KATHMANDU UNIVERSITY

SCHOOL OF ENGINEERING

DEPARTMENT OF GEOMATICS ENGINEERING

FINAL REPORT ON

IDENTIFICATION OF APPROPRIATE LOCATION FOR WINDFARM SITES

USING GIS AND AHP APPROACH

A CASE STUDY OF MYAGDI DISTRICT

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Abstract

Due to the minimal environmental effect and low costs of production, operation, and maintenance, wind energy is one of the most appealing renewable energy sources. Finding the ideal sites for wind farms to be constructed and run profitably in Nepal's Myagdi district is the aim of this study. This study examined the five crucial factors that have a significant impact on a location's suitability, using the Geographic Information System (GIS) and AHP approaches. Wind velocity, land suitability for land use, elevation, proximity to roads, and proximity to a power plant are the five requirements. The existing literature study served as the basis for assigning ratings to each criterion. The AHP method was used to get the normalised weights of each criterion based on the ratings. A distinct suitability map was made for each criterion, with five degrees of suitability from best suitability, which is rated as 5, to no suitability, which is rated as 1. After a weighted overlay of the five maps, the final suitability map was created. It has five classifications, with 1 denoting the least suitable sites in the Myagdi district and 5 representing the best appropriateness sites. According to this assessment, the Myagdi regions with the high and highest suitability for the installation of wind turbines are 430.11 km^2 and 2.0189 km^2 , whereas the areas with the lowest and least suitability are 115.297 km^2 and 921.438 km^2 . In conclusion, if wind turbines are installed on the chosen locations, this research will improve the renewable energy resources that are now present in Myagdi District.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

List of Abbreviations

AHP	Analytical Hiearchical Process
DEM	Digital Elevation Model
GW	GigaWatt
GWh	GigaWatt hour
KW	KiloWatt
LULC	Land Use Land Cover
M	Meter
MCDA	Multi Criteria Decision Analysis
MCDM	Multi Criteria Decision Making
MW	Megawatt
NBC	Nepal National Building Code
NEA	Nepal Electricity Authority
SPUP	Solar Photovoltaic Plan
UTM	Universal Transverse Mercator
Vc	Cut in velocity
Vr	Rated Velocity
Vf	Cut out velocity
VDC	Village Development Committee
WGS	World Geodetic System
WECS	Water and Energy Commission Secretariat
WPP	Wind Power Plant
WSM	Weighted Scenario Method

1. Introduction

1.1 Background

In recent years, the world's search for sustainable and renewable energy sources has gotten more intense due to the growing problems brought on by climate change and the limited supply of traditional energy sources. Wind energy is particularly noteworthy among these renewable energy sources as a potential source of efficient and clean energy production. Wind energy is a form of renewable energy that harnesses the power of the wind to generate electricity. It is considered a clean and sustainable source of power because it does not produce greenhouse gas emissions or other pollutants associated with fossil fuels. Finding areas with the best wind-power potential is crucial as countries look to switch to more environmentally friendly energy sources. Wind energy has grown significantly as a clean and sustainable alternative to conventional fossil fuels. Onshore wind farms, situated on land, and offshore wind farms, located in bodies of water, have become prominent installations globally. Technological advancements, including larger and more efficient turbines, improved materials, and enhanced control systems, have contributed to increased energy production and cost-effectiveness. Wind energy offers numerous advantages, such as reducing greenhouse gas emissions, providing a domestic energy source, and contributing to job creation. However, challenges include intermittency and the need for energy storage solutions to ensure a consistent power supply. The global expansion of wind energy reflects its vital role in the transition toward a more sustainable and environmentally friendly energy landscape. (Baffoe & Sarpong, 2016)

For Nepal, the country's diverse topography, characterized by hills and mountains, presents varied wind patterns that can be tapped for electricity generation. While the development of wind energy in Nepal has been relatively modest compared to other renewable sources like hydropower, the government has recognized the significance of diversifying its energy mix to enhance sustainability and address growing energy demands. Various regions in Nepal have been identified as having favourable wind conditions for potential wind farm installations. Continued efforts to assess wind potential, invest in appropriate technology, and formulate supportive policies can further unlock Nepal's capacity to harness wind power, contributing to a more balanced and resilient energy infrastructure.

The history of wind energy in Nepal has been characterized by a gradual exploration and development of this renewable energy source. Nepal, without proper wind energy resource assessment and detailed technical analysis for wind power development, already faced a bitter experience in the wind energy sector when the initiative undertaken by the Nepal Electricity Authority (NEA) in 1989 to produce power through wind energy by installing two wind generators of 10 kW capacities, which got a jolt within three months of the project commencement. This acts as a major barrier to wind power development in Nepal and is regarded as wasteful resources and no one is interested in investing in the wind energy sector. Nepal began actively considering wind energy in the 1990s, conducting initial assessments of wind potential and implementing pilot projects. These early initiatives sought to determine whether using wind energy to generate electricity was feasible. To show the viability of wind energy, the government has spent years building small-scale wind farms, frequently in cooperation with foreign groups. The government of Nepal has recognized the importance of renewable energy, including wind power, as part of its strategy to address the growing demand for electricity and reduce dependency on traditional energy sources. Ongoing efforts involve wind monitoring, technology advancements, and policy support to further integrate wind energy into the national energy portfolio and contribute to the country's sustainable development goals. (Neupane, Kafle, Karki, & Kim, Solar and wind energy potential assessment at provincial level in Nepal: Geospatial and economic analysis, January 2022)

The purpose of this study is to assess wind power's suitability in the context of Myagdi District, a location with distinct environmental and geological features. Myagdi District, which is situated in Western Development Region of Nepal has a lot of potential to improve the state of renewable energy. We use the Analytical Hierarchy Process (AHP), a well-known decision-making process that enables a thorough and organized assessment of complex, multi-criteria problems, to methodically evaluate the viability of wind power implementation in this location.

1.1.1 Multi-Criteria Decision Making (MCDM)

Multiple Criteria Decision Making (MCDM) is a decision analysis approach designed to handle situations where decisions involve multiple and often conflicting criteria. MCDM methods provide a systematic framework for evaluating and selecting alternatives based on various criteria simultaneously. These criteria may include cost, time, risk, and other factors relevant to the decision context. MCDM methods help decision-makers by considering the trade-offs and preferences among these criteria, often involving mathematical models or algorithms to generate a comprehensive evaluation. The goal of MCDM is to identify the most suitable alternative that optimally balances the conflicting objectives, providing a valuable tool in fields such as business, engineering, and public policy where decisions are complex. (Al-Shabeeb, Al-Adamat, & Mashagbah, October 2016)

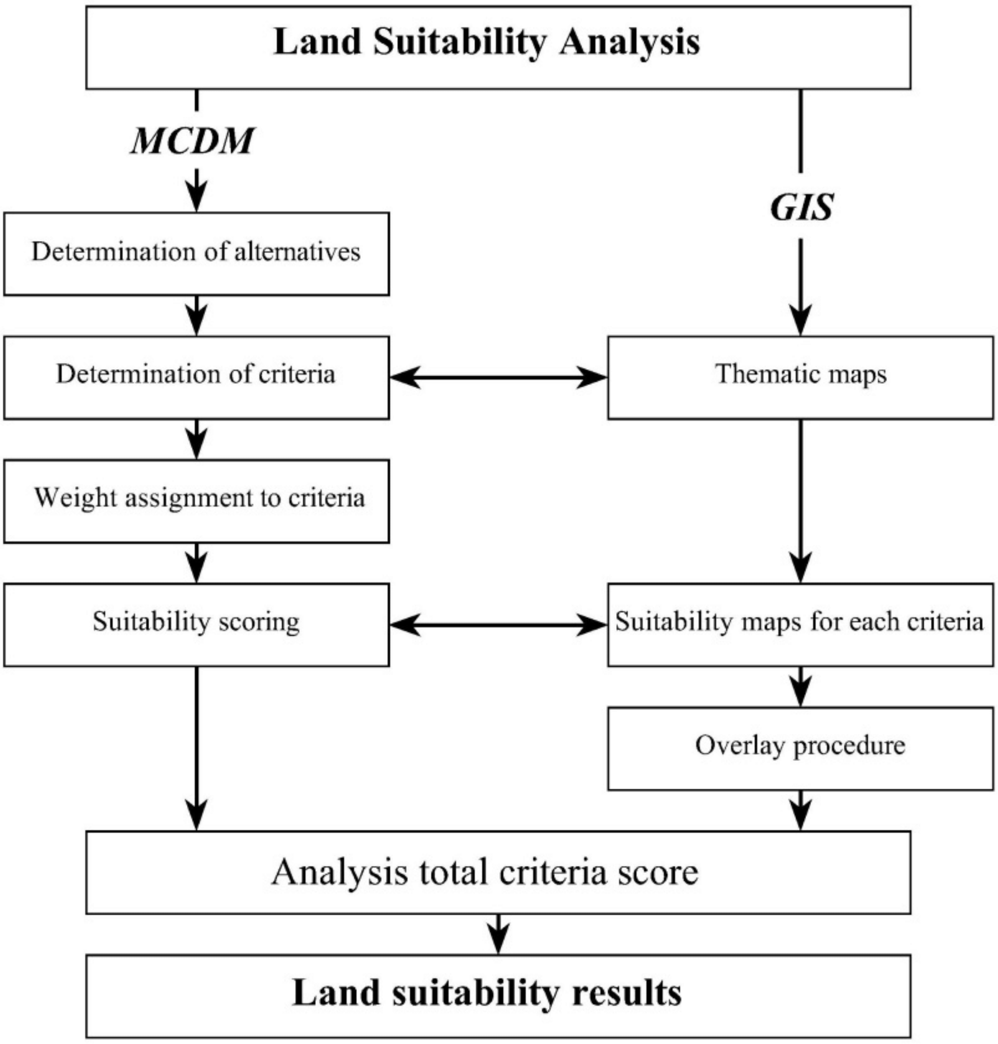

Figure 1: MCDM and GIS

1.1.2 Analytical Hierarchical Process (AHP)

The Analytic Hierarchy Process (AHP) is a structured decision-making methodology developed by Thomas L. Saaty in the 1970s. AHP facilitates complex decision analysis by organizing problems into a hierarchical structure with a goal at the top, criteria in the middle, and alternatives at the bottom. Decision-makers employ pairwise comparisons, assigning relative importance using a scale developed by Saaty. Mathematical checks ensure consistency in judgments, and eigenvalues and eigenvectors are employed to derive weights for criteria and alternatives. These weights, reflecting the priorities of each element, are aggregated to provide an overall ranking of alternatives. AHP offers a systematic approach to decision-making, enhancing transparency and aiding in the selection of the most suitable alternative based on established criteria. Its applications span diverse fields, including project management, resource allocation, risk assessment, and strategic planning.

It consists of three steps:

1. Developing the hierarchy of attributes germane to the selection of multiple alternatives.
2. Identifying the relative importance of the attributes.
3. Scoring the alternatives' relative performance on each element of the hierarchy.

1.2 Problem of Statement

Myagdi's unique topography and climatic conditions offer potential for harnessing wind energy, but an absence of systematic assessments hinders its realization. This study aims to address this gap by employing the Analytical Hierarchy Process (AHP) to systematically analyze various criteria, including wind speed, to residential areas, transportation accessibility, elevation, and land availability to determine the most suitable locations for wind power installations. By doing so, this study seeks to provide valuable insights into the feasibility and optimization of wind power projects in Myagdi District, contributing to the district's energy sustainability goals and providing a template for similar assessments in diverse geographical contexts. It cannot be un-noticed that the production of ample energy would benefit Nepal in this transition era of energy from non-renewable to renewable sources.

1.3 Scope

The scope of the study on wind power suitability in Myagdi District using the Analytical Hierarchy Process (AHP) encompasses a multidimensional analysis of factors influencing the feasibility and optimization of wind energy installations. The geographic scope covers Myagdi District, considering its unique terrain and climatic conditions, and aims to provide localized insights into the potential for harnessing wind energy. This project covers all village and municipalities parts of the Myagdi district to find a proper wind power site. In this study, 5 factors are taken into consideration and they are roads, wind velocity, power stations, land use land cover and slope. Most of the values which are assigned during analysis are assumed based on different research papers of various authors. By utilizing a GIS approach, this study aims to establish a systematic and sustainable installation of wind farm in the district.

2. Objectives

The key objective of this project was:

• To utilize AHP to prioritize and rank potential sites within Myagdi District for wind power projects, integrating various criteria and ensuring a systematic and transparent decision-making process.

The secondary objectives of this project are:

- To comprehensively describe current technologies, strategic innovation and monitoring tools.
- To perform suitability analysis using GIS based MCDM.

3. Literature Review

(Mostafaeipour, Sedaghat, Dehghan-Niri, & Kalantar, 2011) conducted feasibility study of wind energy of Shahrbabak, Kaman province, of Iran. The author used two-parameter Weibull distribution function for wind analysis and wind power density for energy generation and concluded that the site is suitable for the installation of small wind energy farm. (Mostafaeipour A. , Feasibility study of harnessing wind energy for turbine installation in province of Yazd in Iran, 2010) in another work conducted the feasibility study of wind potential of Yazd province of Iran. In this work, the author analyzed the 13-year wind data and used the measured data at the height of 10 m. The study suggested that the site is suitable for wind farm development.

Keyhani investigated the wind climate for the energy production at Tehran, the capital of Iran. In this work, the author used the two-parameter Weibull distribution function for seasonal wind analysis using measured data at the height of 10 m (Keyhani, Ghasemi-Varnamkhasti, Khanali, & Abbaszadeh, 2010). Kwon investigated the wind uncertainty of a Kwangyang Bay of Chonnam Peninsula of the southern coast of Korea and found 11% wind uncertainty. The author used probability models for wind variability including air density, surface roughness factor, wind speed, Weibull parameters, and error estimation of long-term wind speed based upon the Measure-Correlate-Predict method for uncertainty analysis (Kwon, 2010).

3.1 Wind power as a significant renewable energy source

Due to the importance of selecting a renewable energy source or determining the facility/location for the selected renewable energy or determining the materials to be used or activities related to it renewable energy farm investment, many studies exist in the literature. Several research papers and articles on the potential of wind energy generation over some regions of Nepal and in some countries of the world were studied and researched. The continuation of life on Earth depends on energy. It will continue to be the fundamental basis for societal, economic, and international peace growth. The global need for energy has been rising rapidly. Earth's conventional energy resources are finite. The worldwide shortage of fossil fuel reserves, their finite supply, and their volatile costs have forced an urgent search for alternate energy sources and sharply raised interest in renewable energy sources (Abdel Rahman Al-Shabeeb, 2016) Not only for reducing the consumption of fossil fuels, the enhancement and development of renewable energy also helps in minimizing global warming. To quickly decarbonize and prevent further global warming, renewable energies like solar and wind power are essential (Neupane, Kafle, Karki, Kim, & Pradhan, Solar and wind energy potential assessment at provincial level in Nepal: Geospatial and economic analysis, 2022)

Although there are several ways to generate renewable energy, one of the most promising is wind energy, which might help meet the world's growing energy needs (Chedid & Rahman, 1997). From a technological, environmental, socioeconomic, and political perspective, wind power is the most deserving of a wider widespread deployment among all the cleaner energy production options (geothermal, solar, tidal, biomass, and hydro), according to Talinli. Many people are starting to recognise the significance of wind energy as a crucial long-term renewable energy source since it is clean, free, and renewable. Using wind energy hence reduces dependency on traditional fossil fuel-based electricity generation. Consequently, this ensures environmental sustainability as well as supply security (Talinli, Topuz, Aydin, & Kabakcı, 2011).

Upreti & Shakya, provided the information that up to 46.76 m/s of extreme wind speed and 238 kW/m^2 of power density are present. About 3.387 MWh/m^2 of energy may be produced annually on average. 6074 sq. km of the country's land might be used for wind energy, with a wind power density of more than 300 watts per square meter. At 5 MW per sq kilometer, more than 3,000 MW of electricity might be produced. Nepal only began compiling wind speed statistics from 1967. Till 2010, according to Upreti & Shakya, 29 out of 40 wind measuring stations installed by the Department of Hydrology and Meteorology were functioning effectively. Out of the 29 stations, 7 were in the higher Himalayan region, 11 in middle mountain region and 11 in the Terai plains in the south. Upreti & Shakya also provided the conclusive information that in comparison to high altitude valleys and mountain ridges, low altitude valleys have wind speeds that are smaller in magnitude. Nepal National Building Code NBC 104 :1994 on wind load has divided the whole country into two regions; The lower plains and hills generally including the southern plains (Terai), Kathmandu Valley and areas generally below 3000 m altitude where the basic wind velocity of 47 m/s is adopted and the second zone lies above 3000 m where the basic wind velocity of 55 m/s is adopted. According to Department of Hydrology and Meteorology, there are currently 36 wind measuring stations in Nepal including Agrometeorology station, Synoptic station and Aeronautical station, and among them, there are 9 wind measuring working condition stations in Gandaki Province (Upreti & Shakya).

3.2 Application of the AHP model for suitability analysis through MCDA

Using multi-criteria decision analysis to make decisions is a compelling way to arrive at an integrated decision-making outcome. Al-Shabeeb et al. (2016) used five criteria—wind speed, rainfall, slope, altitude, and land use—to determine which locations in the northwest of Jordan were both appropriate and extremely suitable for the building of wind farms. Based on assessments of the relevant literature and the opinions of experts, they assigned ratings to each criterion. Likewise, in order to establish windmills in Saudi Arabia, (Baseer & S. Rehman) also used MCDM approach-based GIS modelling based on various climatic, economic, aesthetic, and environmental criteria, such as wind resources, accessibility by roads, proximity to the electrical grid, and ideal distance from various settlements and airports. To ascertain the best locations for large-scape WPPs and SPVP, GIS and AHP based on MCDM were employed by (Rekik & Alimi, 2023). AHP was utilised for the appropriateness analysis in the a fore mentioned research projects. This is an important task because different criteria have variable values for the same problem. The weight of the criteria was computed based on their relative importance.

(Natei Ermias Benti, Site suitability assessment for the development of wind power plant in Wolaita area, Southern Ethiopia: an AHP-GIS model, 2023) used Multi-criteria decision-making (MCDM) methods, encompassing techniques such as the weighted sum method (WSM), Analytical Hierarchy Process (AHP), weighted linear combination (WLC), and more, are employed for wind farm location assessments. Among these, AHP stands out for its simplicity, ease of use, and capability to evaluate decision consistency. AHP allows for the incorporation of both qualitative and quantitative criteria, empowering decision-makers to assign relative weights based on their expertise. Previous studies have successfully combined AHP with Geographic Information System (GIS) to select wind energy sites based on various factors.

Wind farm siting can be considered as a Multi Criteria Decision Making (MCDM) problem that consists of a set of alternative locations and a set of selection criteria. This study applied a multi-criteria decision approaching using an Analytical Hierarchy Process with an Ordered Weigh Averaging AHP-OWA aggregation function to derive wind farm land suitability index and classification under a Geographical Information System (GIS) environment. The linguistic quantifier's version of the AHP-OWA aggregation function was used to classify lands based on their suitability for wind farm installation. Different selection criteria were considered including economical (distance to road, terrain slope), social (urban area), environmental (historical locations, wildlife and natural reserves) and technical (wind power density, energy demand matching, percentage of sustainable wind, turbulence intensity, dunes). A case study of the proposed approach is implemented and presented for Oman (Sultan Al-Yahyai, 2012)

(Ozim, et al., 2021) used Geographic Information System (GIS) and Multi-Criteria Decision Analysis (MCDA) to spatially analyse and model wind farm site suitability in Nasarawa State. Aiming to integrate the environmental, social, and economic aspects of decision-making for identifying sustainable wind farm sites. The study distinguished between two sets of decision criteria: decision constraints and decision factors. The zones were standardized based on fuzzy logic to depict varying degrees of suitability across the State. The MCDA applied the weighted linear combination method, with relative weights generated through pairwise comparisons of the analytic hierarchy process to analyse three policy scenarios: equal weights, environmental/social priority, and economic priority scenario. A combination of resulting composite maps from the constraints and the factors gave the final suitability maps.

4. METHODOLOGY

4.1 Study Area

Myagdi district is located in the western part of Gandaki Province and it extends from 28.3417°N to 83.5666°E. The district, with Beni as its district headquarters, covers an area of 2,297 km². The altitude of the study area ranges from 792m above sea level (Ratnechaur VDC) to 8167m above sea level (Dhaulagiri Himal). According to census 2021, the total population of Myagdi district is 107,033 with a 0.57% annual population change. The study area has a 46.60/km² population density.

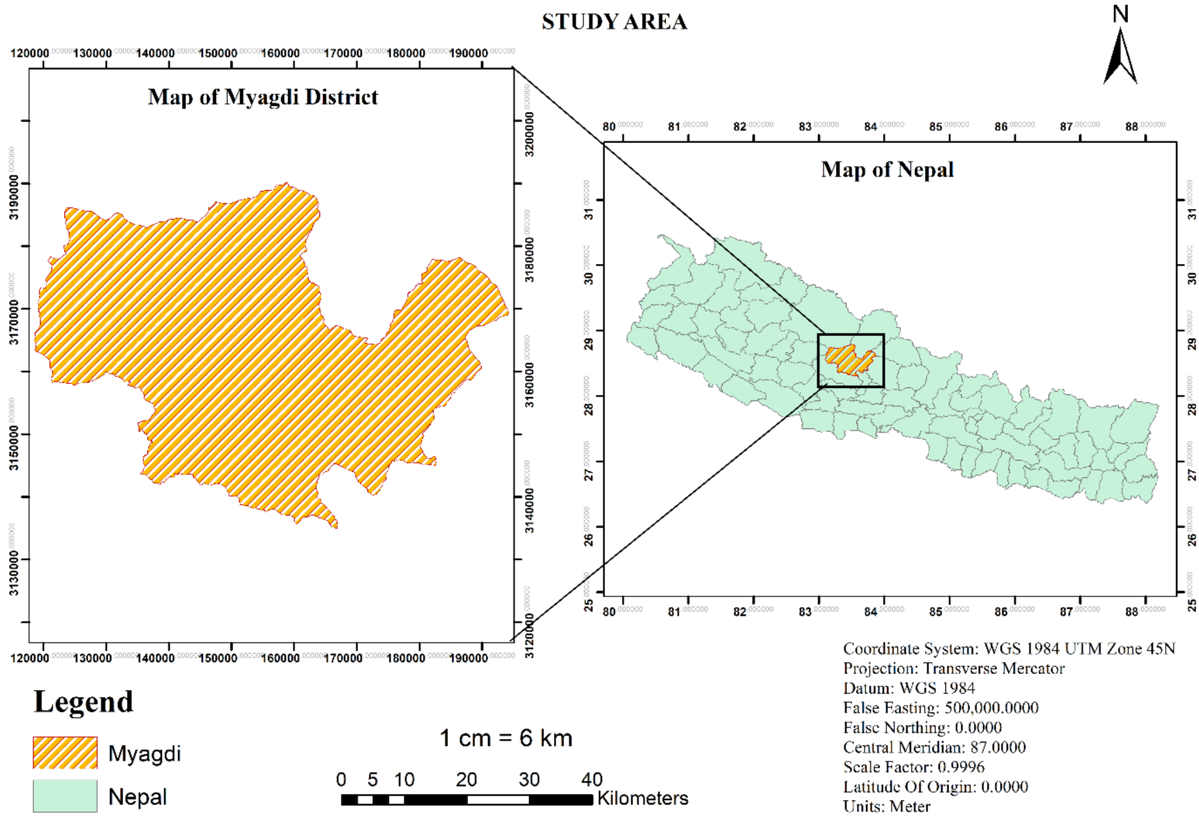

Figure 2: Study Area (Myagdi)

4.2 Materials Used

4.2.1 Data Used

Data downloaded from various sources as well as data provided from supervisor is used in this analysis. This study employed a total of five different categories of data. All the data were converted to the same projection system(WGS 1984 UTM zone 45N).

Table 1: Data Types

S.N.	Types of Data	Data Type
1.	LULC	Raster
2.	DEM	Raster
3.	Wind Velocity	Raster
4.	Power Stations	Vector
5.	Roads	Vector

4.2.2 Software Used

For GIS-based research, the software utilized in this study is Esri ArcGIS 10.8.2. An online APH calculator is used to determine the weightage for each criterion on a pairwise comparison basis.

4.3 Work Flow

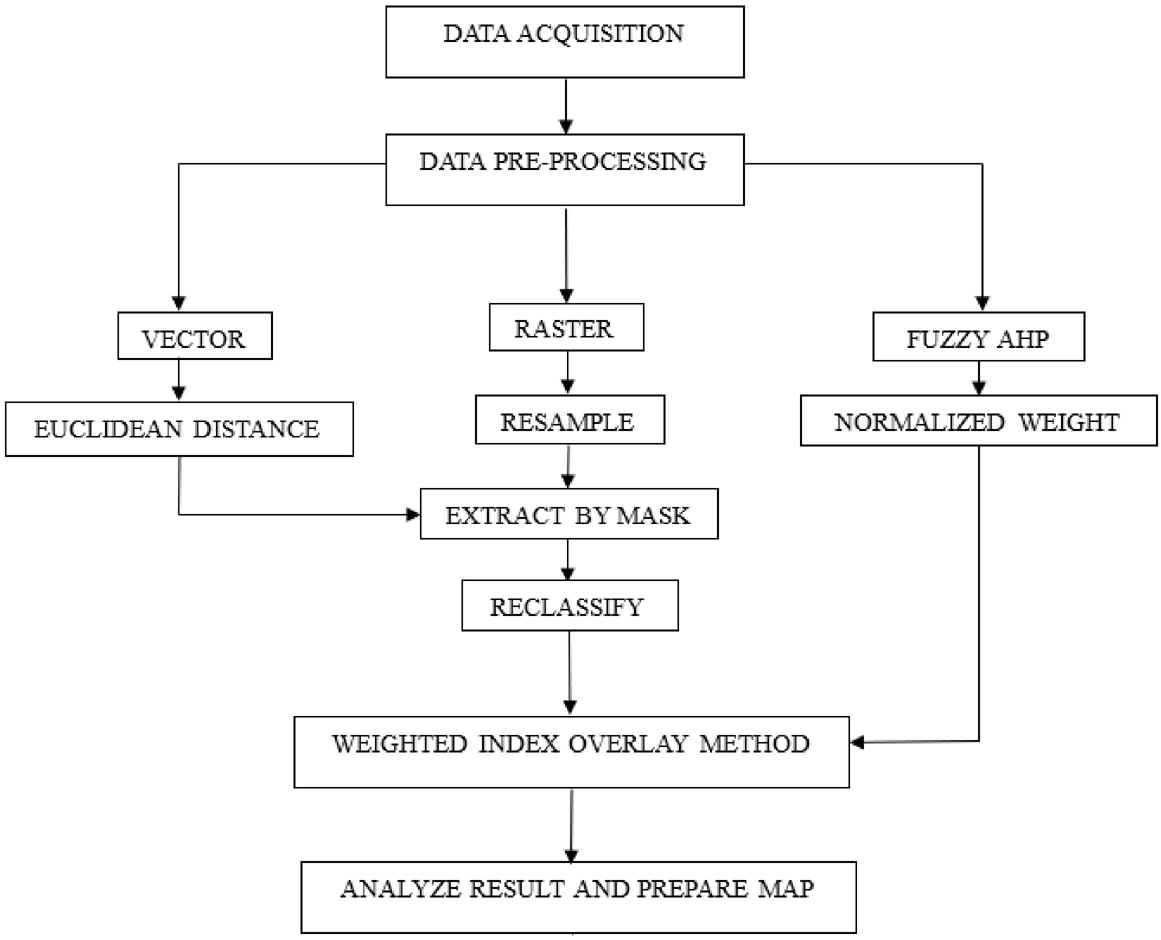

Figure 3: Work Flow Diagram

The collection of data related to the project is the initial concern of any project. Raster, vector data according to the criterion and Digital Elevation Model (DEM), Land Use Land Cover (LULC) of study area are the primary data to begin the work. The suitability analysis for the best location of windmill in Gandaki Province is done by MCDA using FAHP technique as show in the figure 3.

4.4 Data description of wind farm siting

4.4.1 Wind Speed

The average interpolated wind speed is one of the main and highest weighted criterion in siting a wind farm in almost all reviewed studies (Albraheem, Lamya, Awlaqi, & Lama, 2023). In this study, the average wind speed data from the Global Wind Atlas is used. Since, the wind speed in Myagdi district ranges from 2.5m/s to 23m/s, the data is classified into five classes.

Table 2: Classification of Wind Speed

Values	Suitability	Wind Speed (m/s)
1	Not Suitable	<3
2	Least Suitable	3-4
3	Moderately Suitable	4-5
4	High Suitability	5-6
5	Highest Suitability	>6

4.4.2 Land Use/Land Cover

The decision on whether to build a wind farm is influenced by land use since certain areas such as forests, wetlands, aviation zones, archaeological sites, etc do not allow wind farms to be constructed even in the presence of strong winds. Thus, it may be generally concluded that the terrain types that are most suited are shrubland, grassland, and barren land, whereas the least suitable land types are thought to be forests, water bodies, and built-up regions (Natei Ermias Benti, Site suitability assessment for the development of wind power plant in Wolaita area, Southern Ethiopia: an AHP-GIS model, 2023).

Table 3: Classification of LULC

Value	Suitability	LULC
1	Not Suitable	Waterbody, Glacier, Forest, Riverbed, Built-up area
2	Least Suitable	Snow, Other wooded land
3	Moderate Suitability	Cropland
4	High Suitability	Bare rock
5	Highest Suitability	Bare soil, Grassland

4.4.3 Elevation

The height of the site has a big impact on the direction and speed of the wind. Wind turbines are usually situated higher in the atmosphere to harness stronger winds (Amr S. Zalhaf, 2022). Lower-lying locations are more likely to have obstructions (like buildings) and could be wind turbulent. Higher altitude locations would be better because windbreaker interference would be less of an issue (Effat & El-Zeiny, 2022)There are fewer wind turbulences at higher elevations and wind speeds are more consistent. (Baban & Parry, 2001). Thus, higher elevations are more desirable for wind farm locations.

Table 4: Classification of Elevation in Myagdi District

Values	Suitability	Elevations (m)
1	Not Suitable	<3000
2	Least Suitable	3000-4000
3	Moderate Suitability	4000-5000
4	High Suitability	5000-6000
5	Highest Suitability	>6000

4.4.4 Power Station

Transporting power to customers using existing power transmission lines enormously decreases the cost of the project (Nasery, Matci, & Avdan, 2001). A distance of 500m is considered as having least suitability because of the safety reasons.

Table 5: Classification Based on Distance from Power Station

Values	Suitability	Distance from Power Stations (m)
1	Not Suitable	0-500
2	Least Suitable	>15000
3	Moderate Suitability	8000-15000
4	High Suitability	5000-8000
5	Highest Suitability	500-5000

4.4.5 Road

One important economic factor is accessibility to highways; ideally, the wind farm location will be reachable from the current road system, preventing the need to build a new roadway. Additionally, if the vehicles can quickly access the site, there will be a huge reduction in construction and maintenance expenses (Pamučar, Gigović, Bajić, & Janošević, 2017) . To minimize the potential of accidents and fatalities caused by ice-throwing and falling turbine parts, a minimum safety distance of 500 m must be maintained (Moradi, Yousefi, Noorollahi, & Rosso, 2020).

Table 6: Classification Based on Proximity to Road

Values	Suitability	Distance from Roads (m)
1	Not Suitable	0-500
2	Least Suitable	>15000
3	Moderately Suitable	8000-15000
4	High Suitability	5000-8000
5	Highest Suitability	500-5000

4.5 Determination of Criteria Weightage Using AHP for Data Analysis

The weightage of the criteria was generated from the pairwise comparison technique of AHP. Total of 5 number of criteria is assigned by giving an input of numbers and names. On the sale of 1 to 9 the criterion importance is denoted with respect to AHP priorities.

Table 7: Criteria Allocation

S.N	Assigned Numbers	Suitability
1.	1	Unsuitable
2.	2	Less Suitable
3.	3	Moderately Suitable
4.	4	Suitable
5.	5	Most Suitable

Each criteria is divided and given a rating value from 1 to 5 based on their suitability.

The AHP pairwise comparison technique produces the weights for the criteria. By constructing the ratio matrix, AHP establishes overall weights for evaluation and assigns weights based on pairwise comparisons to gauge the relative importance of each criterion. As seen in the table below, the comparison matrix shows how important the assigned criteria are in relation to the criteria in a row in a column. A scale from 1 to 9, with 1 indicating that both column and row components are equally essential.

	Criterion A	Criterion B	Criterion C
Criterion A	1	9	5
Criterion B	1/9	1	7
Criterion C	1/5	1/7	1

Figure 4: Pairwise Comparison Matrix in AHP calculator online

Table 8: Pairwise Comparison Matrix

	Wind Speed	LULC	Elevation	Roads	Power Stations
Wind Speed	1	1/2	4	2	2
LULC	2	1	5	3	1
Elevation	1/4	1/5	1	1/4	1/3
Road	½	1/3	4	1	1
Power Station	1/2	1	3	1	1

After assigning the score to each relative criteria pairwise comparison is analyzed to produce the sum of the weights to 1.

Table 9: Obtained Weightage Priority from Online AHP calculator

Criteria	Percentage %	Rank
LULC	34%	1
Wind Speed	26%	2
Power Station	19%	3
Road	15%	4
Elevation	6%	5

5. RESULTS AND DISCUSSION

The weighted overlay method is used to combine all data layers, and the scores obtained from the weighted overlay are reclassified into five classes to determine the final suitability indices for the district. Figure 8 displays the final wind farm suitability map. There are five classes on this map: class 1 is the area least suited for the development of wind farms, and class 5 is the best suited. The table below shows the area and percentage of land covered by different classes of suitability.

Table 10: Area and Percentage area of the Suitable Zones

Suitability Type	Area in sq.km	Percentage
Not Suitable	115.2969	5.15
Least Suitability	921.43783	40.87
Moderate Suitability	785.590825	34.85
High Suitability	430.110075	19.08
Highest Suitability	2.018958	0.089

Among criteria we selected for this suitability analysis it was found that alongside windspeed, LULC and Power Station are other crucial factor to determine the best suited location within the district.

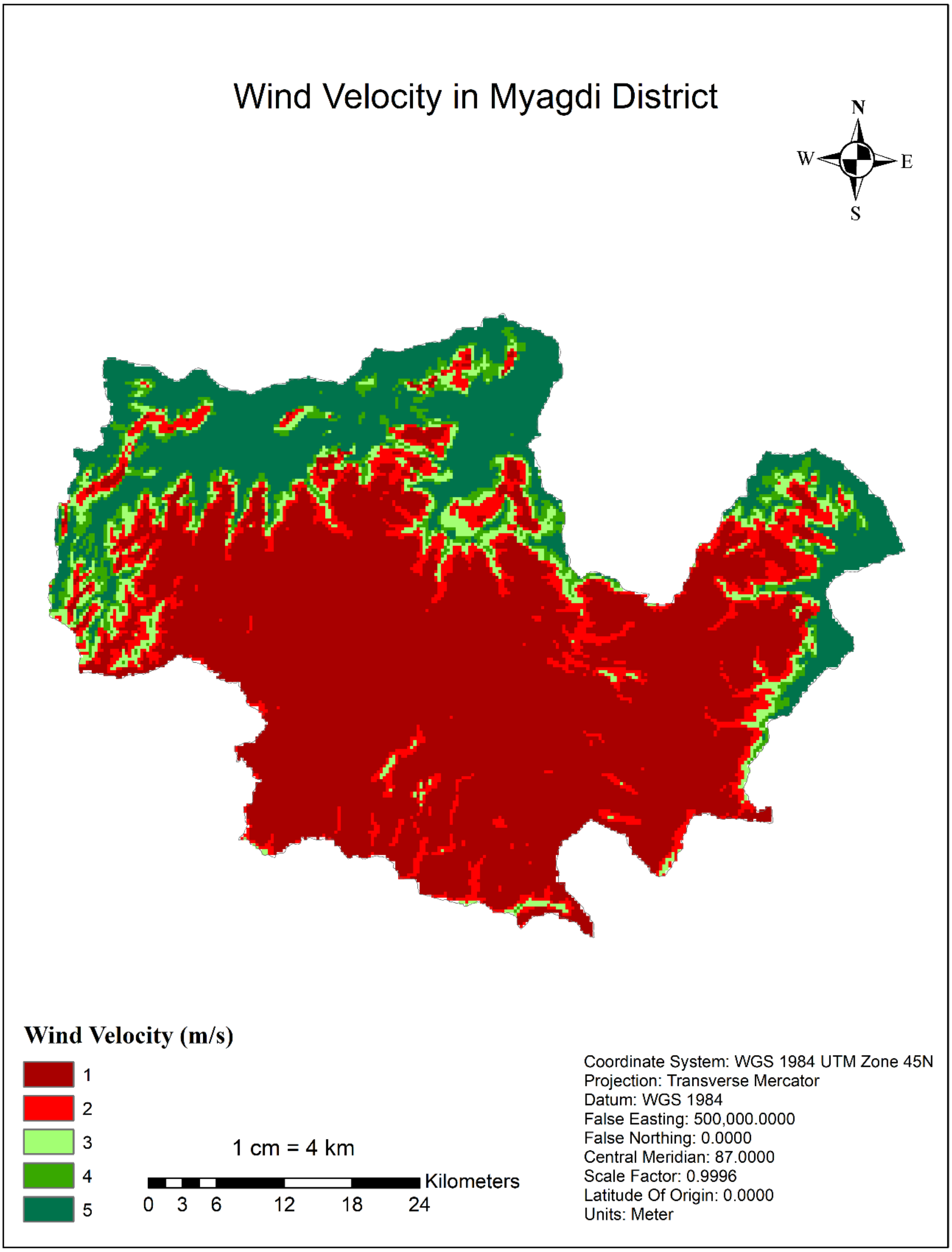

Figure 5: Wind Suitability Map

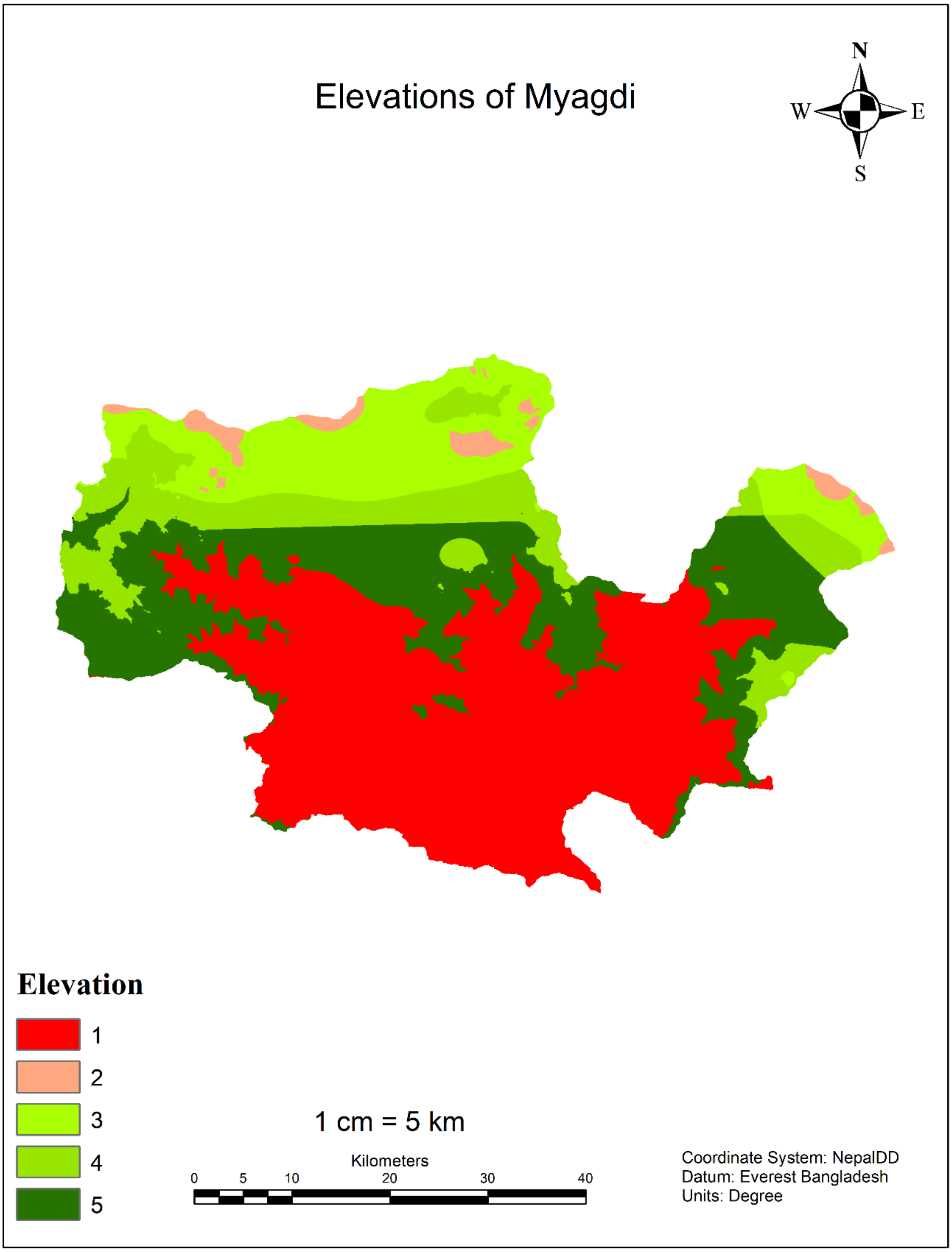

Figure 6: Elevation Suitability Map

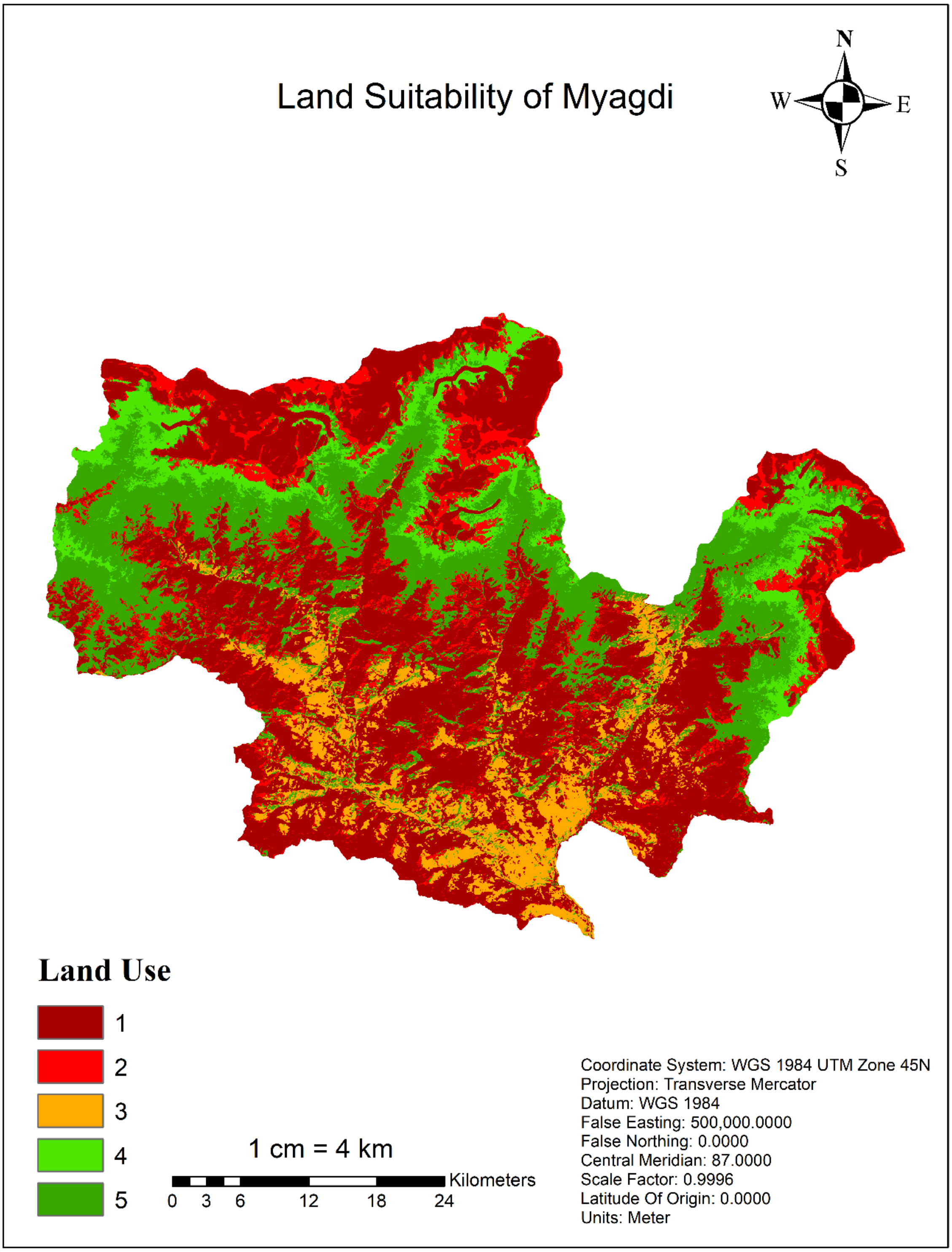

Figure 7: Land Use/Land Cover Suitability Map

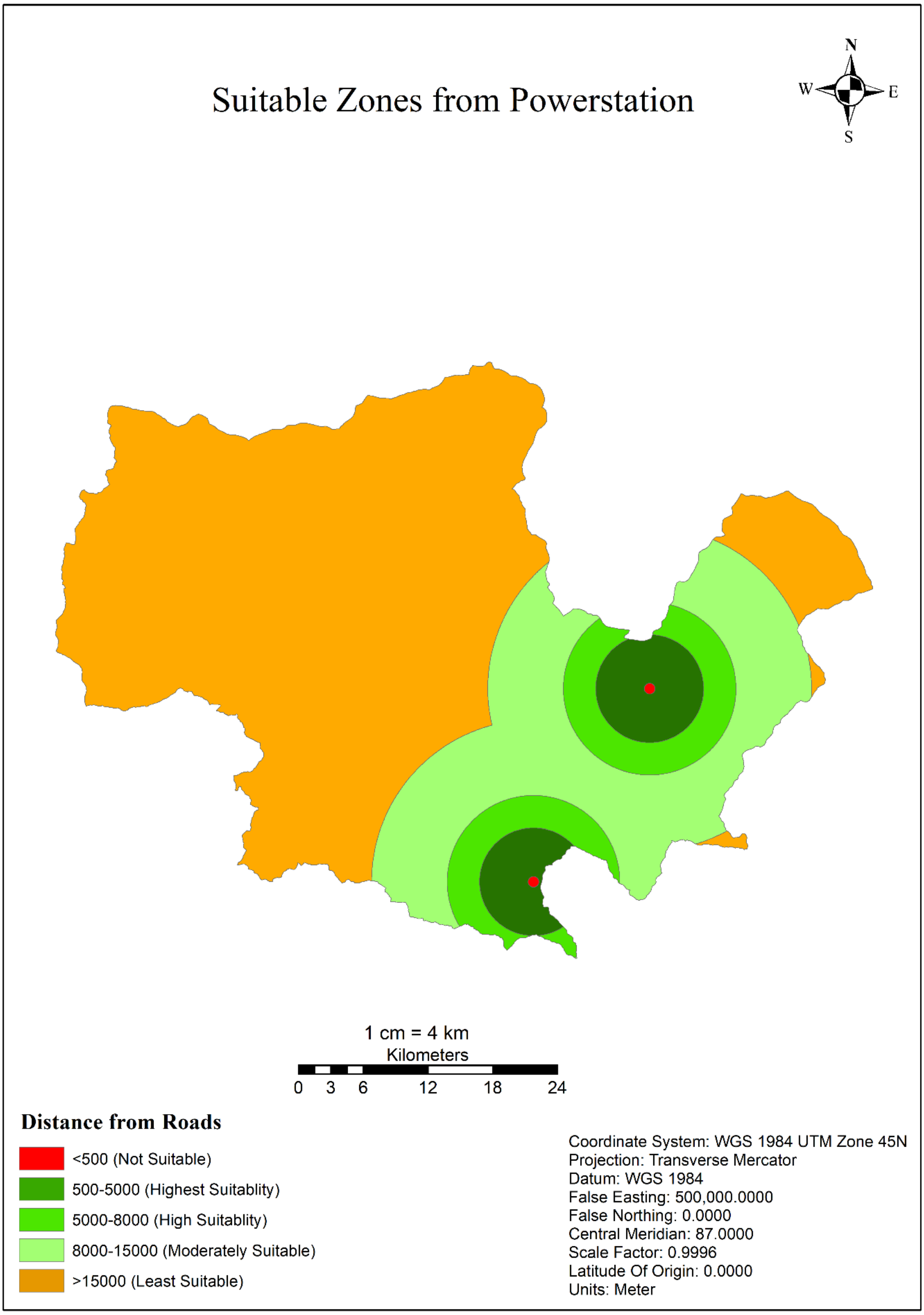

Figure 8: Power Station Proximity Suitability Map

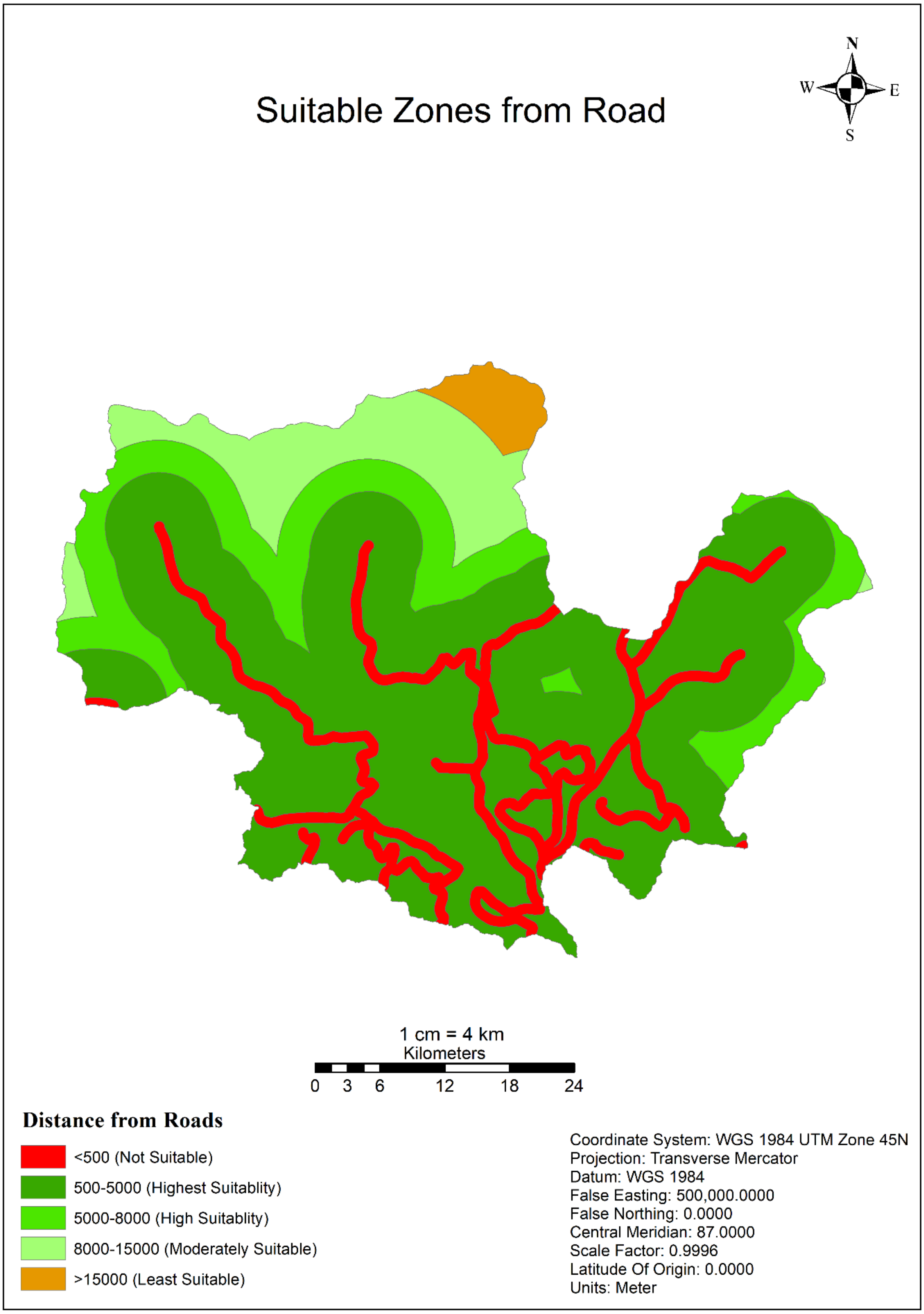

Figure 9: Road Proximity Suitability Map

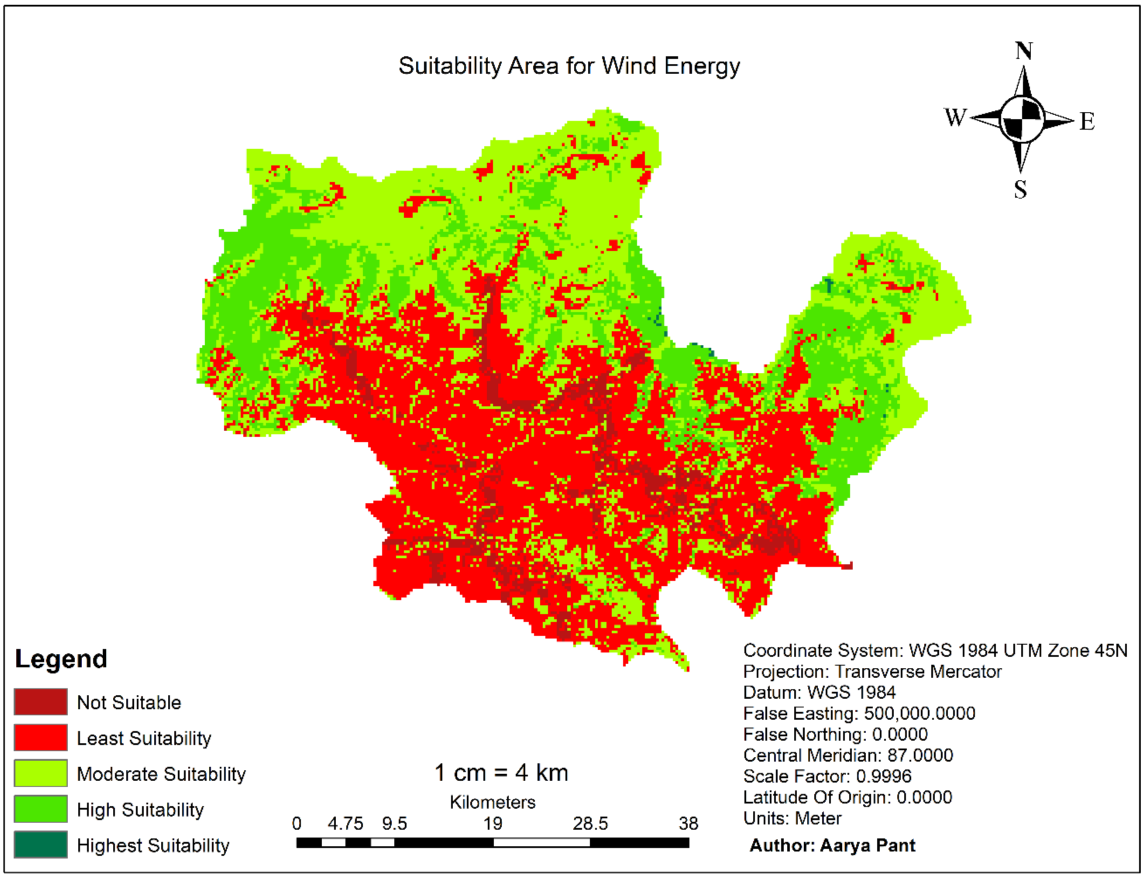

Figure 10: Final Suitability Map

6. CONCLUSIONS

The identification of appropriate locations for windfarm sites using GIS and the Analytical Hierarchy Process (AHP) in the case study of Myagdi District has been a comprehensive and insightful endeavor. The integration of spatial analysis through GIS and the multi-criteria decision-making approach of AHP has provided a systematic and robust methodology for site selection. Through the analysis of various factors such as wind speed, topography, land use, and environmental considerations, the GIS-based approach has allowed for a thorough examination of the geographical landscape. The AHP methodology, on the other hand, facilitated the prioritization of these factors based on their relative importance, providing a structured framework for decision-making. The findings of this study highlight specific areas within Myagdi District that exhibit favorable conditions for wind energy development. These areas not only have high wind speeds but also take into account various environmental and land-use considerations, ensuring sustainable and responsible development. The successful application of GIS and AHP in this case study underscores the effectiveness of these tools in the decision-making process for renewable energy projects. The methodology employed can serve as a valuable template for similar studies in other regions, fostering the efficient and strategic expansion of wind energy infrastructure. However, it is crucial to acknowledge the limitations of the study, such as the availability and accuracy of data, potential changes in environmental conditions, and evolving technology. Ongoing monitoring and periodic reassessment will be essential to adapt to these dynamic factors. In conclusion, the identification of appropriate locations for windfarm sites in Myagdi District using GIS and AHP has provided valuable insights for sustainable energy planning. The combination of spatial analysis and a structured decision-making process offers a robust methodology that contributes to the responsible development of renewable energy resources. This study not only contributes to the academic understanding of wind energy site selection but also offers practical implications for policymakers, energy developers, and local communities involved in the transition towards a cleaner and more sustainable energy future.

7. RECOMMENDATIONS

This research is intended to serve as a foundational analysis to help planners create plans for future renewable energy and urban development projects. These studies can be used by towns and regions to create comprehensive construction blueprints for smaller-scale wind turbine installations. Furthermore, this work can support appropriateness mapping for hybrid energy systems, such as photovoltaics, where new and significant criteria must be applied to the methodology. It is important to update the suitability model with more recent wind patterns, microclimate assessments, AHP requirements, and sophisticated GIS tools. Environmental impact studies may be incorporated into the project to guarantee the least degree of ecological damage in the research region. It is possible to do research on the social and economic impacts of wind energy projects in order to ensure community acceptance and fair benefits. The Gandaki scale of the study can be extended to a national or multi-provincial size.

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