GIS-AHP-Based Site Suitability Analysis for Sustainable Special Economic Zones in Haryana: Lessons from Past Projects

Dr Joginder Singh[1] and Manisha[2]

[1]Assistant Professor in Geography, Govt. College Jassia, Rohtak
[2]M.A. Student, JVMGRR College, Charkhi. Dadri

Received : 11-01-2026 Accepted : 25-02-2026

Abstract

This paper critically examines the failure of the Gurgaon–Jhajjar Reliance Haryana Special Economic Zone Limited (RHSL) — one of India's largest proposed SEZ projects announced in 2005 — and identifies suitable locations for future Special Economic Zone (SEZ) development in Haryana. The RHSL initiative collapsed despite substantial commitments due to inappropriate site selection on fertile agricultural land, fragmented land acquisition, policy instability, and economic unviability. Drawing on primary and secondary sources, the study analyses land acquisition processes, rehabilitation and resettlement (R&R) measures, protests, and policy shifts. To address recurring issues, a Geographic Information System (GIS)–based Analytical Hierarchy Process (AHP) model identifies suitable sites for processing and non-processing SEZs. Land capability, proximity to national highways, state highways, railway networks, and class-I towns served as decision criteria. Secondary spatial data from NATMO and HARSAC were analyzed using ArcGIS. Results show Haryana is far more suitable for non-processing and IT/ITES-oriented SEZs, while large multi-service processing SEZs face severe constraints due to high-quality agricultural land. The study links SEZ development to urbanization in Haryana, evaluates its role in regional development versus inequality, and examines denotification policies' impact. It offers planning and policy insights for sustainable SEZ development in agrarian states.

Keywords: Special Economic Zones, GIS, Analytical Hierarchy Process, Site Suitability, Haryana, IT/ITES, Land Acquisition, Denotification, Regional Inequality.

1. Introduction :

A Special Economic Zone (SEZ) is a designated geographical area where economic regulations related to trade, investment, and business operations are more liberal than in the rest of the country. SEZs aim to boost exports, attract domestic and foreign direct investment, create employment, and streamline administrative processes through single-window clearances and fiscal incentives.In India, the Special Economic Zones Act was enacted in 2005 and became operational in 2006, leading to a surge in approvals. However, many SEZs failed to meet their objectives. Failures have been attributed to policy uncertainty, land acquisition disputes, inadequate infrastructure, and—most critically—inappropriate site selection (Singh, 2015). In contrast, China's success with SEZs stems from rigorous, science-based location choices aligned with regional economic, physical, and infrastructural realities.

India's approach prioritised rapid quantitative expansion over qualitative, spatially efficient planning, resulting in many economically unsustainable projects (Devadas & Gupta, 2011).Haryana exemplifies these challenges. The state ranked among the leaders in northern and north-western India for SEZ approvals and land allocation. As of March 2025, Haryana has 25 formal approvals under the SEZ Act, 22 notified SEZs, and 8 operational SEZs (sezindia.gov.in, State-wise distribution as on 18.03.2025). Despite this, Haryana remains one of India's most agriculturally advanced states—often called the nation's "bread basket"—with over 95% of its land classified as high-quality farmland. Proposing most SEZs on fertile agricultural land has raised serious concerns about regional equity, agricultural sustainability, long-term food security, and livelihood displacement.The collapse of the Gurgaon–Jhajjar Reliance Haryana Special Economic Zone Limited (RHSL)—India's largest proposed SEZ—vividly illustrates the perils of neglecting scientific site selection. This flagship project, announced in 2005–2006 as a joint venture between Reliance Industries and the Haryana State Industrial & Infrastructure Development Corporation (HSIIDC), targeted multi-product development on thousands of acres but never materialised into operational units, exports, or employment generation. Its failure stemmed from site selection on prime agricultural land, fragmented acquisition, policy reversals (e.g., MAT imposition and tax holiday withdrawal), and socio-economic conflicts.

Site selection for SEZs is inherently multi-dimensional, influenced by physical, economic, and social factors. Ramachandran and Biswas (2007) advocated integrating land capability, connectivity (roads and rails), proximity to urban centres, land cost, displacement minimisation, and speculation risks through spatial buffering. Devadas and Gupta (2011) used multi-criteria evaluation to balance positive (e.g., accessibility) and negative (e.g., fertile land) attributes. Mitra (2007) stressed labour availability, market access, and city size, while Grasset and Landy (2007) noted that locational needs vary by SEZ type (e.g., processing vs. non-processing/IT-ITES).Building on this literature and lessons from Haryana's experience—including empirical insights from Singh (2014) on socio-economic impacts such as livelihood disruption and income loss in affected villages—the present study selects five key criteria: land capability, proximity to national highways, state highways, railway networks, and class-I towns. These are integrated via the Analytical Hierarchy Process (AHP) within a Geographic Information System (GIS) framework. Recognising functional differences, the analysis separately evaluates suitability for processing SEZs (large-scale, land-intensive, manufacturing-oriented) and non-processing SEZs (smaller-scale, service/IT-ITES-oriented, lower environmental impact). This differentiated, evidence-based approach provides nuanced, policy-relevant guidance for sustainable SEZ development in agrarian states like Haryana, minimising agricultural conflict while enhancing economic viability.

1.1 The Gurgaon–Jhajjar Reliance Haryana Special Economic Zone Limited (RHSL): Causes of Failure

Announced in 2006 as a joint venture between Reliance Industries Limited (RIL) and the Haryana State Industrial & Infrastructure Development Corporation (HSIIDC), the RHSL was envisioned as India’s largest multi-product SEZ, initially targeting approximately 25,000 acres across

Gurgaon and Jhajjar districts (later scaled to ~8,250 acres). It promised ₹1.4 trillion in investment, 500,000 jobs, residential/commercial components, a power plant, logistics hub, and cargo airport. Land acquisition combined state-led compulsory acquisition under the Land Acquisition Act 1894 (HSIIDC acquired and transferred ~1,400 acres in Gurgaon for "New Gurgaon") and direct purchases by Reliance in Jhajjar (~7,100 acres at inflated rates of ~₹2.2 million/acre). However, the assembled land remained fragmented and non-contiguous, violating SEZ contiguity norms. Ultimately, only 1,383.68 acres were formally notified and transferred to RHSL at a cost of ₹399.85 crore. No units were established, no manufacturing or processing firms commenced operations, no labour force was engaged, and zero exports were generated—rendering the project economically unviable (CAG audits confirmed complete failure to meet export objectives).

Rehabilitation and Resettlement (R&R) Package : The Haryana R&R Policy 2007 (revised 2010)—often termed the "Haryana model"—was applied alongside the central SEZ framework. It included annuity payments (initially ₹30,000–₹42,000 per acre, escalating annually), one job per affected family (with 25% reservation for Haryana domiciles), residential plots where ≥75% holdings were acquired, skill-training centres, and infrastructure services. Reliance disbursed ₹50.71 crore in annuities by March 2013. Empirical primary surveys conducted across affected villages in Gurgaon and Jhajjar (Singh, 2014) reveal that while compensation and annuities provided short-term income buffers for landed households, the packages failed to restore livelihoods for the majority. Most respondents reported a shift from agriculture to casual wage labour, increased household debt due to rising living costs in the peri-urban fringe, and inadequate skill training that did not match emerging industrial needs. Landless Dalits and tenant cultivators—excluded from many benefits due to caste-based eligibility norms—faced acute marginalisation.

Farmer Protests and Socio-Economic Impacts : Protests, though localised and led by dominant Jat landowners through khap panchayats and organisations such as BKU and BBSS/KMSS, highlighted deeper socio-economic distress. Rallies involving 3,000+ farmers from 130 villages and mahapanchayats underscored grievances over undervalued compensation (market rates often 20–30 times higher than paid) and livelihood erosion. However, as documented in ethnographic and survey-based studies, the movement never scaled into a mass mobilisation because dominant castes systematically excluded landless and lower-caste groups (Levien, 2013; Singh, 2014). Primary data from Singh's (2014) field survey further quantify the impacts: average household income declined by 35–45% in the first two years post-acquisition for small and marginal farmers; food security deteriorated due to loss of cultivable land; and women's workforce participation shifted precariously from farm to informal domestic work. These findings align with broader empirical evidence on Haryana SEZs, where land acquisition disproportionately burdened agrarian households without commensurate employment gains (Singh, n.d. [SEZs and Regional Development paper]).

Critical Examination and Root Causes of Failure : The project's collapse stemmed from multiple interlocking factors: (i) inappropriate site selection on fertile double-cropped land without environmental or contiguity safeguards; (ii) central policy reversals (2009–2012) imposing land caps, Minimum Alternate Tax, and withdrawal of tax holidays; (iii) global slowdown and prohibitive land costs; and (iv) fragmented acquisition. In 2012 Reliance surrendered the project; the BoAdenotified it in 2013 (subject to benefit refund), and Haryana reclaimed the land in 2014, paying ₹343.51 crore. The land was repurposed under the Delhi-Mumbai Industrial Corridor as the Model Economic Township (now MET City), which—only after denotification—has generated ~40,000 jobs and attracted 600+ companies. The original SEZ phase, however, produced none of these outcomes, confirming the empirical verdict of Singh (2014) that ad-hoc land acquisition for SEZs in Haryana generated high social costs with negligible economic returns.

1.2 SEZs, Regional Development, and Countering Regional Inequality

SEZs were conceptually designed to promote balanced regional development by attracting investment to backward areas, generating employment, and reducing disparities. In Haryana, however, empirical evidence reveals the opposite outcome. Singh's spatial analysis (n.d.) of SEZ approvals shows overwhelming concentration in southern NCR districts (Gurgaon, Jhajjar, Faridabad, Palwal), which already possessed superior connectivity and infrastructure, while western and northern agrarian districts (e.g., Sirsa, Fatehabad, Ambala) received negligible allocations. This pattern exacerbated Haryana's historic east-west divide: NCR districts recorded 2–3 times higher per-capita income and industrial investment than western counterparts by 2011–12.

Primary socio-economic surveys (Singh, 2014) quantify the inequality effects: in SEZ-affected villages around Gurgaon-Jhajjar, average monthly household income rose modestly for landed families (via annuities) but fell sharply for landless and small farmers due to livelihood loss; inter-district development indices widened, with Gurgaon's Human Development Index surging while western districts stagnated. Broader studies confirm that SEZs in Haryana contributed to "enclave development" rather than backward linkages or skill diffusion, with employment generation remaining low and skill-mismatched (Aggarwal, 2006; Levien, 2013).

Denotification Policies and Their Influence : Central SEZ Rules permitting denotification (with benefit refund and state consent) have profoundly shaped Haryana's trajectory. Post-2011 policy corrections triggered widespread denotifications, including RHSL in 2013–14. While this enabled land repurposing (e.g., MET City's eventual success), it eroded investor confidence and slowed large-scale projects. Haryana subsequently converted several denotified SEZs into industrial estates, illustrating policy adaptability but underscoring how instability dampened the state's overall SEZ growth profile. Singh's empirical work (2014) concludes that without scientific site selection and inclusive R&R, SEZs reinforce rather than counter regional inequality—precisely the lesson informing the GIS-AHP analysis that follows.

2. **Analytical Hierarchy Process (AHP) Model :**

The Analytic Hierarchy Process (AHP), developed by Thomas L. Saaty in the 1970s, is a robust multi-criteria decision-making (MCDM) framework designed to handle complex problems with multiple, often conflicting criteria (Saaty, 1980). Widely applied in spatial planning, land-use suitability, and resource allocation, AHP effectively integrates qualitative expert judgments with quantitative data in a structured, transparent, and replicable manner (Alonso &Lamata, 2006). Its strength lies in decomposing intricate decisions into a hierarchy, enabling systematic prioritization while incorporating checks for logical consistency.The AHP process comprises four core stages:

1. **Problem Structuring (Hierarchy Modelling)**: The decision problem is organized into a hierarchical framework. The overall goal occupies the top level, criteria (and sub-criteria, if applicable) form the intermediate levels, and decision alternatives (here, potential locations across Haryana) constitute the bottom level. This decomposition clarifies relationships among elements and facilitates focused evaluation (Singh, 2013).
2. **Pair-wise Comparisons (Valuation)**: At each level, elements are compared in pairs to determine relative importance. Saaty's fundamental 1–9 scale is used:
    - 1 = Equal importance
    - 3 = Moderate importance of one over the other
    - 5 = Strong importance
    - 7 = Very strong importance
    - 9 = Extreme importance Intermediate values (2, 4, 6, 8) allow finer distinctions, while reciprocals (e.g., 1/3, 1/5) express the reverse preference (Saaty, 1977; Saaty& Vargas, 1991). For example, if land capability is deemed moderately more important than proximity to national highways for processing SEZs, the comparison yields a value of 3 (or 1/3 in the reciprocal cell). These judgments populate a reciprocal comparison matrix.
3. **Priority Derivation**: Relative weights are computed from each matrix using the principal eigenvector method (corresponding to the largest eigenvalue). This yields normalized local priorities (within a level) that sum to 1. Global priorities are then obtained by propagating weights down the hierarchy, ensuring the overall contribution of each criterion to the goal is logically consistent.
4. **Synthesis and Consistency Check**: Final composite priorities are synthesized by aggregating weighted scores across levels. To validate judgments, the Consistency Index (CI) is calculated as $(\lambda\_max - n)/(n - 1)$, where λ_max is the principal eigenvalue and n is the matrix size. The Consistency Ratio (CR) is then derived as CI / RI, where RI is the average random index for matrices of size n (e.g., RI $\approx$ 1.12 for n=5). A CR $\leq$ 0.10 is generally acceptable, indicating judgments are sufficiently consistent and not random; higher values necessitate revision of comparisons to reduce inconsistency and bias (Saaty, 1980; Janic&Reggiani, 2002).

In this study, two separate AHP models were constructed to reflect the distinct requirements of SEZ types:

- **Processing SEZs** (large-scale, manufacturing-oriented) emphasize land capability (highest weight) due to extensive land needs and potential environmental/agricultural impacts.

- **Non-processing SEZs** (e.g., IT/ITES, service-based) prioritize accessibility (national/state highways, railways, class-I towns) over land quality, as they require smaller parcels and generate minimal disruption.

Criteria weights, derived from expert-informed pair-wise comparisons (detailed in subsequent tables), were applied via GIS weighted overlay in ArcGIS. This integration of AHP with GIS produces spatially explicit suitability maps, offering a scientifically defensible, reproducible framework for SEZ site selection in Haryana. Recent applications in India—such as urban development suitability in Hisar City (Haryana), landfill siting in Rohtak, and agricultural zoning in northern regions—demonstrate the efficacy of AHP-GIS for land-use decisions in similar agrarian and rapidly urbanizing contexts.This approach directly addresses lessons from Haryana's SEZ failures (e.g., RHSL), where ad hoc site choices led to agricultural conflict and project collapse, by ensuring criteria alignment with regional realities and differentiated SEZ needs.

3. Objective of the Study :

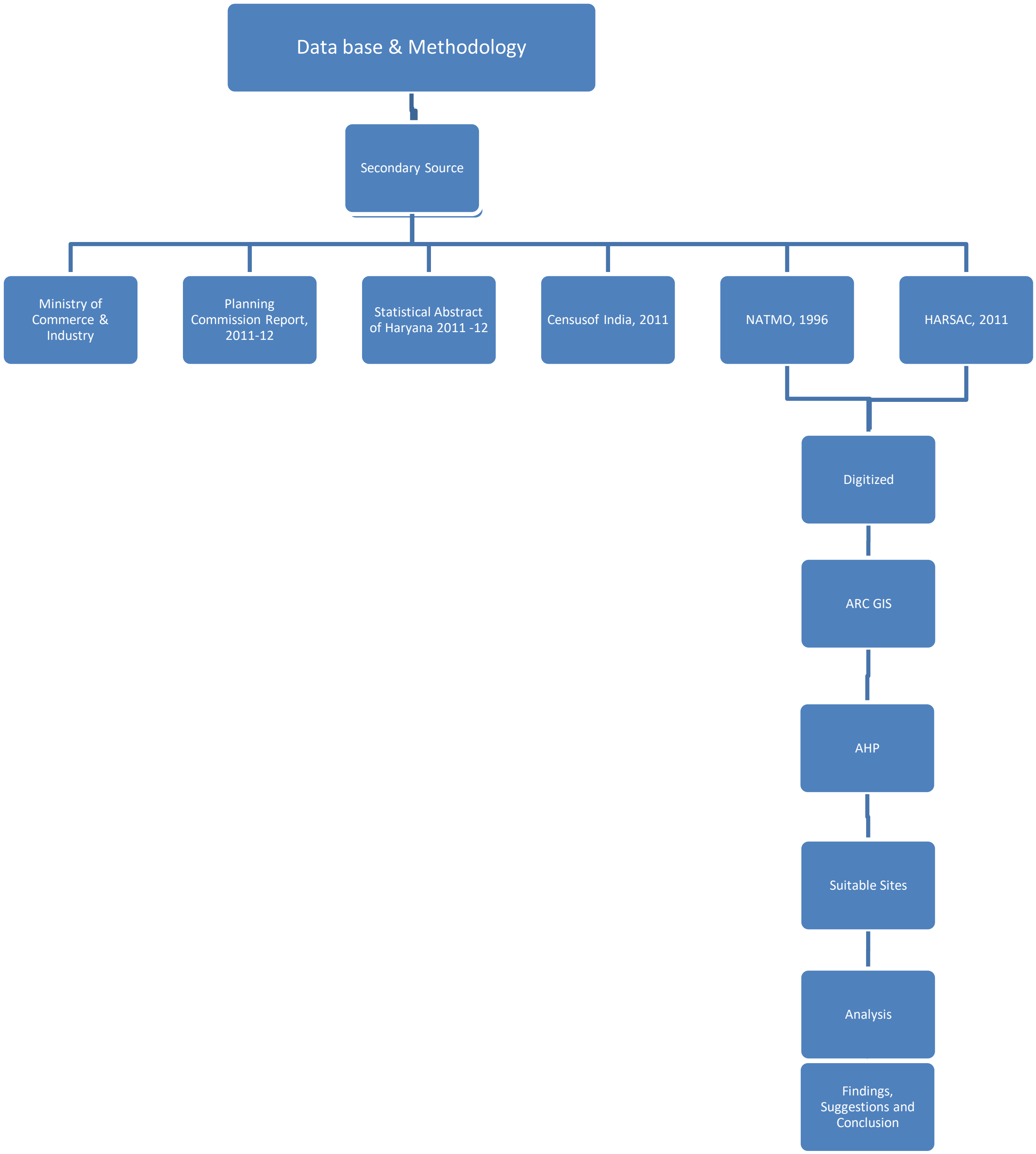
The primary objective of the present study is to identify potential and suitable sites for the development of Special Economic Zones (SEZs) in the state of Haryana using a GIS-based multi-criteria decision-making approach. The study aims to evaluate spatial suitability by integrating land capability and infrastructural accessibility parameters in order to support sustainable and regionally balanced SEZ planning.

4. Data Sources and Methodology :

The present study is based predominantly on secondary data sources. Spatial data on land capability were obtained from the National Atlas and Thematic Mapping Organisation (NATMO), New Delhi. Information related to transportation infrastructure—including national highways, state highways, railway networks—and class-I towns was sourced from the *Atlas of Haryana* prepared by the Haryana Space Applications Centre (HARSAC), Hisar.All spatial datasets were digitised, georeferenced, and converted into a uniform spatial framework using ArcGIS software. The digitised thematic layers were subsequently transformed into raster format to facilitate spatial analysis. These layers were then integrated into the Analytical Hierarchy Process (AHP) model, where relative weights were assigned to each criterion based on their significance in SEZ site selection.The AHP-derived weights were applied through a GIS-based weighted overlay analysis to generate suitability maps for SEZ development. The model was executed separately for processing and non-processing SEZs, enabling the identification of spatially suitable locations for the sustainable development of SEZs in Haryana.

The figure 1.1 highlights the flow chart of research methodology.

Figure 1.1


Data base & Methodology
Secondary Source
Ministry of Commerce & Industry
Planning Commission Report, 2011-12
Statistical Abstract of Haryana 2011 -12
Censusof India, 2011
NATMO, 1996
HARSAC, 2011
Digitized
ARC GIS
AHP
Suitable Sites
Analysis
Findings, Suggestions and Conclusion

5. Details of the Criteria :

The identification of suitable sites for Special Economic Zone (SEZ) development requires the application of region-specific criteria that reflect both physical and socio-economic conditions. A review of existing literature reveals that SEZ development in India has largely followed an ad hoc and unplanned trajectory, which has significantly undermined the effectiveness of the SEZ policy. One of the principal reasons for the limited success of SEZs in India is the absence of scientifically grounded site selection mechanisms.

Selecting appropriate locations for SEZ development is inherently complex, as SEZ performance depends on multiple interrelated factors. These include regional physical characteristics, socio-economic conditions, infrastructural availability, and the functional nature of the SEZ itself. The relative importance of these factors varies according to the type of SEZ, particularly between processing and non-processing categories. Drawing upon relevant literature and regional characteristics of Haryana, the present study employs the following criteria for SEZ site selection: land capability, proximity to national highways, state highways, railway networks, and class-I towns.

5.1 Land Capability

Land capability constitutes one of the most critical determinants in SEZ site selection, particularly in agriculturally productive regions. Haryana is widely recognised as one of India's most developed agricultural states and plays a crucial role in national food security. At the same time, the state has emerged as a prominent destination for SEZ development and has one of the highest proportions of land allocated to SEZs among the north-western states.Based on land capability assessment, five categories of land quality have been identified in the state: very good land, good land, fair land, poor land, and land unsuitable for agriculture. Empirical evidence indicates that more than 95 per cent of Haryana's total geographical area consists of very good, good, or moderately good agricultural land. In order to minimise adverse impacts on agriculture and food security, only poor-quality land and land unsuitable for agricultural use were considered suitable for SEZ development in the present analysis.Land capability was assigned the highest weight in the case of processing-type SEZs, as such SEZs require large contiguous land parcels and often exert significant environmental pressure. In contrast, relatively lower weight was assigned to land capability for non-processing SEZs, such as IT/ITES zones, which require comparatively smaller land areas and have minimal environmental impacts.

5.2 National Highways, State Highways, and Rail Network

Accessibility to transportation infrastructure is a key economic consideration in SEZ site selection. Proximity to national highways, state highways, and railway networks significantly reduces transportation costs, enhances logistical efficiency, and improves regional connectivity. Empirical studies suggest that manufacturing and operational costs increase substantially with greater distance from major transport corridors.In the present study, national highways, state highways, and railway lines were therefore accorded high priority in the site selection process. Buffer zones of 2 kilometres were generated around these transportation networks to assess spatial accessibility. Multiple buffer layers were subsequently employed to calculate distance-based suitability, ensuring that locations closer to major transport infrastructure received higher suitability scores.

5.3 Class-I Towns

Proximity to urban centres is another crucial determinant of SEZ suitability, as cities function as economic hubs that provide markets, labour, services, and institutional support. Class-I towns, in particular, offer significant advantages in terms of skilled labour availability, consumption markets, and supporting infrastructure.However, the locational preference relative to urban centres varies according to the type of SEZ. Multi-service and processing SEZs are generally located outside urban areas due to their large land requirements and potential environmental impacts, including air and water pollution. These SEZs require expansive land parcels that are rarely available within city limits and may adversely affect surrounding urban environments.

Figure 1.2

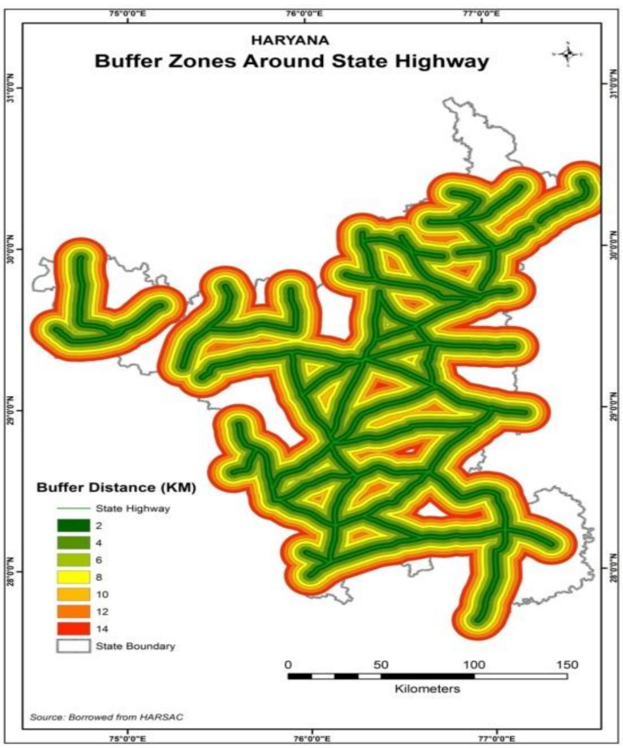
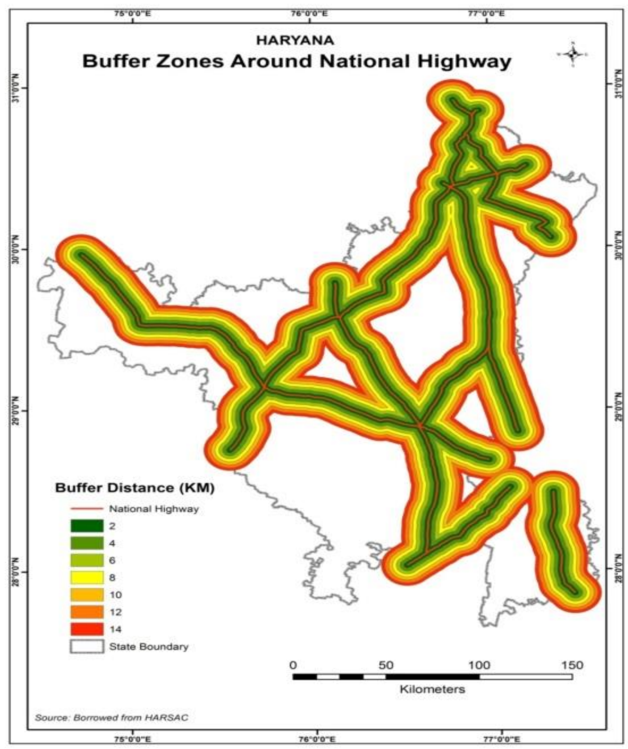


Figure 1.3



In contrast, non-processing SEZs, especially those related to IT and IT-enabled services, are characterised by low pollution levels and modest land requirements. Such SEZs are often advantageously located within or near urban areas to benefit from skilled labour pools and advanced service infrastructure.To account for these variations, multiple concentric buffer zones at 2-kilometre intervals were created around class-

I towns. A distance-based suitability function was applied to evaluate the spatial relationship between potential SEZ sites and major urban centres, allowing differential weighting based on SEZ type.The primary output of the Analytical Hierarchy Process (AHP) is a set of relative weights assigned to each criterion, derived through systematic pair-wise comparisons. After identifying the relevant criteria, hierarchical relationships among them were established and quantified using numerical preference scores. These scores reflect the relative importance of each criterion in relation to the overall objective and are based on informed expert judgment, as proposed by Saaty (2003). The pair-wise comparison matrix serves as the core mechanism for determining the relative priority of each criterion. In this matrix, each criterion is compared with every other criterion to assess its relative importance. The matrix is reciprocal in nature: values assigned in the upper triangular matrix represent the relative dominance of one criterion over another, while the corresponding lower triangular values are their reciprocals. The principal diagonal of the matrix always consists of unity values, indicating that each criterion is equally important when compared with itself.

Figure 1.4

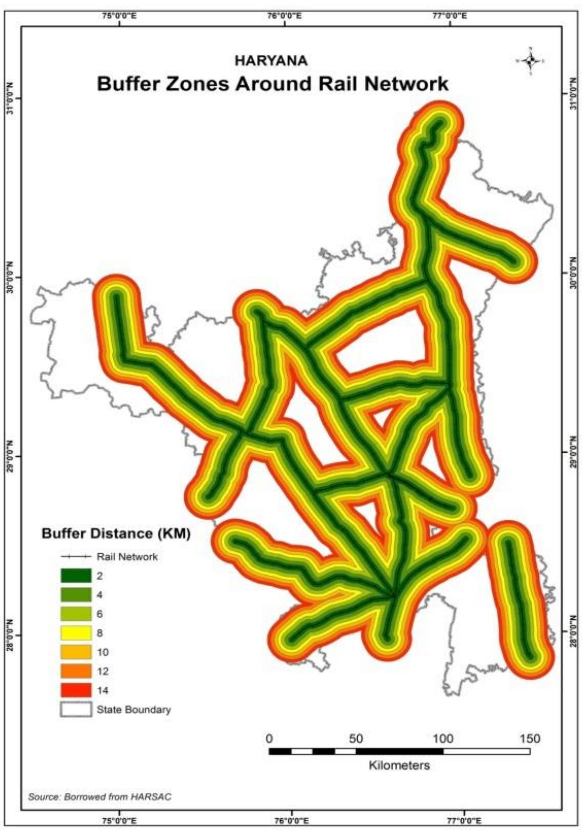
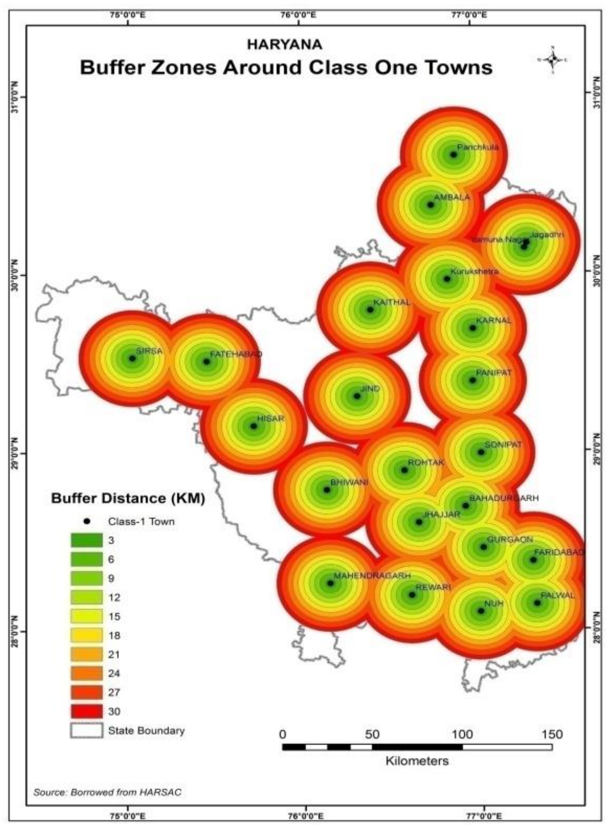


Figure 1.5



6. Pair-wise Comparison of Criteria :

Relative importance is expressed using Saaty's fundamental scale ranging from 1 to 9, where a value of 1 denotes equal importance and a value of 9 indicates extreme importance of one criterion over another (Saaty, 1977; Saaty& Vargas, 1991). Intermediate values reflect varying degrees of preference. When the column criterion is considered more important than the row criterion, reciprocal values between 1/2 and 1/9 are assigned.

Once the pair-wise comparison matrix is constructed, the principal eigenvector corresponding to the maximum eigenvalue is computed to derive the relative weights of the criteria. The eigenvector associated with the largest eigenvalue provides the best-fit estimate of relative priorities, ensuring that criteria with greater importance receive higher weight values (Saaty& Vargas, 1991; Saaty, 2003). Since the components of the eigenvector sum to unity, the resulting weights represent the proportional contribution of each criterion to the overall decision-making process and are subsequently used to generate the final SEZ site suitability map.In the present study, the criteria considered for SEZ site selection include land capability, accessibility to national highways, state highways, railway networks, and proximity to class-I towns. Each criterion was carefully evaluated and adjusted in accordance with the regional characteristics of Haryana and the functional requirements of different SEZ types.

The results of the pair-wise comparison indicate that land capability was assigned the highest weight in the case of processing-type SEZs. This reflects Haryana's predominantly high-quality agricultural land and the regulatory emphasis on prioritising wasteland and barren land over single-cropped and double-cropped agricultural land for SEZ development, as stipulated in official SEZ guidelines. Given the state's agrarian significance, protection of fertile land was considered a critical planning consideration.Conversely, for non-processing SEZs—particularly IT and IT-enabled services (IT/ITES) zones—greater weight was assigned to connectivity-related criteria, including proximity to highways, rail networks, and class-I towns. These SEZs require relatively smaller land parcels and benefit significantly from access to skilled labour, urban infrastructure, and service networks. Accordingly, national highways, state highways, railway networks, and class-I towns were delineated spatially and weighted appropriately within the AHP framework, taking into account variations in land capability zones. This differentiated weighting approach ensures that the AHP model accurately reflects both regional land-use constraints and sector-specific locational requirements, thereby enhancing the robustness and policy relevance of the SEZ site suitability analysis.

Table 1.1 Pair-wise Comparison Matrix for the Processing Type SEZ

Criteria	Land Capability	National Highway	State Highway	Rail Network	Urban Centre
Land Capability	1	1.33	2	4	3
National Highway	0.75	1	1.33	2	3
State Highway	0.5	0.75	1	2	3
Rail Network	0.25	0.5	0.5	1	0.66
Urban Centre	0.33	0.33	0.33	1.5	1

Total	2.83	3.91	5.16	10.5	10.66

Prepared by the Researcher

Table 1.2 Pair-wise Comparison Matrix for the Non-Processing Type SEZ

Criteria	National Highway	State Highway	Urban Centre	Land Capability	Rail Network
National Highway	1	1.33	0.8	4	4
State Highway	0.75	1	0.66	2.5	2
Urban Centre	1.25	1.5	1	3	2.5
Land Capability	0.25	0.4	0.33	1	0.75
Rail Network	0.25	0.5	0.4	1.33	1
Total	3.5	4.73	3.19	11.83	10.25

Prepared by the Researcher

The five criteria that were chosen for raster GIS themes were categorised using the standard values. Then, for both types of SEZ, the AHP pair-wise comparison matrix is built. This is based on how each component rates relative to the other factors, as given in Table 1.2.

Table 1.3 Normalised Pair-wise Matrix for the Processing Type SEZ

Criteria	Land Capability	National Highway	State Highway	Rail Network	Urban Centre	Total
Land Capability	0.35	0.34	0.39	0.38	0.28	1.74
National Highway	0.27	0.26	0.26	0.19	0.28	1.25
State Highway	0.18	0.19	0.19	0.19	0.28	1.03
Rail Network	0.09	0.13	0.10	0.10	0.06	0.47
Urban Centre	0.12	0.08	0.06	0.14	0.09	0.50

Prepared by the Researcher

Table 1.4 Normalised pair-wise Matrix for the Non-Processing Type SEZ

Criteria	National Highway	State Highway	Urban Centre	Land Capability	Rail Network	Total
National Highway	0.29	0.28	0.25	0.34	0.39	1.55
State Highway	0.21	0.21	0.21	0.21	0.20	1.04
Urban Centre	0.36	0.32	0.31	0.25	0.24	1.49
Land Capability	0.07	0.08	0.10	0.08	0.07	0.42
Rail Network	0.07	0.11	0.13	0.11	0.10	0.51

Prepared by the Researcher

7. Normalisation, GIS Processing, and Weighted Overlay Analysis :

Following the construction of the pair-wise comparison matrices, all criteria were normalised, and relative weights were derived separately for processing-type and non-processing-type SEZs using the Analytical Hierarchy Process (AHP). These weights represent the proportional importance of each criterion in the site suitability evaluation.

After preparing the thematic datasets, a topological framework was developed through essential geometric and thematic editing of the original spatial data. To facilitate spatial computation and analysis, all vector-based thematic layers were converted into raster format. Raster-based analysis was preferred because spatial computations such as overlay and weighting are computationally more efficient and analytically robust in raster environments than in vector formats (Chang, 2006).

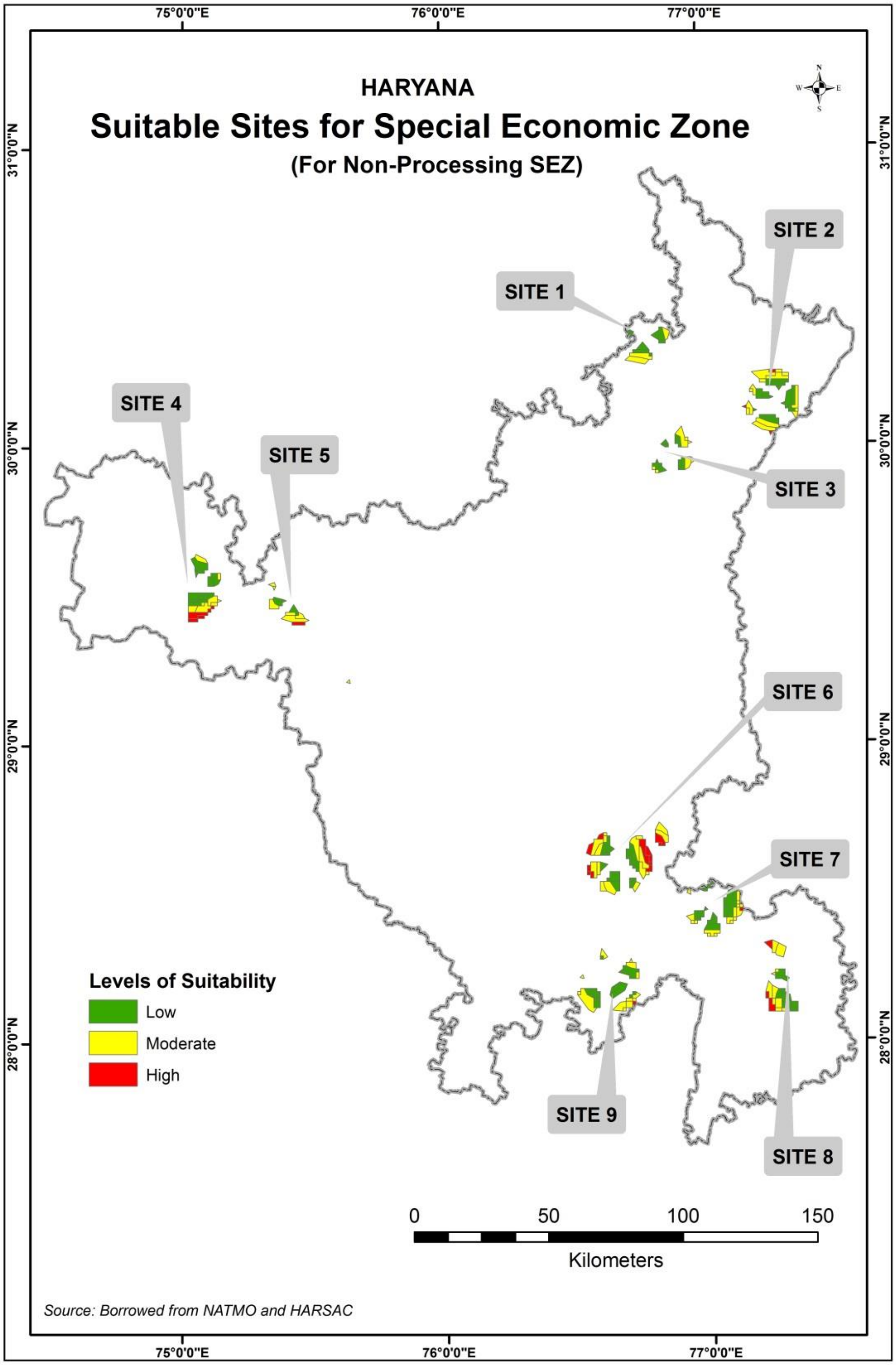
Each raster layer was structured so that every cell within the study area contained a numerical value representing its suitability with respect to a particular criterion. In order to generate composite suitability maps for SEZ development, all derived raster datasets were integrated using the weighted overlay technique available in the ArcGIS spatial analysis tools. For the weighted overlay operation, input layers must consist of discrete integer values. The land capability dataset already satisfied this requirement, as it was categorised into discrete land quality classes (e.g., poor land assigned a value of 2). In contrast, proximity-based layers derived from distance calculations (such as distance from roads, railways, and urban centres) produced continuous floating-point values. These layers were therefore reclassified into discrete suitability classes, with each class assigned an appropriate integer value.

During the reclassification process, suitability values were adjusted so that land categories representing very good, good, and moderately good agricultural land were constrained, while poor and agriculturally unsuitable land was prioritised. The final weighted overlay model was implemented using the ArcGIS spatial analysis environment, integrating all reclassified raster layers according to their respective AHP-derived weights. The resulting suitability maps for processing and non-processing SEZs are presented in Figures 1.6 and 1.7, respectively.

8. Consistency Assessment of the AHP Model :

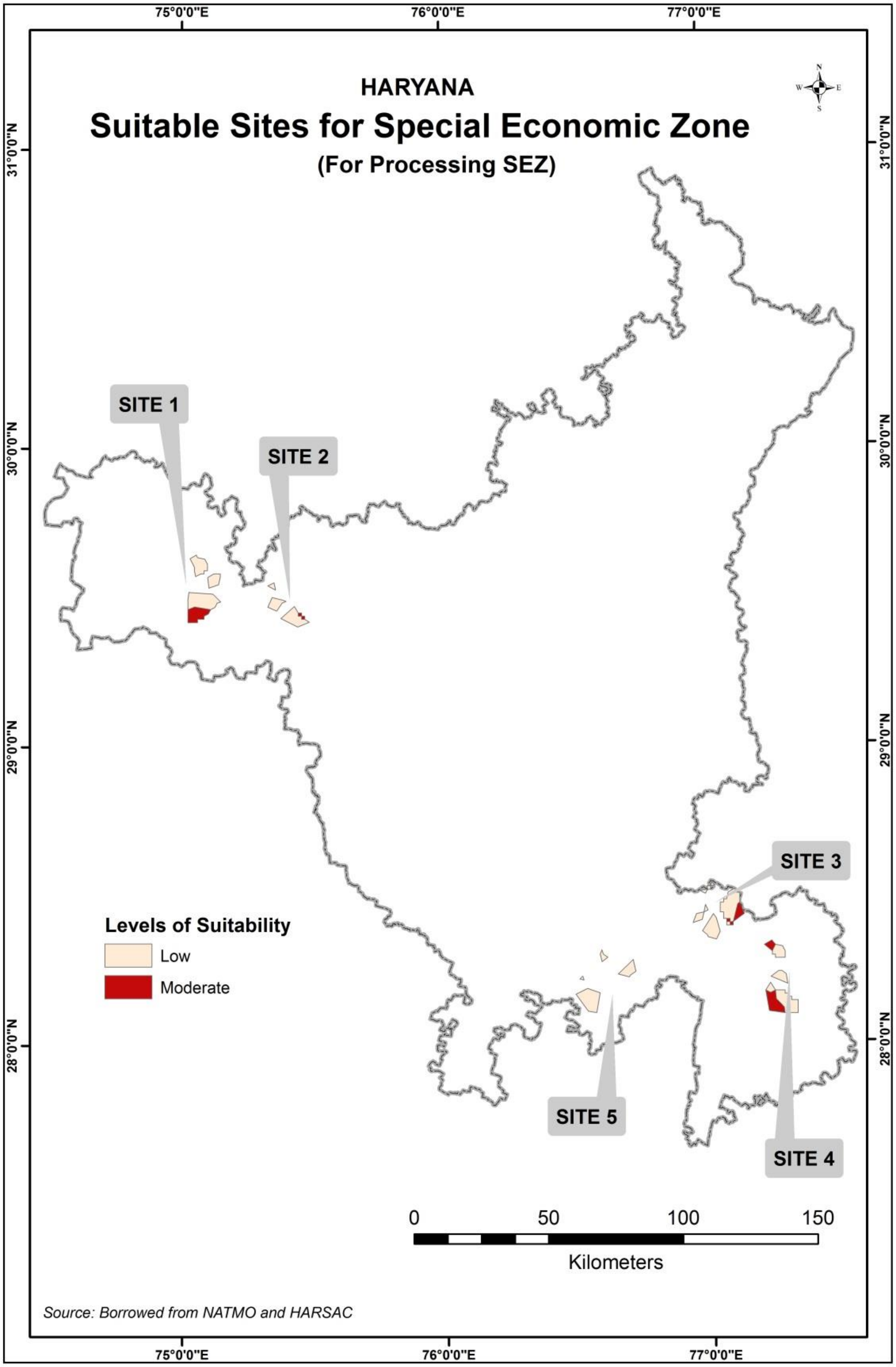
To ensure the reliability of the derived weights, the consistency of the pair-wise comparison matrices was evaluated using the Consistency Ratio (CR). The CR measures the likelihood that the judgments in the pair-wise comparisons were made randomly. According to Saaty (1980), a CR value of less than 0.10 indicates an acceptable level of consistency, whereas values exceeding this threshold suggest unreliable judgments that may compromise the validity of the results (as cited in Tienwong et al., 2009).

Figure 1.6



HARYANA
Suitable Sites for Special Economic Zone
(For Non-Processing SEZ)
75°0'0"E
76°0'0"E
77°0'0"E
31°0'0"N
30°0'0"N
29°0'0"N
28°0'0"N
SITE 1
SITE 2
SITE 3
SITE 4
SITE 5
SITE 6
SITE 7
SITE 8
SITE 9
Levels of Suitability
Low
Moderate
High
0
50
100
150
Kilometers
Source: Borrowed from NATMO and HARSAC

Figure 1.7


75°0'0"E
76°0'0"E
77°0'0"E
31°0'0"N
30°0'0"N
29°0'0"N
28°0'0"N
HARYANA
Suitable Sites for Special Economic Zone
(For Processing SEZ)
SITE 1
SITE 2
SITE 3
SITE 4
SITE 5
Levels of Suitability
Low
Moderate
0
50
100
150
Kilometers
Source: Borrowed from NATMO and HARSAC

In the present study, the calculated Consistency Ratio was 0.02 for processing-type SEZs and 0.01 for non-processing-type SEZs. Since both values are well below the accepted threshold of 0.10, the pair-wise comparisons are considered consistent. Consequently, the derived weights are deemed reliable and suitable for use in the SEZ site suitability analysis.

9. Identification of Suitable Sites for SEZ Development :

The identification of suitable sites for SEZ development was carried out using a GIS-based weighted overlay approach. This method integrates multiple spatial criteria into a single composite suitability surface, enabling the identification of locations that best satisfy the defined conditions. Overlay mapping is a fundamental GIS technique widely used in spatial planning and land suitability analysis to support informed decision-making.

While GIS provides the spatial framework for overlaying and analysing multiple datasets, the AHP contributes by assigning systematic and rational weights to individual criteria based on their relative importance.

The integration of GIS (Geographic Information System) and AHP (Analytical Hierarchy Process) provides a powerful, multi-criteria decision-making framework that effectively merges rigorous quantitative spatial analysis with structured expert-based qualitative judgment. GIS handles the geospatial data processing, visualization, and overlay of thematic layers (e.g., land capability maps, proximity buffers to highways/railways/urban centres), while AHP systematically derives relative weights for each criterion through pair-wise comparisons, eigenvector calculations, and consistency checks ($CR < 0.10$ in this study). This hybrid approach substantially reduces subjectivity—common in traditional site selection—by grounding decisions in transparent, replicable mathematical priorities and spatial realities, thereby enhancing the robustness, objectivity, and defensibility of the results.

By applying AHP-derived weights to the reclassified raster layers via weighted overlay in ArcGIS, the model synthesises disparate spatial datasets into a composite suitability surface. This generates an objective, transparent assessment of potential SEZ locations, where each cell's final suitability score reflects the combined influence of all criteria, prioritised according to their relative importance for processing versus non-processing SEZs.

This integrated methodology ensures that site suitability outcomes are not only scientifically grounded but also aligned with Haryana's unique planning priorities—particularly the protection of fertile agricultural land, promotion of sustainable development, and minimisation of land-use conflicts in an agrarian state.

Table 1.5 Areas under Different Levels of Suitability in Haryana (In Square Kilometres)

Levels of Suitability	Non-Processing Type SEZ	Processing Type SEZ
Low	530.49	431.50
Moderate	557.14	95.30
High	113.23	---
Total	1200.86	526.80

Prepared by the Researcher

10. Spatial Distribution and Extent of Suitable SEZ Sites :

The GIS-AHP suitability analysis identifies approximately 1,700.66 km² of Haryana's land as potentially viable for SEZ development. Haryana's total geographical area is 44,212 km² (constituting about 1.34% of India's landmass). Thus, the identified suitable area represents roughly 3.85% (often rounded to about 4% in policy discussions) of the state's total area. This limited extent underscores the severe spatial constraints for large-scale SEZ expansion in a state where over 95% of the land is classified as very good, good, or moderately good for agriculture, with high cropping intensity and critical contributions to national food security.

Of the total suitable land, nearly 70% (1,200.86 km²) is appropriate for non-processing SEZs (primarily IT/ITES and service-oriented zones), while only about 30% (526.80 km²) suits processing-type SEZs (manufacturing/multi-product). In proportional terms, non-processing SEZs account for approximately 2.71% of Haryana's geographical area, compared to just 1.20% for processing SEZs. This marked disparity highlights the structural incompatibility of expansive, land-intensive processing SEZs with Haryana's predominantly high-quality agricultural landscape, where large contiguous parcels of poor or unsuitable land are scarce.

A breakdown by suitability levels further reveals nuances:

- For non-processing SEZs, only ~9.4% (113.23 km² / 1,200.86 km²) falls in the high-suitability category—indicating truly optimal sites with the best alignment of low-impact land, strong connectivity, and urban proximity. The remaining ~90% is split roughly equally between low (44%) and moderate (46%) classes, suggesting many viable but sub-optimal locations that may require targeted infrastructure improvements. Despite these limitations, non-processing SEZs exhibit markedly higher overall feasibility, as they demand smaller parcels, generate lower environmental pressure, and align well with proximity to skilled labour in class-I towns and transport corridors.
- For processing-type SEZs, no area qualifies as high-suitability, reflecting the near-absence of large, contiguous, low-capability land parcels meeting stringent requirements. About 80% of the identified land (primarily low and moderate categories) indicates only marginal feasibility—suitable perhaps for smaller or hybrid projects but inadequate for large multi-

service/processing zones without significant trade-offs in agricultural productivity or environmental sustainability.

Figures 1.6 and 1.7 (suitability maps for non-processing and processing SEZs, respectively) illustrate pronounced spatial variability. Non-processing SEZs show a broader and more dispersed pattern of suitable patches, while processing SEZs are far more restricted, often fragmented or peripheral.

The analysis pinpoints nine discrete locations as suitable for non-processing SEZ development, compared to only five for processing-type SEZs—further evidencing greater flexibility for service-oriented zones. Districts such as Ambala, Yamuna Nagar, Kurukshetra, and parts of Jhajjar (despite Jhajjar's overall advantages) show limited or unfavourable conditions, especially for processing SEZs, due to higher land capability, poorer connectivity in some sub-regions, or environmental sensitivities.

In contrast, districts like Sirsa, Fatehabad, Gurgaon, Palwal, and Rewari offer comparatively better prospects for both categories, though suitability remains predominantly low to moderate (particularly for processing). Peri-urban and transitional zones—such as areas around Jagadhri (Yamuna Nagar), Bahadurgarh (Jhajjar), and the Faridabad-Palwal corridor—display moderate suitability, benefiting from transitional land uses, improving infrastructure, and proximity to urban markets without fully encroaching on prime farmland.

Jhajjar district stands out as the most favourable overall for SEZ development. Its advantages stem from:

- Strategic proximity to the National Capital Region (NCR), enabling access to Delhi's markets, talent pool, and logistics;
- Robust multi-modal connectivity (national/state highways, rail networks, and proximity to the Kundli-Manesar-Palwal Expressway and proposed DMIC alignments);
- Relatively lower land prices compared to saturated districts like Gurgaon and Faridabad, reducing acquisition costs and speculation pressures;
- Availability of some poorer/wasteland patches suitable for non-agricultural conversion.

These attributes make Jhajjar particularly attractive for non-processing and service-oriented SEZs (e.g., IT/ITES parks), which can leverage urban-adjacent advantages with minimal land footprint.

In summary, the results unequivocally demonstrate Haryana's greater suitability for non-processing SEZs (IT/ITES, services) over large-scale processing SEZs. The dominance of fertile agricultural land, combined with environmental safeguards, food security imperatives, and land-use policies, severely limits feasibility for manufacturing-intensive projects. Future SEZ development in Haryana should therefore prioritise non-processing, IT/ITES, and service-oriented zones on low-capability or marginal lands—better aligned with the state's physical, socio-economic, and agrarian characteristics—to promote sustainable, inclusive growth while minimising conflicts. This evidence-based approach, rooted in GIS-AHP integration, offers a replicable model for policy formulation in other agriculturally intensive states facing similar dilemmas.

References :

Aggarwal, A. (2006). Economic impacts of SEZs: Theoretical approaches and analysis of newly notified SEZs in India. MPRA Paper 20902.

Alonso, J. A., &Lamata, M. T. (2006). Consistency in the analytic hierarchy process: A new approach. *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 14*(4), 445–459. https://doi.org/10.1142/S0218488506004114.

Altuzarra, A., Moreno-Jiménez, J. M., & Salvador, M. (2007). A Bayesian prioritisation procedure for AHP group decision making. *European Journal of Operational Research, 182*(1), 367–382. https://doi.org/10.1016/j.ejor.2006.08.025.

Brown, L. (1966). Some aspects of land capability assessment in Africa. *African Affairs, 65*(261), 307–316.

Chang, K. T. (2006). *Introduction to geographic information systems* (3rd ed.). McGraw-Hill.

Dalalah, D., Hayajneh, M., &Batieha, F. (2010). Application of the analytic hierarchy process (AHP) in multi-criteria analysis of the selection of cranes. *Jordan Journal of Mechanical and Industrial Engineering, 4*(5), 567–578.

Devadas, V., & Gupta, R. (2011). Planning for special economic zones: A regional perspective. *Institute of Town Planners, India Journal, 8*(2), 53–58.

Grasset, J., & Landy, F. (2007). Special economic zones in India: Between international integration and real estate speculation. *Man & Development, 29*(4), 65–76.

Janic, M., &Reggiani, A. (2002). An application of the analytic hierarchy process to the evaluation of transport projects. *Transportation Planning and Technology, 25*(2), 115–128.

Levien, M. (2013). Regimes of Dispossession: Special Economic Zones and the Political Economy of Land in India. University of California, Berkeley.

Marinoni, O. (2004). Implementation of the analytic hierarchy process with VBA in ArcGIS. *Computers & Geosciences, 30*(6), 637–646. https://doi.org/10.1016/j.cageo.2004.03.010.

Mitra, S. (2007). Special economic zones: Rationale and pitfalls in implementation. *Man & Development, 29*(4), 41–50.

Ramachandran, R., & Biswas, D. (2007). Locating land for special economic zones: A methodology. *Man & Development*, *29*(4), 51–64.

Reinders, M. J., de Koning, G. H. J., &Veldkamp, A. (1990). Dynamic land capability modelling: A case history. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *329*(1255), 411–419.

Saaty, T. L. (1977). A scaling method for priorities in hierarchical structures. *Journal of Mathematical Psychology*, *15*(3), 234–281. https://doi.org/10.1016/0022-2496(77)90033-5.

Saaty, T. L. (1980). *The analytic hierarchy process: Planning, priority setting, and resource allocation*, McGraw-Hill.

Saaty, T. L. (2003). Decision-making with the AHP: Why is the principal eigenvector necessary? *European Journal of Operational Research*, *145*(1), 85–91. https://doi.org/10.1016/S0377-2217(02)00227-8

Saaty, T. L., & Vargas, L. G. (1991). *Prediction, projection and forecasting*. Kluwer Academic Publishers.

Singh, B. (2013). *Urban sprawl and land transformation in Rohtak City: A study using remote sensing and GIS techniques* (Unpublished doctoral dissertation). Department of Geography, Maharshi Dayanand University, Rohtak.

Singh, J. (2014). Implications of Special Economic Zone (SEZ) in Haryana. LAP Lambert Academic Publishing (empirical primary survey-based study).

Singh, J. and Singh B. (2014). Special Economic Zones (SEZs) and Regional Development in Haryana, International Research Journal of Commerce Arts and Science, Vol. 5, issue 2, pp 384-394.

Tienwong, K., Pathumnakul, S., &Piewthongngam, K. (2009). Application of AHP for evaluation of decision consistency. *International Journal of the Computer, the Internet and Management*, *17*(SP1), 1–6.

Web Sources

Government of India. (n.d.). *Special Economic Zones*. https://www.sezindia.nic.in

Government of India. (n.d.). *SEZ instructions (Instruction No. 65)*. https://www.sezindia.nic.in/writereaddata/Instructions/Instruction%20No.65.pdf

Government of Haryana. (2015). *Jhajjar district official website*. https://jhajjar.nic.in