faces in its industry. This includes both the challenges and opportunities that arise from competition, as well as potential customer bases in different locations. For example, while an expensive mobile brand may face little competition in a rural area, it may also have few customers, whereas, in a metro city, there is intense competition but also a larger customer base. Similarly, certain items like agricultural products can face both competition and demand in rural areas. The nuances of market dynamics are best understood by those actively involved in the specific business.

During the questionnaire session, experts were asked to focus on this kind of situation. So, in many cases, the greater amount of competition is directed toward a more favourable industry choice for that city. As the IT industry is flourishing and Durgapur is one of the most considered IT sectors in West Bengal after Kolkata, the IT industry has huge potential to grow in the city. On the other hand, the steel industry is facing very little competition because running a new steel industry is a mammoth task.

3.6 Summary

The chapter successfully evaluates the competencies of industries through the AHP, experts' opinions, and Porter's model. The application of AHP perceives the sub-criteria and forces on a quantitative scale. The study finds that the IT industry will face the most competition and is followed by the non-metal sector, education, and healthcare, while steel and MSE will face the least. The dual nature of business competence shows that an industry that is facing the most competition has also the most chance to grow over time. The role of competition in establishing a business unit from an investor's point of view has been highlighted in the dual nature of competition.

Appendix-3.A

Here the inputs from the experts' survey has been processed to obtain the weightage of the five forces of Porter, through AHP. The experts are referred to Table 3.A.1 for pair-wise comparison of the five forces of Porter.

Table 3.A.1: Saaty's 9-point scale

Intensity of importance	Definitions	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour the selected activity over the other activity in the pair
5	Strong importance	Experience and judgement strongly favour the selected activity over the other activity in the pair
7	Very strong importance	Experience and judgement very strongly favour the selected activity over the other activity in the pair
9	Extreme importance	Experience and judgement extremely favour the selected activity over the other activity in the pair
2, 4, 6, 8	Intermediate values between 1 and 3, 3 and 5, 5 and 7, and 7 and 9, respectively	Adds latitude to the experts in selecting intermediate values
Reciprocals of above	In the (i, j) pair of activities, if the assigned weight is k, then in (j, i) pair, the weight will be $1/k$.	

Source: Saaty, 1987

Now, referring to Table 3.A.2, the expert has felt that 'Power of supplier' is moderately important compared to the 'Threat of entry' assigning a value of '3' from Table 3.A.1. Hence, 'Threat of entry' will have the inversed value of '1/3' compared to 'Power of supplier'. Similarly, eall other cells are provided with their respective weights.

Table 3.A.2: Pairwise comparison of Porter's Five Forces by the expert(s)

Forces from Porter's framework	Threat from new entrants	Power of suppliers	Power of buyers	Threat of substitutes	Intensity of rivalry
Threat from new entrants	1	1/3	1/6	1/2	1/3
Power of supplier	3	1	1/8	1/3	1/4
Power of buyer	6	8	1	2	4
Threat of substitute	2	3	1/2	1	1/2
Intensity of rivalry	3	4	1/4	2	1

Table 3.A.3: Table 3.A.2 after normalization so that column sums become unity

	Threat of entry (A)	Power of supplier (B)	Power of buyer (C)	Threat of substitute (D)	Intensity of rivalry (E)
A: Entrants	0.066666667	0.020408163	0.081632653	0.085714286	0.054794521
B: Suppliers	0.2	0.06122449	0.06122449	0.057142857	0.04109589
C: Buyers	0.4	0.489795918	0.489795918	0.342857143	0.657534247
D: Substitute	0.133333333	0.183673469	0.244897959	0.171428571	0.082191781
E: Rivals	0.2	0.244897959	0.12244898	0.342857143	0.164383562

Table 3.A.4: Matrix showing row average of Table 3.A.3

Forces/criteria	**Row average**	
Threat of entry, **A**	0.061843258	Consistency Ratio = 0.09 (Saaty, 1987)
Power of supplier, **B**	0.084137545	
Power of buyer, **C**	0.475996645	
Threat of substitute, **D**	0.163105023	
Intensity of rivalry, **E**	0.214917529	

Appendix-3.B

Table 3.B.1: Pairwise Comparison of the 'Threat of entry' by Expert

Sub-forces	Economies of scale **A1**	Product differentiation **A2**	Capital requirement **A3**	Switching cost **A4**	Access to distribution channel **A5**	Government policy **A6**
A1	1	0.33	0.17	0.50	0.33	0.50
A2	3.00	1.00	0.13	0.33	0.25	0.33
A3	6.00	8.00	1.00	2.00	4.00	2.00
A4	2.00	3.00	0.50	1.00	0.50	0.25
A5	3.00	4.00	0.25	2.00	1.00	0.50
A6	2.00	3.00	0.50	4.00	2.00	1.00

Table 3.B.2: Pairwise Comparison of the 'Power of supplier' by Expert

Sub-forces	Number of suppliers **B1**	Supplier's concentration **B2**	Shifting cost to change a supplier **B3**	Threat of forward integration **B4**
B1	1	0.14	0.25	0.25
B2	7.00	1.00	2.00	3.00
B3	4.00	0.50	1.00	0.50
B4	4.00	0.33	2.00	1.00
Total	16.00	1.97	5.25	4.75

Table 3.B.3: Pairwise Comparison of the 'Power of buyer' by Expert

Sub-forces	Number of buyers **C1**	Buyer's concentration **C2**	Buyer's sophistication **C3**	Switching cost **C4**	Price sensitivity **C5**	Threat of backward integration **C6**	Importance of the product to buyer **C7**
C1	1	3.00	3.00	0.50	0.33	0.17	0.33
C2	0.33	1.00	2.00	0.33	0.50	0.33	0.50
C3	0.33	0.50	1.00	0.50	0.50	0.20	0.13
C4	2.00	3.00	2.00	1.00	0.50	0.11	0.25
C5	3.00	2.00	2.00	2.00	1.00	0.50	0.33
C6	6.00	3.00	5.00	9.00	2.00	1.00	2.00
C7	3.00	2.00	8.00	4.00	3.00	0.50	1.00

Table 3.B.4: Pairwise comparison of the 'Threat of substitute' by expert

Sub-forces	Number of substitutes **D1**	Obvious advantage of substitute **D2**	Buyer's switching cost **D3**	Profitability level of substitute industries **D4**
D1	1	0.33	0.17	0.33
D2	3.00	1.00	0.13	0.33
D3	6.00	8.00	1.00	2.00
D4	3.00	3.00	0.50	1.00

Table 3.B.5: Pairwise comparison of the 'Intensity of rivalry' by expert

Sub-forces	Number of rivals **E1**	Switching cost **E2**	Industry growth **E3**	Product differentiation **E4**	Diversity of rival **E5**	Threat of horizontal integration **E6**
E1	1	0.33	0.17	0.50	0.25	0.50
E2	3.00	1.00	0.13	2.00	0.50	0.33
E3	6.00	8.00	1.00	3.00	0.50	2.00
E4	2.00	0.50	0.33	1.00	0.33	0.33
E5	4.00	2.00	2.00	3.00	1.00	2.00
E6	2.00	3.00	0.50	3.00	0.50	1.00

Rest of the operations for Table 3.B.2-5 have been done as done in Table 3.A

Chapter 4: Land Use Land Cover (LULC) Simulation for Durgapur

4.1 Introduction

To support the regeneration of Durgapur, the competitive condition of various industries has already been evaluated in Chapter 3. The subsequent step involves strategically aligning these industries and directing the city's growth in an organized manner. Thus, it becomes necessary to know the direction along which the city is growing and where the growth is concentrated. The growth direction will help to position conducive industries and provide necessary infrastructure. Accordingly, this chapter examines the spatial expanse of the city. QGIS 3.30.2 and ArcGIS 10.8 (student version) have been used to prepare the LULC map and maps for spatial variables/factor. QGIS 2.18.1 along with its plugin 'Module for Land Use Change Evaluation' (MOLUSCE) has been used for the LULC simulation.

4.2 The Methodology of Simulation

The methodology consists of five steps (Figure 4.1).

Step-1: **Defining the Study Area:** Area under Durgapur Municipal Corporation, DMC, in Fig. 2.1 has been selected.

Step 2: **Collect, Correct and Classify Satellite Images:** LULC maps for the years 2000, 2010, and 2020 are used from the Resourcesat satellite image database. The acquired maps are corrected and classified into four classes: built-up, vacant, vegetation and water body using available bandwidth.

Step-3: Assess LULC Change: The change in LULC during the period, 2000-2010 is measured. The future LULC map for 2020 is predicted in the open-source software MOLUSCE-QGIS 2.18.1. Multi-Layer Perceptron Neural Network (MLPNN) along with pre-defined growth factors/ spatial variables are used in this process. The future land uses of the region are defined as the factor multiplied by the probability of chance in the initial map. The probability of chance is defined by the factors that represent the spatial growth of the region. Observing the growth pattern and regional setting of the city, population, distance from road, river, and slope have been selected as catalysts of land transformation (factor maps).

Step-4: Validation: The predicted LULC map for 2020 is compared with the actual map of 2020 for validation. The κ −validation process has been used here following similar studies by Hakin et al. (2019) and Ashaolu et al (2019).

Step-5: Simulation: Upon reaching the desired confidence level, the map for 2031 is simulated.

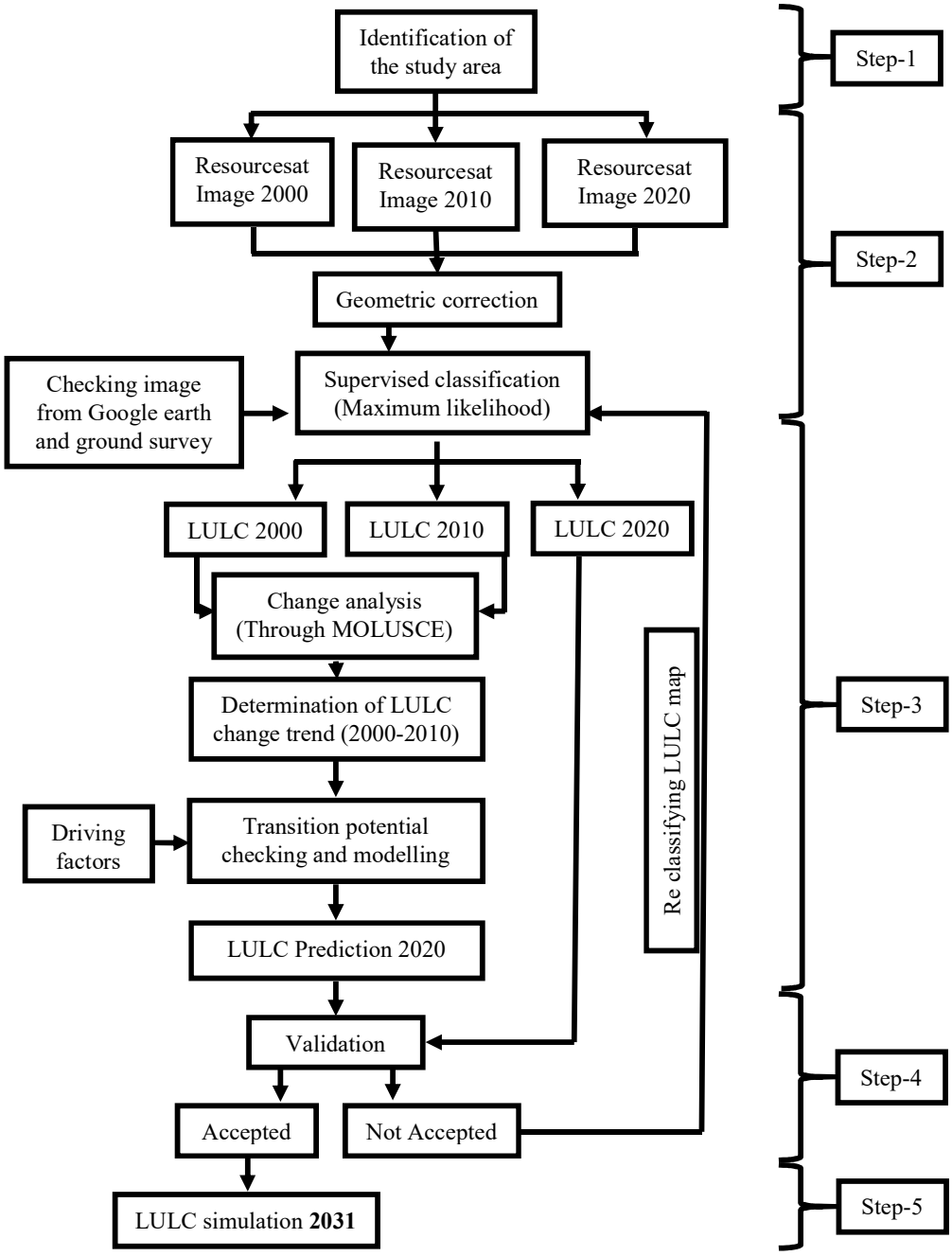


Figure 4.1: Flowchart showing the methodology to do the LULC simulation

4.3 Data Collection and their Classification

Satellite images captured through Resourcesat-1, 2 Linear Imaging and Self Scanning Sensor (LISS-III) are acquired from the open source archives of Bhuvan (https://bhuvan.nrsc.gov.in/home/index.php) supported by the National Remote Sensing Centre (NRSC). Images are collected for the years 2000, 2010, and 2020 (Table 4.1). Details of the maps are mentioned below.

Table 4.1: Sources of spatial images and their variables

Data	Satellite	Year of acquisition	Bands/ colour	Resolution	Number of bands
LULC 2000	Resourcesat-1, LISS-III	2000	Multispectral	24m	4
LULC 2010, LULC 2020	Resourcesat-2, LISS-III	2010, 2020	Multispectral	24m	4

Source: https://www.nrsc.gov.in/thematic_lulc

The conventional concept of toposheet was introduced by the Survey of India during the British era. NRSC divides India into some tiles containing specific data, which are termed as toposheet. F45D02, F45D06, F45D07, and F45D03 are the identification numbers of the toposheets in the clockwise sense from the top left. The images are acquired for the years 2000, 2010, and 2020, at 10 year intervals. The acquired images are of 24m resolution with multispectral 4 bands in GeoTIFF format. The acquired GeoTIFF file has been reclassified and four land use classes are created named built-up, vacant, vegetation and water body (Table 4.2). The location is georeferenced as WGS 84/UTM zone 45N.

Table 4.2: LULC classification and their description

Band number	Band Class name	Description	Colour
1	Built-up	Any land which is covered with building	
2	Vacant	Vacant land, agricultural cultivated and non-cultivated land, barren area	
3	Vegetation	Land covered with trees, forest	
4	Water body	River, pond, and water reservoir	

The acquired maps are corrected and merged to form a single map. QGIS 2.18.1 is used to perform the operation (Figs. 4.1, 4.2 and 4.3). During reclassification, the acquired images are cross-checked with the ground-level survey to evaluate the accuracy of collected data. Raster images are overlapped with an administrative boundary for a clearer assessment of LULC change and city boundaries. A maximum-likelihood algorithm has been used for image classification. It is a supervised classification technique, which has been proved to be very useful for image classification (Satya, Sashi, & Deva, 2020). In the procedure, each pixel will belong to one of the four bands assigned by the system algorithm while the image is processed (Table 4.2). The software uses band properties and reflectance to classify the image into desired classes.

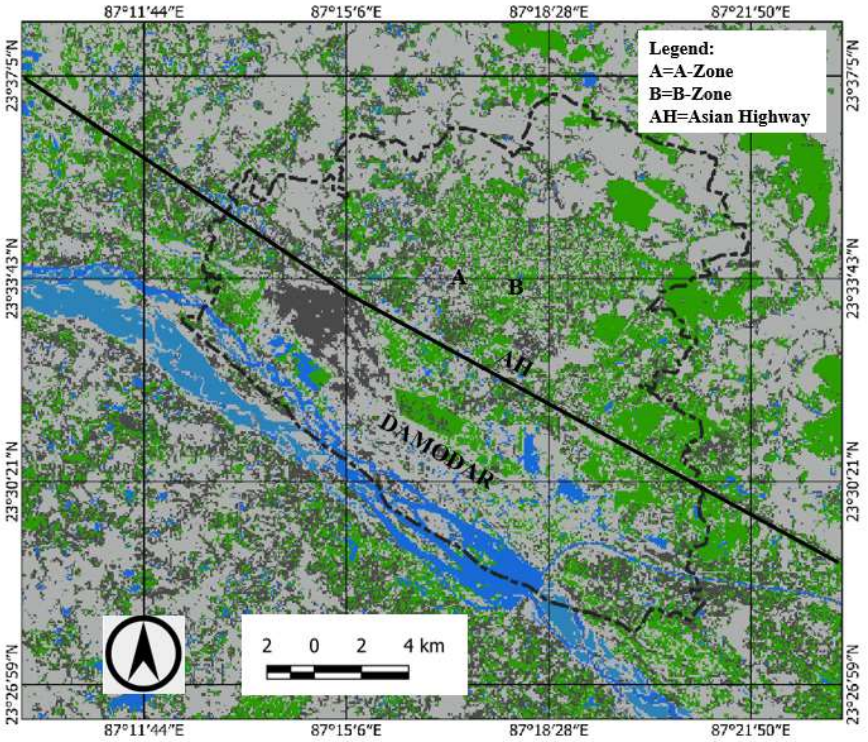


Figure 4.2: LULC of Durgapur in 2000 (Study area is marked in chain dot line)

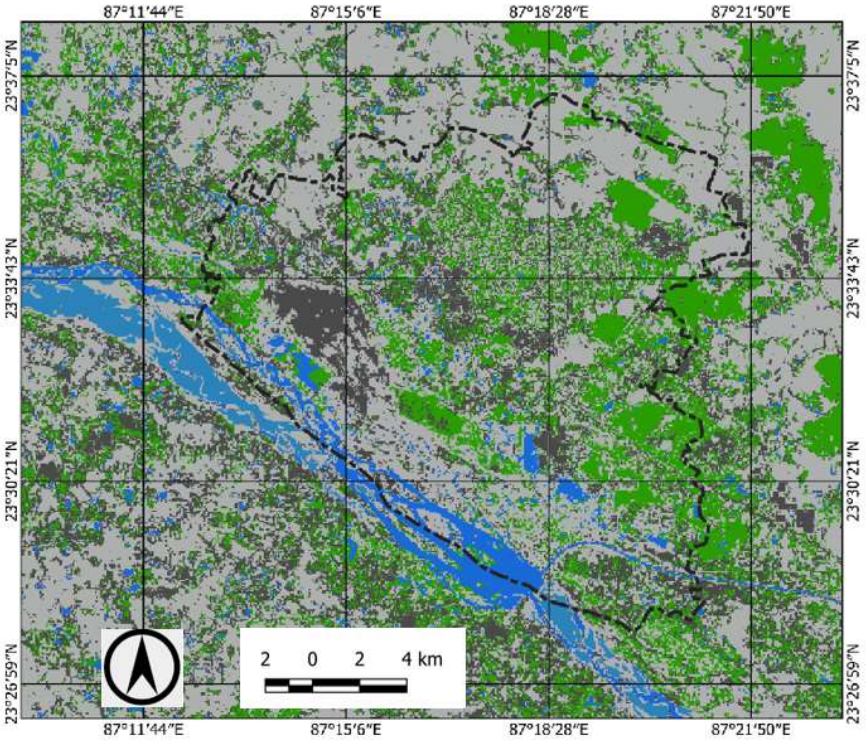


Figure 4.3: LULC of Durgapur in 2010 (Study area is marked in chain dot line)

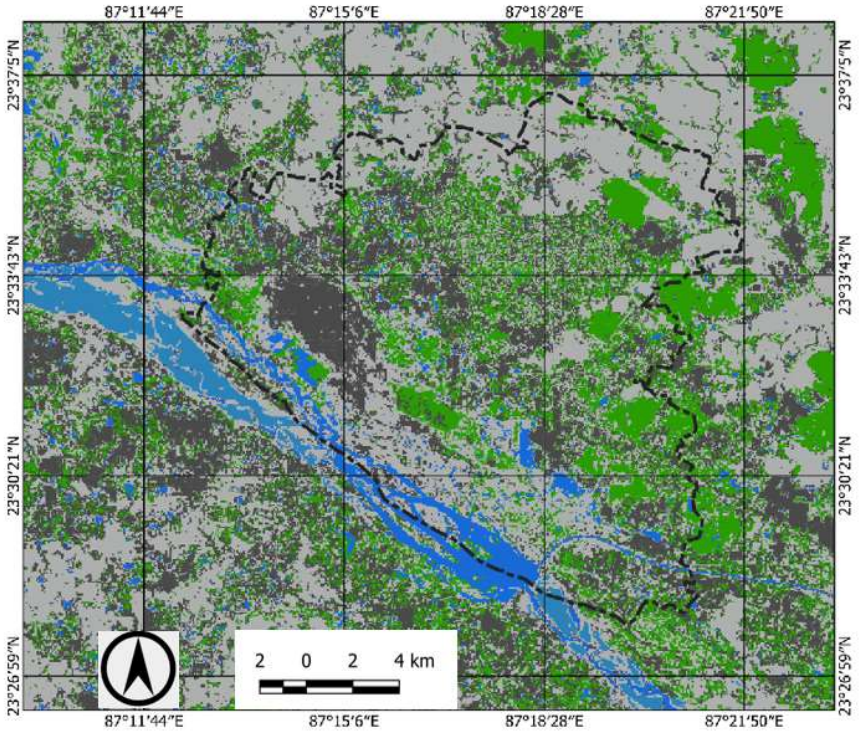


Figure 4.4: LULC of Durgapur in 2020 (Study area is marked in chain dot line)

Previous studies have mentioned that driving factors/spatial variables are useful in simulating future LULC. Population, road, river, and slope have been used as factor map in the similar kind of previous analysis (Hakim Y, Baja, Rampisela, & Arif, 2019; Ashaolu, Olorunfemi, & Ifabiyi, 2019). Observing the nature of Durgapur, the above-mentioned variables is chosen as factors. During the selection of factors, it should be noted that correlation between two factors should be low. It is done so to avoid multi-collinearity.

Table 4.3: Parameters of factor map

Data	**Range**	**Unit**	**Classifying method**
Distance from road	0-13080	Meter (m)	Euclidean distance
Distance from river	30-23000	meter (m)	Euclidean distance
Slope	0-45	Degree	Ranked
Population density	611-11240	Population/sq, km	Ranked

***Distance from Roa*d:** To prepare this data, the road layout of the region is drawn in the free student version (SV) of ArcGIS 10.8. The vector file is rasterized through Euclidean distance. Asian Highway, AH-1, also known as the Grand Trunk Road and National Highway, NH-2, is passing straight through the CBD of Durgapur, leaving a significant impact on its spatial growth of Durgapur (Figure 4.5). Stretching between Kolkata to Delhi, the highway passes straight through the heart of Durgapur. The increased intensity of red colour in Fig. 4.5 signifies proximity to roads.

***Distance from river*:** A part of Rivers Damodar and Ajoy flows through the study area, and a Euclidean distance map containing the distance from the river is created (Fig. 4.6). River Damodar, running from northwest to southeast direction along the Southern limits of the study area, naturally has great influence on the steel factory, water supply, agriculture and forest profile of the study area. Again, the environment of a city protected by the neighbourhood forest and agricultural cover. In Figure 4.6, once again, the red colour signifies proximity to the river.

***Population Density*:** This is acquired from the ward-wise data in the Census of India report, 2011. The data is ranked in QGIS 2.18.1 and rasterized in ArcGIS 10.8(SV). Population density in a region is one of the major indicators of added urban facilities that attracts more population in future (Figure 4.7). The lighter shades in Fig. 4.7 represent higher density. Ward 15 is the densest ward followed by Wards 5, 13 and 21.

***Slope*:** The slope map is created in ArcGIS 10.8(SV) from the Digital Elevation Modelling (DEM) file obtained from the Bhuban database. The site is close to the Chotanagpur plateau, having a moderate slope. The slope influences the placement of infrastructural facilities in the region, especially the water supply and drainage systems (Figure 4.8). Black colour indicates steeper slope.

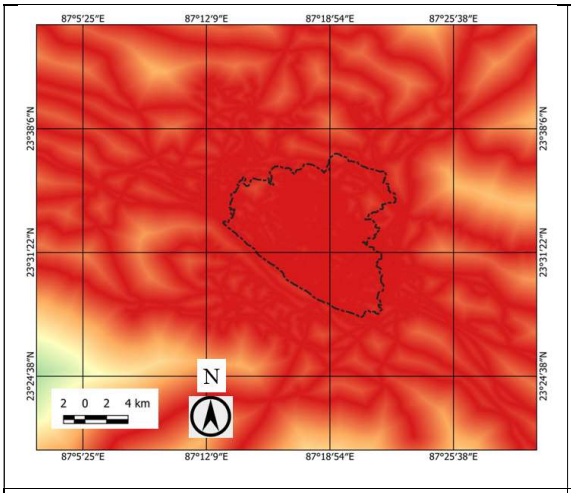


Figure 4.5: Driving factor- distance from road (2020)

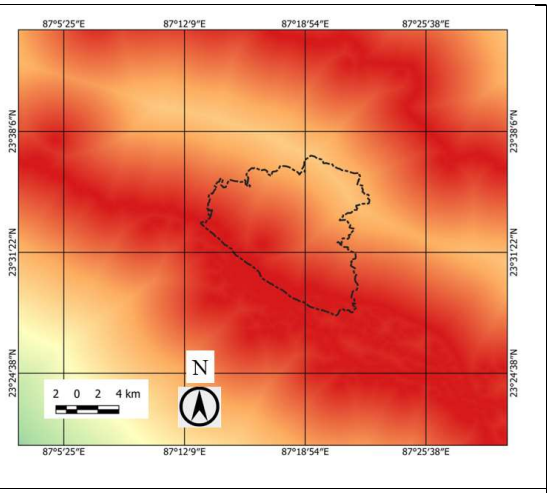


Figure 4.6: Driving factor-distance from river (2020)

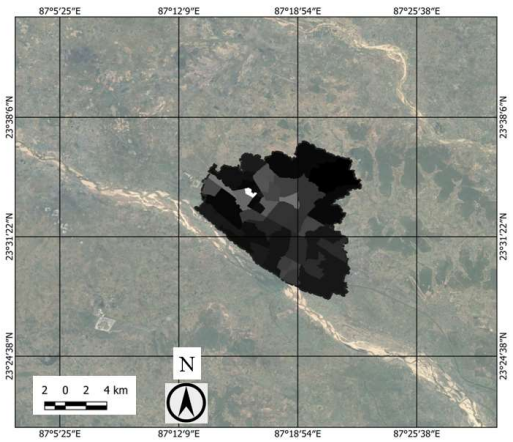


Figure 4.7: Driving factor- population density (2011)

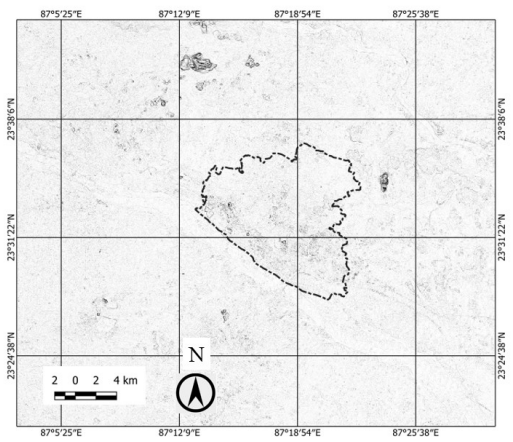


Figure 4.8: Driving factor- Digital Elevation Modelling (2020)

To run the prepared data in MOLUSCE-QGIS, geometrical information of each map must be identical on extent, pixel size, and projection.

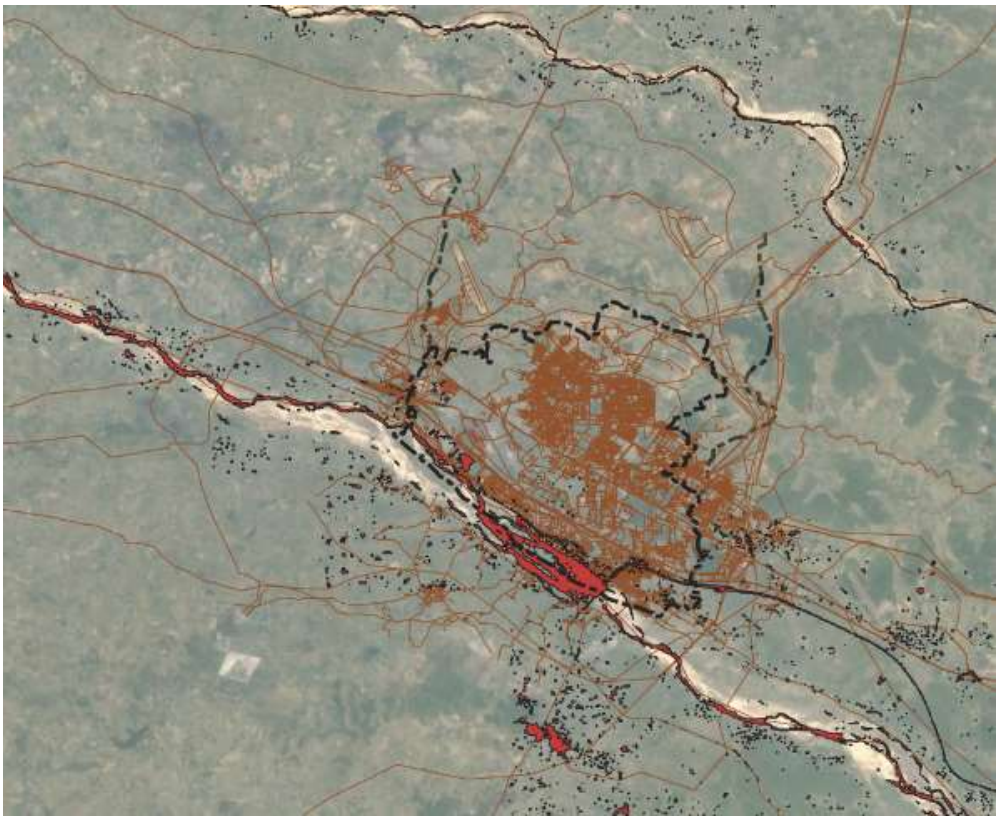


Figure 4.9: Snapshot of road network and river in the region (2020)

The Multi-Layer Perceptron Neural Network (MLPNN[14]) has been used to determine the future LULC. The model takes account of two features: the probability of a change of a state with respect to other classes and the estimated number of pixels that might change in a period. The LULC change can mathematically be expressed as

$$L(t+1) = P_{ij} \times L(t) \quad (4.1)$$

Here $L\ (t+1)$ and $L(t)$ are the LULC status at time $(t+1)$ and (t), and P_{ij} is the probability of change (Ashaolu, Olorunfemi, & Ifabiyi, 2019). The analysis uses LULC maps for time horizons 2000, 2010, and 2020 to predict LULC map for 2031. The change in the LULC from 2000 to 2010 has been used to create transition potential and improve the Markov chain algorithm (Hakim Y, Baja, Rampisela, & Arif, 2019; Kamaraj & Rangarajan, 2022). Using the transition potential and Markov chain algorithm, LULC for 2020 is simulated and compared with actual 2020 LULC. This assesses the degree of accuracy of the current algorithm. Upon satisfactory validation, the model is used for future LULC simulation.

Satellite images as discussed are collected and fed in QGIS 3.30.2. Simulating factors in the form of future population distribution are also prepared. Since this is a pixel-based operation geometry of the fed raster images is also checked to keep them uniform in terms of size and number of pixels.

4.4 LULC Change, Prediction and Validation

Table 4.4 and 4.5 describe the difference between the LULC area in 2000-2010 and 2010-2020, respectively.

Table 4.4: LULC change during 2000-2010

	Year-2000		**Year-2010**			
	Area in km² (A)	**Area in % (B)**	**Area in km² (C)**	**Area in % (D)**	**Change in area (km²) (C-A)**	**Change in % (D-B)**
Built-up	33.000	21.429	42.000	27.273	9.000	5.844
Vacant	64.020	41.571	58.100	37.727	-5.920	-3.844
Vegetation	47.740	31.000	46.200	30.000	-1.540	-1.000
Waterbody	9.240	6.000	7.700	5.000	-1.540	-1.000
Total	154	100	154	100		

The study suggests that within ten years, between 2000 and 2010 (Table 4.4), During this period, built-up space increased from 33 km^2 to 42 km^2, making it the highest land cover change, which is 5.8 %. The vacant are in the region experienced 3.8% percentage reduction, while their percentage contribution

[14] Jensen, J. R., 2015, Introductory digital image processing: a remote sensing perspective, 4 Ed., Pearson education, p.448

to the total area was 41.5% in the year 2000. It needs to be noticed that within this period, only built-up space increased, while water body, vegetation, and vacant spaces got depleted.

Also, in the time span of 2010-2020 (Table 4.5), built-up space increased from 42 km^2 to 52.3 km^2 making it the most increased land use, which is 6.68 %. In this period, the water body was almost the same, while vegetation and vacant space decreased at the rate of around 2.1% and 3.2% respectively.

Table 4.5: LULC change during the time span of 2010-2020

	Year-2010		**Year-2020**			
	Area in km^2 (E)	**Area in % (F)**	**Area in km^2 (G)**	**Area in % (H)**	**Change in area (km^2) (G-E)**	**Change in % (H-F)**
Built-up	42.000	27.273	52.300	33.961	10.300	6.688
Vacant	58.100	37.727	53.100	34.481	-5.000	-3.247
Vegetation	46.200	30.000	43.000	27.922	-3.200	-2.078
Waterbody	7.700	5.000	5.600	3.636	-2.100	-1.364
Total	154	100	154	100		

MOLUSCE plugin uses Multi-Layer Perceptron Neural Network (MLPNN), weight of evidence, multi-criteria evaluation, and logistic regression to predict future land use. Here MLPNN has been used for prediction purposes, which will train a model that further will use the validation though the overall kappa statistics (Jensen, 2015). which is also used to evaluate the accuracy of the model (Source: https://docs.nextgis.com/docs_ngqgis/source/molusce.html, accessed on 26.06.2024).

$$K = \frac{N\sum_{i=1}^{k} x_{ii} - \sum_{i=1}^{k}(x_{i+} \times x_{+j})}{N^2 - \sum_{i=1}^{k}(x_{i+} \times x_{+j})} \quad (4.2)$$

Where k is the number of rows (e.g., land cover classes) in the error matrix, x_{ii} is the number of observations in row i and column i, and x_{i+} and x_{+j} are the marginal totals of or row i and column j, respectively, and N is the total number od samples

With LULC 2000 as the initial and LULC 2010 as the final and other factor maps, the transition model training was done.

This step produces the transition, which is used to simulate future LULC. The working principle of ANN is the interaction between connected neurons and the change in weight between their connections, which have been followed here. The modification of change in weight between the neurons depends on the input data and desired output time series. The procedure is called 'Neural Network Learning'. It trains the algorithm for LULC change, which shows the probability of directions for LULC change in the projected future. The trained model is used to simulate the LULC map for 2020.

The effectiveness of the model is determined through validation, where the simulated map of recent past, projected from two older maps, is compared with the actual downloaded LULC map. A validation is carried out between the available reference map (actual downloaded map of 2020) and the simulated map of 2020 by calculating the kappa values (Satya, Sashi, & Deva, 2020, Al-sharif & Pradhan, 2014; Ashaolu, Olorunfemi, & Ifabiyi, 2019; Hakim Y, Baja, Rampisela, & Arif, 2019). If the value reaches the desired confidence level, then the model is accepted and the process for future LULC map starts.

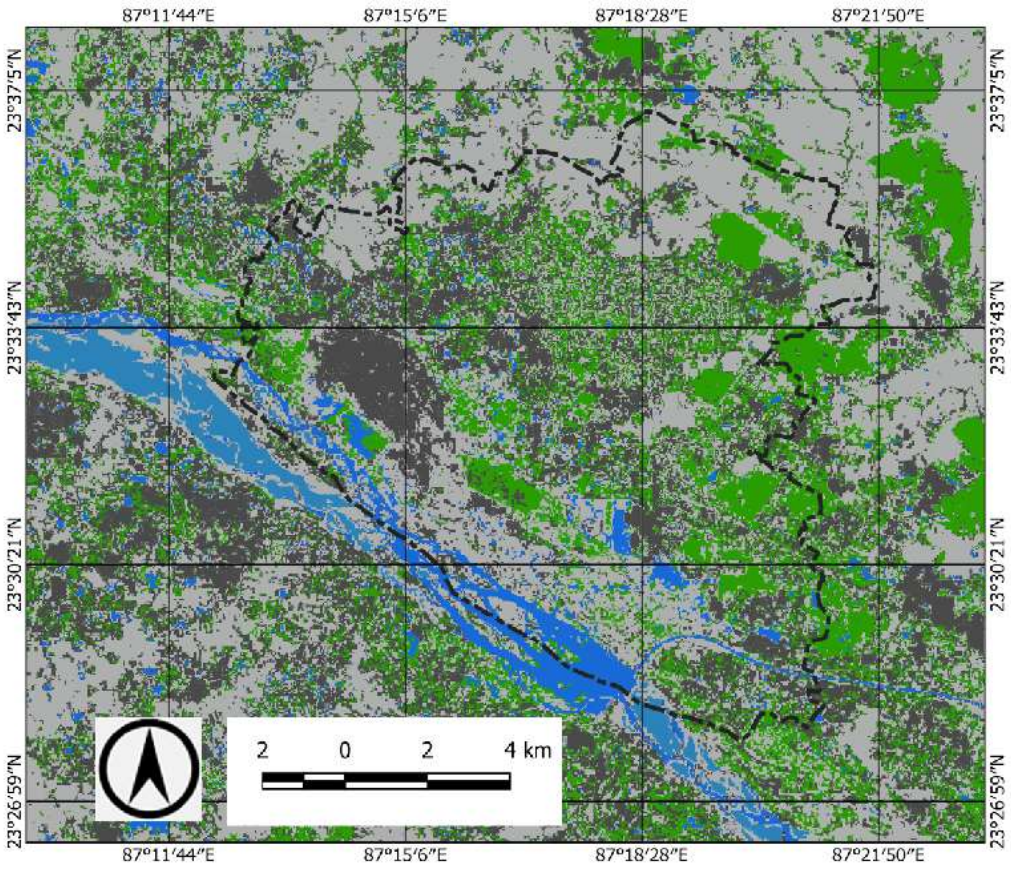


Figure 4.10: Simulated LULC for 2031

Overall correctness assesses the overall performance of the model and measures the accuracy of the simulated map. It ranges between 0% and 100 % representing 'no similarity' and 'complete similarity', respectively. Kappa location assesses the ability to assess the location of the pixels correctly. The simulated LULC map for 2020 shows a correctness (overall Kappa) of 72%. In a similar study, it is found that achieving an overall Kappa correctness of 65-75% is found to be satisfactory (Hakim Y, Baja, Rampisela, & Arif, 2019; Kamaraj & Rangarajan, 2022). With this accuracy of the model, LULC for 2031 is carried out. During the future LULC simulation, the LULC map for 2010 is considered an initial map, the LULC map for 2020 is considered the final map, and the 10 number of iterations is carried out.

Future LULC 2031 (Figure 4.10) suggests that percentage-wise water bodies decreased the least with the value of 0.3%. The built-up area is showing an increase of 6 sq. km. Within the four land use classes, vegetation, and water body decreased, while built-up and vacant increased. The LULC simulation done here is a pixel-wise operation (Table 4.6).

Table 4.6: LULC change in span 2020-2031

	Year 2020		**Year 2031**			
	Area in km^2 (I)	**Area in % (J)**	**Area in km^2 (K)**	**Area in % (L)**	**Change in area (km^2) (K-I)**	**Change in % (L-J)**
Built-up	52.300	33.961	56.000	36.364	3.700	2.403
Vacant	53.100	34.481	51.000	33.117	-2.100	-1.364
Vegetation	43.000	27.922	41.000	26.623	-2.000	-1.299
Waterbody	5.600	3.636	6.000	3.896	0.400	0.260
Total	154	100	154	100		

It is observed that, built up area have increased most with 2.4%. However, vegetation and vacant decreased most in terms of percentage area, with 1.3% and 1.4% respectively. The amount of water body is so low in the area that even a minor change inflicts big percentage change. It is seen on the map that the outgrowth towards North-West direction is growing fast. It is also seen that the built-up has become denser in the steel city area along with the city centre (Central Business District) location.

It is observed that city growth is being concentrated in Bidhannagar to the north-west of Durgapur, Muchipara to the south-east of Durgapur and along the Asian Highway-1. In addition, the rural portions surrounding Durgapur, have showed growth and land transformation (vacant land and vegetation to built-up space).

4.5 Summary

LULC simulation is done by academically accepted software packages, QGIS 2.18.1, QGIS 3.30.2, MOLUSCE, and the student version of ArcGIS 10.8. The study evaluates the growth concentration of four primary land covers, namely vegetation, water body, build-up, and vacant. Though the water body almost remains as it is, a major transformation is observed from vacant to built-up. It is also observed that the city is growing following the Asian Highway-1 route, primarily towards the Bardhhaman side. The newly developed Bidhhannagar is one such example.

Chapter 5: Growth Models for Durgapur

5.1 Introduction

The identified supplementary industries must be supported with appropriate urban infrastructure and essential amenities. To determine the necessary infrastructure, including greeneries and ground coverage, it is essential to project the city's population using the relevant growth variables identified in section 1.7.3. A multivariate polynomial regression model has been used to establish the relationship between these growth variables and the city's population.

5.2 Selection of Variables for the Growth Model

The variable representing the growth of city have already been proposed in Chapter-1, where Population density, Population size, Distance from CBD, Infrastructure, Ground coverage, Greeneries, Employment, and Market potential are usually used for predicting the growth of a city. It is found that city population size is being referred as the primary indicator of the city's growth in multiple studies (Aguayo, Wiegand, Azocar, Wiegand, & Vega, 2007; Sridhar, 2010; N, Jenamani, & Mahanty, 2017). It is proposed to develop a regression model to predict future population. Since 'population' and 'population density' are correlated factors, population density has not been considered for developing the regression model. Further, since the model is proposed to predict the population in Durgapur as a whole, the variable 'distance from CBD' is deemed redundant.

5.3 Model Formulation

Table **5.1** provides the data corresponding to the growth variables proposed above for Durgapur. Population size (A) is the total population of Durgapur as obtained from the decadal reports published by the Census of India. The percentage of roads within Durgapur has been used as a representative indicator of the factor 'Infrastructure' (B). 'Ground coverage' (C) is figured out from the total share of built-up space (per cent), obtained from unpublished report of the DMC and LULC maps. 'Greeneries' (D) is the ratio of forest, orchard, agricultural, and grassland concerning the total area in the study area expressed as percentage. Employment (E) is obtained from the employment percentage of each census year. Expenses incurred by DMC in maintenance head, published in annual reports of DMC, has been accepted as a passive measure of market potential (F), since investment is expected to be proportionate to earning. As mentioned in section 1.7.3, all expenses have been converted considering 2011 as the basis year, and the amounts are in crores of rupees spent annually. The generated revenue is adjusted

with year-wise inflation rate. These data are compiled from census reports, municipal documents, and GIS maps along with primary surveys and different published literatures.

Table 5.1: Year wise values of the criteria for Durgapur

Year	Population size (A)	Infrastructure (B)	Ground coverage (C)	Greeneries (D)	Employment (E)	Market potential (F)
1961	41696	6	16	57	62	6.7
1971	206638	6	25	56	31	49.9
1981	311798	8	26	43	27	486.5
1991	425836	12	28	37	27	117.6
2001	493405	14	33	32	31	42.1
2011	566517	13	36	23	35	19.1

Source: Primary survey, unpublished document from DMC, and Census of India 1961-2011

Various regression methods including stepwise regression and hierarchical regression have been tried in this thesis. Only multivariate polynomial regression was found to be the suitable one. An open-source application TAYLORFIT RSA (Response Surface Analysis) has been used to build the models. Vaccari et al. (Vaccari & Wang, 2007; Vaccari D. A., 2018) have showed the applicability of this software is well established in the fields of time series analysis, sociology, and demography. Various combinations of explanatory variables have been tried and these following models are finalised.

Population count and population density are correlated, hence only absolute population count has been accounted leaving back the measure 'population density'. Likewise, the variable 'distance form CBD' is deemed irrelevant since the formulation is dealing with one city only whereby 'distance to CBD' is basically an invariant. Thus, an attempt has been made in the following to predict population (Pop), in light of existing Ground Coverage ($Gr\ Cov$), Market Potential ($Mkt\ Pot$), Employment (Emp), Greeneries (Gr), and Infrastructure (Inf).

Model 1

$$Pop = -0.7975 + 0.0675(Gr\ Cov)^2(\mathrm{M}kt\ Pot)^{-1} + 0.5212(Gr\ Cov)^2(Emp)^{-1} - 0.0134(Gr\ Cov)^2 \quad (5.1)$$

Model 2

$$Pop = 0.7809(Inf)^2(Gr)^{-1} + 2.1235(Gr\ Cov)(Emp)^{-1} - 18.726(\mathrm{I}nf)^{-1}(Mkt\ Pot)^{-1} \quad (5.2)$$

Model 3

$$Pop = -0.7045 + 8.5211(Inf)(Gr)^{-1} + 0.0983(Gr\ Cov)^2(Emp)^{-1} \quad (5.3)$$

Model 4

$$Pop = 3.9358(Gr\ Cov)(Emp)^{-1} + 0.0089(Inf)^2 - 0.0254\ (Gr) + 0.0159(Gr\ Cov)^2(Mkt\ Pot)^{-1} \quad (5.4)$$

Model 5

$$Pop = 7.5493 + (-0.0016)(Gr)^2 + (-0.000576)(Emp)^2 + (0.0102)(Inf)^2 \quad (5.5)$$

Model 6

$$Pop = 13.801 + (-0.0452)Emp + (0.1832)Inf + (-0.2046)Gr \quad (5.6)$$

Table 5.2: Combined percentage of error of models

Year	Eqn-1: % error	Eqn-2: % error	Eqn-3: % error	Eqn-4: % error	Eqn-5: % error	Eqn-6: % error	Remarks
1961	-15.53	-37.76	-42.46	-1869.4	-19.989	-3.71429	Eq. (1) is most accurate followed by Eq. (2)
1971	-5.84	-4.46	-6.32	42.27	-13.852	0.902913	
1981	-5.69	4.64	2.92	106.22	-55.106	-68.7588	
1991	-0.72	-2.38	3.14	68.01	-50.771	-69.6188	
2001	5.33	-8.56	-5.13	15.88	-49.22	-70.7383	
2011	-0.89	8.68	2.79	-48.63	-36.174	-74.5115	
Root mean square of errors	18.36	40.27	43.53	1874.82	40.69	57.93	

The R^2 and Adjusted R^2 of each model are greater than 0.9.

The obtained models are tested with the actual population in each census year and their errors are calculated in Table 5.2. Lastly, the root mean square for each equation is figured out to find the efficient one.

Root mean square values of errors over the decadal predicted population from Equations (5.1-5.6) are 18.36, 40.27, 43.53, 1874, 40 and 57, respectively, which suggests that Equation (5.1) is most efficient, followed by other models. Since the equations are dynamic in nature, they evolve continuously.

5.4 Remarks

In this chapter six equations have been derived from the raw data in Table 5.1 where measure of ground coverage, market potential, employment, greeneries, and infrastructure of the study area have been used to predict population for the study area. There being only six set of data, the population count being accepted from the census reports published after each turn of decade, error in the model cannot be eliminated significantly. The first equation is the best while the error generated by the second equation, the second best-model, generates more than twice error compared to the first model.

Chapter 6: Development Proposal for Durgapur

6.1 Introduction

This chapter aims at fostering sustainable economic and social progress by strategically enhancing the city's economic base, infrastructure, and societal values. Urban regeneration schemes rejuvenate the concerned cities and seek to stem the urban rot through renovation efforts and improvement initiatives (Davidson, 1996). Urban management plays a crucial role in maximizing the efficiency of the urban development projects and establish effective coordination between the stakeholders (Stren, 1993; Rakodi, 2001).

As per the Accenture strategy (2017) and World Steel Association (2023) reports, the recent upward trajectory seen in the global steel sector suggests that growth pattern in steel industry will be continuing. SAIL also have its plan for expansion in Durgapur without having any major impact on city's employment (Asansol Durgapur Development Authority, ADDA, 2023). Concerning the progress of Durgapur, and to retain the essence of Durgapur as Steel City, it is presumed that the key foundation of the city, the steel industry, will persist.

It has been stated in Chapter 1 that the case of Jamshedpur provides an excellent example of how a city would progress by focusing on a similar industrial scenario wherein both the raw material and consumable finish products are processed in the city to absorb the fluctuations in price and demand in-house, adopting some kind of forward and backward integration.

In this chapter, the regeneration proposal is represented in terms of employment, to understand the upcoming additional population load due to the proposal. The proposal has been formulated considering the competitive ranks of the potential new entrant industries (Chapter-3), growth direction of industries noticed in Jamshedpur and some planning liberties executed by the author. It is presumed that the steel industry in Durgapur will keep receiving necessary patronage from the Central Government, since the need for steel can never be over-emphasized. The projected population of Durgapur in 2031 will be 904780 and 749219, respectively, as per the population projection in Chapter-2 and the ADDA report (Asansol Durgapur Development Authority, 2023). So, a rounded-off average of 8,50,000 is accepted as the total projected population of Durgapur in 2031. 40% of the total population, i.e., 338865, is taken as an ideal amount of total employment (T). The required city infrastructure is calculated next from growth equations Eqs. (5.1) and (5.2).

6.2 Proposed Distribution of Industries

Let the proposed employment be represented by D, while the current employment situation is denoted by A. Considering the total employment, T, to be 338865, 40% of the projected population in 2031, proposed employments in each sector is computed as a proportionate percentage of the total employment, C. The additional employment for the proposal is obtained by subtracting existing employment from proposed employment in each sector (F).

Table 6.1: Industry wise proposed employment distribution in the study area

	Year 2020		Year 2031		Difference between 2031 and 2020	
Industry	**Total jobs**		**Proposed job distribution**		**Percent change**	**Additional employment due to the first proposal**
	Absolute	**Percent**	**In percent***	**Absolute**		
	A	B	C	$D = T \times C$	$E = C - B$	$F = D - A$
Steel	12931	4.7	7 (8)**	23721	2.3	10790
ASI	24879	9.1	12 (13)**	40664	2.9	15785
Non-metal	6480	2.4	5 (10)**	16943	2.6	10463
SSE	91350	33.4	25 (21)**	84716	-8.4	-6634
Healthcare	13200	4.6	4 (6.14)**	13555	-0.6	355
Educational	12500	4.8	4.6 (8.5)**	15588	-0.2	3088
IT	5350	2.0	4.5 (2.8)**	15249	2.5	9899
Shopping mall	4154	1.5	2 (3.78)**	6777	0.5	2623
MSE	71260	26.1	24 (17)**	81328	-2.1	10068
Balance	31266	11.4	12 (10)**	40664	0.6	9398
Total	**273365**	**100**	**100**	**338865**		**65550**

* Author's proposal.
** The terms within parentheses are the percentages noted in Jamshedpur in 2021 (ref. Table 1.2)

Steel sector for Durgapur have been increased from 4.7% to 7% with an increase in employment of 10790. The increase in steel sector is supported by the fact that SAIL already has its plan for an expansion, without acquiring additional land[15].

Subsequently, Ancillary to Steel Industry (ASI) and Non-metal sector is proposed to be expanded by 12% and 5% from existing 9.1% and 2.4%, respectively. This is mainly proposed to support the ongoing expansion of steel sector and help Durgapur to diversify its industry distribution.

The sharp increase Steel sector, ASI and Non-metal sector is supported by its competitive environment depicted in Chapter-3.

[15] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1913865, Accessed on June 2024

It is proposed to reduce the Small Scale Enterprise (SSE) by 8.4% with a reduction of 6634 jobs in this sector. The reduction will be done by imposing more tax and enforcing land use controls. The idea is not to encourage this sector.

Since Durgapur is emerging as a healthcare and educational hub in this region and it is in parity with that in Jamshedpur, these sectors have been left untouched without any major modification.

Employment in the Information Technology (IT) sector has almost been doubled from existing 2~2.5%, with an hike of 9899 jobs since in Chapter-3 it has been proved to be the most competitive sector. Also during experts' opinion survey, it surfaced out that Durgapur has the potential to become a major IT hub in the upcoming years, there being engineering, medical and management knowledgebase and demand. Eastern India does not possess any major IT hub apart from Kolkata. Also Kazi Nazrul Islam Airport have been constructed in Andal, near Durgapur, which is also India's first private greenfield airport, providing quicker connectivity.

The procedure of industrial transition has been briefly described in Section 6.5.

6.3 Space Requirement for the Proposed Industries

To identify the land requirement for the proposed industry, with reference to Table 6.2, the average area for each type of industry, marked H, has been assessed through primary survey. Average number of employees serving in each category of industry, identified by I, has also been figured out during this step. The total proposed employment, G, is divided by the average number of employees for each industry, I, to obtain the required number of industrial units for the respective industry, say, *J*. Finally, the identified number of units, J, is multiplied by the average area required for each industrial units, H, to figure out the total land requirement, say K, for this proposal.

Table 6.2: Land requirement due to proposed industry distribution

Industry proposal	**Additional employment due to proposal-1**	**The average area for a single unit (sq. m)**	**Average number of employment in a single unit**	**Proposed units**	**Land requirement (sq. m)***
	G	H	I	$J = G/I$	$K = J \times H$
Steel	10790	Not applicable	Not applicable	NIL	No (DSP already have land for its expansion)
Ancillary to Steel Sector (ASI)	15785	20000	2000	7.89 ≈8	157848
Non-metal	10463	2500	300	34.8 ≈35	87194
SSE	-6634	12	5	Not applicable	Not applicable
Healthcare	355	15000	500, 80	4.4 ≈ 4	60000
Educational	3088	90000	300	10.2 ≈10	926337
IT	9899	1500	100	98.9 ≈99	148484
Shopping mall	2623	1856	1500	1.7 ≈ 2	3246
MSE	10068	30	20	503.4 ≈ 503	15101
Balance	9398				
Total					**1398210 = 1.4 sq. km**
***Actual J has been used**					

It is observed that 1.4 sq. km space, earmarked for industries, is required to uphold the proposal.

Infrastructural Requirement

To evaluate the required support, Eqns. 5.1 and 5.2 might be referred to. For the year 2031, population of Durgapur is considered as 850000.

Considering the total population of Durgapur to be 850000, trial has been made in Tables 6.3 and 6.4 to generate a few possible set of values for the explanatory variables.

Abbreviations

$$Pop = Population, \quad Gr\ Cov = Ground\ coverage, \quad Mkt\ Pot = Market\ potential,$$

$$Emp = Employment, Inf = Infrastructure$$

In Table 6.3, Eq. 5.1 has been used to evaluate the population based on assumed values of the five explanatory variables. The population have been shown in column 6, and the values of the explanatory variables are shown in columns (1) through (5).

Model 1:

$$Pop = -0.7975 + 0.0675(Gr\ Cov)^2(\mathrm{M}kt\ Pot)^{-1} + 0.5212(Gr\ Cov)^2(Emp)^{-1}$$
$$- 0.0134(Gr\ Cov)^2 \quad (5.1)$$

Table 6.3: Explanatory and dependent variables for Model-1

Sl.	Ground coverage (1) %	Market potential (2) Crores p.a.	Employment (3) %	Infrastructure (4) %	Greeneries (5)	Population (in lakh) (6)
1	48	100	31	-	-	8.6
2	50	70	32	-	-	8.8
3	55	100	33	-	-	8.48
4	45	100	31	-	-	7.48
5	55	100	32	-	-	10
6	60	100	33	-	-	10.2

Eq.5.2 is similarly used to assess the population from values of the explanatory variables in Table 6.4.

Model 2:

$$Pop = 0.7809(Inf)^2(Gr)^{-1} + 2.1235(Gr\ Cov)(Emp)^{-1}$$
$$-18.726(\mathrm{I}nf)^{-1}(Mkt\ Pot)^{-1} \quad (5.2)$$

Table 6.4: Table showing possible values of variables for Model-2

Sl.	Ground coverage (1) %	Market potential (2) Crores p.a.	Employment (3) %	Infrastructure (4) %	Greeneries (5)	Population (in lakh) (6)
1	50	100	40	18	-	8.9
2	50	100	45	20	-	10.1
3	45	200	40	18	-	8.7
4	45	200	40	15	-	6.7
5	50	200	35	18	-	9.3
6	50	200	30	18	-	9.8

The study observes that the expansion of infrastructure, ground coverage, and employment significantly influences population growth. In both the models, different sets of variables have been tested to analyse their impact on population dynamics. Findings indicate that optimal infrastructure development should be maintained at 18%, with ground coverage of 45% and employment levels at 40% of overall population. Thus greeneries would occupy around 37~40% of the total space will be adequate (Gaikadi & Kumar, 2024). Market potential have been tried to keep at 100-200, as during 1991 the market potential of the city was 117, and survey suggested that Durgapur was performing well during 1991.

6.4 Required Civic Amenities

URDPFI 2015 has a very specific requirement for the social infrastructure for a specific slab of population. Referring to the population increment, a basic requirement has been delineated. Considering 4.6 as the average household size (Asansol Durgapur Development Authority, ADDA, 2023), it is found that 65500 additional jobs computed in Table 6.1 might add 301300 extra people. Amenities for the residents are computed in Table 6.5.

Table 6.5: Requirement of basic civic amenities due to added population

Facility/ Civic amenities **(1)**	**Requirement as per URDPFI 2015 (Population served per unit) (2)**	**Units proposed** **(3)**	**Unit area-sq. m (URDPFI 2015)** **(4)**	**Area sq. m** **(5)**
	L	$M = 301300/L$	N	$O = M \times N$
Pre-primary nursery school	2500	121	800	96416
Primary school	5000	60	4000	241040
Senior secondary school	7500	41	18000	723120
Integrated school	100000	3	35000	105455
School for physically challenged	45000	7	7000	46868
College	125000	3	50000	120520
Multi-speciality hospital	100000	3	90000	271170
Community room	5000	60	750	45195
Community hall	15000	20	2000	40173
Recreation club	100000	3	10000	30130
Music centre	100000	3	1000	3013
Meditation centre	100000	3	5000	15065
Community park	100000	3	50000	150650
Neighbourhood park	15000	20	10000	200866
District sports centre	100000	3	80000	241040
Neighbourhood playing area	15000	20	15000	301300
Total				**2632022 sq. m ≈ 2.63 sq. km**

6.5 Spatial Arrangement

To direct the development in the proposed direction, the industrial proposal along with infrastructural requirement have been positioned in strategic locations of land use map. During the positioning of

industries, it is taken care that there is a conducive relation among the industry and its surroundings. The proposed change has been marked in hatch within the proposed land use (Fig. 6.1).

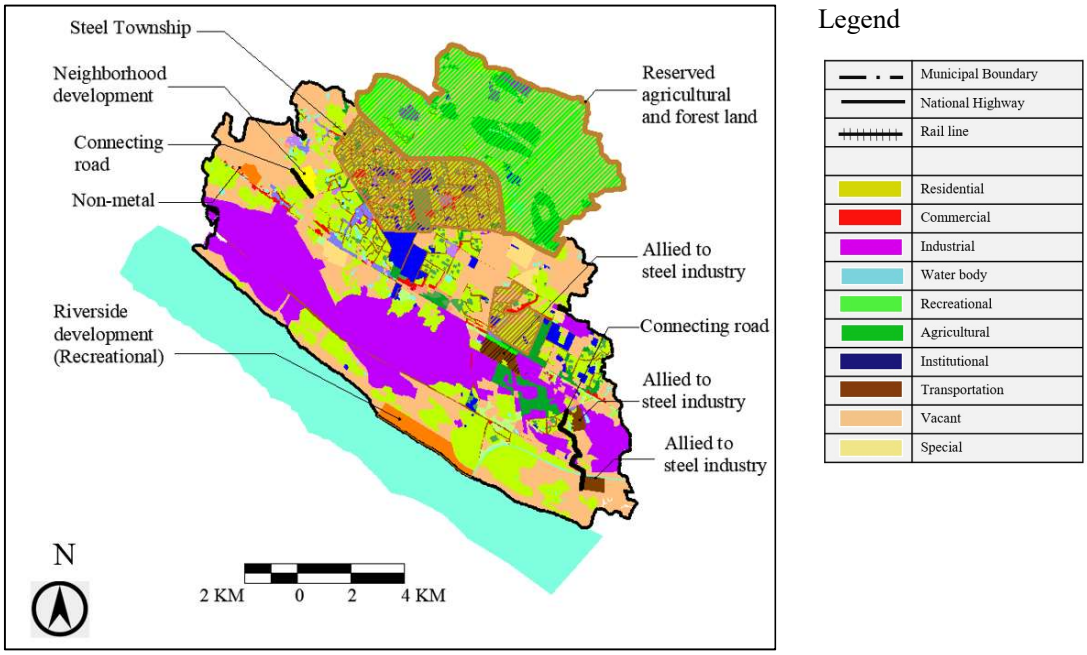


Figure 6.1: Draft proposal in the land use map of Durgapur

Salient features of the proposed spatial distribution:

a. The major non-metal industry is proposed to be set-up in the north-west side of Durgapur. Being near Benachity, the oldest wholesale market of this region, it would be easier for the manufacturers to sale their commodities. In addition, the less polluting industries are set to be positioned here.

b. The ASI industries are primarily positioned in the south-west side. Already Panagarh has an unorganized automobile zone in this location. It is also planned that the pollution-generating industries will be clustered at a single zone, so that it can be handled in a better way.

c. Connecting roads are proposed in strategic locations to reduce the travel distance. Multiple accesses between two strategic locations are planned to avoid accidental blockages.

d. In front of the ASI industries, a strip of greeneries is proposed to arrest floating particulate matters emitted by them.

e. The forest and agricultural land on the northern side of the city are to be retained. The agricultural land provides a fruitful agricultural base for this region. In addition, to protect the native cultural background of this region, the land use has to be protected from rapid changes.

6.6 Sample Development Approach for Industrial Civic Area

The details about the physical condition of the industrial civic area have been already described in Chapter 2. The industrial civic areas in Durgapur are primarily being owned by two major companies, SAIL and MAMC. Until now, local administration does not have any right to proceed with any construction in these areas. In this context, it is proposed that the dilapidated buildings be repaired/retrofitted and used for proposed supplementary industries along with providing civic amenities for all kind of residents, keeping the fabric of a planned industrial town intact. The idea of the proposal is that there will be least modification to the existing get-up of the buildings. Before commencing, a detailed Building Condition Survey (BCS) is proposed to evaluate the structural condition of the buildings. Full demolition of a quarter or building will be done only if the existing structure cannot be reused or it may trigger safety hazards. The idea is to retain the flavour of a planned factory town as much as possible, this being the prime identity of Durgapur. If there is a long stretch of dilapidated buildings, it is proposed to construct a multi-storeyed employment centre over there after complete or partial demolition. On the other hand, if there are dilapidated quarters fragmented over a parcel of land with some occupied quarter's in-between, those dilapidated quarters can be put to use for smaller business units. During the reuse of dilapidated structures, it is expected that none of the buildings shall be more than G+5 at maximum. This has been proposed to keep the skyline of the city very similar to the existing one.

The rejuvenation of the industrial area will be carried out in phases. Initially, the most dilapidated locations will be restored and reused. Gradually the less dilapidated quarters will be taken up. Referring to Figure 2.12 and Figure 2.13, the procedure of rejuvenation will be carried out inward from the periphery, since most dilapidated structures are present outskirts, where demand is lower. Fig. 6.2 provides a range of samples to illustrate the solution idea.

Sample Development-1

Location of the sample: B-Zone, Durgapur

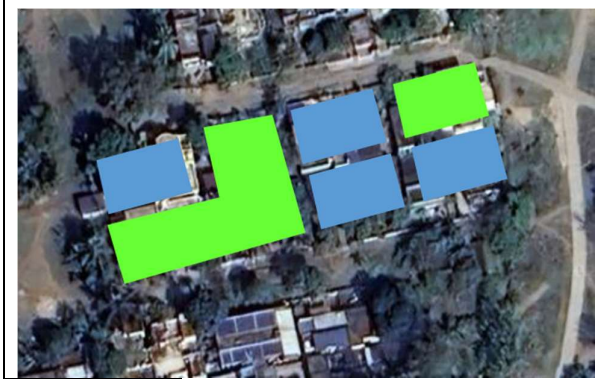
Co-ordinate: 23.567326 N, 87.326563 E

Scale- Not to scale

Existing condition

Option-1

Legend	
	Occupied quarter
	Dilapidated vacant quarter
	Reused quarter



Option-2

Figure 6.2: Series of Google Map snapshot showing the graphical representation of sample development-1

If the dilapidated quarters are dispersed within the quarters being used presently, they may not be combined. In this case, it is proposed to use the said dilapidated quarters as separate small business units, namely pre-schools, shops, and SSEs. However, if BCS permits, then three quarters, shown in

green in Figure 6.2, may be combined and could be used as some training academy (Option-2, Figure 6.2).

Sample Development-2

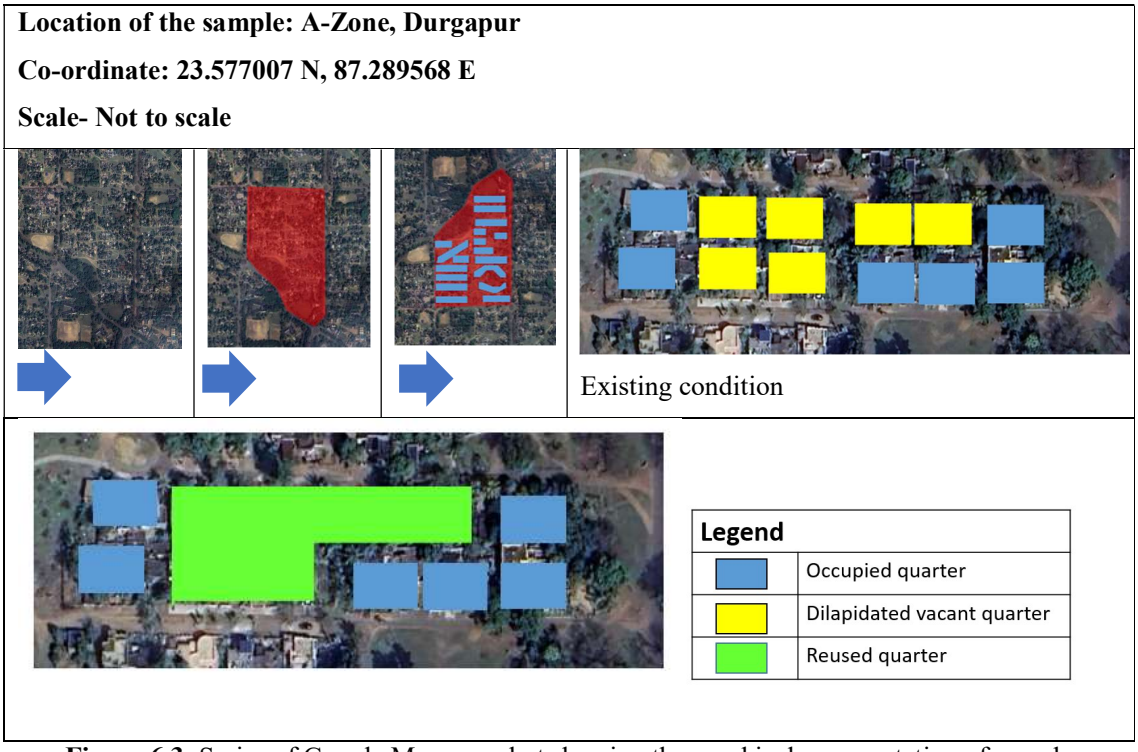


Figure 6.3: Series of Google Map snapshot showing the graphical representation of sample development-2

In this case, since there is a close presence of dilapidated quarters, these quarters can be combined and put to use for those centres, which require a larger area for operation, say, primary schools, Micro-, Small-, and Medium Enterprise (MSME) training centres, etc.

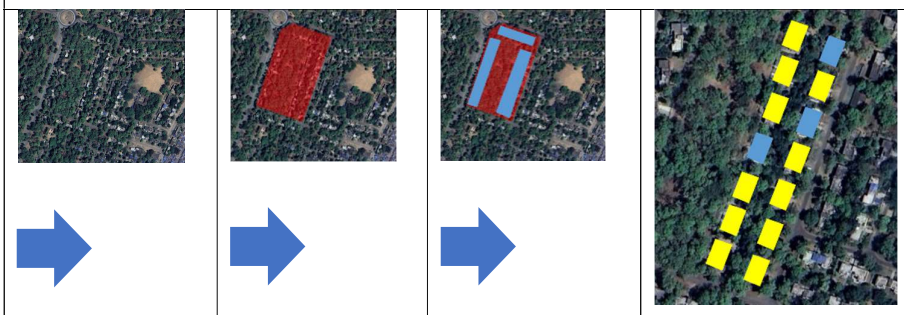
In Fig. 6.4, since there is a close cluster of dilapidated quarters, it is proposed that a multi-storeyed office building be constructed after complete demolition of the existing facilities. The generated employment in this unit could be accommodated in the remaining quarters nearby to reduce the concern of commuting long distances.

Sample Development-3

Location of the sample: MAMC civic area

Co-ordinate: 23.531871 N, 87.322699 E

Scale- Not to scale



Existing condition

Figure 6.4: Series of Google Map snapshot showing the graphical representation of sample development-3

I

Sample Development-4

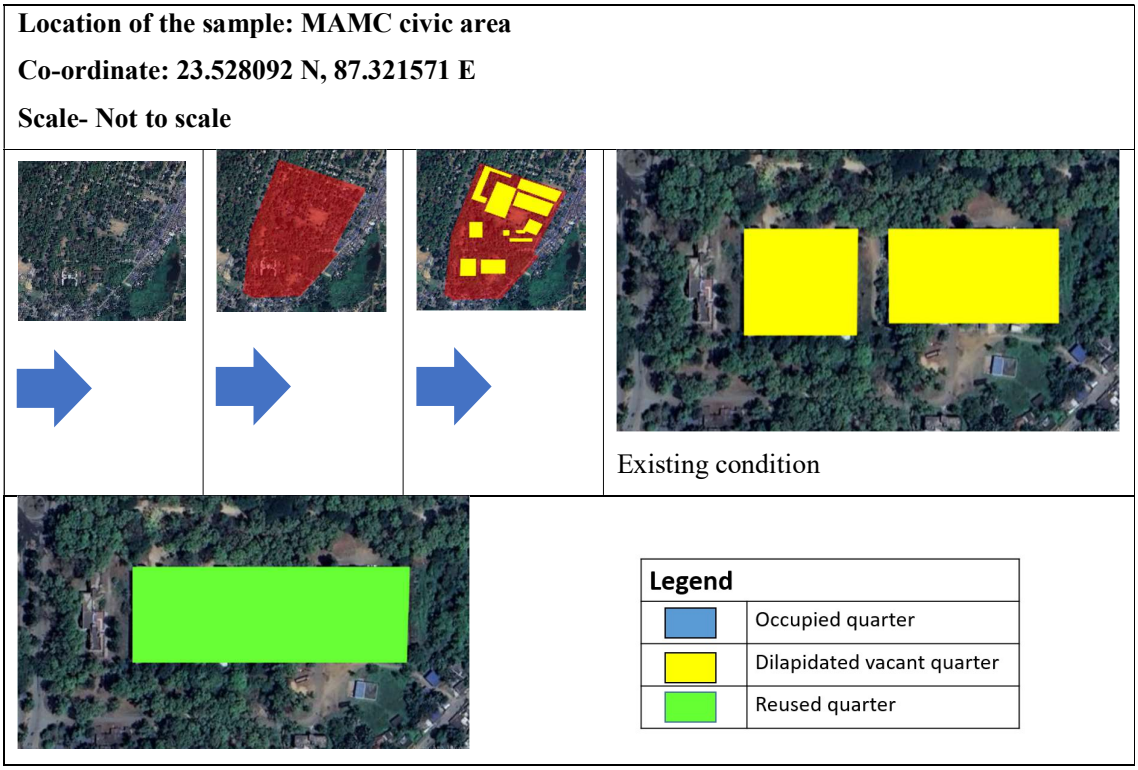


Figure 6.5: Series of Google Map snapshot showing the graphical representation of sample development-4

Due to the existence if large chunk of dilapidated lands in MAMC township, it is proposed that two adjacent buildings be demolished and put to use for a larger structure, namely, hospital, warehouse, sports academy, etc. The main purpose of the above-mentioned samples is to provide insight into the possible use of dilapidated structures, mainly within the industrial civic areas. The use is not restricted only in generating employment, but also to providing various civic amenities, including sports centre, markets, old age homes, etc., which will be compliant to the needs of the town. To provide a residential facility for new appointees in these centres, the nearby quarters can be used after necessary repairs and retrofitting. This kind of use of residential facilities will generate additional service employments.

6.7 Management of Urban Rejuvenation Projects

PMBOK segregates a project into five process groups to meet the desired goal (Project Management Institute, 2021). Here the micro-level job for urban rejuvenation scheme for Durgapur has been segregated as per the PMBOK process groups.

Table 6.6: PMBOK process group and their associated factors in urban development projects for Durgapur

Process Group (As per PMBOK)	Job	Participant	Organization
Initiating	• Identifying the needs of the community • Community awareness program • Meeting with community • Meeting with possible investor and political counterparts	• Project management consultants (PMC) • Town planning department • State Urban Development Department	• Durgapur Municipal Corporation (DMC) • Asansol Durgapur Development Authority (ADDA) • Department of Urban Development and Municipal Affairs, West Bengal • Steel Authority of India Limited (SAIL)
Planning	• Drafting the objective and requirements in the development plan • Bidding and tender • Assigning job • Capacity building • Defining project scope, boundary	• Town planning department • State Urban Development Department • Local community groups	• Durgapur Municipal Corporation (DMC) • Stakeholder's group • Local community groups • ADDA • SAIL
Execution	• Land acquisition • Construction • Initiation of rehabilitation	• Skilled labor • Executing agency • Local self-help group	• Executing agency • DMC • Local self-help group • ADDA
Monitoring and controlling	• Updating project scope and boundary • Documenting the divergence • Addressing the negative impacts	• Executing agency • Local Town planning department	• ADDA • Executing agency

Closing	• Assessing the outcome with objective and scope • Delineating maintenance guidelines • Rehabilitation • Auditing	• Executing agency • Local town planning department • State urban development department • Auditor	• ADDA • DMC • Department of Urban Development and Municipal Affairs, West Bengal

With the proposed phase-wise segregation of jobs, it becomes necessary to evaluate the progress and success of the project. Criteria have been selected from the existing well-established urban rating systems. Comprehensive Assessment System for Built Environment Efficiency for Urban Development (CASBEE-UD), LEED for Neighborhood Development (LEED-ND), Building Research Establishment Environmental Assessment Methodology (BREEAM), and Green Star Communities are some of those systems (Ali-Toudert, Ji, Fahrmann, & Czempik, 2020) (Tilaki & Marzbali, 2014). The physical condition of a structure, its economic implication, and socio-cultural impact are the factors that are set to evaluate the efficiency of the project management procedure.

Table 6.7: Factors to evaluate urban development projects in Durgapur

Physical condition of the structure	Economic viability	Socio-cultural impact
• Building condition Services • Access to pedestrian and vehicular movement • Recreational facility • Healthcare service • Future expansion	• Revenue generation • Proportion of secondary and service sector • Employment Opportunity • Generation of tax	• Accessibility of the community in the project • Facility availed by low-income groups • Disabled people's concern • Placement of public opinion in legal platform • Dispute addressing system • Educational opportunity

6.8 Local Managerial Issue in Managing Development Project

During the project sanction, political and bureaucratic affirmation might prove lengthy sometimes. DMC and ADDA prioritize schemes after finalization of funding. However, fund availability should also be analyzed alongside prioritizing the projects. Feasibility analysis for regional development projects is generally conducted by the private enterprises or research institutions before a nod from the state urban development board. Often political and social interests conflict and delay the proceedings. Stakeholders' input from societal committees is essential during development work to understand the

project's impact on society. A centrally controlled web-application-based monitoring and control system, like the one used by Bengal Aerotropolis Projects Limited in Andal, might come in handy. This system integrates the supply chain management, work progress control, and financial control systems utilizing a project management software like Primavera or Basecamp with proper manpower training for effective handling. Development projects are typically outlined by research institutes or consultants involving in-house experts like town planners, economists, architects, and civil engineers at times. Deviations often occur while execution when responsible organizations (an institute or a consultant) aren't involved, causing gaps between forecasted scenarios and actual requirements, when internal teams from ADDA or DMC struggle to reorient the schemes considering existing conditions due to mixed responsibilities, generating ethical and quality issues. In addition, the responsible contractor company hires necessary staff only during the execution phase to minimize manpower hiring charges, while closing phases often provide valuable learnings that currently, lack documented inventory within DMC and ADDA offices. It leads to loss of knowledgebase. Transfer of officials can further aggravate the situation. Forming co-ordination committee and internal development team could be a solution.

6.9 Implementation Strategy for Industry Transition

Implementing a development strategy in the Indian context necessitates obtaining both legal and institutional support from the local municipality. The provision of legal support is accomplished through various laws, while institutional support is obtained from the development documents prepared by the authorized organization, i.e., LUDCP. Durgapur has already begun its transition from metallurgy to service sectors, such as Information technology (IT), educational institutions, and non-metal production, etc. The strategy for industrial transition holds for two types of industrial scenarios, one that involves an established industry expanding into new business areas, leading to a transformation from one type of business profile to another, while the other scenario entails the entry of a completely new player in the study area.

A combination of these two scenarios constitutes the transition process within the industry. Researches indicate that solution selling is often employed as a primary strategy, utilizing a blend of both products and services (Davies, Brady, & Hobday, 2007; Fang, Palmatier, & Steenkamp, 2008). The establishment facilitates a collaborative atmosphere for the manufacturing industries to transition into the service sector by utilizing their expertise in manufacturing. The metallurgy and manufacturing sectors in Durgapur have demonstrated their ability to identify various types of system solutions, indicating that they are already taking steps towards offering service-oriented solutions. The Ghareka platform is one such example by Shyam Steel. To effectively address this situation, it is necessary to prioritize the broader needs and circumstances of customers while facilitating their transition. By utilizing Porter’s model in conjunction with the AHP analysis, the most favorable competitive industry

within the city has been identified. Consequently, there will be a shift from metallurgy-based industries towards those focused on meeting consumer demands. This transformation encompasses service sectors such as IT consulting, and metal-affiliated automobile manufacturing, as well as employment opportunities provided by educational institutions like schools and colleges. Durgapur plays a significant role as a promising provider of employment opportunities, not only in the automotive and other metal-related industries but also in service sectors like IT. This has been endorsed by the Confederation of Indian Industry, CII, as well (Sethi, 2022). Additionally, Durgapur is recognized as an emerging destination for IT within India. To expedite this development, local government authorities have taken steps such as providing training to personnel and designating Special Economic Zones, SEZ. Hence, a stepwise list of actions to support the transition is given below.

Step-1: Assessing the land based on their industrial productivity.

Step-2: Designating land for industrial purposes in strategic locations through LUDCP, CDP and other development documents.

Step-3: Develop manpower for upcoming industries through training and fostering skilled professionals.

Step-4: Providing legal support during land acquisition. RFCTLARR Act 2013 (The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation, and Resettlement Act, 2013) is helpful in this case.

Step-5: Encouraging schemes for investors to set up business, i.e., providing subsidized land and tax benefit.

Step-6: Providing infrastructural support for the upcoming industries.

Step-7: Product identification. At the outset, established manufacturing companies will adopt a solution-oriented approach leveraging their expertise in core products. The emerging industry will play a supporting role during this transition phase. Automation plays a pivotal role in contemporary manufacturing and these upcoming IT sectors will reinforce this further.

Chapter 7: Conclusions

7.1 Observations

This research highlights the complex challenges faced by the Government-run Indian steel cities like Durgapur, particularly in the context of the industrial decline and urban transformation initiated by the WTO agreement, 1995. The findings of the study indicate that while these cities gradually developed into economic hubs, many industries presently struggle with infrastructure deterioration, economic stagnation, and social challenges. The application of Porter's framework and the Analytical Hierarchy Process (AHP) has provided a structured basis to assess competitive advantages of supplementary industries that could add to present employment count and could be a useful strategy for revitalization of the present study area.

A key observation is that there is limited availability of comprehensive studies focused on Indian steel cities, necessitating an extensive review of case studies across the globe and their adaptation in the local context. The interdisciplinary nature of this research, combining strategic management, urban planning, economic analysis, and geospatial techniques, has reinforced the importance of integrated planning approaches to address industrial decline. Field studies and stakeholder interactions further underscored the need for data-driven decision-making to inform sustainable urban development strategies.

Overall, this study contributes to the discourse on industrial city transformation by offering a methodological framework that can be applied to similar urban contexts. The findings emphasize the necessity of policy interventions, infrastructure investment, and economic diversification to ensure the sustainable development of steel cities in India.

7.2 Contribution

Durgapur was originally conceptualized as a steel city. However, over time, many small supporting industries developed till the 1990s. With the globalization though the WTO agreement in 1995, closure of multiple industries exacerbated economic challenges and curbed job opportunities that in the long run contributed to the deterioration of civic infrastructure due to reduced need and lack of maintenance during the last thirty years. To facilitate the regeneration of Durgapur, it is essential to introduce some viable supplementary employment facilities for economic diversification and create additional job opportunities. Infrastructural requirement for the added employment can be catered by repairing and reusing the surplus facilities within the Steel and MAMC Townships, necessitating minimal investment.

Based on the main research objective, the contribution of the thesis are as follows.

a) Assessing the degrading employment opportunities and amenities in the study area.
b) Ranking the supplementary employment opportunities according to their competitive edge in the present market conditions in Durgapur.
c) Detecting the growth direction and nature of growth consolidation in Durgapur.
d) Making efficient use the surplus civic facilities in Durgapur according their structural health.

7.3 Strategies and Recommendations

Based on the research and subsequent analyses, the strategies and recommendations are as follow:

I. If the industries have forward and backward integration, the raw material price constraint and supply chain is smoother (with corresponding addition in basic employment), while the ancillary industries produce end-products which have retail marketability and adds to the service employment.
II. The employment opportunities of the city should be diversified, with more emphasis on tertiary sectors.
III. The vacant land within the steel township should be conserved during the process of regeneration to retain the original flavour of steel city. They can be developed into organized open spaces, parks and play grounds for mental and physical recreation and activities of the inmates of all ages.
IV. The steel city must be reinstated by SAIL to its past glory and make alternative use of their civic amenities, which would earn revenue.
V. The closed industrial sites under MAMC, HFCL and other industries could be used for ASI sectors. The selection of industries will be such that the attire of the factory town is retained.
VI. The dilapidated quarters of existing/closed industries could be used to host the upcoming employment after necessary structural repair through a proper memorandum of understanding (MoU) between the two organizations, one providing employment and the other offering stay and associated facilities.
VII. The agricultural base of ADDA in the vicinity of DMC should be carefully nurtured to provide adequate supply of fresh agricultural produce, strictly conserving the agrarian land use and purify the air quality.
VIII. The forest and urban forest region in the ADDA should be safeguarded and enhanced to harness the environmental degradation. Trees create noise barrier apart from purifying air.
IX. The riverfront regions by the Rivers Damodar and Ajay could be developed to facilitate recreation and water sport facilities, which could generate revenue while curbing riverbank erosion.

X. A joint committee/ agency must set up to coordinate activities by SAIL and DMC during the regeneration process, so that the two action areas function in tandem and complement each other seamlessly. A quick action can reduce the cost of revival of the aging facilities, which dictated the choice of prediction year only five years hence.

XI. The PMBOK guidelines should be followed, under the mentorship of the aforesaid co-ordination agency while implementing regeneration schemes.

7.4 Scope for Further Research

This thesis specifically focuses on developing and testing a mechanism for the regeneration of an Indian steel city. However, certain aspects could not be comprehensively addressed within the scope of this study and may be explored further in future research.

a) The environmental aspects of the study have been considered only while planning for the location of new industries. However, future research can include the industry-specific environmental issues in a working model.

b) The implications of multiple Central government policy-related issues in addressing the problems in the steel sector warrant for further investigations. The steel industry in most steel towns across India is significantly influenced by government regulations and policies, which can be modelled in an integral form. Currently there are multiple schemes that address one issue at a time, while wellness indicates a complete regeneration.

c) The proposal, if implemented, needs to be reviewed at regular intervals and fine-tune the proceedings. The competitive environment of the industries can be re-assessed and necessary amends be made.

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