A STUDY ON LOCATION FACTORS OF HEAVY INDUSTRIAL FACILITIES IN MONGOLIA USING ANALYTIC HIERARCHY PROCESS

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1. Abstract

This study utilizes the Analytical Hierarchy Process (AHP) to analyze factors influencing heavy industry location in Mongolia, guided by Weber's industrial location theory. By engaging industry professionals, the research prioritized 19 influencing and five limiting factors across four dimensions: environment, infrastructure, resources, and society. Key findings highlight the importance of environmental factors, particularly water resources and land cover, alongside infrastructure elements like railways and power stations. Resource proximity, political stability, and labor force also emerged as critical.

A comprehensive spatial analysis using MCDA techniques identified optimal locations for iron ore industry development, incorporating infrastructure and resource availability. The study's outcomes offer actionable insights for industrial zone planning and transportation network development, ensuring informed decision-making in Mongolia's heavy industry sector.

2. Research Objective:

This research aims to identify important factors for determining the heavy industry location and their order of importance. Then, it will define the industrial development zones and develop a unified mapping using the Analytical Hierarchy Process (AHP) and GIS mapping method, Multi-Criteria Decision Analysis (MCDA). The results will be used to determine Mongolia's heavy industry development zones and create a comprehensive transport and logistics network plan.

3. Methodology

The research methodology consists of 3 phases. **First**, the Literature review identifies heavy industry location factors and then makes a questionnaire survey. **Second,** the rank and weights of factors are identified through AHP analysis. **Third,** the heavy industry (iron ore) development zones will be defined, and a unified mapping will be developed using the GIS mapping method and MCDA.

4. Questionnaire survey

The survey aims to ascertain the weight and ranking of factors influencing industrial location decisions. It was designed as a questionnaire utilizing a pair-wise comparison matrix encompassing influencing and limiting factors. Conducted from January to March 2024, the survey was distributed to 60 experts meeting specific criteria: (1) possessing a profound understanding of the industry landscape and (2) serving as decision-makers capable of influencing the future development of the identified factors. To ensure equal participation of all parties, 50 experts (Ministries, Local administration, Associations, private sector, Academic institutions, Universities, and Researchers) were involved in the survey. The author also contacted each expert to check their understanding of the questionnaire and ensure the answers were unbiased. The experts' ages average is 40. Most of the education level was a master's degree, and most organizations were Ministries. Their years of working experience in heavy industry sector average of experiences is 20 years. They ensured the consistency index of the AHP approach.

5. Rusalts

5.1 Analytical Hierarchy Process (AHP)

#	Criteria	Weight	Rank	Priority
	Environmental			
1	Surface and Groundwater Resources	**0.307**	1	31%
2	Land cover	**0.195**	2	19%
3	Regulatory Environment	**0.192**	3	19%
4	Climate and environmental factors	**0.159**	4	16%
5	Engineering-geological assessment	**0.148**	5	15%
	Infrastructure			
1	Railways	**0.250**	1	25%
2	Power station	**0.242**	2	24%
3	Power transmission lines	**0.207**	3	21%
4	Ports	**0.153**	4	15%
5	Roadway	**0.148**	5	15%
	Resources and Spatial location			
1	Mineral resources	**0.305**	1	30%
2	Proximity to Raw Materials	**0.223**	2	22%
3	Proximity to Market	**0.174**	3	17%
4	Mining License of Mongolia	**0.170**	4	17%
5	Location of existing heavy industries	**0.128**	5	13%
	Society and Economy			
1	Political Stability and Security	**0.335**	1	33%
2	Labor force	**0.257**	2	26%
3	Tax Incentives and Benefits	**0.247**	3	25%
4	Population density	**0.161**	4	16%

Table 1. The weight and ranking of criteria in the AHP's result

Key Findings: The Analytical Hierarchy Process (AHP) analysis, a robust and practical decision-making tool, has yielded significant insights into the factors influencing industrial location efficiency operations in Mongolia. By considering 19 influencing factors and five limiting factors across four key dimensions: environment, infrastructure, resources, and society, the study provides a practical and relevant framework for informed decision-making in industrial location planning in Mongolia. This analysis is crucial as it provides a comprehensive understanding of the factors that drive industrial location efficiency operations, thereby confidently guiding your decision-making process.

5.2 Multi-Criteria Decision Analysis (MCDA)

Iron ore industry

After calculating AHP, the main resources of the iron ore industry are iron ore deposits, which are considered in terms of 3 levels of resources. Infrastructure for developing iron ore production includes railways, power lines, and power stations. Therefore, iron ore resources, railways, power lines, power stations, ports, roadways, cities and towns, unemployed citizens, lakes, rivers, and underground water resources were the main factors determining the industrial area. Also, five factors were considered as unsuitable areas or limiting factors.

Each factor map was created using the rank order matrix method (AHP) to create a thematic layer and calculate each factor's weight value. Table 2 shows the rank and weight of the criteria.

The integrated overlap layer is processed by adding and multiplying by the map algebra method:

Si=F1*0.169+F2*0.169+F3*0.169+F4*0.085+F5*0.085+F6*0.085+F7*0.040+F8*0.040+F9*0.040+F10*0.040+F11*0.020+F12*0.020+F13*0.010+F14*0.010+F15*0.010.

The final results of Multi-criteria decision analysis in GIS is a recommendation for future action for decision-makers presented in the form of a suitability map. **Figure 1** presents suitability maps for industrial site selection in the iron ore industry generated in ArcGIS using AHP and MCDA. Red represents the most suitable locations. In contrast, blue represents the most unsuitable locations. This suitability map represents macro-ranked sites based on the survey's selection criteria, which are social, economic, and environmental. The resulting map was further analyzed for development as industrial zones.

	Factors	Name
INFLUENCING FACTORS	Iron deposits (more than 20 million tons of reserves)	F1
	Iron deposits (3-20 million tons of reserves)	F2
	Railways	F3
	Iron deposits (reserves below 3 million tons)	F4
	Power transmission lines (existing)	F5
	Power transmission lines (planning)	F6
	Power station (existing)	F7
	Power station (planning)	F8
	Ports	F9
	Roadway	F10
	Cities and towns	F11
	Unemployed citizens	F12
	lake	F13
	River network density	F14
	Groundwater Resources	F15
LIMITING BASE FACTORS	Land cover	F16
	Topographic slope	F17
	Direction	F18
	Specially protected areas	F19
	Forest and water reserve area and headwaters of rivers	F20

Criteria	Rank	Weight
F1	1	0.169
F2	2	0.169
F3	3	0.169
F4	4	0.085
F5	5	0.085
F6	6	0.085
F7	7	0.040
F8	8	0.040
F9	9	0.040
F10	10	0.040
F11	11	0.020
F12	12	0.020
F13	13	0.010
F14	14	0.010
F15	15	0.010

Table 2. Iron Industry criteria Rank and weight

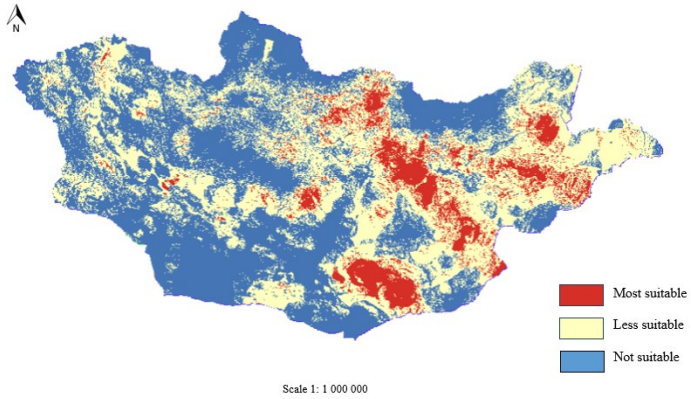

Figure 1. Final Result For Iron Ore Industry Development Zone

6. Conclusion

Mongolia's industrial planning and development require a nuanced approach considering its unique economic, environmental, and social conditions. The innovative methodologies applied in this study offer a solid foundation for informed decision-making and strategic planning, aiming for sustainable industrial growth and economic diversification.

7. Future work

This research focuses exclusively on the iron ore industry development zone. Future work will involve identifying and mapping industrial development zones for heavy industries such as coal, copper, metal, and non-metal minerals. Moreover, our study of the AHP results made it possible to determine the industrial development zones of heavy industries.