

A Multi-Nodal Industrial–Urban Transformation Model: Evidence from a Longitudinal Study of Jubail Governorate, Saudi Arabia (1983–2025)

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Abstract

Despite the rapid expansion of industrial cities worldwide, existing industrial development models remain largely sector-specific and inadequately explain the long-term co-evolution of industrial production, logistics systems, urban growth, environmental governance, and institutional continuity. Addressing this gap, this study develops a multi-nodal industrial–urban transformation model that conceptualizes industrial regions as integrated spatial systems whose evolution is shaped by the dynamic interaction between production networks, infrastructure, governance, and urbanization.

Jubail Governorate, Saudi Arabia, is employed as a longitudinal case study to investigate regional transformation over the period 1983–2025 through a systematic comparison between the author's 1983 doctoral research and contemporary datasets obtained from the Royal Commission for Jubail and Yanbu (RCJY), GASTAT, GOSI, SABIC, Saudi Aramco, SWCC, and other official sources. A mixed-methods longitudinal design integrates historical comparison, statistical analysis, and spatial interpretation to examine changes in industrial structure, demographic dynamics, logistics infrastructure, urban expansion, environmental performance, and institutional development.

The findings reveal that Jubail has undergone a profound transition from a planned industrial city into an integrated multi-nodal industrial–urban region characterized by functionally interconnected production, logistics, residential, and environmental systems. This transformation has been sustained through long-term institutional governance, continuous infrastructure investment, industrial diversification, logistics integration, and coordinated regional planning. The proposed model demonstrates that durable industrial competitiveness emerges not from industrial expansion alone but from the synergistic interaction between industrial production, logistics connectivity, environmental sustainability, and urban development within an adaptive institutional framework.

Beyond documenting the evolution of Jubail Governorate, the study contributes an analytically transferable framework for interpreting industrial–urban transformation in rapidly industrializing regions. The proposed model provides a conceptual and strategic foundation for regional planning, industrial policy, and sustainable urban development while offering practical insights aligned with the objectives of Saudi Vision 2030 and broader international debates on integrated industrial urbanization.

Keywords: Multi-Nodal Industrial–Urban Transformation; Industrial–Urban Systems; Longitudinal Regional Analysis; Industrial Logistics; Regional Planning; Sustainable Industrial Urbanization; Jubail Governorate; Saudi Arabia.

نموذج التحول الصناعي-الحضري متعدد العقد: دراسة طويلة للتحول الإقليمي في محافظة الجبيل (1983-2025)

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قسم التخطيط الحضري والإقليمي - جامعة الإمام عبد الرحمن بن فيصل - الدمام - المملكة العربية السعودية

الملخص

على الرغم من التوسع المتسارع للمدن الصناعية في مختلف أنحاء العالم، فإن النماذج السائدة لتفسير التنمية الصناعية ما تزال في معظمها قطاعية الطابع، ولا تقدم إطاراً متكاملًا يفسر التطور طويل الأمد للعلاقات المتبادلة بين الإنتاج الصناعي، وشبكات الخدمات اللوجستية، والنمو الحضري، والإدارة البيئية، واستمرارية الحوكمة المؤسسية. وانطلاقاً من هذه الفجوة البحثية، تقدم هذه الدراسة نموذجاً للتحول الصناعي-الحضري متعدد العقد، ينظر إلى الأقاليم الصناعية بوصفها منظومات مكانية متكاملة يتشكل تطورها من خلال التفاعل الديناميكي بين شبكات الإنتاج، والبنية التحتية، والحوكمة، والتحضر.

واتخذت الدراسة من محافظة الجبيل في المملكة العربية السعودية حالةً طويلةً لتحليل التحول الإقليمي خلال الفترة (1983-2025)، وذلك من خلال المقارنة المنهجية بين نتائج أطروحة الدكتوراه التي أعدها الباحث عام 1983 والبيانات المؤسسية الحديثة الصادرة عن الهيئة الملكية للجبيل وينبع، والهيئة العامة للإحصاء، والمؤسسة العامة للتأمينات الاجتماعية، وشركة سابك، وشركة أرامكو السعودية، والمؤسسة العامة لتحلية المياه المالحة، إلى جانب مصادر رسمية أخرى. واعتمدت الدراسة منهجاً طويلاً مختلطاً يجمع بين المقارنة التاريخية، والتحليل الإحصائي، والتفسير المكاني، بهدف تحليل التحولات التي شهدتها الهيكلة الصناعية، والديناميات السكانية، والبنية التحتية اللوجستية، والتوسع العمراني، والأداء البيئي، والتطور المؤسسي.

وتكشف النتائج أن محافظة الجبيل قد انتقلت من مدينة صناعية مخططة إلى إقليم صناعي-حضري متعدد العقد، تتكامل داخله منظومات الإنتاج، والخدمات اللوجستية، والاستخدامات الحضرية، والإدارة البيئية ضمن بنية وظيفية مترابطة. وقد تحقق هذا التحول بفضل استمرارية الحوكمة المؤسسية، والاستثمار طويل الأجل في البنية التحتية، والتنويع الصناعي، وتكامل شبكات النقل والخدمات اللوجستية، والتخطيط الإقليمي المنسق. كما يبين النموذج المقترح أن القدرة التنافسية المستدامة للأقاليم الصناعية لا تتحقق من خلال التوسع الصناعي وحده، وإنما تنشأ من التفاعل التكامل بين الإنتاج الصناعي، والاتصال اللوجستي، والاستدامة البيئية، والتنمية الحضرية، ضمن إطار مؤسسي قادر على التكيف مع المتغيرات.

ولا تقتصر إسهامات الدراسة على توثيق مسار التحول الذي شهدته محافظة الجبيل، بل تمتد إلى تقديم إطار تحليلي قابل للتطبيق في دراسة وتخطيط الأقاليم الصناعية سريعة النمو في مختلف السياقات. كما يوفر النموذج المقترح أساساً نظرياً واستراتيجياً لدعم سياسات التخطيط الإقليمي، والتنمية الصناعية، والتحضر المستدام، مع تقديم رؤية تطبيقية تتوافق مع مستهدفات رؤية المملكة العربية السعودية 2030، وتساهم في إثراء النقاشات الدولية حول العمران الصناعي المتكامل والتنمية الإقليمية المستدامة.

الكلمات المفتاحية: التحول الصناعي-الحضري متعدد العقد؛ المنظومات الصناعية-الحضرية؛ التحليل الإقليمي الطولي؛ الخدمات اللوجستية الصناعية؛ التخطيط الإقليمي؛ التحضر الصناعي المستدام؛ محافظة الجبيل؛

المملكة العربية السعودية.

1. Introduction

Jubail Governorate represents one of the world's most significant examples of planned industrial–urban transformation. Since the establishment of the Royal Commission for Jubail and Yanbu (RCJY) in 1975, the governorate has evolved from a small coastal settlement into an integrated regional industrial system combining petrochemicals, mining, logistics, energy infrastructure, and modern urban development. This transformation reflects Saudi Arabia's long-term strategy of economic diversification, spatial planning, and institutional continuity, positioning Jubail as a leading model of sustainable industrial urbanization.

The governorate's development has extended far beyond the original Jubail Industrial City. During the past four decades, the expansion of Jubail II, the establishment of Ras Al-Khair Industrial City, and the emergence of the Highway 95 logistics corridor, including MCCL Yard 2, have created a polycentric industrial region in which production, transportation, energy systems, and logistics operate as an integrated spatial network. Supporting infrastructure—including ports, railways, desalination plants, gas-processing facilities, and utility corridors—has reinforced the governorate's role as one of the Kingdom's principal industrial growth poles.

At the same time, Jubail has experienced profound demographic, environmental, and urban transformations. Population growth, residential expansion, improvements in environmental management, and increasing economic diversification have reshaped the governorate from a temporary industrial settlement into a mature urban region characterized by permanent communities, advanced public services, and internationally recognized environmental standards. These developments illustrate the close interaction between industrial investment, institutional governance, and sustainable urban planning.

Despite the extensive literature on industrial cities and regional development, most previous studies have examined Jubail Industrial City as an isolated urban entity. Limited attention has been given to the governorate as an integrated industrial–urban region encompassing Jubail Al-Balad, Jubail Industrial Cities I and II, Ras Al-Khair, and the Highway 95 logistics corridor. Moreover, few studies have employed a longitudinal perspective capable of evaluating structural transformation over more than four decades using consistent historical and contemporary datasets.

This study addresses that gap by comparing the governorate's development between 1983 and 2025, using the author's doctoral dissertation completed in 1983 as a historical baseline and integrating recent institutional data from the Royal Commission for Jubail and Yanbu (RCJY), GASTAT,

GOSI, SABIC, Saudi Aramco, SWCC, and other official sources. Through a combination of historical comparison, statistical analysis, and spatial interpretation, the study examines industrial growth, demographic change, environmental performance, and regional spatial restructuring.

Rather than viewing Jubail as a single industrial city, the study proposes a broader conceptualization of Jubail Governorate as an integrated multi-nodal industrial–urban system whose development is driven by the interaction of industrial production, logistics, infrastructure, governance, and environmental management. Based on this analytical framework, the research also outlines strategic development directions extending toward 2050 in support of Saudi Vision 2030 and long-term regional sustainability.

Unlike conventional case studies that primarily document industrial development, this section adopts a model-building approach in which empirical findings are progressively synthesized into a transferable analytical framework capable of explaining industrial–urban transformation beyond the Jubail case.

Research Questions

Main Research Question

How has Jubail Governorate transformed into an integrated industrial–urban region between 1975 and 2025, and what development mechanisms have contributed to its evolution into a multi-nodal regional system extending toward 2050?

Sub-Questions

1. What are the major industrial and economic transformations that have occurred in Jubail Governorate during the period 1975–2025?
2. How has industrial development influenced demographic growth, social change, and labor-force dynamics in the governorate?
3. What spatial and urban expansion patterns have accompanied industrial development in Jubail?
4. What role have infrastructure, energy systems, and logistics networks played in shaping the regional industrial–logistics corridor?
5. To what extent have environmental policies and institutional governance contributed to sustainable industrial and urban development?
6. How can current transformation indicators be utilized to develop future development scenarios for Jubail Governorate through 2050?
7. What characteristics make Jubail a global model of sustainable industrial urbanization and multi-nodal regional development?

Research Objectives

Main Objective

To analyze the industrial–urban transformation of Jubail Governorate between 1975 and 2025 and to explore its future development trajectory toward 2050 as an integrated industrial–urban region.

Specific Objectives

1. To identify and analyze the industrial and economic development of Jubail Governorate over the past five decades.
2. To examine the demographic and social transformations associated with industrial growth.
3. To analyze patterns of urban expansion and spatial change using temporal and spatial indicators.
4. To evaluate the role of infrastructure, energy systems, and logistics networks in promoting regional integration.
5. To assess the contribution of environmental policies and institutional governance to sustainable industrial and urban development.
6. To explain the interrelationships among industrial growth, urban development, population dynamics, and environmental sustainability within a unified analytical framework.
7. To develop future development scenarios for Jubail Governorate for the period 2035–2050.
8. To propose a strategic planning vision that supports the objectives of Saudi Vision 2030 and long-term sustainable regional development.

2. Historical Evolution of Jubail Governorate

Jubail Governorate possesses a long history of human settlement that predates its modern industrial development by several millennia. Archaeological evidence from the Dosariyah site, dating to the sixth millennium BCE, demonstrates early coastal settlement and maritime interaction with southern Mesopotamia, while the Al-Dafi archaeological site documents continuous occupation during the early Islamic period. Together with heritage landmarks such as the Old Jubail Port and Al-Tuwaiya Tower, these sites establish Al-Jubail Al-Balad as the historical nucleus of the governorate and an enduring center of maritime activity along the Arabian Gulf.

Until the early 1970s, Jubail remained a relatively small coastal town whose economy depended primarily on fishing, pearling, and regional trade. The rapid growth of Saudi Arabia's petroleum economy, however, created new national priorities emphasizing industrial diversification and regional development. Owing to its strategic location on the Arabian Gulf

and its proximity to major hydrocarbon resources, Jubail was selected as one of the Kingdom's principal industrial growth poles.

A decisive turning point occurred in 1975 with the establishment of the Royal Commission for Jubail and Yanbu (RCJY), which introduced an integrated model of industrial and urban planning. Rather than developing industrial facilities independently, the Commission adopted a comprehensive approach that combined industrial zones, residential districts, transport infrastructure, utilities, environmental management, and community services within a unified planning framework. This institutional continuity became one of the defining characteristics of Jubail's long-term development.

The original Jubail Industrial City subsequently evolved into the core of a much broader regional industrial system. During the early 2000s, Jubail II significantly expanded downstream petrochemical production and advanced manufacturing through new utility corridors, high-capacity infrastructure, and value-added industrial zones. This expansion substantially increased the governorate's industrial capacity while strengthening its position within global petrochemical supply chains.

Regional integration accelerated further with the establishment of Ras Al-Khair Industrial City, which developed into Saudi Arabia's principal mining and metals complex. Supported by specialized port facilities, rail infrastructure, and large-scale utility systems, Ras Al-Khair created the upstream component of a regional value chain supplying aluminum, phosphate products, and mineral-based industries. At the same time, the emergence of the Highway 95 logistics corridor, including MCCL Yard 2, added an important logistics and modular fabrication hub linking upstream mining activities with downstream manufacturing in Jubail.

The regional industrial system has been further reinforced by strategic infrastructure, particularly the Wasit and Fadhili Gas Plants, desalination facilities, transport corridors, and integrated utility networks. These investments transformed Jubail from an individual industrial city into a polycentric industrial–urban region in which industrial production, logistics, energy infrastructure, environmental management, and urban development operate as an interconnected system. This historical evolution provides the foundation for understanding the governorate's

Summary and Structural Interpretation

The historical and policy context reveals a **multi-layered structural evolution**, where:

- **Upstream activities** (Ras Al-Khair) generate mineral value

- **Mid-chain activities** (Yard 2 and logistics corridors) provide modular fabrication and supply-chain integration
- **Downstream activities** (Jubail II) create advanced industrial value

Together, these nodes constitute a **Unified Industrial–Logistics Corridor** that extends across the entire governorate and forms the backbone of eastern Saudi Arabia’s economic diversification under Vision 2030.

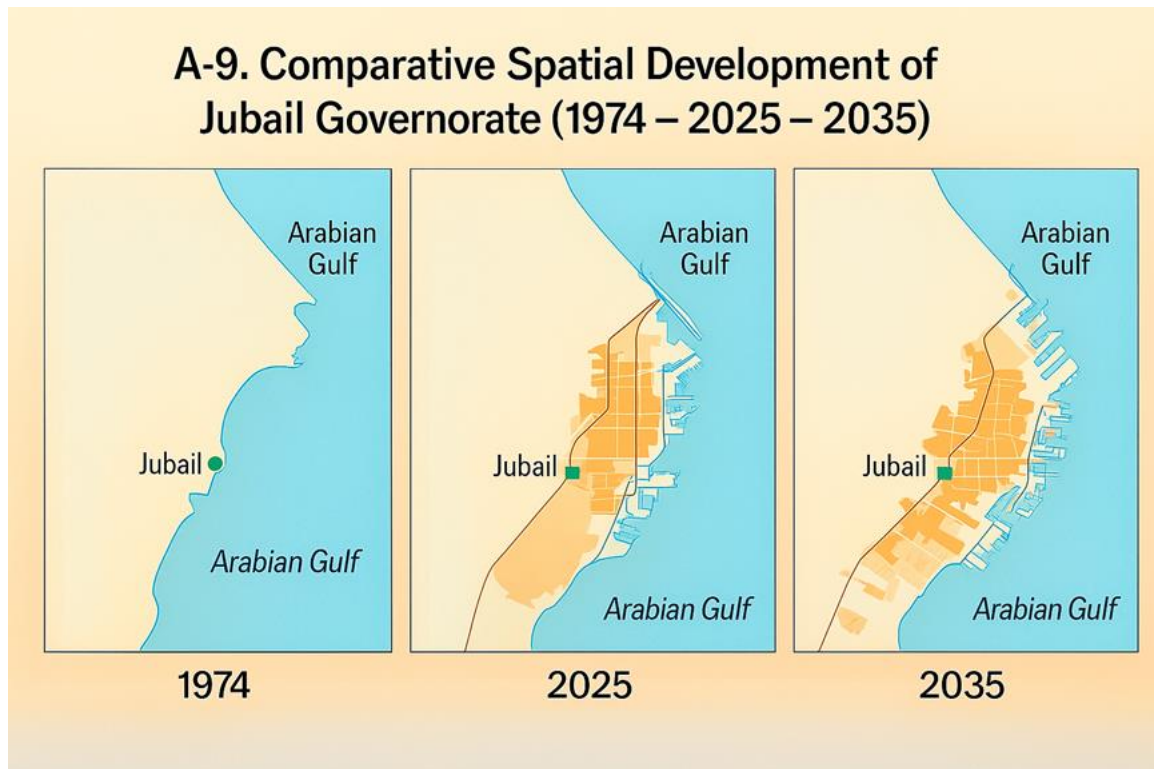


Figure 1 Comparative Spatial Development of Jubail Governorate (1974-2025-2035)

This figure compares the spatial development of Jubail Governorate across three stages: its limited urban footprint in 1974, the significant urban and industrial expansion achieved by 2025 through the establishment of Jubail Industrial City, and the projected 2035 configuration reflecting further growth toward an integrated coastal industrial–urban corridor. The panels illustrate the progressive intensification of land uses, expansion of industrial and residential districts, and increasing connectivity along the Arabian Gulf.

3. Previous Studies and Research Gap

3.1 Previous Studies

Research on industrial–urban transformation has expanded considerably over the past four decades, encompassing industrial cities, regional development, logistics, and sustainable urbanization. International studies have examined the evolution of major industrial regions such as Houston, Rotterdam, Singapore, and Busan, emphasizing the relationships between industrial clustering, port development, transportation infrastructure, and

regional competitiveness. More recent studies have further highlighted the growing importance of integrated logistics systems, environmental sustainability, and industrial diversification in shaping large-scale industrial regions.

Within Saudi Arabia, previous research has focused primarily on Jubail Industrial City as one of the Kingdom's flagship industrial developments. Early studies by Al-Jarallah (1983, 1993, 1995, 1996) documented the initial stages of industrialization and analyzed demographic change, environmental impacts, and urban development during the formative years of the city. Subsequent studies examined planning practices, environmental management, industrial expansion, and sustainability within Jubail Industrial City, while economic analyses assessed its contribution to national industrial diversification and Vision 2030.

Official planning reports prepared by the Royal Commission for Jubail and Yanbu (RCJY), together with reports published by organizations such as the World Bank, UN-Habitat, UNIDO, OECD, and Oxford Business Group, have provided extensive statistical and planning information concerning industrial investment, infrastructure, environmental management, and institutional development. These publications constitute an important empirical foundation for understanding the governorate's industrial evolution.

Despite the richness of this literature, most previous studies have adopted sector-specific perspectives, focusing separately on industrial production, urban planning, environmental management, logistics, or economic performance. Consequently, relatively little attention has been devoted to understanding the governorate as an integrated regional system in which industrial production, mining, logistics, transportation, energy infrastructure, environmental governance, and urban development interact within a unified spatial framework.

3.2 Research Gap

A critical review of the literature reveals three major gaps.

First, previous research has largely treated Jubail Industrial City as an individual urban entity, with limited consideration of the wider governorate that now includes Jubail Al-Balad, Jubail II, Ras Al-Khair Industrial City, and the Highway 95 logistics corridor.

Second, few studies have adopted a longitudinal perspective capable of comparing the governorate's transformation over more than four decades using consistent historical and contemporary datasets. Consequently, the cumulative impacts of industrialization on demographic change, spatial

restructuring, environmental performance, and regional integration remain insufficiently understood.

Third, existing studies have rarely integrated industrial development, logistics infrastructure, energy systems, environmental sustainability, and urban growth within a single analytical framework. Similarly, limited attention has been given to future regional development scenarios capable of supporting long-term strategic planning.

3.3 Contribution of the Present Study

This study addresses these gaps by conceptualizing Jubail Governorate as an integrated multi-nodal industrial–urban region rather than a single industrial city. Using the author's 1983 doctoral dissertation as a historical benchmark together with recent institutional datasets, the research provides a longitudinal assessment of industrial, demographic, spatial, environmental, and infrastructural transformation between 1983 and 2025. It further develops an integrated analytical framework that links industrial production, logistics, governance, and sustainability while outlining strategic development directions toward 2050.

4. Methodology

4.1 Research Design

This study adopts a longitudinal comparative research design to examine the industrial–urban transformation of Jubail Governorate between 1983 and 2025. The analysis compares the conditions documented in the author's 1983 doctoral dissertation with contemporary institutional data to evaluate long-term changes in industrial development, demographic structure, spatial expansion, infrastructure, and environmental performance. The study employs a mixed-methods approach combining quantitative statistical analysis with qualitative interpretation of planning and institutional developments.

4.2 Data Sources

The research integrates primary and secondary data from multiple official sources. The primary historical dataset is derived from the author's doctoral dissertation completed in 1983, which provides the baseline for longitudinal comparison. Contemporary information was obtained from the Royal Commission for Jubail and Yanbu (RCJY), the General Authority for Statistics (GASTAT), the General Organization for Social Insurance (GOSI), Saudi Aramco, SABIC, the Saline Water Conversion Corporation (SWCC), and other governmental publications. These datasets include demographic statistics, industrial indicators, employment records,

infrastructure development, environmental performance, and spatial planning information.

To enhance reliability, information from different institutions was cross-validated wherever possible, while GIS-based spatial interpretation was used to verify major patterns of urban and industrial expansion.

4.3 Analytical Framework

The analysis is organized around four interrelated dimensions that collectively explain the governorate's transformation:

- **Industrial development**, including industrial growth, investment, diversification, and regional value-chain integration.
- **Demographic transformation**, including population growth, labor-force dynamics, and residential development.
- **Spatial development**, focusing on urban expansion, industrial corridors, and the emergence of a multi-nodal regional structure.
- **Environmental sustainability**, including air quality, desalination capacity, green spaces, wastewater management, and institutional environmental governance.

These dimensions are analyzed through comparative statistical indicators, historical interpretation, and spatial analysis to identify long-term structural changes between 1983 and 2025.

4.4 Conceptual Model

The study conceptualizes Jubail Governorate as an integrated multi-nodal industrial–urban system consisting of three complementary functional components:

- **Jubail Industrial City** as the downstream manufacturing center.
- **Ras Al-Khair Industrial City** as the upstream mining and metals hub.
- **The Highway 95 logistics corridor**, including MCCL Yard 2, as the regional logistics and industrial integration axis.

Supporting infrastructure—particularly the Wasit and Fadhili Gas Plants, ports, railways, desalination facilities, and utility networks—provides the strategic framework linking these components into a unified regional industrial system.

4.5 Research Contribution

Unlike previous studies that examined individual industrial facilities or isolated urban areas, this research applies a longitudinal regional perspective to explain the transformation of Jubail Governorate over more than four decades. The methodology combines historical comparison with contemporary institutional data within a unified analytical framework, providing a comprehensive assessment of industrial, demographic, spatial, environmental, and infrastructural change while supporting future regional planning toward 2050.

5. Building the Multi-Nodal Industrial–Urban Transformation Model

5.1 Building the Multi-Nodal Industrial–Urban Transformation Model: An Introduction

The preceding sections established the historical, theoretical, and methodological foundations of this research. Drawing upon a longitudinal comparison between the 1983 baseline and the contemporary conditions of 2025, the present section synthesizes the empirical evidence to explain the mechanisms through which Jubail Governorate evolved from a planned industrial city into an integrated multi-nodal industrial–urban region. Rather than presenting industrial, demographic, spatial, and environmental changes as isolated outcomes, the analysis demonstrates that these dimensions interacted continuously over more than four decades, producing a coherent regional transformation driven by institutional continuity, strategic planning, and sustained infrastructure investment.

The findings indicate that the transformation of Jubail cannot be adequately interpreted using conventional models that treat industrial cities as self-contained urban entities. Instead, the governorate has progressively developed into a regional system composed of interconnected industrial, logistical, infrastructural, environmental, and urban nodes whose functions reinforce one another within a unified spatial structure. This systemic perspective shifts the analytical focus from the growth of individual industrial facilities to the evolution of an integrated regional production landscape.

Building on this interpretation, the present study proposes the **Multi-Nodal Industrial–Urban Transformation Model** as its principal theoretical contribution. The model conceptualizes long-term industrial development as a cumulative process in which industrial investment stimulates infrastructure expansion, infrastructure enables industrial diversification, diversified production generates logistics integration, and these interactions collectively reshape demographic patterns, urban structure, and

environmental governance. Through successive stages of regional development, these interdependent processes give rise to an integrated industrial–urban system characterized by functional specialization, spatial connectivity, institutional coordination, and increasing regional resilience.

The proposed model is derived inductively from the longitudinal evidence assembled throughout this research rather than from a single theoretical tradition. While informed by the literature on industrial urbanization, regional development, growth poles, logistics systems, and sustainable planning, it integrates these perspectives within a unified explanatory framework grounded in the empirical evolution of Jubail Governorate. Consequently, the model is intended not only to interpret the Jubail experience but also to provide a conceptual framework for analysing comparable industrial regions undergoing rapid structural transformation.

Accordingly, this section is organized into six interrelated components. It begins by examining industrial transformation as the primary catalyst of regional change, followed by demographic and spatial restructuring, environmental sustainability, and the emergence of an integrated multi-nodal industrial–urban system. The discussion then identifies the principal planning implications of these findings before presenting future development scenarios extending toward 2050. Together, these components establish the empirical, conceptual, and strategic foundations of the proposed **Multi-Nodal Industrial–Urban Transformation Model**.

5.2 Industrial Transformation: The Primary Driver of Regional Change

The longitudinal evidence demonstrates that industrial development constituted the primary catalyst of Jubail Governorate's transformation over the period 1983–2025. While demographic growth, urban expansion, logistics development, and environmental improvements were all significant dimensions of regional change, each evolved largely in response to successive waves of industrial investment. Rather than functioning as an isolated economic sector, industrialization initiated a cumulative development process that progressively reshaped the governorate's spatial structure, institutional capacity, and regional economy.

The comparison between the 1983 baseline and the contemporary situation reveals the remarkable scale of this transformation. During the study period, the number of industrial establishments expanded from fewer than twenty to more than 950 facilities, while the industrial workforce increased from approximately 12,000 employees to over 180,000. At the same time, cumulative industrial investment exceeded SAR 900 billion, reflecting the

governorate's emergence as one of the world's largest integrated industrial complexes. Industrial production also evolved from a narrow concentration in basic petrochemicals to a diversified portfolio encompassing downstream petrochemicals, advanced manufacturing, mining, metals processing, logistics services, and energy-intensive industries.

These quantitative changes represent more than simple industrial growth. They reflect successive stages of structural diversification that progressively expanded the governorate's functional complexity. The establishment of Jubail II marked a transition from large-scale petrochemical production toward higher-value downstream industries supported by advanced utility systems and specialized industrial infrastructure. The subsequent development of Ras Al-Khair Industrial City introduced a complementary upstream production system centred on mining, aluminium, phosphate processing, and maritime industries. Together, these developments extended the regional industrial value chain beyond the boundaries of the original industrial city.

A further stage of transformation emerged through the development of the Highway 95 logistics corridor, particularly MCCL Yard 2, which introduced large-scale modular fabrication, heavy industrial services, logistics staging, and supply-chain integration. Rather than representing an independent industrial zone, this corridor performs an integrative function by linking upstream mineral production with downstream manufacturing through coordinated logistics and industrial support services. Consequently, the governorate's industrial structure evolved from a single production centre into a spatially integrated network of specialized yet mutually dependent industrial nodes.

This evolution illustrates an important characteristic of long-term industrial transformation. Industrial investment did not merely increase production capacity; it generated new functional relationships between production, infrastructure, logistics, and urban development. As industrial activities diversified, demand expanded simultaneously for transportation networks, utility corridors, residential communities, educational institutions, environmental management systems, and specialized labour markets. Industrial growth therefore acted as the initiating force of a broader regional restructuring process whose effects extended well beyond the industrial sector itself.

From the perspective of the proposed **Multi-Nodal Industrial–Urban Transformation Model**, industrial transformation constitutes the first stage in a cumulative sequence of regional development. Sustained industrial investment stimulates infrastructure expansion; infrastructure

enables production diversification; diversification requires logistics integration; and these interconnected processes subsequently reshape demographic dynamics, urban development, environmental governance, and regional competitiveness. In this sense, industrialization should be understood not as an end in itself but as the principal engine initiating a broader process of industrial–urban transformation.

The empirical evidence from Jubail therefore suggests that the long-term success of major industrial regions depends less on the expansion of individual industrial facilities than on the capacity of industrial investment to generate increasingly integrated regional systems. This interpretation provides the first conceptual pillar of the **Multi-Nodal Industrial–Urban Transformation Model**, upon which the subsequent dimensions of demographic transformation, environmental sustainability, regional integration, and strategic planning are progressively constructed.

Industrial performance between 2020 and 2025 demonstrates substantial expansion, diversification, and value-chain deepening across the governorate.

Table 2. Key Industrial Indicators (1983 vs. 2025)

Indicator	1983	2025	% Change	Source
Total Industrial Establishments	~20	950+	+4,650%	RCJY (2024)
Industrial Workforce	~12,000	180,000+	+1,400%	GOSI (2024)
Industrial Share of National GDP	<1%	~7%	—	GASTAT
Main Industrial Products	Basic petrochemicals	Diversified petrochemicals, metals, energy, advanced materials	—	SABIC/ARAMCO

Key Patterns

- Jubail now hosts **one of the largest petrochemical complexes in the world**.
- Ras Al-Khair contributes an industrial output exceeding **16 million tons/year** of metals and minerals.
- Yard 2 supports the region’s industrial ecosystem via **modular fabrication, pre-assembly, and heavy logistics**.
- Total cumulative investments in Jubail alone exceed **SAR 900 billion**.
- **5.2.1 Industrial Investments and Growth**
- RCJY reports show:
- **SAR 706.21 billion** total investments by 2023.
- **SAR 580.36 billion** from private industry (82%).
- **SAR 125.86 billion** from RCJY in infrastructure, utilities, and environmental systems.

Table 3. Socioeconomic and Industrial Indicators (2023)

Indicator	2023 Value	Interpretation
Total Investments	SAR 706.21B	Historic capital expansion
Private Sector Share	SAR 580.36B	Indicates strong investor confidence
Royal Commission Share	SAR 125.86B	Continued state leadership in planning
Industrial Workforce	~105,000	Stable expansion tied to diversification
Housing Units	35,000+	Reflects demographic maturity
Population	218,289 (city); ~505,000 (governorate)	Strong growth trajectory

5.2.2 Multi-Node Industrial System Indicators

Table 4. Comparative Industrial Indicators

Node	Workforce	Population	Main Industries	Total Investment	Strategic Role
Jubail Industrial City	100,000+	250,000+	Petrochemicals, manufacturing	~SAR 900B	Downstream hub
Ras Al-Khair Industrial City	11,458	11,119	Mining, metals	SAR 182.48B	Upstream anchor
Highway 95 Corridor / Yard 2	Variable logistics workforce	—	Fabrication, heavy logistics	Private investments	Mid-chain integrator

This tri-nodal model is foundational to Jubail's new industrial geography.

5.2.3 Industry Growth Rates

Recent RCJY performance data highlight:

- **Manufacturing growth:** +11% (2023)
- **Light industries growth:** +77% (2023)
- **Logistics activity:** accelerating westward toward Abu Hadriyah Road
- This confirms the shift toward:
- **Value-park industries (Jubail II)**
- **Green-metals and mining (Ras Al-Khair)**
- **Regional logistics and staging (Yard 2)**

5.3 Demographic and Spatial Transformation: Restructuring the Regional Urban System

Industrial expansion in Jubail Governorate was accompanied by profound demographic and spatial restructuring, confirming that industrialization functioned not merely as an economic process but as a comprehensive regional transformation mechanism. The longitudinal comparison demonstrates that changes in population distribution, urban form, residential development, and regional connectivity occurred in parallel with successive phases of industrial growth, reinforcing the close interdependence between economic production and spatial organization.

Between 1983 and 2025, the governorate's population increased from approximately 45,000 inhabitants to more than 500,000, representing one of the most rapid demographic transformations among planned industrial regions in the Middle East. Equally significant was the qualitative transformation of the population structure. The early industrial phase was characterized predominantly by a temporary expatriate workforce concentrated around industrial facilities. Over time, however, sustained economic expansion, improved public services, educational institutions, and residential development encouraged the emergence of permanent communities and multi-generational households. Increasing labour-force participation among Saudi nationals, together with rising female participation in the workforce, further reflected the transition toward a mature and diversified urban society.

The spatial consequences of this demographic transformation were equally substantial. Urban growth progressively expanded beyond the boundaries of the original industrial city, giving rise to a polycentric urban structure in which residential districts, industrial zones, logistics corridors, and public infrastructure became increasingly interconnected. Rather than concentrating growth within a single urban core, development extended across the governorate through coordinated investments in transportation networks, utility systems, housing, and community services.

Within this evolving regional structure, **Al-Jubail Al-Balad** emerged as the governorate's principal residential and urban centre. By 2025, more than half of the governorate's population resided outside the industrial cities, confirming that long-term regional growth depended not only on industrial production but also on the development of stable urban communities capable of supporting an increasingly diversified economy. This shift transformed Al-Jubail Al-Balad from its traditional role as a historic coastal settlement into the primary urban anchor connecting industrial development with residential expansion and public services.

At the regional scale, spatial restructuring was reinforced by the progressive integration of transportation corridors, logistics facilities, ports, utility infrastructure, and industrial clusters. The Highway 95 corridor, together with expanding port and rail systems, strengthened functional connectivity among Jubail Industrial City, Jubail II, Ras Al-Khair, and emerging logistics zones. Consequently, demographic growth and urban expansion became increasingly organized around regional accessibility rather than simple proximity to industrial production.

From the perspective of the proposed **Multi-Nodal Industrial–Urban Transformation Model**, demographic and spatial transformation represent the second stage of regional evolution. Once industrial investment

establishes the economic foundation for growth, population expansion, residential development, and spatial integration progressively reorganize the regional urban system. Urban development therefore emerges not as an independent process but as a structural response to industrial diversification and expanding regional connectivity. Industrial production creates employment opportunities; employment stimulates population growth; demographic expansion generates demand for housing, infrastructure, education, and public services; and these interactions collectively reshape the spatial organization of the governorate.

The Jubail experience demonstrates that successful industrial regions ultimately evolve beyond production-oriented landscapes into integrated urban systems where economic functions and residential communities develop simultaneously. This transition from an industrial city to a diversified regional urban structure constitutes the second conceptual pillar of the **Multi-Nodal Industrial–Urban Transformation Model**, providing the demographic and spatial foundation upon which environmental sustainability, regional integration, and long-term resilience are subsequently built.

Jubail’s demographic profile has matured significantly since 1983.

Table 5. Key Demographic and Labor Indicators

Indicator	1983	2025	Source
Total Population	~45,000	~505,000	GASTAT (2022)
Saudi Nationals	25%	57%	GASTAT
Female Labor Participation	<10%	35%	GOSI (2024)
Total Workforce	12,000	180,000+	GOSI

Key Transformations

- Al Jubail Al Ballad became a big urban residential center.
- A shift from a **transient migrant workforce** (1980s) to a **permanent family-based community**.
- Increased professionalization in engineering, logistics, environmental management, and manufacturing.
- Rising female participation reflects Vision 2030 labor-market reforms.

5.4 Spatial and Urban Expansion

Spatial development reflects a linear coastal and inland expansion pattern.

Key Spatial Trends

- Urban growth of Al Jubail Al Ballad advanced eastward toward **Highway 95 logistics corridor**, and Southward toward the **Nave Bace and to reach the Desalination Plant**
- Urban growth advanced eastward toward industrial clusters and westward toward **Highway 95 logistics corridor**.

- Total built-up area of Jubail Industrial city expanded from **<10 km² (1983)** to **>60 km² (2025)**.
- The integrated utility corridors and seawater cooling systems in Jubail II enable high-energy industries.
- Ras Al-Khair's spatial planning integrates:
 - industrial clusters
 - residential districts
 - logistics and port zones
 - environmental buffer systems

5.4 Environmental Sustainability and Institutional Governance: Enabling Long-Term Regional Resilience

Environmental sustainability represents one of the defining characteristics of Jubail Governorate's long-term transformation. Unlike many rapidly industrializing regions where economic expansion has frequently been accompanied by environmental degradation, the longitudinal evidence demonstrates that industrial growth in Jubail was progressively matched by the expansion of environmental governance, infrastructure investment, and institutional capacity. This parallel evolution illustrates that environmental management was not a secondary outcome of development but an integral component of the regional transformation process.

The comparison between the 1983 baseline and contemporary conditions reveals substantial improvements across multiple environmental indicators. Air-quality compliance now exceeds 95 percent, desalination capacity has increased more than fourteen-fold, green areas have expanded significantly, and wastewater treatment and recycling systems have become integral components of industrial resource management. Continuous environmental monitoring, supported by advanced information systems and regulatory oversight, has enabled the governorate to accommodate large-scale industrial expansion while maintaining progressively higher environmental standards.

These achievements were made possible by the institutional framework established by the Royal Commission for Jubail and Yanbu (RCJY). Throughout the study period, the Commission maintained a unified governance structure that integrated industrial planning, environmental regulation, infrastructure provision, and urban development within a single institutional system. This continuity reduced administrative fragmentation, facilitated coordinated investment, and enabled environmental considerations to be incorporated into every stage of regional development rather than being addressed only after industrial expansion had occurred.

The interaction between environmental governance and infrastructure development further strengthened regional resilience. Major investments in

desalination facilities, utility corridors, wastewater treatment, environmental monitoring, and industrial waste management created the supporting systems required for sustained industrial growth. Consequently, environmental infrastructure evolved alongside industrial production, reducing ecological risks while increasing the efficiency and reliability of regional resource systems.

From the perspective of the proposed **Multi-Nodal Industrial–Urban Transformation Model**, environmental sustainability and institutional governance constitute the stabilizing mechanisms of long-term regional transformation. Whereas industrial investment initiates development and demographic expansion reorganizes the urban system, institutional governance ensures coordination among increasingly complex regional functions. Environmental management therefore performs a dual role: protecting ecological resources while simultaneously reinforcing the long-term competitiveness and operational resilience of the regional economy.

The Jubail experience demonstrates that successful industrial regions cannot be explained solely through economic growth or spatial expansion. Their long-term sustainability depends equally upon the capacity of governance institutions to coordinate industrial development, environmental protection, infrastructure investment, and urban planning within a coherent strategic framework. This institutional dimension distinguishes the proposed model from conventional industrial development theories by recognizing governance as an active driver of regional transformation rather than merely an administrative support function.

Accordingly, environmental sustainability and institutional governance represent the **third conceptual pillar** of the **Multi-Nodal Industrial–Urban Transformation Model**. Together with industrial transformation and demographic–spatial restructuring, they establish the conditions under which large industrial regions can evolve into resilient, competitive, and environmentally sustainable urban systems.

Table 6. Environmental and Sustainability Indicators

Indicator	1983	2025	Improvement	Source
Water Desalination Capacity	100,000 m ³ /day	1,500,000 m ³ /day	+1400%	SWCC
Air Quality Compliance	Low	>95%	Major improvement	RCJY
Green Area Coverage	<2 km ²	~18 km ²	+800%	RCJY
Monitoring Stations	—	20+	—	RCJY/MoEWA

Environmental Achievements

- Continuous air-quality monitoring across 20+ stations.
- Efficient waste management and industrial-effluent regulation.
- Green belts and landscaping buffers reduce heat island effects.
- Wastewater recycling supports industrial cooling and irrigation.

5.7 Regional Industrial Expansion West of Jubail

The **Highway 95 industrial–logistics corridor** has emerged as a strategic extension of Jubail’s industrial footprint.

Key Components

- **MCCL Yard 2:** Heavy fabrication, modular assembly, storage, staging.
- **Wasit Gas Plant:** Primary gas backbone enabling large-scale industrial expansion.
- **Connectivity:** Linking Jubail ↔ Ras Al-Khair via a unified corridor.

Ras Al-Khair Indicators

- Residents: **11,119**
- Workforce: **11,458**
- Housing: **3,959 units**
- Investments: **SAR 182.48B**
- Industrial waste recycling: **55.10%** (notable circular-economy achievement)

5.8 Synthesis of Trends

A cohesive spatial pattern emerges across industrial, urban, demographic, and environmental indicators:

1. Industrial Resilience

From basic petrochemicals (1980s) to a diversified, global-scale industrial base.

2. Demographic Stability

A permanent, skilled, family-oriented population underpins long-term growth.

3. Spatial Urban Integration

Al Jubail Al Ballad, Jubail 1, 2 , 3, Yard 2, Ras Al-Khair, and Highway 95 form a unified regional industrial–logistics corridor.

4. Environmental Leadership

High compliance with environmental standards and significant green expansion.

5.5 Emergence of the Multi-Nodal Industrial–Urban Transformation Model

The preceding analyses collectively demonstrate that the transformation of Jubail Governorate cannot be adequately explained through conventional industrial-city models that focus primarily on industrial expansion or urban

growth as independent processes. Instead, the longitudinal evidence reveals the gradual emergence of a structurally integrated regional system in which industrial production, logistics infrastructure, demographic transformation, environmental governance, and institutional continuity evolved through continuous interaction over more than four decades.

This pattern of development suggests that the governorate's transformation followed a cumulative rather than linear trajectory. Industrial investment initiated the process by establishing the economic base for regional development. Expanding industrial production subsequently generated demand for transportation infrastructure, utility networks, logistics facilities, housing, education, and public services. These investments stimulated demographic growth and spatial expansion, while increasing regional complexity required progressively stronger institutional coordination and environmental governance. Each phase therefore reinforced the next, creating a self-sustaining cycle of industrial and urban development rather than a sequence of isolated planning interventions.

The resulting regional structure differs fundamentally from the traditional concept of an industrial city. Rather than concentrating economic activity within a single production centre, Jubail Governorate evolved into a functionally differentiated regional system composed of complementary development nodes. Jubail Industrial City became the principal downstream manufacturing centre, Ras Al-Khair Industrial City developed as the upstream mining and metals hub, while the Highway 95 logistics corridor emerged as the regional axis integrating production, transportation, and industrial support services. These specialized nodes are linked by strategic infrastructure, including ports, railways, gas-processing facilities, desalination systems, utility corridors, and advanced transportation networks, all operating within a unified institutional framework.

The analysis further demonstrates that the interaction among these nodes generates capabilities that exceed the sum of their individual functions. Industrial specialization increases production efficiency, logistics integration enhances regional connectivity, infrastructure investment improves operational reliability, environmental governance strengthens long-term sustainability, and coordinated planning promotes balanced urban growth. Together, these interactions produce an adaptive regional system capable of accommodating continuous industrial diversification while maintaining environmental quality and urban livability.

Based on these findings, this study proposes the **Multi-Nodal Industrial–Urban Transformation Model** as an analytical framework for understanding the long-term evolution of large industrial regions. The

model explains regional transformation as a dynamic process driven by the interaction of five mutually reinforcing dimensions:

1. **Industrial Transformation**, which provides the initial economic engine for regional development.
2. **Infrastructure and Logistics Integration**, which connect production systems and expand regional functionality.
3. **Demographic and Spatial Transformation**, which reorganize settlement patterns and urban structure.
4. **Environmental Sustainability and Institutional Governance**, which ensure long-term resilience, resource efficiency, and strategic coordination.
5. **Regional Functional Integration**, through which specialized industrial, logistical, environmental, and urban nodes operate as a coherent territorial system.

Unlike conventional industrial development models that emphasize individual sectors or isolated urban centres, the proposed framework interprets regional transformation as an evolving network of functional relationships. The explanatory power of the model lies not in any single development component but in the cumulative interaction among these five dimensions, which collectively determine the trajectory of long-term industrial–urban evolution.

Although developed from the longitudinal experience of Jubail Governorate, the proposed model is intended to extend beyond the immediate case study. Its conceptual structure provides a transferable analytical framework for examining other large industrial regions undergoing rapid structural transformation, particularly where industrial diversification, logistics integration, environmental sustainability, and institutional continuity jointly influence regional development outcomes. Consequently, the model contributes not only to the interpretation of the Jubail experience but also to broader theoretical discussions concerning industrial urbanization, regional planning, and sustainable territorial development.

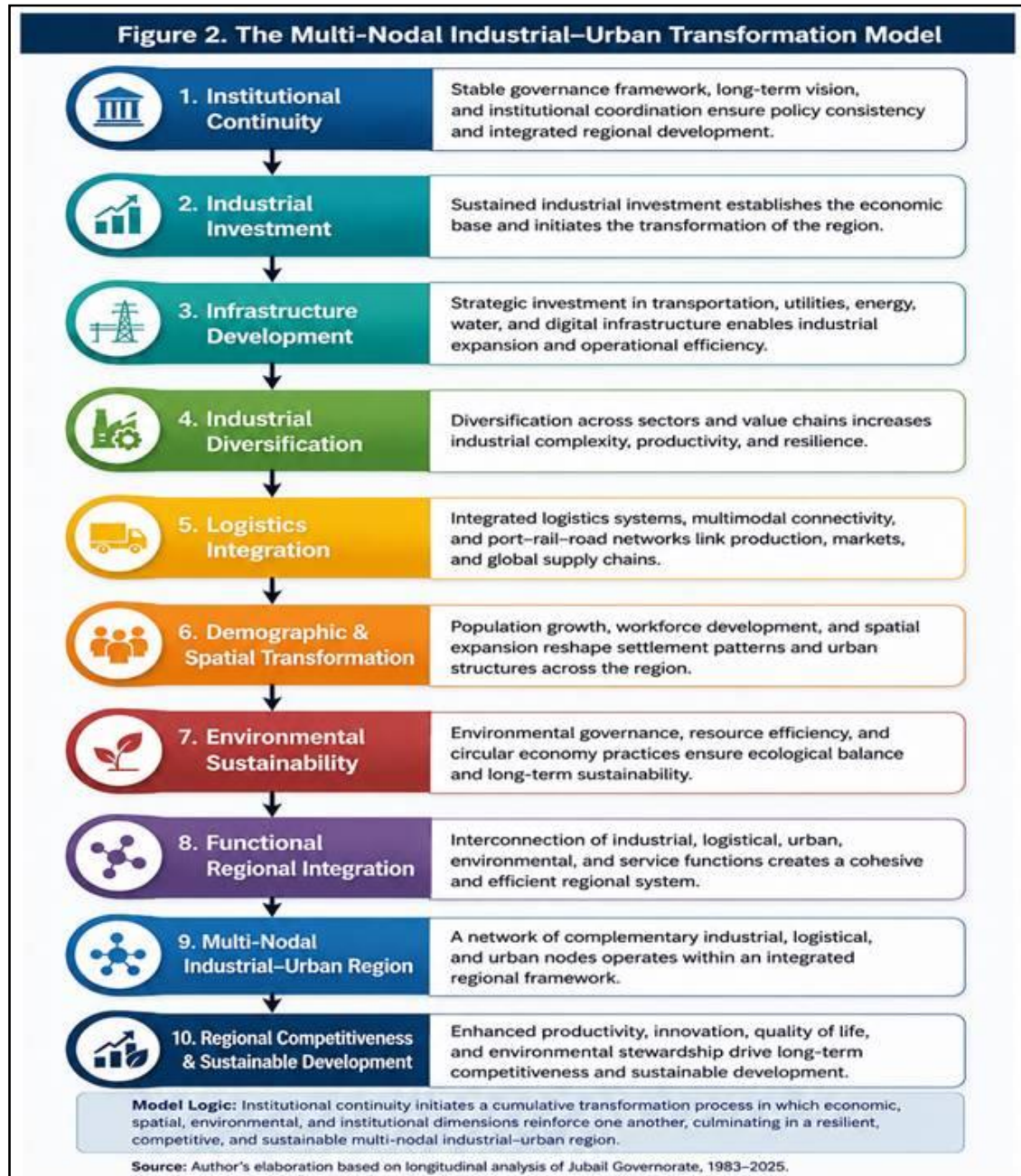


Figure 2: The Proposed Multi-Nodal Industrial–Urban Transformation

Figure 2 presents the **Multi-Nodal Industrial–Urban Transformation Model** proposed in this study, which synthesizes the longitudinal evidence derived from the transformation of Jubail Governorate between 1983 and 2025. The model conceptualizes regional transformation as a cumulative and sequential process initiated by **institutional continuity**, which provides the governance stability necessary to sustain long-term industrial investment. Industrial investment subsequently stimulates **infrastructure development**, creating the physical and operational foundation for **industrial diversification** and the expansion of regional value chains. As production systems become increasingly diversified, **logistics integration**

strengthens functional connectivity among industrial, transport, and service networks, facilitating broader **demographic and spatial transformation** through urban expansion, population growth, and the development of permanent communities. These processes are reinforced by **environmental sustainability**, which enhances resource efficiency and long-term resilience through integrated environmental governance. The interaction of these dimensions ultimately generates **functional regional integration**, whereby specialized industrial, logistical, environmental, and urban nodes operate as complementary components of a unified territorial system. The final outcome is the emergence of a **Multi-Nodal Industrial–Urban Region** capable of achieving higher levels of **regional competitiveness and sustainable development**. Accordingly, the model illustrates that the long-term evolution of major industrial regions is not driven by industrial expansion alone, but by the cumulative interaction of institutional, economic, infrastructural, spatial, environmental, and governance processes operating within an integrated regional framework.

5.6 Planning Implications: From Industrial Growth to Integrated Regional Development

The proposed **Multi-Nodal Industrial–Urban Transformation Model** provides several planning implications that extend beyond the empirical findings of the Jubail case. By demonstrating that long-term industrial development is driven by the interaction of industrial production, infrastructure, logistics, environmental governance, and urban development, the model suggests that future planning strategies should adopt a comprehensive regional perspective rather than focusing on individual industrial projects or isolated urban centres.

The first implication concerns the scale of planning. The findings indicate that large industrial regions should be planned as integrated territorial systems in which industrial zones, residential communities, logistics corridors, transportation networks, utility infrastructure, and environmental resources are coordinated within a unified regional framework. This regional perspective reduces spatial fragmentation, strengthens functional connectivity, and improves the long-term efficiency of public and private investment.

A second implication relates to industrial diversification. The experience of Jubail demonstrates that sustainable regional development depends not only on expanding industrial production but also on strengthening the functional relationships between upstream industries, downstream manufacturing, logistics services, research institutions, and supporting infrastructure. Planning should therefore prioritize value-chain integration

and regional specialization rather than the isolated expansion of industrial capacity.

The third implication concerns urban development and quality of life. As industrial regions mature, demographic growth generates increasing demand for housing, education, healthcare, cultural facilities, public spaces, and recreational amenities. The findings suggest that these elements should be regarded as strategic infrastructure supporting long-term economic competitiveness rather than as secondary social services. A balanced relationship between industrial production and urban livability is therefore essential for attracting skilled labour, supporting permanent communities, and enhancing regional resilience.

Environmental governance represents a fourth planning implication. The Jubail experience demonstrates that environmental management is most effective when integrated into the planning process from the earliest stages of development. Continuous environmental monitoring, efficient resource management, circular-economy practices, and coordinated institutional oversight should therefore be considered fundamental components of industrial planning rather than corrective measures introduced after development has occurred.

Finally, the findings emphasize the importance of institutional continuity. The long-term transformation of Jubail was facilitated by the consistent planning and governance framework provided by the Royal Commission for Jubail and Yanbu (RCJY). Stable institutions capable of coordinating industrial investment, infrastructure provision, environmental regulation, and urban development create the conditions necessary for sustained regional transformation over extended periods.

Collectively, these planning implications reinforce the central proposition of the **Multi-Nodal Industrial–Urban Transformation Model**: successful industrial regions evolve through the coordinated interaction of economic, spatial, environmental, and institutional systems. Consequently, future regional planning should prioritize functional integration, adaptive governance, and balanced territorial development as the principal foundations of sustainable industrial urbanization.

5.7 Future Development Scenarios: Applying the Multi-Nodal Industrial–Urban Transformation Model (2035–2050)

The **Multi-Nodal Industrial–Urban Transformation Model** developed in this study provides a conceptual basis for exploring the future evolution of Jubail Governorate beyond the period covered by the empirical analysis. Rather than predicting a single deterministic future, the model identifies the principal structural processes that are expected to shape regional development as industrial diversification, technological innovation,

demographic maturity, environmental sustainability, and institutional continuity continue to interact over time.

Building upon these processes, the future development of Jubail Governorate can be interpreted through three complementary and sequential scenarios. These scenarios should not be regarded as competing alternatives; instead, they represent successive stages in the continuing evolution of an integrated industrial–urban region.

Scenario One: Industrial Consolidation (2035–2040)

The first stage is expected to be characterized by continued industrial expansion and increasing economic diversification. Existing petrochemical industries will continue to evolve toward higher-value production, while mining, metals processing, advanced manufacturing, hydrogen technologies, and low-carbon industries are expected to occupy an increasingly important position within the regional economy. Continued investment in strategic infrastructure, energy systems, and industrial services will further strengthen Jubail's competitiveness within global industrial networks.

Scenario Two: Regional Functional Integration (2040–2045)

As industrial activities continue to diversify, functional integration among the governorate's principal development nodes is expected to become increasingly important. Greater coordination between Jubail Industrial City, Ras Al-Khair, and the Highway 95 logistics corridor will strengthen regional production systems through improved multimodal transportation, digital logistics platforms, advanced utility networks, and integrated supply chains. At this stage, the governorate will increasingly function as a unified regional production system rather than a collection of separate industrial centres.

Scenario Three: Sustainable Metropolitan Industrial Region (2045–2050)

The final stage represents the full maturation of the regional system. Industrial competitiveness will increasingly depend upon the simultaneous advancement of economic productivity, environmental sustainability, urban quality of life, and institutional innovation. Continued investment in public services, higher education, research and development, environmental infrastructure, cultural facilities, recreational amenities, and sustainable mobility will strengthen the governorate's capacity to attract skilled labour and support permanent communities while maintaining international industrial competitiveness.

Across these successive stages, the underlying structure of the proposed **Multi-Nodal Industrial–Urban Transformation Model** remains unchanged. Industrial investment continues to stimulate infrastructure

development; infrastructure supports functional specialization; specialization strengthens logistics integration; integrated production systems promote demographic and urban development; and institutional governance maintains environmental sustainability and regional resilience. Consequently, future transformation is interpreted not as a sequence of isolated development projects but as the continued evolution of an adaptive regional system whose components become progressively more interconnected over time.

The future trajectory outlined in these scenarios aligns closely with the strategic objectives of Saudi Vision 2030 and subsequent national development initiatives. More importantly, it demonstrates the broader applicability of the proposed analytical model. Although derived from the experience of Jubail Governorate, the model provides a conceptual framework capable of supporting long-term planning and comparative analysis in other rapidly industrializing regions where coordinated industrial growth, regional integration, and sustainable urban development constitute the principal drivers of territorial transformation.

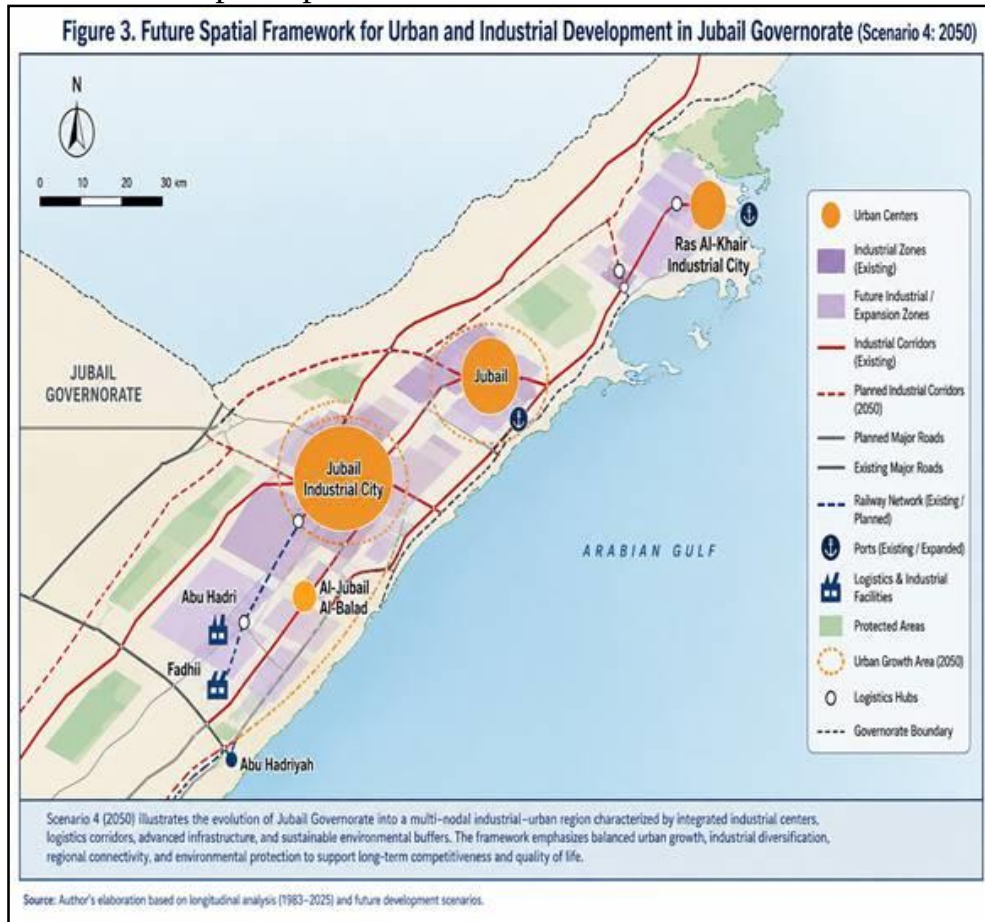


Figure 3. Spatial Application of the Proposed Multi-Nodal Industrial–Urban Transformation Model: Jubail Governorate 2050 Scenario.

Figure 3 illustrates the spatial expression of **Scenario 4 (2050)**, depicting the anticipated evolution of Jubail Governorate into a fully integrated **Multi-Nodal Industrial–Urban Region**. The proposed framework envisions the governorate as a functionally interconnected regional system structured around three complementary development nodes: **Jubail Industrial City** as the principal downstream manufacturing and industrial services hub, **Jubail City (urban centre)** as the primary residential, administrative, and service core, and **Ras Al-Khair Industrial City** as the upstream mining and metals production centre. These nodes are linked through an integrated network of industrial corridors, major highways, railway infrastructure, logistics facilities, and expanded port systems, creating a continuous production and distribution axis extending along the Arabian Gulf coast. The scenario also identifies future industrial expansion areas, protected environmental zones, and urban growth boundaries, emphasizing the importance of balancing economic development with environmental stewardship and spatial sustainability. Rather than representing a conventional urban expansion plan, the framework visualizes the territorial application of the **Multi-Nodal Industrial–Urban Transformation Model**, demonstrating how industrial specialization, logistics integration, coordinated infrastructure, institutional governance, and sustainable urban development collectively contribute to regional competitiveness and long-term resilience. Accordingly, the figure translates the study's analytical model into a strategic spatial vision for Jubail Governorate beyond 2050.

6. Conclusions and Future Outlook

This study has examined the long-term industrial–urban transformation of Jubail Governorate between 1983 and 2025 through a longitudinal comparative framework integrating historical evidence with contemporary institutional data. Using the author's 1983 doctoral dissertation as a historical baseline, the research traced more than four decades of change in industrial development, demographic dynamics, spatial expansion, infrastructure, and environmental performance.

The findings demonstrate that Jubail has evolved far beyond its original role as a planned industrial city. The governorate has developed into an integrated multi-nodal industrial–urban region in which Jubail Industrial City, Ras Al-Khair Industrial City, and the Highway 95 logistics corridor operate as complementary components of a unified regional production system. This transformation has been supported by sustained institutional governance, strategic infrastructure investment, and continuous industrial diversification, resulting in substantial improvements in economic performance, urban development, and environmental management.

The study contributes to the literature in three principal ways. First, it provides one of the few longitudinal assessments of industrial–urban transformation spanning more than four decades using consistent historical and contemporary datasets. Second, it advances a regional analytical perspective that conceptualizes Jubail Governorate as an integrated industrial–urban system rather than a collection of independent industrial developments. Third, it demonstrates how industrial production, logistics, infrastructure, environmental governance, and urban development can be examined within a unified analytical framework applicable to large industrial regions.

From a planning perspective, the findings highlight the importance of maintaining balanced regional development by integrating industrial expansion with environmental sustainability, urban livability, and community services. The continued evolution of Jubail will depend not only on industrial growth but also on strengthening transportation connectivity, logistics integration, public amenities, environmental resilience, and high-quality residential environments. These priorities are closely aligned with the objectives of Saudi Vision 2030 and the Kingdom's long-term industrial and regional development strategies.

Despite its comprehensive scope, the study has certain limitations. The analysis relies primarily on available institutional datasets, while some historical indicators remain incomplete or unavailable for specific periods. In addition, future development scenarios are based on current planning assumptions and should therefore be interpreted as strategic planning frameworks rather than deterministic forecasts.

Future research may extend the present analysis by incorporating predictive spatial modelling, artificial intelligence, digital twins, and high-resolution geospatial data to simulate future industrial expansion and urban growth under alternative development pathways. Comparative studies involving other large industrial regions in Saudi Arabia and internationally would also contribute to a broader understanding of sustainable industrial urbanization.

In conclusion, Jubail Governorate represents one of the most significant examples of planned industrial transformation in the contemporary Middle East. The governorate's experience demonstrates how long-term institutional continuity, integrated regional planning, and sustained infrastructure investment can support the emergence of a globally competitive and environmentally responsible industrial–urban region. The analytical framework developed in this study provides a foundation for future research and strategic planning in rapidly evolving industrial regions both within Saudi Arabia and beyond.

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