



URBAN ENVIRONMENTAL EVOLUTION AND BUSINESS SUSTAINABILITY IN PUNE: A BAI AND IMURA MODEL-BASED ANALYSIS

Dr. Sreenath U

Associate Professor, Department of Economics, National Defence Academy, Pune
Email id: sreenathunni@gmail.com

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Abstract

Urban environmental change is not only a municipal planning concern. It also shapes the operating conditions of firms, industries, workers, markets, and local economic systems. This study examines the environmental evolution of Pune city through the Bai and Imura model and interprets this evolution from a business sustainability perspective. The model classifies urban environmental issues into four categories: poverty-related issues, rapid industrialization-related issues, rapid economic growth-related issues, and wealthy lifestyle-related issues. Using secondary data from Census sources, Pune Municipal Corporation reports, socio-economic surveys, Maharashtra industrial statistics, transport records, and pollution-related institutional sources, the study maps Pune's urban indicators to these four categories. The analysis indicates that Pune has made visible progress in several Type I indicators, including water access, sanitation, literacy, and infant mortality. Type II issues remain important because of the city's strong MSME and industrial base, although selected air pollution indicators remain within prescribed standards in the data used. The city's present environmental pressure is more strongly reflected in Type III and Type IV issues, particularly vehicle growth, two-wheeler dependence, electricity consumption, solid waste generation, e-waste, and lifestyle-related health concerns. The study argues that these issues have direct implications for business sustainability, industrial efficiency, workforce conditions, infrastructure reliability, compliance planning, logistics, and emerging circular-economy opportunities. The paper contributes by extending the Bai and Imura model from an environmental classification framework to a diagnostic framework for understanding the changing business sustainability conditions of a rapidly growing Indian city.

Keywords: Bai and Imura model; business sustainability; MSMEs; infrastructure pressure; sustainable urban management; Pune city.

1. Introduction

Urbanization has emerged as one of the most characteristic processes in the current economic development. Cities focus population, jobs, infrastructure, markets, public service, and innovation systems. They also contribute a significant portion of the economy. Cities contribute significantly to total global GDP and jobs in the private sector, making urban development a key driver of economic growth and employment creation (World Bank, 2024b). Meanwhile, the rapid urbanisation puts pressure on land, transport, housing, water, sanitation, energy systems, waste management, and environmental quality. Such is the future of urban development, which is not only about growth but also about the ability of cities to be more sustainable, resilient, inclusive and economically productive (UN-Habitat, 2022).

In developing economies, urban development tends to go hand in hand with industrial growth, the informal sector, insufficient infrastructure, and growing consumption, making this relationship particularly significant to these countries. The UN expects a continued significant growth in the urban population, with almost 68 per cent of the world's population projected to be urban in 2050 (United Nations, 2019). India is a heart of the transition. It is expected to attract many people, undergo economic changes, and offer infrastructure for industry, services and entrepreneurship to its cities. The advantages of urbanization, however, are not given. Cities can create agglomeration benefits, but congestion, environmental stress, public health dangers and higher operating costs can also result when urban systems don't keep up with economic expansion.

Pune is a relevant case study to analyse this relationship. The city has transitioned from a regional urban center to a large economy based on industry, education, services and technology. It supports a large number of micro, small and medium enterprises, large industries, growing commerce, growing vehicle ownership and electricity/urban service demands. This builds the relevance of Pune's environmental transition not just for urban planners, but also for the firms, MSMEs, industry associations, workers, investors and sustainability managers. An environmental change in such a City changes the business environment. It impacts on labour health, commuting time, logistics efficiency, waste responsibilities, resource usage, compliance exposure and the long-term competitiveness of the urban economy.

The Bai/Imura model is a helpful one for exploring this transition. The model assumes that urban environmental change is an evolutionary process, that is, various types of environmental problems emerge in cities at various stages of evolution. It comes up with four general types: Type I poverty related issues, Type II rapid industrialization related issues, Type III rapid economic growth related issues, and Type IV wealthy lifestyle related issues (Bai & Imura, 2000). In the original environmental literature, this classification is useful to describe the transition of urban environmental challenges as urban growth occurs. The same framework may be applied to the external business environment of a city to understand the changes in the external environment of a city over time. The social and health status of the labour force is affected by poverty-related issues. Industrialization related issues impact resource efficiency, production systems and compliance. Mobility, energy consumption and logistics and their impact on infrastructure reliability are influenced by growth related problems. Lifestyle-related issues generate new challenges and opportunities in waste management, e-waste, sustainable consumption and health services and circular-economy business models.

In the present study this extended meaning is taken to explore the evolution of the environment in the city of Pune. The primary aim of the analysis is to identify the scope of Pune in the framework of Bai and Imura through indicators of population, slums, income, health, water, sanitation, literacy, industrial composition, pollution, vehicle growth, electricity consumption and waste generation and health concerns related to lifestyle. The study's contribution is in interpreting these indicators in the framework of business sustainability and urban economic management. This is crucial because the impacts of urban environmental issues are increasingly tied to business continuity, infrastructure costs, regulatory demands, employee productivity, both market opportunities and strategic decisions around sustainability.

The study thus suggests that the implementation of municipal policy in addressing Pune's transition towards type III and type IV issues cannot be viewed exclusively as a study of municipal policy. It

should also be considered a business and management issue. Vehicle growth, dependence on two-wheelers, electricity, solid waste, e-waste, and health concerns related to lifestyle suggest pressures that can impact productivity, cost structure, reliability of urban services, and the sustainability strategies of businesses in the city. The concurrent pressures also provide opportunities to develop cleaner technologies, energy efficiency, recycling, green services, e-waste management, sustainable packaging, and circular economy entrepreneurship. The relevance of the study is that it establishes a link between the evolution of urban environment and the economic activity in Pune.

1.1 Research Gap and Objectives

Most of the research existing on urban environmental evolution was based on stage and/or classification aspects in order to understand the evolution of urban environmental problems as a result of urbanization and economic development. One of the most important aspects of the model is the fact that the problem of environment in the city does not occur in a linear and fixed way, as is the case with the Bai and Imura model. Rather, their environmental profiles are a result of moving mixes of poverty, industrialization, economic development, consumption, institutional capability and urban policy interventions (Bai & Imura, 2000). This approach to research has helped to inform urban environmental planning by demonstrating the change of urban environmental priorities at various stages of urban development.

But the business and management implications of this change are not well developed. Urban environmental change is frequently perceived as a planning, pollution control or a municipal management problem. There is less focus on the impact of such change on firms, MSMEs, industrial clusters, users of urban infrastructure, workers, commercial establishments, and sustainability-minded managers. This gap matters because the environment in cities can impact the costs and viability of operating a business. Unsanitary and ill health circumstances can impact on the stability of the workforce. Compliance risks and reputational risks can be heightened due to industrial pollution. Logistics can be less efficient if there is congestion. Firms may be vulnerable to energy-related cost pressures due to their high electricity consumption. Regulatory obligations and new opportunities for circular economy arise from waste and e-waste.

This study aims to fill that void by applying the Bai and Imura model to the city of Pune and interpreting the model results using a business sustainability lens. Does not make causal estimates at the firm level. Rather, a descriptive and analytical approach by secondary indicators, a case-study method is applied. The aim is to categorize the environmental development of Pune and then link the categorization with the changing business environment of Pune.

The study has the following specific objectives:

1. To classify Pune's urban environmental issues using the Bai and Imura Type I–IV framework.
2. To examine how Pune's environmental transition reflects changes in poverty-related conditions, industrialization pressures, economic growth pressures, and lifestyle-related pressures.
3. To interpret these environmental categories in relation to business sustainability, MSME operations, workforce conditions, infrastructure pressure, resource efficiency, and urban economic management.
4. To identify managerial and policy implications for firms, MSMEs, industry stakeholders, urban planners, and policymakers concerned with sustainable urban economic development.

2. Literature Review

2.1 Urban Environmental Evolution and the Bai and Imura Model

Bai and Imura (2000) has created a stage model of urban environmental evolution, which was applied to analyze the evolution of urban environmental issues in the East Asian cities. Their typology categorizes urban environmental issues into four types: Type I – poverty related issues, Type II – rapid industrialization related issues, Type III – rapid economic growth related issues, and Type IV – rich lifestyle related issues. The model is helpful because it does not assume that problems in the environment are immutable or the same everywhere. It acknowledges that urban environmental profiles vary depending on changing economic structure, infrastructure provision, income growth,

institutional capacity and policy response of cities. The model also does not require a linear interpretation since many cities have multiple problems that occur at multiple stages.

The Bai and Imura model is used in this study not only as an environmental classification tool, but also as a diagnostic tool for the sustainability of businesses. The four issue types are understood within the context of the workforce, industry compliance, mobility, energy consumption, waste management, opportunities for circular economy and managerial decision-making.

2.2 Urbanization, Business Sustainability, and Urban Economic Systems

The recent literature on urban sustainability has focused on the need for cities to be considered both economic and environmental systems. Productivity, inclusion, infrastructure, resilience and ecological quality are all areas that need to be addressed in concert for sustainable urban development (UN-Habitat, 2022). Important for the research of business and management is the relevance of this for the business processes, for the functioning of business organizations and for their dependence on the quality of urban systems. Poor transport facilities can result in longer commute times and logistics costs. Lack of good waste governance can lead to compliance and reputation risks. Sick workers and poor health conditions can impact worker productivity and absenteeism. Energy and water systems that are not reliable can increase operating risks. The issues presented here indicate that the quality of the urban environment can affect the cost and dependability of business activities.

Industrialization, MSMEs concentration, vehicle growth, electricity consumption and waste generation are all characteristics of a complex urban economic system which can be seen in the context of Pune. The business perspective on the evolution of the environment can provide insights into how the environmental pressures at the city level turn into managerial and economic issues.

2.3 MSMEs, Industrial Sustainability, and Environmental Management

Micro, Small and Medium Enterprises (MSMEs) form the backbone of MSME Industry in Pune and also these enterprises are significant in terms of business relevance in the present study. This makes Type II environmental issues not just a pollution control issue but an issue of industrial sustainability and competitiveness as well.

The literature on SME and MSME sustainability indicates that SMEs are not only economically relevant but also these smaller businesses may face limitations in terms of sustainability oriented practices. Some of these restrictions are financial ones, such as limited funding, but also include a lack of technical knowledge, poor access to clean technology, poor managerial capacity, and uncertainty about return on investment from environmental investments. Zaman et al. (2025) demonstrate that sustainability in SMEs is multi-dimensional and that it is associated with environmental responsibility, resilience, competitiveness and long-term strategic adaptation. This is significant as sustainability pressures can be identified by smaller enterprises; however, they may not always have the capacity and/or resources to effectively respond.

Some recent studies also highlight some facilitators and barriers for sustainable business in SMEs. Sustainable business practices in SMEs are found to be influenced by interacting enablers and barriers, such as technological readiness, digital transformation, pressure from green consumption, vendor support, and constraints related to implementation of sustainable business practices (Basit et al., 2024). Meanwhile, implementation challenges are substantial, particularly in developing economy settings where companies might have financial, operational and institutional limitations. The findings are applicable to the city of Pune as a city with a high concentration of MSMEs needs more than general environmental regulation. It needs enabling systems to facilitate and promote the implementation of cleaner production, waste minimization, energy efficiency and compliance by smaller firms.

The Bai and Imura framework includes industrial pollution, industrial solid waste, resource use and inadequate pollution controls as Type II problems. These are well connected with the issue of industrial sustainability. Environmental indicators, such as SO₂, suspended particulate matter, electricity consumption in industry, and industrial waste, are also indicators of management decisions regarding production technology, compliance, process efficiency, and resource use. The existence of MSMEs and large industrial units in Pune also creates an obligation to consider environmental

management issues for employment, competitiveness, operating costs and economic sustainability of the city.

2.4 Urban Growth, Infrastructure Pressure, and Circular-Economy Opportunities

Mobility is an important component connecting urban development and business performance. The transportation of workforce, goods, customers, and services is vital to the operations of firms. Congestion and delays to travel can increase when the number of vehicles increases more rapidly than the capacity in public transport and road infrastructure. This impacts employee commuting, logistics efficiency, delivery schedule, parking needs, customer access, and urban cost. Recent studies on congestion and logistics also demonstrate the cost of congestion, lower service quality and deterioration of urban freight efficiency due to congestion (Frąckowiak et al., 2025). The percentage of two-wheelers among registered vehicles could thus be taken as an indicator of both environmental issues and a sign of mobility stress in the urban business system in Pune.

The type IV issues are related to lifestyle change, increased consumption, and secondary waste. Solid waste, e-waste, commercial waste and lifestyle related diseases in Pune are signifying the importance of responsible consumption, waste system, and health oriented business practices.

Circular economy literature can shed light on why Type IV issues are also opportunities for businesses. The principles of circular economy focus on minimizing waste, maximizing product value, maximum reuse and recovery and redesigning products and systems. The authors Möslinger et al. (2023) believe that CE and waste management measures can contribute to climate neutral urban futures, through the reduction and optimization of waste flows. The same angle is applicable for Pune as solid waste and e-waste should not be considered as a problem merely at the end. They also offer possibilities for the recycling industry, e-waste processors, repair shops, sustainable packaging companies, green logistics companies and recycling companies.

3.1 Research Framework and Methodology

3.1 Research Framework: Bai and Imura Model with Business Sustainability Extension

The Bai and Imura model has been taken as the core model in the classification of urban environmental evolution in Pune. Bai and Imura (2000) divide the urban environmental problems into four categories: poverty-related, rapid industrialization-related, rapid economic growth-related and wealthy lifestyle-related.

In this article, the Bai and Imura framework is further extended with the perspective of business sustainability. The interpretation of each environmental category is related to the business operating, the urban economic system and the managerial decision making. This enables the linkage of Type I to Type IV issues with workforce conditions, industrial sustainability, infrastructure pressure, resource efficiency, waste systems, opportunities for circular economy and workplace wellbeing.

Table 1 shows the analytical framework in this research. The four environmental categories of Bai and Imura are included in the table and an interpretation of business and management is added for each category.

Table 1. Extended Bai and Imura Framework for Urban Environmental and Business Sustainability Analysis

BAI AND IMURA ISSUE TYPE	ENVIRONMENTAL FOCUS	PUNE INDICATORS USED IN THE STUDY	BUSINESS AND MANAGEMENT INTERPRETATION
Type I: Poverty-related issues	Basic urban deprivation, inadequate infrastructure, unsafe water, sanitation gaps, and health vulnerability	Population growth, slum population, per capita income, infant mortality rate, drinking water access, toilet facilities, literacy	Workforce health, labour stability, human capital, basic urban service reliability, and inclusive urban economic foundations

		rate	
Type II: Rapid industrialization-related issues	Industrial pollution, emissions, industrial waste, resource use, and pollution-control capacity	MSME units, large-scale industrial units, MSME employment, SO ₂ levels, SPM levels, industrial electricity use	MSME sustainability, cleaner production, compliance capacity, environmental risk management, industrial efficiency, and sustainable competitiveness
Type III: Rapid economic growth-related issues	Motorization, rising resource demand, transport pressure, and growth-related pollution	Registered vehicles, two-wheeler share, electricity consumption, commercial and industrial electricity use, NO _x levels	Logistics efficiency, employee commuting, congestion cost, parking pressure, commercial accessibility, energy dependence, and infrastructure reliability
Type IV: Wealthy lifestyle-related issues	High consumption, solid waste, e-waste, lifestyle-related disease, and ecological pressure beyond basic urban needs	Municipal solid waste, e-waste, source-wise waste generation, garbage collection practices, lifestyle-related diseases	Circular-economy opportunities, waste management enterprises, sustainable packaging, responsible consumption, corporate waste responsibility, and workplace health

3.2 Research Design

The study is descriptive and analytical with Case Study design. The city of Pune is considered as the case city due to the fact that it has a mix of all the above factors: demographic growth, industrial activity, concentration of MSMEs, pressure on transport, electricity demand, and changing electricity consumption.

Document-based analysis is also employed in the study, due to the fact that the data sources are based on census material, municipal reports, socio-economic surveys, transport data, industrial statistics, and institutional sources related to pollution. Document analysis is suitable when official and institutional documents can be used to evidence social, economic and environmental conditions (Bowen, 2009).

3.3 Data Sources and Indicator Selection

The study is based on secondary sources like Census of India (1971–2011) material, Pune Municipal Corporation reports, Regional Transport Office data, Pune Socio-Economic Survey (2013), Central Pollution Control Board (CPCB) material and National Institute of Urban Affairs (NIUA) urban statistics. These are suitable because it is a city-level study of environmental and economic indicators. The indicators are selected based on the four categories of Bai and Imura. Type I Indicators: Population, Slum population, Income, Infant Mortality, Drinking water, Sanitation, Literacy. MSMEs, industrial employment, industrial resource use, large scale industrial units, SO₂ and suspended particulate matter are Type II indicators. Vehicle stock, two-wheeler share, electricity consumption and NO_x concentration are all examples of type III indicators. Solid waste, e-waste, commercial waste, garbage disposal practices and lifestyle-related diseases are all type IV indicators.

3.4 Analytical Approach

The analysis is carried out from the following steps: classification of indicators, description comparison, interpretation of business-sustainability, and synthesis of managerial and policy implications. The chosen indicators are then correlated to the four types of issues outlined by Bai and Imura (2000) and later explained with reference to the urban business environment of Pune.

The analysis is interpretive and classification based. It does not rely on econometric tests due to the fact that data are obtained from various institutional sources and different time periods. The study thus does not claim to make causal statements about the performance of firms, and emphasizes implications for business from city-level indicators.

3.5 Scope and Limitations of the Method

The study was confined to the city Pune and the secondary indicators. It is not based on first survey data, regression analysis or causal estimation. The results should thus only be interpreted as a descriptive and analytical classification of the environmental evolution of Pune and the implications for business sustainability.

The primary constraint is that some of the data sources are not all of equal age or uniformity. Some indicators rely on information from Census 2011, socio-economic surveys from previous years, and on previous municipal or environmental reports. This restricts the study from reflecting the latest urban scenario in Pune. Despite these limitations, the data available can still be a valuable resource to understand the general direction of the evolution of the environment, and to illustrate how the framework of Bai and Imura can be expanded to analysis of business sustainability. The approach could be further strengthened by leveraging newer Census data, recent municipal environmental indicators, firm-level surveys, MSME sustainability data, transport analytics as well as longitudinal infrastructure data.

4. Results and Case Analysis

The results are presented in the order of the four issue types distinguished in the model proposed by Bai and Imura. The relevant environmental indicators are explored for each issue type and then the issue type is interpreted with a business sustainability lens.

4.1 Type I Issues: Poverty-Related Urban Conditions and Workforce Foundations

The poor health of type I issues in the Bai and Imura model is linked to poverty, inadequate infrastructure, unsafe drinking water, poor sanitation, low health capacity, and basic urban deprivation (Bai & Imura, 2000). In the business sustainability environment, these indicators are important because they affect the health of the workforce, stability of households, the reliability of labour and human capital formation.

Pune's population, as seen in Table 2, increased from 488,419 in 1951 to 3,115,431 in 2011. The rate was greatest during the 1981-1991 decade, and slowed in the 2001 and 2011 decades. This trend indicates the continued urban growth of Pune but with relatively stabilized growth in recent decades. Demographic basis for assessing urban service pressure and labour-market expansion is given by population trend (Census of India, 2011).

Table 2. Population Growth of Pune City, 1951-2011

CENSUS YEAR	POPULATION	DECADAL CHANGE	% CHANGE
1951	488419	118358	24.2
1961	606777	249328	41.1
1971	856105	347258	40.6
1981	1203363	488067	40.6
1991	1691430	847043	50.1
2001	2538473	576958	22.7
2011	3115431	118358	24.2

Source: Census of India (2011).

Population growth has also been linked to slum growth. As seen in Table 3, the slum population increased from 92,101 in 1961 to 1,025,000 in 2001, while its share rose from 15.18 percent to 40.38 percent. This is indicative of lack of affordable housing, formal systems, sanitation and safe living conditions. It has also a business relevance as informal and low-income workers provide support for the construction industry, services, transport, retail trade, domestic work, and for small-scale production.

Table 3. Slum Population and Urban Growth in Pune City

YEAR	TOTAL POPULATION	SLUM POPULATION	SLUM POPULATION (%)	GROWTH RATE CITY (%)	GROWTH RATE SLUM POPULATION (%)
1961	606777	92101	15.18	2.19	9.63
1971	856105	239701	28	3.50	10.04
1981	1203363	377000	31.33	3.46	4.63
1991	1691430	569000	33.64	3.46	4.2
2001	2538473	1025000	40.38	4.14	6.06

Source: Census of India (various years).

Income indicators in show that the per capita income of Pune was above the national and state averages for the time period of the available data. This indicates that Pune had already built up a more robust urban economic foundation than many other areas. With a higher per capita income, better access to health care, education, housing and services can be achieved. But, rising income is not enough to reduce inequality or vulnerability to settlement. As revealed in Table 4, there is the presence of increasing income along with a large population of slum dwellers in Pune, which suggests that urban economy of Pune has expanded, but not in an inclusive manner.

Table 4. GDP and Per Capita Income Indicators for Pune City

	MAHARASHTRA STATE GSDP (in crores)	PUNE CITY-GDP (in crores)	PER CAPITA INCOME OF PUNE CITY
1999-00	243178	10632	45168
2000-01	238875	10235	41871
2001-02	265582	11013	43384
2002-03	295191	10574	40111
2003-04	310000	12671	46313

Source: Pune Municipal Corporation (2009).

The health indicators also indicate improving basic urban conditions. The infant mortality rate decreased from 2001 to 2011, falling from 32 deaths per 1,000 live births to 22, reflecting progress in maternal and infant care, ease of access to public health services and the wellbeing of households. In the context of the Bai and Imura framework, this implies the presence of some urban health pressures that have been mitigated because of poverty.

Another indicator of Type I transition is water access. As can be seen in the data in Table 5, a significant percentage of the population in Pune had access to individual water connections, whereas a lesser proportion had access to community taps, hand pumps, tube wells, tanker supply or other sources. Figure 1 shows that improvement in basic urban infrastructure is reflected by the availability of piped water through municipal supply. The study also mentions that the water quality is maintained as per IS 10500. This is significant as water safety and security decreases the danger of ailments and also enhances household stability. The indirect benefits for businesses include added reliability in the labor force, improved workplace attendance and the functioning of the urban economy. Limited water

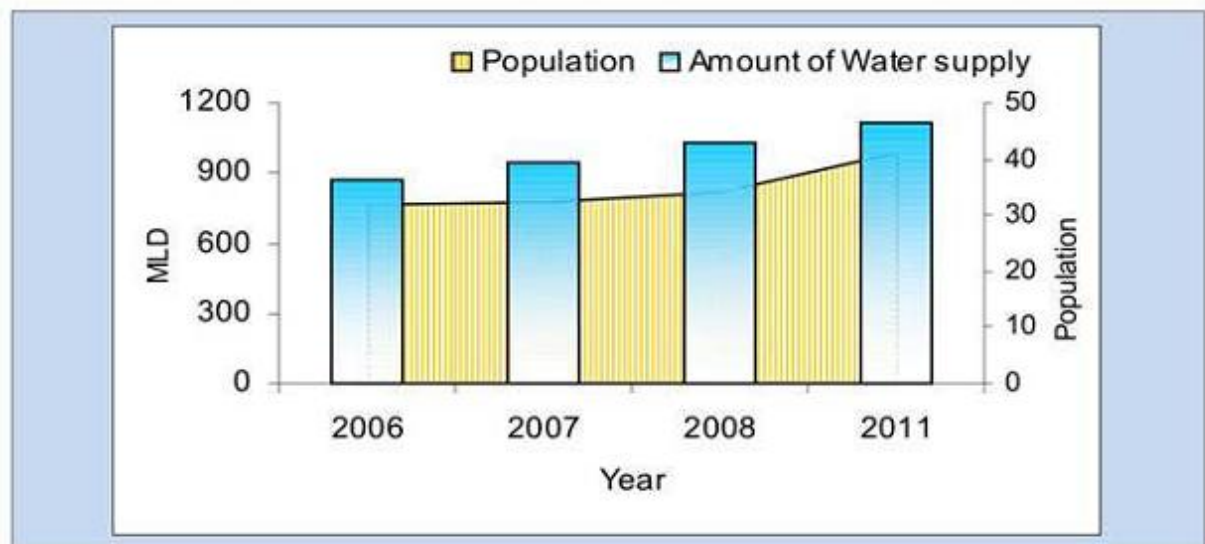
accessibility would make workers and their families more vulnerable to health risks, and impact the quality of urban life.

Table 5. Household Water Sources in Pune City

SOURCE	PERCENT
Individual Connection	80.67
Community Tap	16.52
Private Hand Pump	0.18
Tube Well	0.43
Tanker Supply	0.32
Community hand Pump	0.23
Others	1.65

Source: Pune Municipal Corporation (2009).

Figure 1. Population and Amount of Water Supply in Pune City



Source: Pune Municipal Corporation (2009).

Progress is the same in sanitation indicators as well. Table 6 shows that 57.6 percent of the peoples were provided with attached toilets and 40.0 percent of the peoples were provided with common toilets and only 2.4 percent of the peoples had no toilet facility. This implies that about 97.6 per cent of people had access to common or private toilet facilities. Sanitation access is a key Type I indicator in the Bai/Imura model because it is an indicator of the mitigation of basic urban deprivation. Sanitation access translates to improved living conditions, reduced exposure to waterborne diseases, and improved wellbeing of the workforce in business terms. It also portrays the ability of the city to offer basic infrastructure to sustain high density economic activities.

Table 6. Access to Toilet Facilities in Pune City

TYPE OF TOILET	PERCENT
Attached toilet	57.6
Common toilet	40.0
No toilet	2.4
Total	100

Source: Pune Municipal Corporation (2009).

The literacy data detailed in Table 7 also reflect Pune's progression away from multiple Type I constraints. The proportion of people who could read in the Census 2001 was 76.29 per cent, which

rose to 83.63 per cent in the Socio-Economic Survey 2008-2009 and 88.15 per cent in the UNICEF study 2011. This increases human capital and promotes employability, training, communication in the workplace and awareness of compliance.

Table 7. Literacy Rate Indicators for Pune City

	2001 Census	2008-09 Socio-Economic Survey	2011 UNICEF Study
Literacy Rate (%)	76.29	83.63	88.15
Illiteracy Rate (%)	23.71	16.36	11.85

Source: Census of India (2001), Pune Municipal Corporation (2009), and UNICEF (2011).

Overall, Pune shows signs of having outgrown the most critical Type I pressures, particularly with the water, sanitation, health and literacy aspects. But the fact that slum settlements continue to exist indicates that vulnerability to the poverty-related factors is still a concern. The results suggest that basic urban services continue to be critical for labour stability, human capital formation and inclusive urban economic outcomes.

4.2 Type II Issues: Industrialization, MSMEs, and Environmental Management

Rapid industrialization, industrial pollution, inadequate emission treatment and pressure on air, water, land and resource systems are understood as factors that relate to Type II issues in the Bai and Imura model (Bai & Imura, 2000). These challenges are additional in industrial cities, and are connected to compliance capacity, cleaner production, operating costs and long term sustainability of business.

The issues are especially important in Pune, where the industrial character of the area makes Type II issues very relevant. As per the data presented in table 8, there were 56,663 MSME units with an employment of 301,098 in Pune and 668 large scale units with an employment of 230,681. Pune was the region which had the maximum number of MSMEs in the list. This is a good indication that the environmental change in Pune needs to be looked upon as an issue of sustainability in industries and businesses.

Table 8. MSMEs, Large-Scale Industrial Units, and Employment in Pune and Other Regions of Maharashtra

City	MSMEs		Large-Scale Units	
	Units	Employment	Units	Employment
Pune	56663	301098	668	230681
Mumbai	12341	130672	256	106214
Konkan (Exl Mumbai)	24747	296703	1021	93466
Nashik	22727	165985	289	75862
Nagpur	16017	136204	248	79286
Aurangabad	11672	102076	142	41936
Amravati	7328	55443	49	8192
Maharashtra	151495	1188181	2670	635637

Source: Government of Maharashtra (2010).

The MSME percentage in Pune indicates the city's significance not only as an industrial hub and a city of entrepreneurs but also questions its ability to manage the environment. Finance, technical ability, access to cleaner production, and readiness to comply are among the constraints that smaller firms may experience. According to the sustainability research of SMEs, managerial commitment, technological readiness, financial ability, institutional support, pressure of green consumption, and

implementation obstacles are the key factors that influence sustainable business practices (Basit et al., 2024; Zaman et al., 2025).

Air pollution indicators are useful tools to evaluate the severity of the Type II industrialisation-related problems. Table 9 shows that the SO₂ concentration in Pune lay in the range of 17.1-29.0 µg/m³ and the concentration of SPM ranged from 112.0-166.5 µg/m³. These SO₂ and SPM levels for Pune were in compliance with the SO₂ and SPM limits as prescribed in the data set when compared with several other million-plus cities in India.

Table 9. SO₂ and SPM Levels in Pune and Selected Million-Plus Indian Cities

	(micrograms/m ³)	
City	SO ₂	SPM
NAAQ/Standards	15.0 - 80.0	70.0 - 360.0
Mumbai	6.1 - 111.7	60.6 - 473.2
Calcutta	6.0 - 122.0	77.3 - 833.3
Delhi	10.1 - 85.1	145.3 - 929.8
Hyderabad	5.1 - 70.7	59.3 - 458.0
Ahmedabad	5.4 - 110.9	72.4 - 575.4
Pune	17.1 - 29.0	112.0 - 166.5
Kanpur	8.2 - 22.4	233.7 - 809.2
Lucknow	23.2 - 37.4	382.6 - 672.7
Nagpur	4.3 - 18.8	38.2 - 403.2
Surat	22.4 - 304.0	81.7 - 1215.3
Jaipur	6.1 - 53.7	81.6 - 570.1
Kochi	3.2 - 54.3	10.5 - 271.1
Indore	2.6 - 10.2	77.0 - 812.0
Coimbatore	0.0 - 8.9	2.5 - 133.0
Patna	12.7 - 46.4	132.0 - 1307.0
Bhopal	8.1 - 22.0	85.0 - 393.3
Visakhapatnam	5.5 - 80.8	46.7 - 482.7
Varanasi	18.3 - 27.1	155.0 - 349.0

Source: National Institute of Urban Affairs (2000).

It doesn't imply that the problems associated with industrialization have gone away from Pune. It only implies that the load of SO₂ and SPM is not of an extreme Type II. Pune can thus work towards strengthening their industrial competitiveness by promoting cleaner production, energy efficiency, shared environmental infrastructure and support compliance among MSMEs.

Overall, the results of the Type II analysis indicate that the industrial pollution pressure in Pune appears to have subsided from the worst to a lesser degree, particularly for the indicators of SO₂ and SPM used in this analysis. But environmental management is an on-going issue with the scale of MSME & industrial activity. The capability of compliance, cleaner production, resource efficiency and environmental risk management are therefore essential requirements for Pune's industrial sustainability.

4.3 Type III Issues: Economic Growth, Mobility, Energy Use, and Business Infrastructure Pressure

The Bai and Imura model suggests that type III problems are linked to the growth-related increased demand for resources, motorization, rapid economic growth, growth-induced pollution, and transport pressure (Bai & Imura, 2000). These are manifested in Pune by growth of vehicles, reliance on two-wheelers, electricity use and NO_x levels. The following indicators, outlined in Table 10, outline the impacts of urban growth on the cost, reliability and efficiency of business operation.

Table 10. Registered Vehicles and Two-Wheeler Share in Pune City, 2010-2011

	2010	2011
Total Registered Vehicles	1907711	2093890
Two Wheelers	1418582 (74.36%)	1551968 (74.19%)

Source: Regional Transport Office Pune (2011).

The high percentage of two wheelers means environmental and business considerations. Vehicle growth is a driver of air pollution, congestion, fuel use, and land-use pressures. It also impacts employee commute, delivery times, customer access, parking needs, logistical reliability and work place punctuality. Urban freight congestion can impact the efficiency of urban freight transport, delay related costs, and service quality (Frackowiak et al., 2025).

Another important Type III indicator is electricity use. Industrial consumption was 2,526.1 million kWh and commercial consumption was 522.5 million kWh as presented in Table 11. It also highlights that Pune's economy relies on energy with significant investment in its electricity infrastructure.

Table 11. Sector-Wise Electricity Consumption in Pune City

	Units (Million kwh)
Residential	1351.80
Commercial	522.5
Industrial	2526.1
PMC Buildings	4.96
PMC Street Lighting	38.19
PMC Water Supply	103.82
Others	321.1

Source: Pune Municipal Corporation (2009).

NOx concentration is also a growth related pollution indicator as it is linked to combustion based activity and vehicular emissions. As seen in Table 12, the concentration of NOx in Pune was found to be between 10.1 and 34.0 micrograms per cubic metre, which falls in the prescribed limit in the data set and is lower than some other million-plus cities in India. However, the ongoing growth of the vehicles shows how they will be exposed to pollution pressure in the future related to transport.

Table 12. NOx Levels in Pune and Selected Indian Cities

	Nox
NAAQ/Standards	15.0 - 80.0
Mumbai	5.4 - 115.8
Calcutta	6.0 - 73.1
Delhi	20.1 - 104.5
Hyderabad	7.5 - 124.1
Ahmedabad	3.6 - 70.0
Pune	10.1 - 34.0
Kanpur	7.7 - 63.0
Lucknow	23.0 - 34.4
Nagpur	3.2 - 43.2
Surat	10.0 - 135.7
Jaipur	4.0 - 64.3
Kochi	1.7 - 137.0
Indore	4.4 - 17.4
Coimbatore	0.3 - 19.1
Patna	8.5 - 55.7
Bhopal	12.2 - 32.4
Visakhapatnam	5.1 - 92.0

Source: Central Pollution Control Board (n.d.).

This is backed up by literature on urban mobility. A shift towards other modes of transportation and the enhancement of public transport systems, active mobility and the development of policies to discourage overreliance on private vehicles are essential for sustainable urban mobility (Papadakis et al., 2024). Urban transport also brings people to work and services, and a good public transport system can decrease congestion, travel time and improve access to employment opportunities (World Bank, 2024a).

The evidence on vehicles, electricity consumption and NO_x indicates that the environmental pressures in Pune are more significant than the basic Type I deficits as the city starts to grow. A higher demand for mobility and energy has been created by the city's economic development. These demands include business activity, but in turn also cause infrastructure pressure. This pressure can, if left uncontrolled, drive up costs for companies, decrease logistics efficiency, make commuting more stressful, and make cities less economically sustainable.

In summary, Pune's Type III indicators indicate that environmental pressures around infrastructure are present due to rapid economic growth. The demands for mobility and resources of an expanding urban economy are expressed in the growth of vehicles and the demand for electricity. Energy efficiency, employee mobility, transport-related operational risks, public transport, road-space management and sustainable mobility systems need to be considered in response to these pressures.

4.4 Type IV Issues: Lifestyle Change, Waste Generation, Green Markets, and Business Responsibility

In addition to basic infrastructure issues, type IV issues are linked to wealthy lifestyles, high consumption levels, solid waste, e-waste, lifestyle-related health problems and environmental burdens (Bai & Imura, 2000). In Pune, these pressures are manifested in the form of generation of solid waste, commercial waste, e-waste, garbage disposal habits and lifestyle related diseases.

The estimated amount of solid waste generated in Pune was 885 to 1200 metric tonnes per day (MTCD) during the period under study, which is represented by the data in Table 13. About 400 grams of municipal waste generated per person per day (range from 294 to 540 grams). This is a lifestyle shift in which consumption, packaging, retail activity and growth of service sector start to dominate ecological pressure.

Table 13. Source-Wise Solid Waste Generation in Pune City

SOURCE	PERCENT
Household	40
Commercial	25
Hotels & Restaurants	25
Market Area	5
Vegetable Market	5
Total	100

Source: Pune Municipal Corporation (2009).

The source wise distribution reveals that solid wastes accounted for 50 percent from the commercial establishments, hotels and restaurants and 40 percent from the households. 5 percent each came from market areas and vegetable markets. This reinforces the fact that waste is not a household or municipal problem, it's a business responsibility and a problem for the city.

A total of 2,584 tonnes of e-waste was estimated to be generated in Pune and it was eighth in the list of Indian cities with highest e-waste generation. E-waste is closely associated with the use of technology, the reduction of product lifetimes, and the growth of digital infrastructure. It poses threats in terms of informal deconstruction and mismanaged waste but also offers opportunities for formal recycling, repair, refurbishment, reverse logistics, and resource recovery. Monitoring, circular-

economy approaches and formal processing capacity are essential for effective e-waste management (Bagwan, 2024).

Circular-economy thinking can help to explain Pune's Type IV pressures. It moves away from the concept of disposal towards material recovery, re-use, recycling and value retention. Circular economy strategies can reinforce solid waste management in developing economies and support cities to reduce and optimize waste flows (Mandpe et al., 2023; Möslinger et al., 2023). Therefore, Pune's solid waste and e-waste problems should be taken as opportunities for business innovations and green enterprises development.

As presented in Table 14, 46.2 per cent of households had access to door-to-door garbage collection and 46 per cent to garbage bins. Smaller shares disposed of waste in open spaces, gutters, roads, or other locations. This is a sign that there is improvements in organized collection and that coverage and disposal was not complete.

Table 14. Garbage Collection and Disposal Practices in Pune City

GARBAGE DISPOSAL AREA	PERCENT
Collection at doorstep	46.2
Garbage bins	46
Open space	4.8
Other	2.3
Gutters	0.2
On road	0.6
Total	100

Source: Pune Municipal Corporation (2009).

Lifestyle related diseases are also highlighted as Type IV concern. The proportion of air-borne, water-borne, sexually transmitted and communicable diseases decreased while diabetes and hypertension increased. The pattern of such a shift from deprivation related health problems to lifestyle related health risks has implications for the wellbeing of employees, absenteeism, healthcare expenditure, and workplace productivity.

Overall, Type IV issues have now become pivotal in Pune's sustainability transition. The solid waste, e-waste, commercial waste and lifestyle related diseases show that consumption and business behavior is changing. They also indicate the point of intersection between urban environmental management, business responsibility, and market opportunity.

5. Analytical Discussion

The results suggest that the shifts in the environment in Pune are not linear and happen due to convergence rather than the transition from one to the next. This is relevant as the city still has a residue of poverty related vulnerabilities, particularly through settlements in slum areas, and also has industrial, mobility, energy, waste and lifestyle related pressures. The findings thus corroborate the idea of a multi-layer interpretation of the environmental transition in the city. Earlier urban concerns do not disappear automatically when cities experience growth. Rather, they tend to coexist with more recent environmental stressors linked to industrialization, increased wealth, infrastructure growth, and shifts in consumption.

This layered pattern is aligned with the overall arguments in the field of urban sustainability research. Satterthwaite (1997) suggests that it is not sufficient to evaluate sustainable city only from the perspective of environmental quality at the local level but needs to be evaluated using the broader lens of sustainable development. Pune is relevant because the environmental transition program is happening simultaneously across the housing, health, transport, energy, industrial, waste and economic opportunity sectors. Mahadevia (2001) also highlights the need for taking a wider approach towards sustainable urban development in India. This is crucial in the context of interpreting Type I indicators in Pune. Better water, sanitation, health and literacy conditions have boosted the prospect for urban development, but the prevalence of slums indicates that the gains from growth have not been equally distributed.

The relevance of the Type I findings is, therefore, not limited to welfare improvement but also extends to the business. The health, stability and skill of a city's workforce is integral to the economic system of that city. The progress of Pune towards better water access, sanitation, literacy rates, and infant mortality points to an enhanced human capital base. But the slum settlements are still there, indicating that a certain segment of the working population continues to be vulnerable to insecure housing and access to services that is not uniform. This is important for companies because employees' health, attendance, mobility and long-term productivity affected by their living conditions. The understanding of Type I issues thus becomes related to basic urban services and inclusive business sustainability.

The Type II findings reveal that the industry and MSME base in Pune continues to play a key role in the environmental and economic picture. The fact that there are a large number of MSMEs and industrial workers suggests that industrial sustainability is not just a pollution control problem. It also depends on the managerial skills, institutional support, funding, access to technology, and preparedness to comply. In the context of developing country, sustainability issues faced by SMEs as identified by Durrani et al. (2024) are lack of finance, low environmental knowledge, weak government support, and low compliance capacity. This applies to Pune as it is likely that small enterprises will require external assistance to implement cleaner technologies, to optimise waste management, and to address environmental needs.

The findings further indicate that any environmental regulation needs to be complemented by capacity development for MSMEs. The data on the selected pollutants in Pune (SO₂ and SPM) shows that the pollution levels are within the prescribed limits but the level of industrial activity does need preventive environmental management. However, if MSMEs are to play a role in making production cleaner and resources more efficient, they need practical assistance from industry associations, municipal institutions and state agencies. This can involve: common infrastructure; technical training; streamlined compliance information; cleaner production technologies. This support can make environmental management a source of industrial resilience and competitiveness instead of a regulatory burden.

The third type of findings, particularly relevant for the business-management framing of the article, is the "rationalization" of the experience. The third type of findings, that of "rationalization" of the experience, is particularly important for the business-management framing of the article. Pune's growth has created pressure on infrastructure, as evidenced by the increase in the number of vehicles, dependence on two-wheelers, electricity usage, and the amount of NO_x emitted. In a study on the impact of urbanization on the economy, Pradhan et al. (2021) demonstrate that with a proper transport and ICT infrastructure, urbanization can contribute to economic growth. They also warn that rapid urbanisation without adequate infrastructure can lead to congestion, slums, and diseconomies of scale. Its argument is relevant to Pune, as mobility and energy systems directly impact business operations. Reliable transport is essential to firms for their employees, customers, suppliers and goods movement. They are also reliant on electricity to produce, provide services, support digital systems, and conduct business.

A significant proportion of the two-wheelers in Pune's vehicle fleet reflects a high private transport dependency in the city's mobility system. This will have an impact on congestion, parking, commuting times, road safety and air quality. These are not only transport problems, from a business point of view. They impact on employee attendance, customer access, delivery reliability and logistics costs. The challenges faced by urban logistics in developed and developing economies are identified by Arvianto et al. (2021) as urban growth, environmental problems, and traffic congestion. In addition, their survey reveals that in developing economies, issues such as fleet growth and lack of loading and unloading space are frequent concerns. These results support the study's conclusion that the pressures in Pune are of Type III, which is indicative of a larger problem with urban logistics and business infrastructure.

Cost is one of the factors of congestion as well. Contrary to that, the above mentioned Serok et al. (2022) demonstrate the substantial monetary and time costs, as well as air pollution effects of urban traffic congestion. Their study is not on Pune but the results do provide some insight into how to explain the significance of vehicle growth as a business. When road congestion is high, there are increased "hidden costs" to economic activity in cities. It impacts transport companies, service

providers, retail stores, commuters and companies that rely on timely deliveries. The growth of vehicles in Pune thus needs to be understood not only as a measure of its environment, but as a measure of the increasing pressure on its infrastructure in a city's economy.

The findings of the Type IV indicate that consumption and lifestyle change are emerging as a key aspect of the environmental transition in Pune. Solid waste, commercial waste, hotel and restaurant waste, market waste, e-waste or lifestyle related diseases highlight a city that is imbued with environmental pressure less by poverty or industrialization but by income growth, the use of technology and the growing consumer markets. This interpretation is supported by Webster's (1995) argument that urban environmental problems in developing countries are strongly associated with growth, infrastructure provision, public services and institutional capacity. Solid Waste and E-Waste Management in Pune, as such, requires efforts from coordination of households, firms, municipal authorities, recyclers and informal workers.

Type IV issues are also a chance to link the article more closely with business innovation. The concept of circular economy thinking is appropriate here as it focuses on value recovery, resource efficiency, re-use and new business models rather than disposing of. Geissdoerfer et al. (2017) state that the circular economy is an important sustainability paradigm because it aims to minimize the input of resources, waste, emissions and energy loss. For Pune, this implies that solid waste and e-waste need not be looked at purely as a burden of the municipality. They can also contribute to the recycling businesses, repair systems, refurbishment markets, sustainable packaging, reverse logistics and green entrepreneurship.

So, the discussion here illustrates how Pune's environment has changed and impacts risk and opportunity. Type I vulnerabilities create risks for inclusive workforce development. Type II problems involve industry compliance and environmental management capacity risks. Congestion, energy dependence, and infrastructure reliability are all potential risks associated with Type III pressures. Type IV pressures include risks of waste, e-waste, health and consumption. Simultaneously, every category offers opportunities, too. Human capital is improved through better basic services. Cleaner production may improve the competitiveness of Industry. The idea of sustainable mobility and energy efficiency can cut down the running costs. New circular-economy product market and business models can be generated.

This is a strengthening of the article's contribution to business and management research. This study does not assert that environmental indicators are causal factors in changes to the performance of the firm. Rather, it indicates how the external environment in which the firms operate is influenced by the evolution of the urban environment. Services such as workers, infrastructure, transport, energy, public health, waste services and regulatory systems are essential for the functioning of businesses. When these systems' shift, the business environment also shifts. The Pune case thus shows how an urban environmental model can be expanded to a business sustainability diagnostic model.

The overall discussion validates the assertion that Pune is now at a stage where Type III and Type IV issues require more attention in terms of management and policy. The city has improved in terms of basic urban indicators, but the current challenge for the city is to manage growth, pressure on infrastructure, industrial capacity, consumption, waste and risks linked to lifestyles. This renders the article appropriate for a business, a management journal. It makes the issue of environmental evolution a concern of city planning and also a concern of business sustainability, MSME resilience, urban productivity and strategic decision making.

6. Managerial and Policy Implications

The findings are relevant to the industry, the MSMEs, urban policy makers and firms. The transition of Pune to Type III and Type IV environmental pressures, renders the sustainability of business operations as closely connected with transport systems, energy consumption, waste management, health of the workforces and reliability of urban services. These don't just happen to business. They impact the cost, productivity, compliance, market access and long-term competitiveness.

The main implication for firms and managers is that urban environmental change needs to be considered in their operational and strategic planning. Businesses should evaluate the impact of congestion, reliance on electricity, waste duties, and commute on their businesses. Energy efficiency,

employee mobility planning, responsible waste disposal and workplace health programmes are to be seen as a part of sustainable management. This is particularly important as it affects the mobility of people to jobs, services, and economic opportunities (World Bank, 2024a).

The results show that MSMEs need to find practical and cost-effective sustainability support. Smaller companies can find this challenging to implement without external support. Hence, policy support should be directed towards training, provision of common infrastructure for the environment, streamlined compliance instructions and access to cleaner technologies. Research from around the world indicates a need for targeted support to enable SMEs to engage in green transition and digital transition effectively (OECD, 2023). The use of resource efficiency and cleaner production concepts can also help firms to reduce waste, decrease input consumption and boost competitiveness (United Nations Industrial Development Organization [UNIDO], 2015).

In the case of industry associations, the results suggest that cluster-level sustainability activities are needed. Through common awareness programmes, environmental audits, common waste-treatment systems, cleaner production workshops, and linkages with technology providers, Associations can support member firms. This method is suitable to implement when the number of MSMEs is substantial and they might not be able to do individual environmental requirement.

The findings draw attention to the planners and policy makers in the urban area to pay attention to the issue of environmental governance during the planning process of the cities. Design plans for public transport, parking policy, road-space management, industrial zoning, waste segregation, e-waste systems and commercial waste regulation should take business impacts into account. The environmental transition in Pune demonstrates the need to promote sustainable development in the city from an ecological and economic perspective. An effective city that is more efficient at managing mobility, energy, waste, and public health will be more attractive to businesses, employees, investors, and citizens.

In general the principal lesson is that the city needs to be responsible for the environmental change that has taken place, and that those responsibilities are shared. Companies have to implement sustainable approaches. MSMEs need assistance to enhance compliance and resource utilization. Collective action needs to be coordinated by industry associations. Policymakers need to create infrastructure and regulation that enhances environmental quality and economic performance of cities.

7. Conclusion

This study explored the environmental changes in Pune using the Bai and Imura model and further analyzed the implication of this model to business sustainability. The analysis reveals that Pune has crossed the threshold of a number of concerns of the Type I level, particularly with regard to water access and sanitation, literacy, and health indicators. But the continued existence of slums demonstrates that inclusive urban development is yet to be realized. Type II issues are also relevant as Pune has a huge MSME and industrial base that needs to be focused on cleaner production, compliance capacity and resource efficiency. The most significant current problems are Type III and Type IV problems. Growth of vehicles, dependence on two-wheelers, electricity usage, solid waste, e-waste, commercial waste, and health issues related to lifestyle prove that Pune's environmental issues are linked to economic growth and consumption today. These pressures impact the business environment in terms of mobility constraints, logistics costs, dependence on energy, waste responsibilities, wellbeing of the workforce and market opportunities for sustainability. The study's novelty lies not only in providing a classification system for the environment, but also an environmental diagnostic tool for urban business sustainability, that is, the Bai and Imura model. The competitiveness of the future of Pune will be determined by the ability of all the actors firm, MSMEs, municipal institutions, industry associations, and policy makers to act together and coordinate the strain of growth-related and lifestyle-related environmental pressures.

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