Doi: 10.32592/jorar.2024.16.1.1

Locating New Red Crescent Society bases in North Khorasan Province

Mostafa Ghodousi[1, 4], **Milad Vatani**[2, 4], **Fatemeh Darbandi**[3, 4]

Date of submission: 24 Dec 2022 *Date of acceptance: 22 Aug 2023*

Original Article

Abstract

INTRODUCTION: The present study aimed to locate new Red Crescent Society (RCS) road rescue and relief bases in the North Khorasan province in order to determine appropriate places for establishing new bases.

METHODS: In this research, first the desired criteria were selected based on previous researches and experts' comments on locating the RCS road rescue and relief bases. Then, the preparation and standardization of information layers were performed using the fuzzy method and Analytical Hierarchical Process (AHP) method was used to weigh the criteria. Moreover, the combination of criteria was carried out by using the Weighted Linear Combination (WLC) method. Finally, new bases were located by taking into account the area and other criteria through satellite images.

FINDINGS: The results indicated that among all the sub-criteria, the distance from the accident-prone points had the most weight. After combining the criteria, highest priority and high-priority areas for locating RCS road rescue and relief bases were situated in the northwest, center, south, and east of the province. In this research, nine lots with a total area of 33864 square meters were located in the high-priority area.

CONCLUSION: Properly locating RCS road rescue and relief bases enhances their efficiency; therefore, the management will be able to provide a range of different services to citizens all over the country by taking appropriate measures.

Keywords: Analytical Hierarchical Process; Locating; Red Crescent Society road rescue and relief bases; Weighted Linear Combination

How to cite this article: Ghodousi M, Vatani M, Darbandi F. **Locating New Red Crescent Society bases in North Khorasan Province.** Sci J Rescue Relief 2024; 16 (1): 1-17.

Introduction

Today, due to the significant development of roads, as well as a marked increase in the number of cars and road accidents, it is necessary for the Red Crescent Society (RCS) road rescue and relief bases to perform better in their activities (1-4). RCS road rescue and relief bases provide rescue services and operations to the injured in urgent and critical situations (2). In this regard, the roads of North Khorasan, an area where many accidents happen, have increased the average number of accidents (5-6). On the other hand, the inappropriate location distribution of the bases in North Khorasan has caused some bases to travel very long distances for the mission, and some bases only take care of their surrounding areas (2).

However, there is a need for comprehensive research to choose the right place and allocate the right resources since the proper location of RCS road rescue and relief bases will increase the efficiency and more appropriate performance of bases when accidents occur (7-10). In this

1.PhD in Geospatial Information Systems, Geoinformation Technology Center of Excellence, Faculty of Geodesy and Geomatics Engineering, K.N. Toosi University of Tehran, Tehran, Iran
2. Master in Urban planning, Faculty of Fine Arts, University of Tehran, Tehran, Iran
3. Master in RS & GIS, Islamic Azad University Science and Research Branch, Tehran, Iran
4. Research Center for Emergency and Disaster Resilience, Red Crescent Society of Islamic Republic of Iran, Tehran, Iran

*Correspondence to: Mostafa Ghodousi, Email: mostafaghodosi1@gmail.com

[DOI: 10.61186/jorar.16.1.1]

research, we are looking to locate RCS road rescue and relief bases by considering the spatial performance. Due to the nature of the RCS road rescue and relief bases, these bases should be closer to the hot spots of road accidents in order to provide appropriate services as soon as possible (3-6); nonetheless, they should be settled in a safe place (11-14). Therefore, one of the effective parameters in locating RCS road rescue and relief bases is accessibility to accident-prone points (7). One of the factors that have been given special attention in this research is the identification of accident-prone points and their use as a factor for locating RCS road rescue and relief bases.

The present study aimed to locate the new RCS road rescue and relief bases in North Khorasan province. Locating new RCS road rescue and relief bases has been investigated by examining the locating parameters for RCS road rescue and relief bases, such as the slope of the land, height, fault, distance to population points, the efficiency of the bases, proximity to the road, and proximity to the hot spots of road accidents. Moreover, to investigate the risk of road accidents, the accident-prone points were identified. Therefore, the following question will be answered: where are the suitable places to establish new bases?

Methods

Spatial and descriptive data of the missions (number of people assisted, number of dead and wounded, time and distance from the base), as well as spatial and descriptive information of the bases (number of employees, number of rescue vehicles, number of ambulances and equipment), were obtained from the RCS of North Khorasan province. Data on road accidents were obtained from the Iran Road Maintenance & Transportation Organization and North Khorasan traffic and driving police. Other information related to the population, facilities, and other spatial layers was obtained from the Planning and Budget Organization of North Khorasan Province.

This applied research was conducted based on a descriptive-analytical design. The research data collection methods are a combination of documentary and field methods. Locating plays a major role in the operation of RCS road rescue and relief bases. In this research, the desired criteria are first selected. At this stage, accident-prone points are identified as one of the effective factors in locating RCS road rescue and relief bases. Thereafter, they are prepared and standardized. In the following, the criteria are weighted and combined. Finally, new bases are located, and the proposed new bases are examined. The validity of the research was confirmed by using the complete literature review considering the criteria of previous research, and getting expert opinions about the criteria. Since the spatial layers are fixed, the answer will be the same in multiple repetitions and new combinations of layers, and similar places will be identified to build a new base; in this way, the reliability of the research was confirmed. The overall flowchart of locating RCS road rescue and relief bases is displayed in Figure 1.

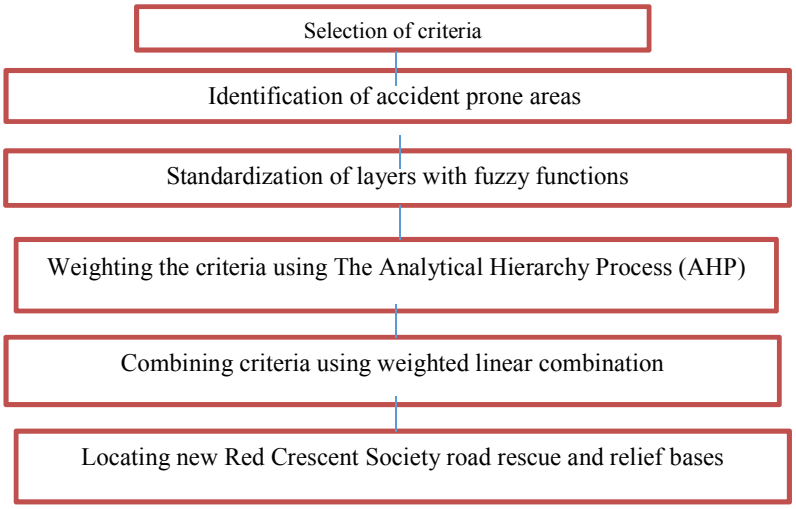


Figure 1. General flowchart of the research

[DOI: 10.61186/jorar.16.1.1]

In choosing locating criteria, the general rule is that these criteria should be determined in relation to the situation of the problem. In this research, an attempt is made to present a complete set of effective factors in the field of locating RCS road rescue and relief bases based on other similar research (15-19).

Preparation and standardization of spatial layers

To determine the necessary criteria for research, it is necessary to turn each criterion into a map for evaluation. A wide range of scales is used to measure criteria. In order to combine and unify the criteria for locating RCS road rescue and relief bases, there is a need to standardize the criteria used in the research. Standardizing criteria signifies equalizing the scope of their changes so that they can be combined with each other. The use of fuzzy functions is one of the common standardization methods. Fuzzy functions operate based on the degree of membership in the fuzzy set and assign an appropriate degree to the inputs based on the membership function. The degree of membership can be continuous, discrete, linear, or non-linear and is expressed by a membership function (7-9). In this research, the locating criteria of RCS road rescue and relief bases were converted into fuzzy standard maps using fuzzy linear decreasing and increasing functions and user-defined.

Determination of accident-prone points

Appropriate measures were implemented to determine accident-prone points based on the instructions of the Iran Road Maintenance & Transportation Organization. In this research, different types of accidents are equated to one type of accident; therefore, car crashes at any point of accident were converted into damage accidents. In this study, the severity and frequency of accidents, as well as the volume of traffic, were taken into account according to the type of road (secondary, main, and highway). In other words, the obtained integrated index (Equation 1) is finally divided by the volume of traffic (Equation 2). The identification of accident-prone points based on the number of accidents may lead to misleading results since the volume of traffic in the road network is different. Therefore, if traffic volume is double in one of the two points where the number of accidents is equal, they should not be considered the same. For each type of road, a stable number was considered the volume of traffic; for example, the secondary road was assigned the number 2, and the highway was considered the number 8. It has been demonstrated that traffic volume is more on the highway. Considering traffic volume, in addition to the severity and frequency of accidents, traffic volume is checked to determine how much traffic has caused this amount of damage and accidents. In other words, if the obtained integrated index is equal for a secondary road and a highway, that spot on the secondary road is more accident-prone since less volume of traffic has caused this number of accidents. Using Equation 1, the financial damage integrated index is calculated, and by dividing this index by the volume of traffic based on the type of road, based on Equation 2, the accident rate of the points is obtained (5-6).

Equation 1: Integrated index of financial damage = (Number of fatal accidents×9) +(Number of injured accidents×Number of damaging accidents +3)

Equation 2: The accident-proneness of points = $\frac{Integrated\ index\ of\ financial\ damage}{type\ of\ road}$

The roads of North Khorasan are divided into three categories: secondary road, main road, and highway. In Equation 2, secondary roads, main roads, and highways are assigned numbers 2, 6, and 8 as indicators for traffic volume. According to equations 1 and 2, the accident-proneness rate of the calculated points and the points with accident-proneness higher than index one are considered accident-prone points in this research (5-6).

Weighting criteria

Weighting determines the relative importance of criteria. This measure should be taken before the information integration operation. The analytical hierarchical process (AHP) method was used for weighting information layers in this research. This method is designed based on two-by-two comparisons and has different levels that divide the issues into a hierarchical structure of criteria, factors, and options. The AHP method compares criteria and options two by two at

[DOI: 10.61186/jorar.16.1.1]

different levels. Saaty suggested the values of this comparison from one to nine. If the comparison of two criteria is 1, it signifies that the two criteria are at the same level, and if the comparison value is 9, it means that there is a marked difference between the two criteria. The comparison matrix is obtained from the pairwise comparison of criteria. In this method, the criteria are weighted by experts (7, 21).

Integration and combination of criteria

The weighted linear combination method was used to locate the road relief stations in North Khorasan province. The fuzzy maps of each of the factors are multiplied by the weights obtained based on the analytical hierarchical process (AHP), and the maps of all overlapping factors are given. Integration or overlay is one of the spatial analyses that can combine spatial layers obtained from separate sources to locate RCS road rescue and relief bases. The new (output) layer is a function of two or more input layers. To this end, the weighted linear combination method (WLC) is used. The weighted linear combination method combines all parameters or layers together; moreover, it considers the importance of each criterion based on the weight given to that parameter (15). As a result, locating RCS road rescue and relief bases by weighted linear combination method has a great ability to provide suitable options.

Findings

This section covers the findings related to collecting locating criteria information and the map of considered criteria, and in the next section, the findings related to the standardization of layers are presented. Thereafter, the results pertained to the weighting and combination of criteria, and finally, the results related to the investigation of the proposed zones are presented.

Collecting locating criteria information

Various factors are involved in locating Red Crescent Society road rescue and relief bases. The locating criteria in this research fall into five main categories: natural factors, welfare services, roads, distance from existing RCS bases (inconsistent use), distance from accident-prone points (danger potential), and accessibility to population centers. In the following, each of the criteria and sub-criteria has been examined. The criteria and sub-criteria considered in this research are illustrated in Table 1.

The natural features of the land are of utmost importance in locating RCS road rescue and relief bases. Three sub-criteria of distance from the fault, height, and slope are considered the main criteria of natural factors. In order to reduce earthquake damage, RCS road rescue and relief bases should be far from the fault. Higher altitudes are not suitable for building RCS road rescue and relief bases. This issue can be attributed to climatic problems and inappropriate accessibility. Moreover, high altitude is one of the main causes of frost. Furthermore, RCS road rescue and relief bases should be built at a suitable slope.

Welfare services and roads

Accessibility to some roadside equipment and facilities is one of the advantages of locating RCS road rescue and relief bases. Among the most important of this equipment are traffic police stations, highways, and welfare complexes. The transportation system, including roads, is another factor that affects location.

Distance from existing RCS road rescue and relief bases (incompatible land use)

The new RCS road rescue and relief bases should be built in a place that is as far away from the existing bases as possible so that there is less overlap in the service area.

Risk potential (distance from accident-prone points)

Examining the potential and risk of danger in different areas based on the examination of the number and repetition of accidents in different areas will lead to the identification of vulnerable points in accidents and places with high-risk potential. The location of the bases should be more attractive to such areas. For this purpose, the accident-prone points were identified in terms of accidents, and the proximity of the accident-prone points was considered an important factor and risk potential. Moreover, in this research, accident-prone points for the main and secondary roads of the province were obtained based on the accidents from 2011 to 2016. In total, 350 accident-prone spots were identified on the roads of North Khorasan.

Accessibility to population centers

Population density is one of the main effective

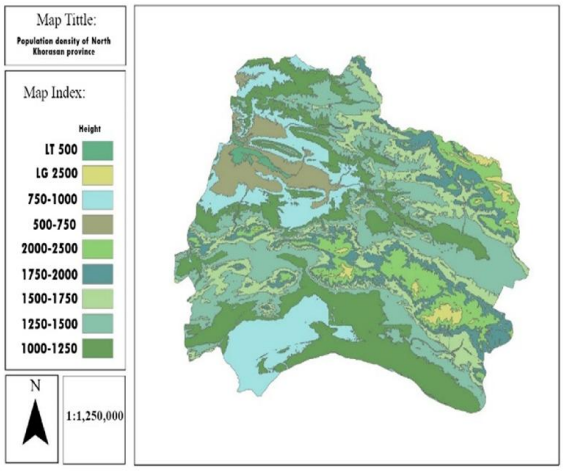
[DOI: 10.61186/jorar.16.1.1]

factors in the establishment of RCS road rescue and relief bases and related planning. The probability of accidents is higher in areas with high population density than in areas with low population density. Therefore, the RCS road rescue and relief bases should be planned according to population density in the covered areas and the rate of accidents. Proximity to villages and cities is very important in the construction of RCS road rescue and relief bases. Information related to criteria and sub-criteria was collected, and their maps are presented in Figure 2.

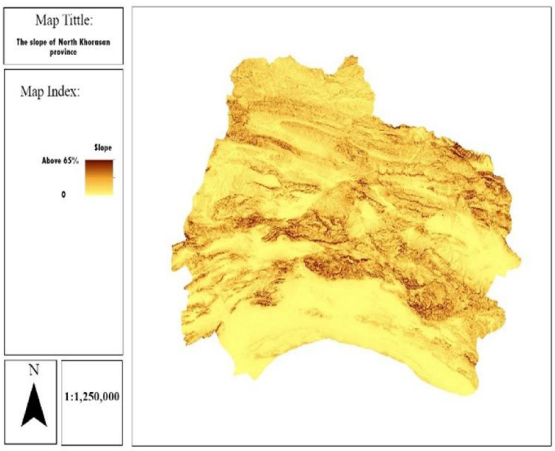
Table 1. Criteria and sub-criteria considered for locating new RCS road rescue and relief bases

Criteria	Sub-criteria
Natural factors	Distance from faults/ Elevation/ Slope
Proximity to inter-road welfare services and roads	Proximity to road authority/ Proximity to the road police stations/ Proximity to inter-road /welfare services complexes/ Proximity to roads
Distance from existing RCS road rescue and relief bases (incompatible land use)	Distance from existing RCS road rescue and relief bases
Risk potential (distance from accident-prone points)	Distance from accident-prone points
Accessibility to population centers	Proximity to cities/ Proximity to villages/ Population density

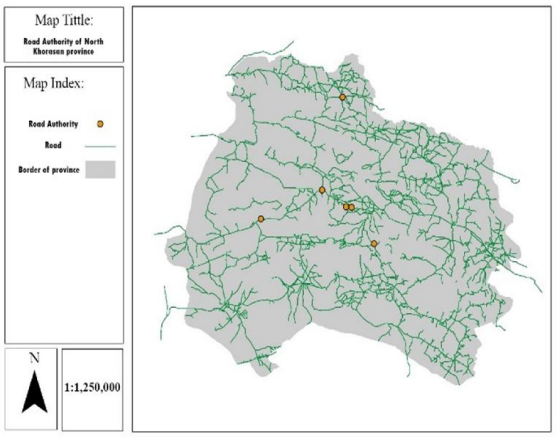
(a): Map of the fault



(b): Elevation map



(c): Earth slope map



(d): Map of location of the road authority

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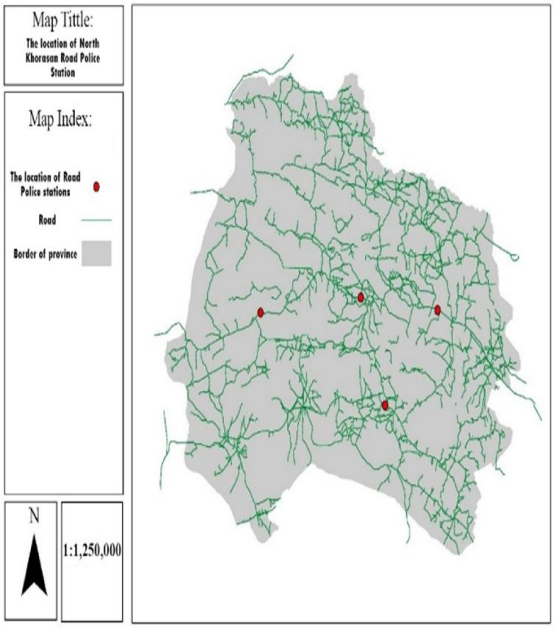
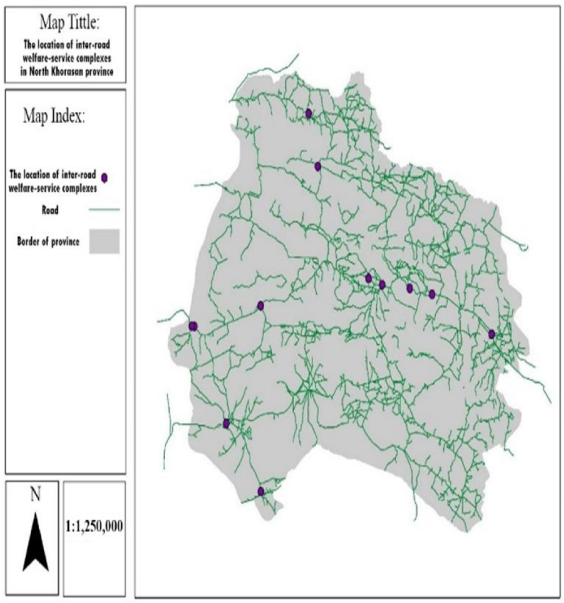
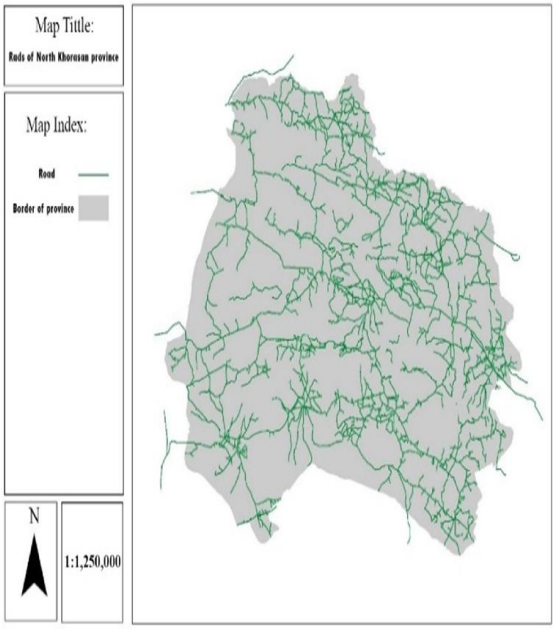


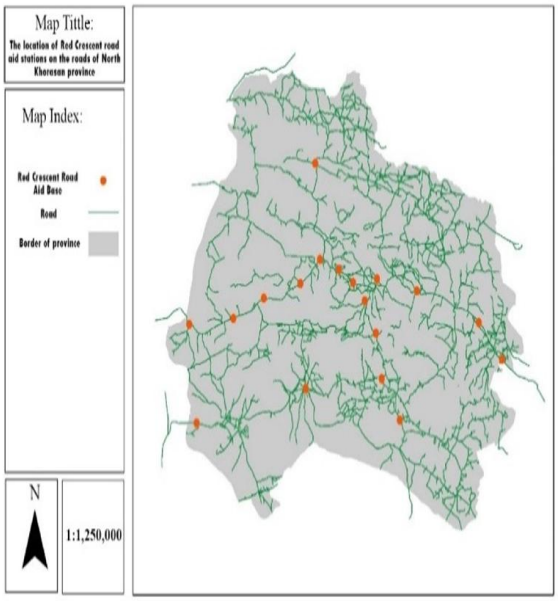
(e): The road police stations map



(f): Map of location of inter-road welfare services complexes



(g): Maps of roads of North Khorasan province



(h): Map of the existing RCS road rescue and relief bases

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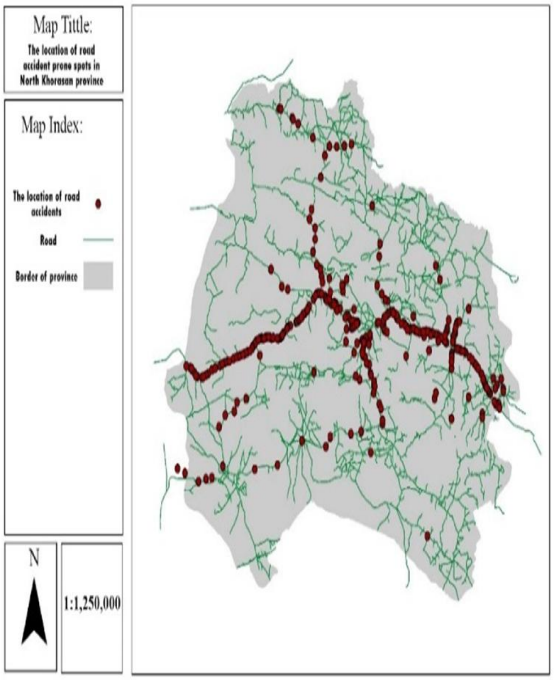
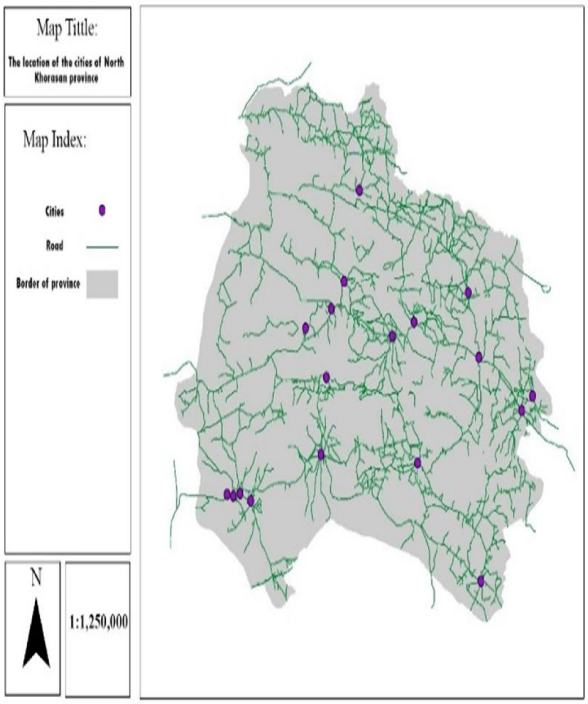
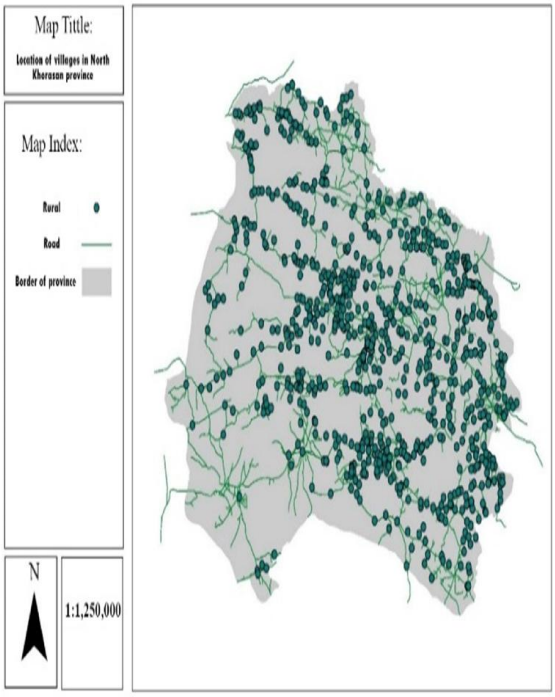


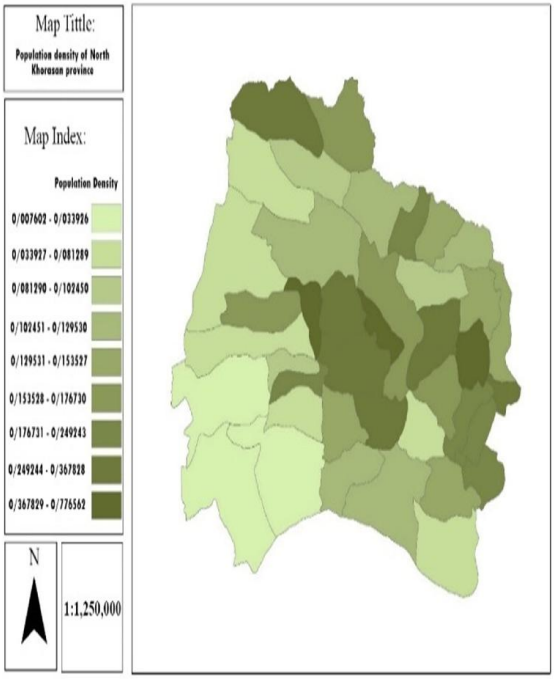
(i): The accident-prone spots map



(j): The cities map



(k): The villages map



(l): Population density map

Figure 2. Maps of research criteria

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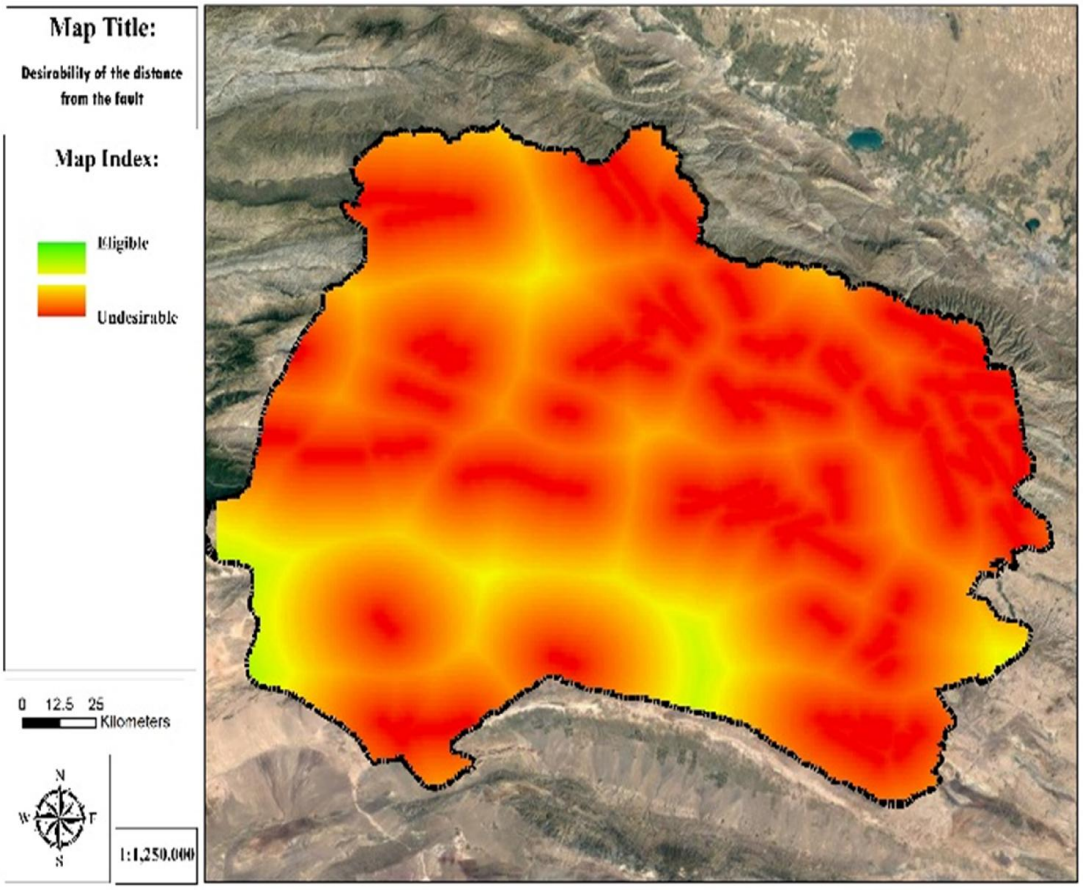
Results of Preparation and standardization of spatial layers

A variety of scales are used to measure criteria. In order to locate and integrate maps, we must standardize the effective layers in locating; that is to say, transforming the layers into a scale that can be integrated with each other using decision-making rules. A point that should be taken into consideration in choosing a fuzzy function for standardization is whether the desired function is increasing (maximizing or ascending) or decreasing (minimum or descending). For instance, regarding the distance from the accident-prone points, the smaller the distance is, the more suitable it is for locating the new RCS road rescue and relief bases. Consequently, the decreasing function was used. After data collection, the Euclidean distance of each criterion is calculated, and after the standardization of the layers, standardized fuzzy maps are prepared using the linear function method. Figure 3 displays the standardized maps of the criteria.



(a): Standardized map of the distance from the fault

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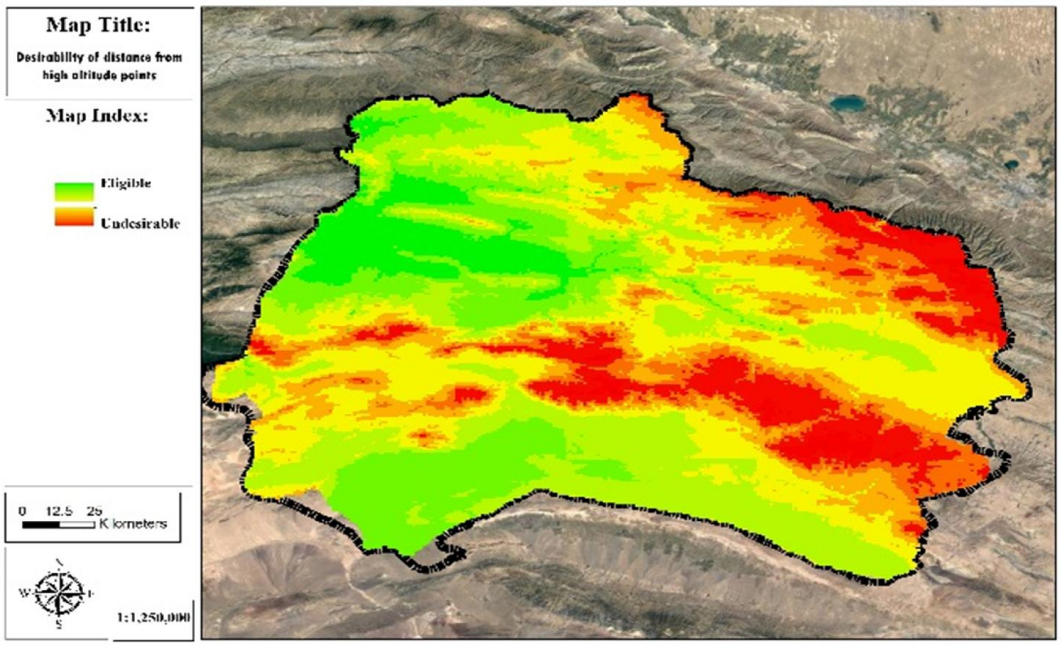
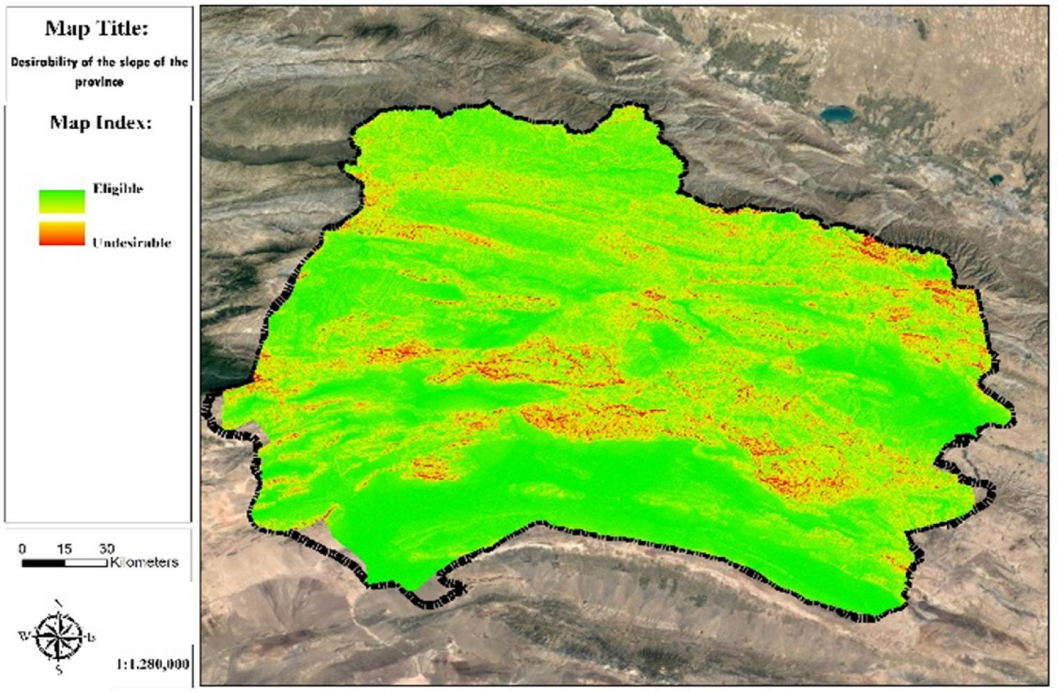


(b): Standardized elevation map



(c): Standardized slope map

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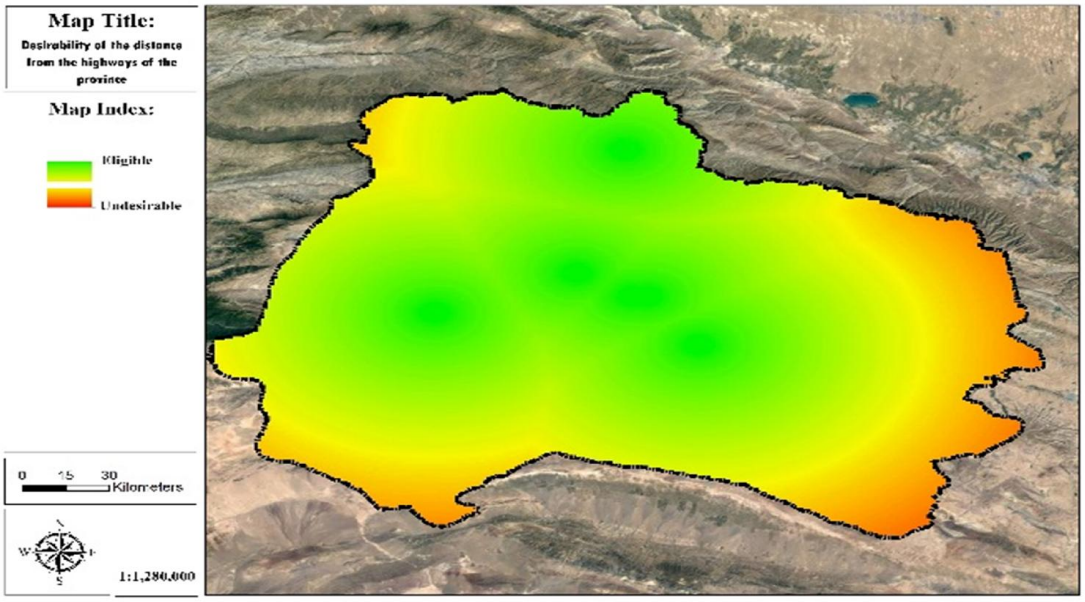
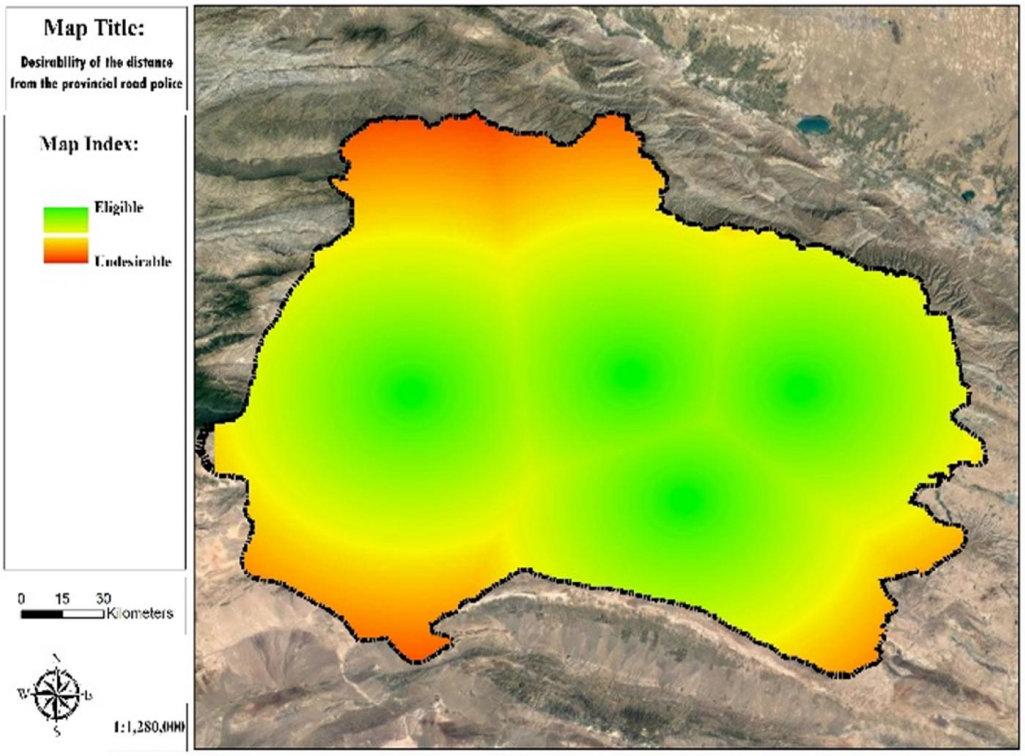


(d): Standardized map of proximity to the road authority



(e): Standardized proximity to the road police map

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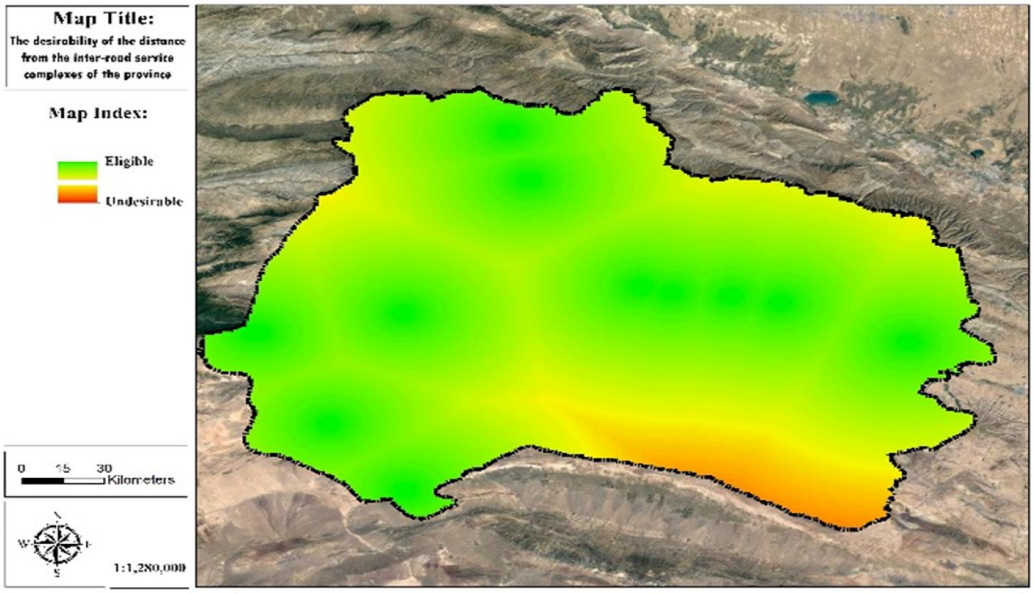
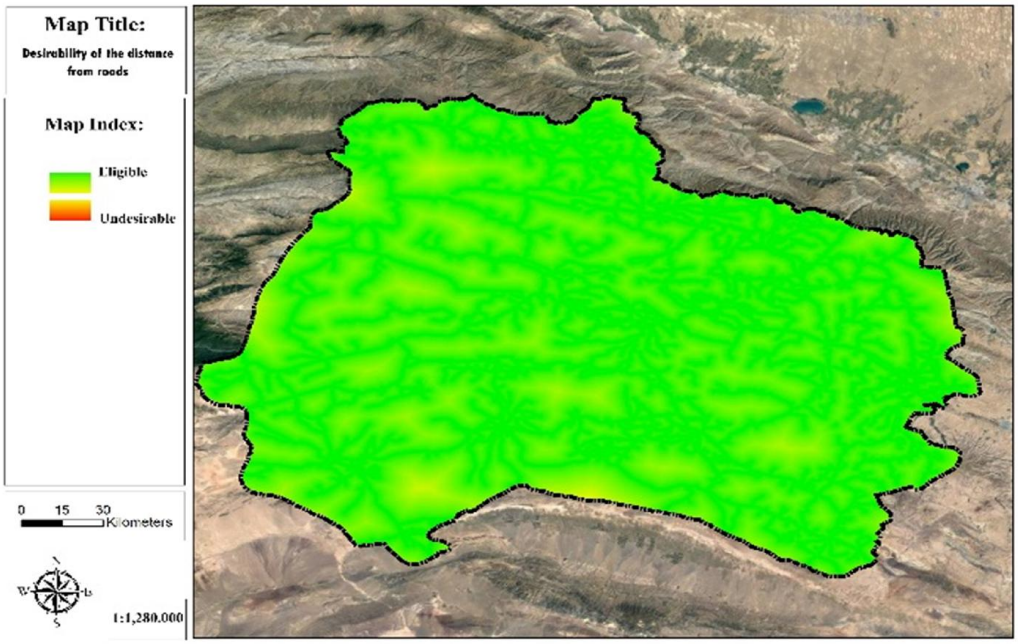


(f): Standardized map of proximity to inter-road welfare services complexes



(g): Standardized map of proximity to roads

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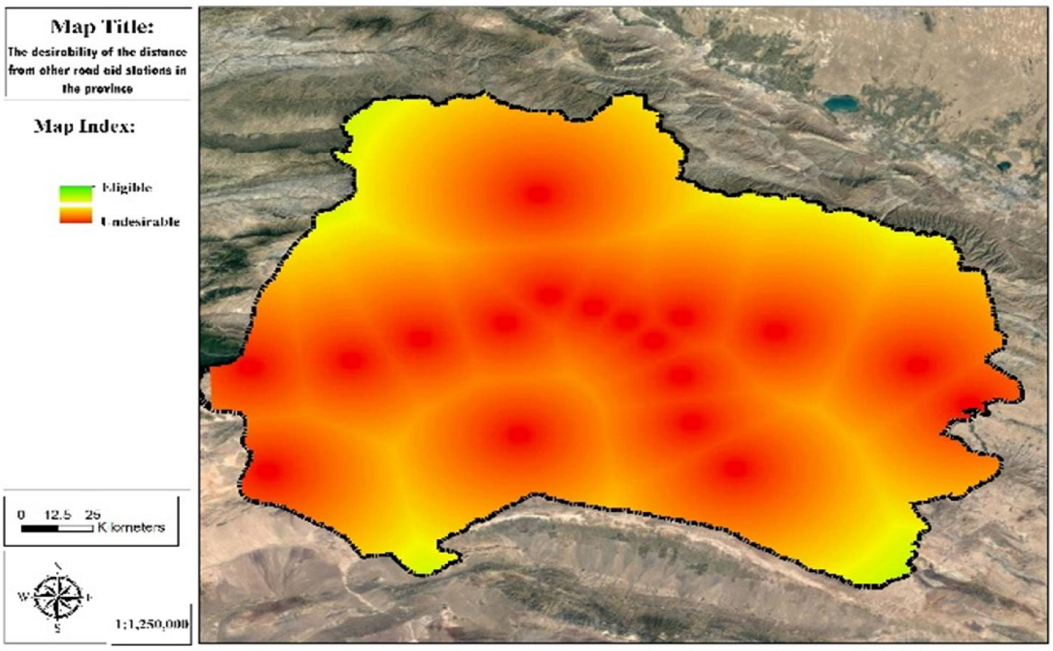
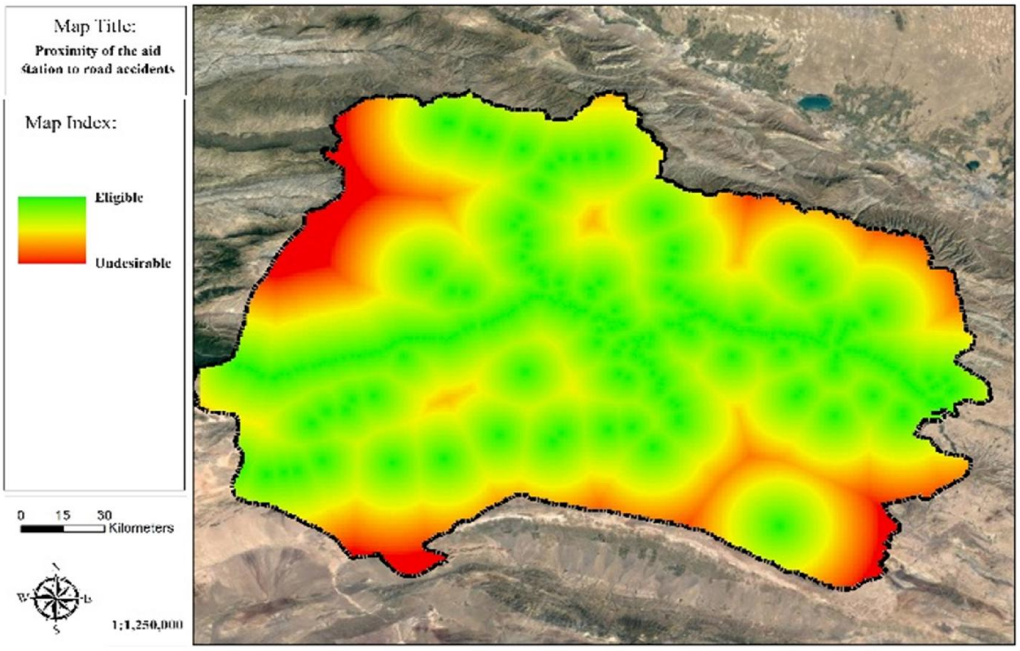


(h): Standardized map of the distance from the existing RCS road rescue and relief bases



(i): Standardized map of proximity to accident-prone areas

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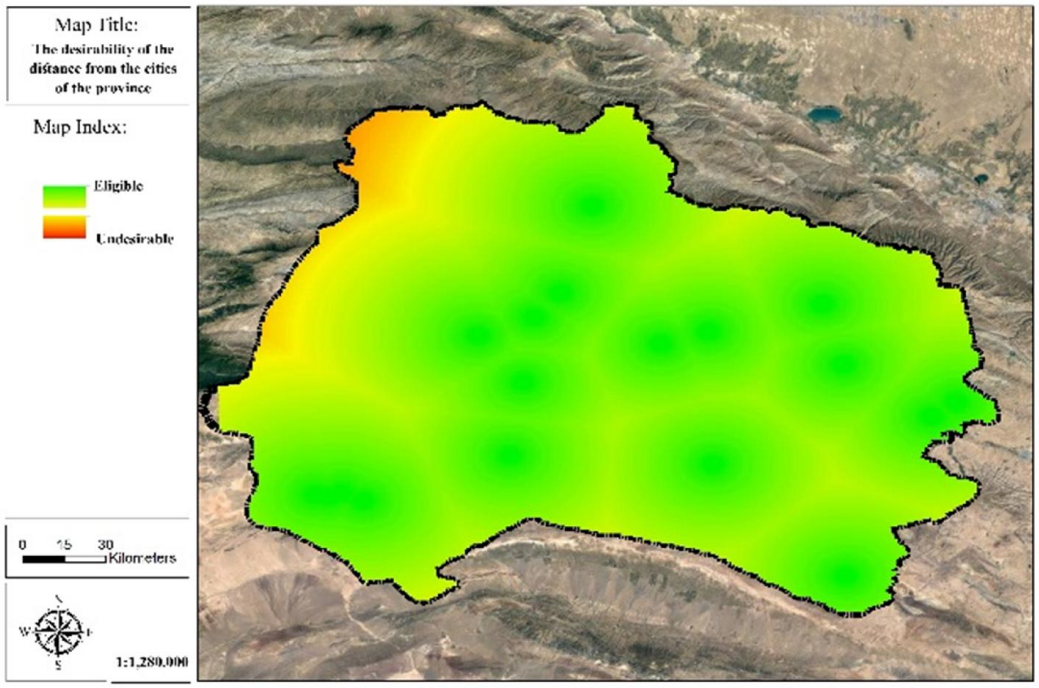
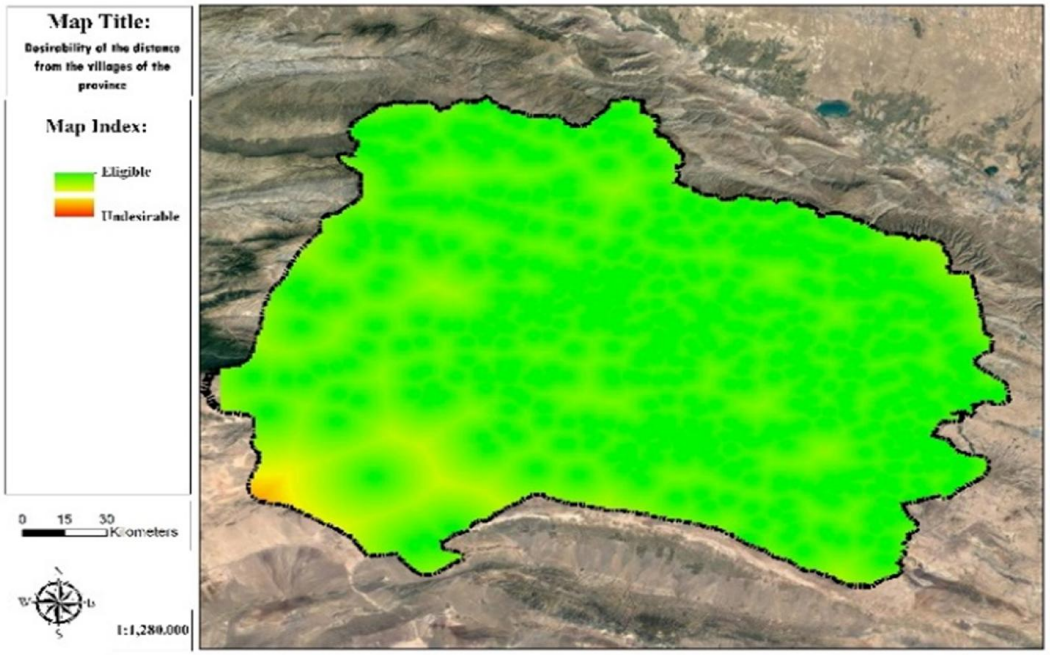


(j): Standardized map of proximity to cities



(k): Standardized map of proximity to villages

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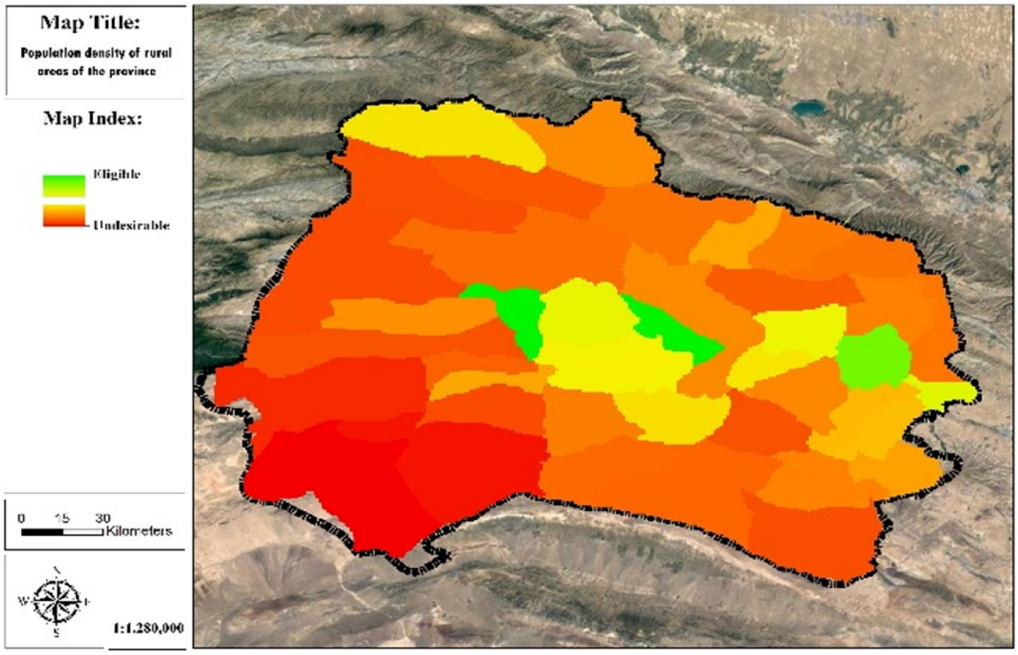

(l): Standardized Population density map

Figure 3. Standardized maps of the criteria

Table 2. Weight of criteria and sub-criteria

Criteria	Weight	Sub-criteria	Weight	Final Weight
Natural factors	0.1	Distance from faults	0.5	0.05
		Elevation	0.2	0.02
		Slope	0.3	0.03
Proximity to inter-road welfare services and roads	0.3	Proximity to road authority	0.166	0.05
		Proximity to the road police stations	0.166	0.05
		Proximity to inter-road welfare services complexes	0.166	0.05
		Proximity to roads	0.5	0.15
Distance from existing RCS road rescue and relief bases (incompatible land use)	0.2	Distance from existing RCS road rescue and relief bases	1	0.2
Risk potential (distance from accident-prone points)	0.2	Distance from accident-prone points	1	0.2
Accessibility to population centers	0.2	Proximity to cities	0.25	0.05
		Proximity to villages	0.25	0.05
		Population density	0.5	0.1

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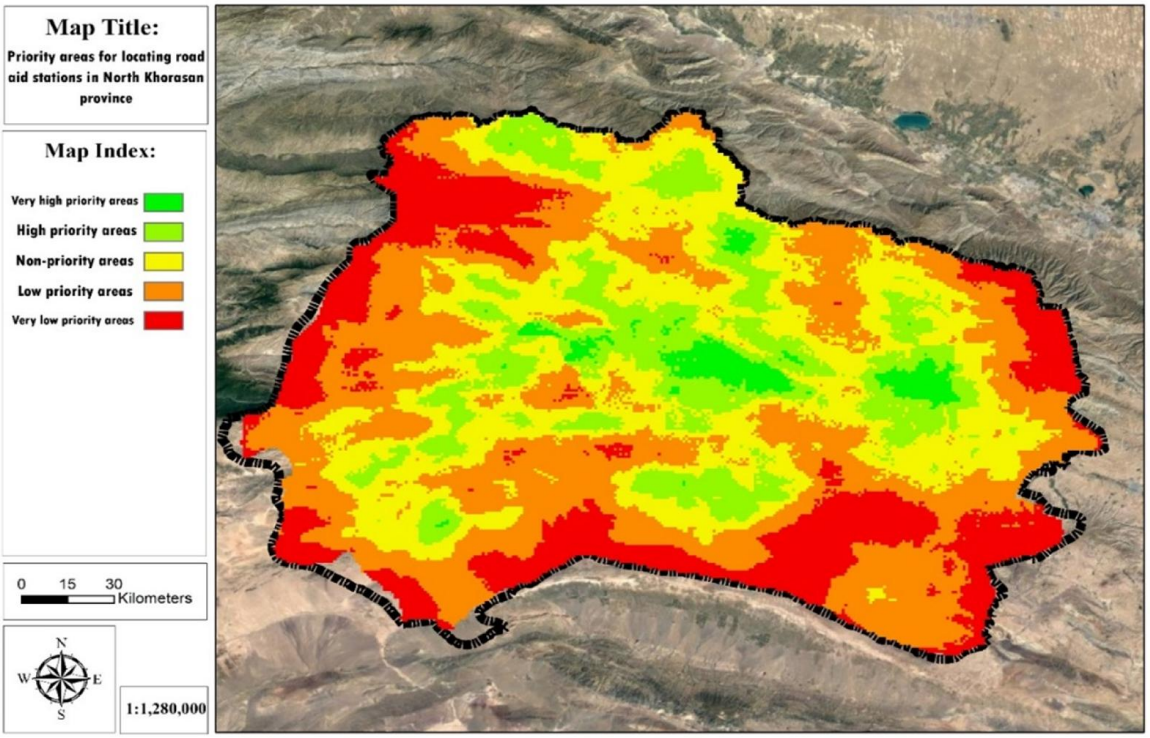

Figure 4. Map of the proposed areas for the locating of new RCS road rescue and relief bases

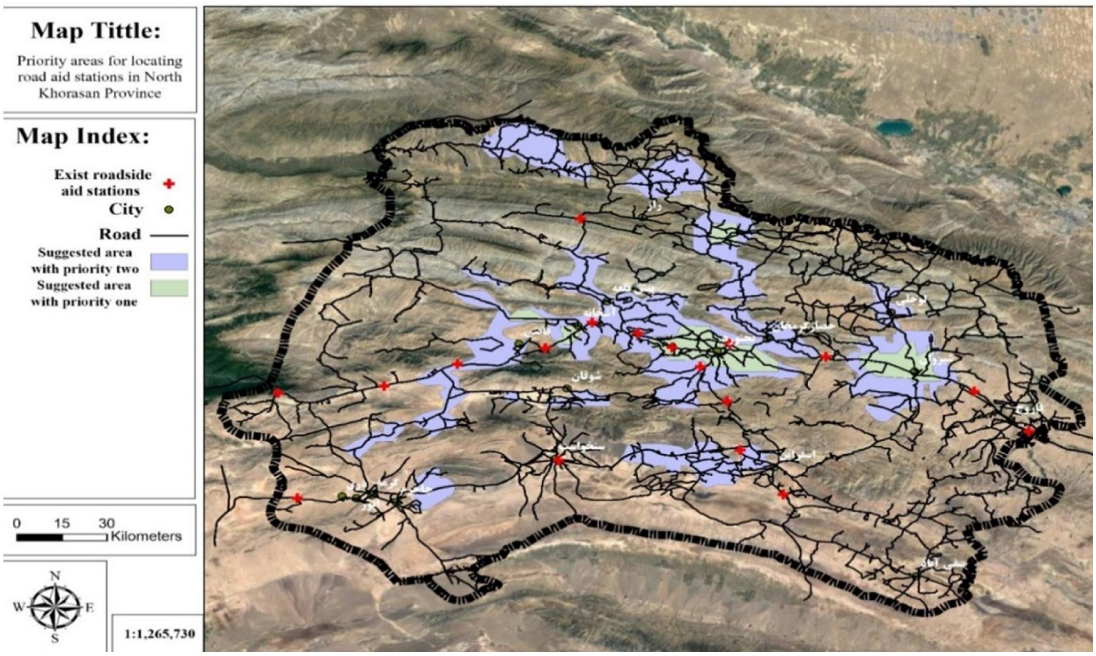

Figure 5. Highest priority and high-priority lands

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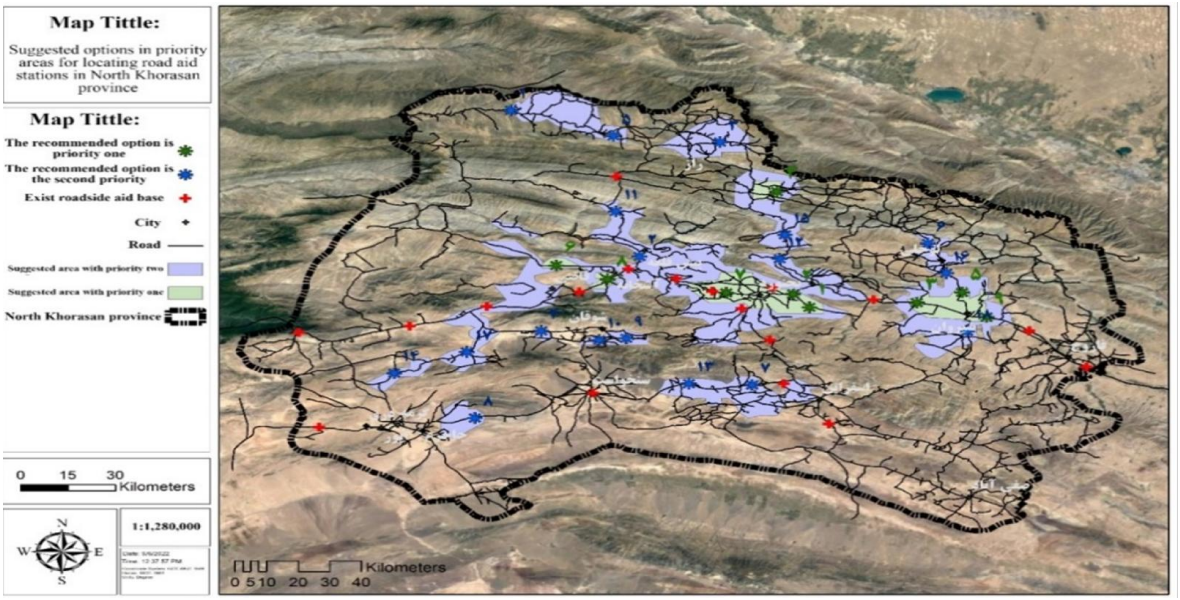

Figure 6. Proposed lands

Weighting results

The results related to weighting are presented in Table 2. According to Table 2, the criteria of welfare services and roads have the most weight, and the criteria of natural factors have the least weight. Among all the sub-criteria, distance from accident-prone points, distance from existing RCS road rescue and relief bases, distance from roads, and population density have the most weight.

Results of integration of criteria

All criteria are combined according to their final weight using the weighted linear combination method. The final map is classified into five categories, and its result is illustrated in Figure 4, which shows the location of the new RCS road rescue and relief bases.

After prioritizing the proposed areas to choose a suitable place to construct a new RCS road rescue and relief bases in North Khorasan province, the proposed lands were located in two areas with highest priority and high priority. Highest priority and high-priority lands on the satellite images are depicted in Figure 5.

Firstly, nine lots with a total area of 33864 square meters were located in the high-priority area. In this research, the distance from the existing RCS road rescue and relief bases, placement in a position with suitable land acquisition conditions, suitable topographical conditions, the presence of infrastructure, proximity to accident-prone points, and observing the principle of timing in providing services to the victims during road accidents were considered. Thereafter, 18 lots with a total area of 51151 square meters were located in the high-priority area due to its greater extent and coverage than the highest priority area. The proposed lands are displayed in Figure 6.

Discussion and Conclusion

Nowadays, due to the significant development of roads and the marked increase in the number of cars and road accidents, it is necessary for the RCS road rescue and relief bases to perform better in their activities. One of the notable issues in improving the performance of RCS road rescue and relief bases is the proper locating of these bases. It enhances the efficiency of the bases, and the management will be able to provide services all over the country by taking appropriate measures. The proposed areas for locating new RCS road rescue and relief bases are situated in the northwest, center, south, and east of the North Khorasan province. However, it is better to consider the land around these points for the construction of new RCS road rescue and relief bases due to the paramount importance of proximity to accident-prone points.

Currently, most of RCS road rescue and relief bases are located on the main roads, and there is no proper access to these stations in the border areas. The new RCS road rescue and relief bases

[DOI: 10.61186/jorar.16.1.1]

should be built in a place that is as far away from the existing bases as possible so that there is less overlap in the service area. Therefore, arrangements should be made to provide proper service coverage for the RCS road rescue and relief bases throughout the province. Because according to the results of this research, distance from existing RCS road rescue and relief bases was among the most important criteria.

Distance from accident-prone points was among the most important criteria. Currently, existing RCS road rescue and relief bases are near the accident-prone points of the main roads; however, for the accident-prone points of the side roads, a solution should be thought of so that the bases are close to those points as well.

Acknowledgments

The authors would like to express their sincere gratitude to all participants in this study.

Conflict of Interests

All the authors declare no conflict of interest regarding the performed study.

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[DOI: 10.61186/jorar.16.1.1]