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Project-Based GIS Integration into Geography Learning: The Case of Landslides

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Abstract

In the integration of GIS, which is the first tool that comes to mind when it comes to geography and technology, into teaching processes, it is necessary to design project-based GIS applications that focus on real-life problems. However, the number of these projects is quite small. It is known that landslides cause the most damage after earthquakes in Turkey. In this context, the aim of this study is to present a project-based GIS application related to landslides, a real-life problem, with all its components and to explain its use in the geography teaching process. The Analytic Hierarchy (AHP) method was used in the GIS application developed within the scope of the study. In this study, a sample project-based GIS application that can be used in the teaching of landslides was developed by reviewing the literature on GIS projects. Each component of this application was designed to be used in geography teaching, and the roles of teachers and students were addressed in these components. According to the research findings, it is recommended that GIS should be used as a "decision support system" in the geography course teaching process, guidance documents should be created for teachers regarding the use of GIS in the teaching process in accordance with the achievements in geography curriculum and solving hardware and software problems regarding the use of GIS in schools.

Keywords: Landslide, GIS, Geography education, Project

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GIS as a Decision Support System

GIS is a decision support system that enables the collection, storage, updating, and analysis of spatial data (Taşbaş, Karadağ & Kösemli, 2015). However, when GIS-based projects are examined, it is seen that the feature of being a decision support system given in this definition is not used much, especially in solving real-life problems. The name of the course in which GIS is used to solve these problems is geography. When considered in the context of geography course, the real-life problems experienced in Turkey, as in many parts of our world today, are related to geography. One of these life problems is landslides, one of the most important natural disasters. When the losses caused by natural disasters in Turkey are analyzed, it is determined that mass movements are the type of natural disasters that cause the most loss of life and property after earthquakes (Ildır, 1995; Özşahin, 2015). It is emphasized that it is prone to landslides, especially due to its rugged terrain, and should be monitored regularly (Alptekin&Yakar, 2020). In addition, the fact that it occurs suddenly and unstoppably makes it necessary to quickly and accurately identify areas that are susceptible to landslides (Şahin, 2021). Today, Remote Sensing (RS) and Geographic Information Systems (GIS), which are considered advanced technological applications, are widely used in their detection. These technologies enable inexpensive, fast, and highly accurate analyses in studies such as predicting landslide areas, modeling, and determining the damage after landslides.

In the Geography Course Curriculum (GCL), one of the limited numbers of learning outcomes in which the use of GIS is recommended is the learning outcome 10.4.1. "Explains the causes and characteristics of disasters." In the explanation of this outcome, there is an explanation as "Examples of using GIS and other spatial technologies in solving geographical problems are given." (MoNE, 2018). However, when the literature on this subject is scanned, it is seen that there are not many examples where GIS and other spatial technologies are used in the solution of geographical problems. Based on this problematic situation, the GIS-supported AHP method was used in this study to realize the outcome 10.4.1. In the research conducted on the study area, it is noteworthy that there are landslides in certain parts of the Üzümlü center and its surroundings, especially around Günebakan and Geyikli. In this study, the Üzümlü district of Erzincan was selected as a sample location, and the same study can be conducted in different regions of Turkey.

Purpose of the Research

The aim of this study is to present a project-based GIS application related to landslides, a real-life problem, with all its stages and to explain its use in the geography teaching process. In this study, the Üzümlü district of Erzincan was selected, and analyses were carried out in this place. In this context, the sub-objectives of this study, which also aims to identify landslide-sensitive areas in Üzümlü and develop a pre-landslide warning system were determined as follows. In the line with the teaching of learning outcome 10. 4.1;

- To raise awareness about landslides, a natural disaster, and the damages they cause to the environment with GIS,
- Determination of the landslide susceptibility of the study area by GIS,
- Gaining geographical skills in GLC by using RS methods and GIS.

The Importance of the Research

The study is important in terms of using GIS technology in the solution of these problems by looking at landslides, one of the disasters included in learning outcome 10.4.1 in GLC, as a geographical problem. In addition, this study is also important in terms of creating a landslide susceptibility map of the selected place, Üzümlü Center, and its surroundings.

Method

In this research, all relevant information/documents were scanned, and a new integrity was created from this information (Creswell, 2002) to develop a project-based GIS application that will enable people to be less affected by this disaster related to landslides, which is one of the real-life problems and is included in learning outcome 10.4.1. in GLC.

Findings

To develop a project-based GIS application related to landslides, first, it should be determined which parameters will be used in identifying and solving the related problem. In this regard, students can be divided into groups and asked to investigate geographical phenomena that may be related to landslides. In this study, by reviewing the literature, it was determined which parameters are used on the subject, and by taking into account the study area, it was determined that analyses can be made according to factors such as height, slope, aspect, precipitation, geology, proximity to rivers, proximity to roads, proximity to fault areas, and NDVI, which are frequently used in the literature.

To determine landslide susceptibility classes, the data used must first be organized in raster format. For this reason, data other than slope, aspect, elevation, and curvature data obtained from DEM data should be converted to raster data. Precipitation data can be converted to raster data by using Spatial Analyst Tools>interpolation>IDW tool, while road, river, and fault data can be converted to raster data by polyline to raster operation. For NDVI analysis, band-8 and band-4 data from Sentinel satellite images with a resolution of 10 m can be compared to each other to determine the plant density in the study area. Data belonging to all factors can be reclassified by using 3D> raster reclass>reclassify tools in the Arc Map interface, and areas belonging to landslide susceptibility classes of these factors can be determined. In this study, the steps given above were applied. During the use of these stages in the geography teaching process, each stage can be assigned to the responsibility of a student group.

The study area covers the administrative boundaries of Erzincan province, Üzümlü district center, and its surroundings. Located between 39°40'30″ North latitude and 39°37'30″ East longitude, the study area is 10.506 hectares. It is a district with a semi-arid continental climate (Figure 1). It is on the North Anatolian fault line (Figure 2).

Figure 1

Study Area (Üzümlü and its Surroundings)

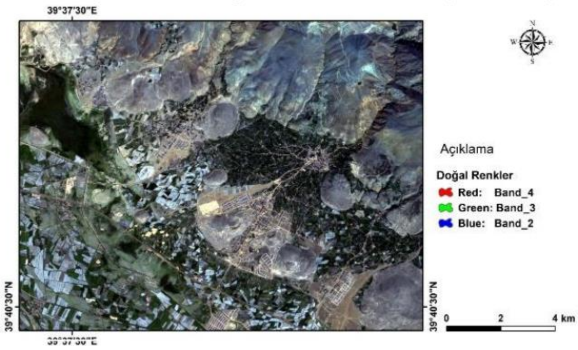
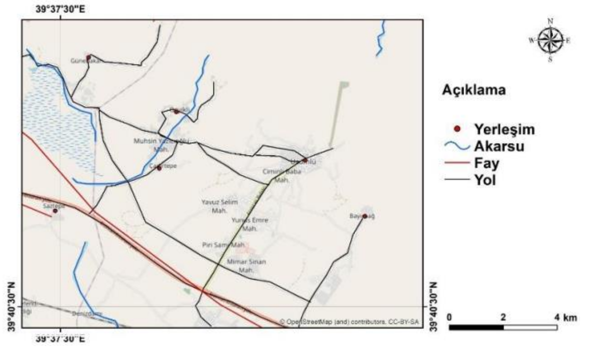


Figure 2

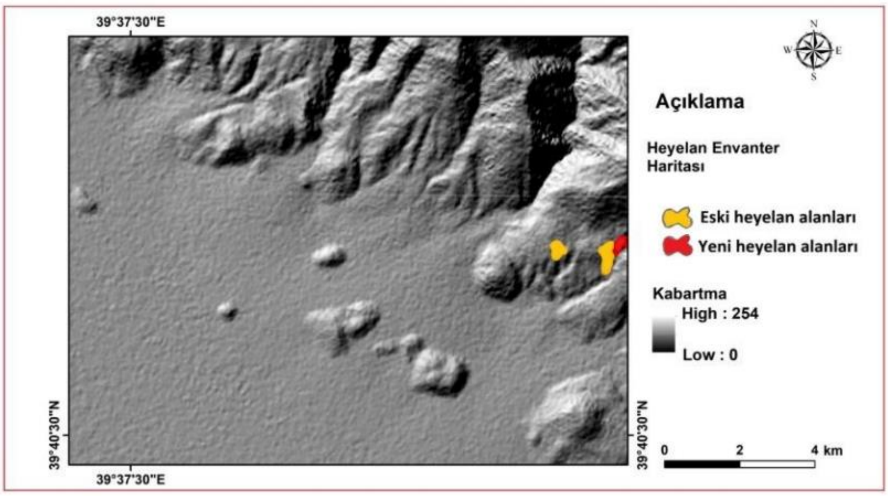
Study Area Settlement, River, Fault and Road Map



In the study area, it is important to determine the landslide areas that have occurred before and to identify the factors that cause landslides. It is assumed that landslides that are thought to occur in the future may occur under similar conditions to the current and past landslides (Yılmaz, 2009). For this reason, the spatial distribution of landslides that occurred in the past can be shown to students using GIS and RS technologies. The landslide inventory map created in the project designed within the scope of this research is given below (Figure 3).

Figure 3

Landslide Inventory Map of the Study Area



When Image 3 is examined, it is determined that there are landslides in and around the center of Üzümlü, while the landslides occurring in Günebakan and Geyikli are not shown. As a result of the analysis carried out to establish the relationship between the lithological structure and landslides, it was determined that the study area is predominantly composed of alluvium, limestone, melange, volcanic rock, slope rubble, debris cone, and shale structure (Figure 4). When the lithologic structure of the area was analyzed, it was determined that 40.25% of the area was very highly sensitive (Table 1).

Figure 4

Landslide Inventory Map of the Study Area

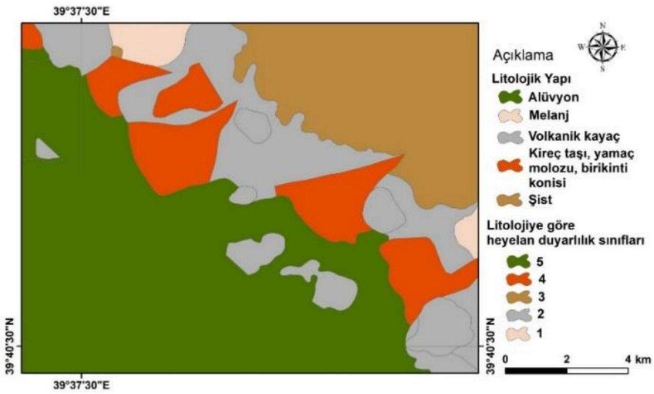


Table 1

Lithology Landslide Susceptibility Classes

Lithology Landslide Susceptibility Classes	%
Very high sensitivity	40,25
High sensitivity	23,81
Sensitive	16,66
Less sensitivity	13,51
Very little sensitivity	5,50
Total area	99,73

The analysis revealed that the study area has a sloping structure between 10° and 50° (Figure 5). 53.80% of the area was found to be very sensitive in terms of slope (Table 2).

Figure 5

Slope Landslide Map of the Study Area

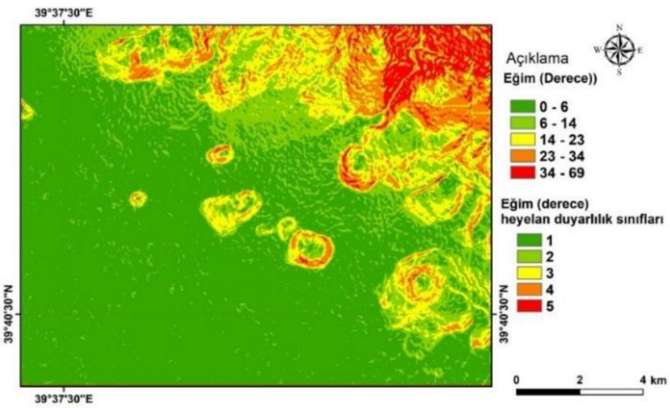


Table 2

Slope Landslide Susceptibility Classes

Slope Landslide Susceptibility Classes	%
Very high sensitivity	53,80
High sensitivity	17
Sensitive	14,30
Less sensitivity	10,30
Very little sensitivity	4,40
Total area	100

Aspect is considered important in the preparation of landslide susceptibility maps due to its relationship with factors such as insolation, winds, and precipitation (degree of saturation). Especially 16.20% of the study area and the north, northeast, and northwest directions were found to be highly susceptible to landslides (Figure 6), (Table 3).

Figure 6

View Landslide Map of the Study Area

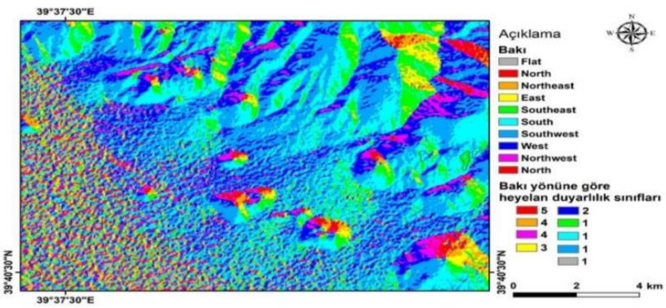


Table 3

View Landslide Susceptibility Classes

View Landslide Susceptibility Classes	%
Very high sensitivity	16,20
High sensitivity	20,30
Sensitive	38,70
Less sensitivity	19,50
Very little sensitivity	4,90
Total area	99,60

Proximity to fault lines is an important factor that increases landslide susceptibility. Our study area is located within the boundaries of the North Anatolian fault line (Figure 7). It was determined that 3.40% of the area is very highly susceptible (Table 4).

Figure 7

Proximity to Fault Landslide Map of the Study Area

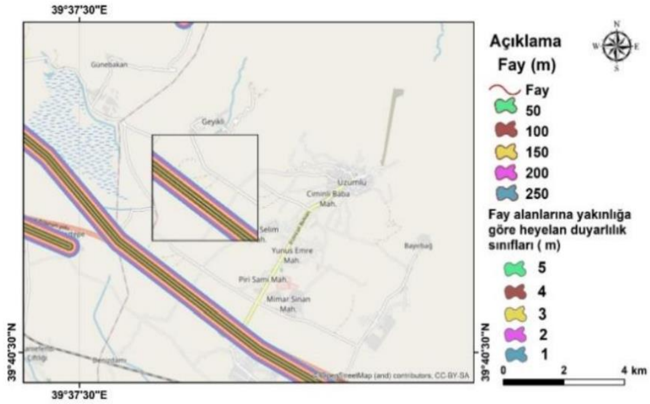


Table 4

Fault Landslide Susceptibility Classes

Fault Landslide Susceptibility Classes	***%***
Very high sensitivity	3,40
High sensitivity	3,30
Sensitive	3,20
Less sensitivity	3,20
Very little sensitivity	3,10
Total area	16,20

There is a relationship between elevation steps and landslides. Changes in precipitation, slope, and soil conditions, along with elevation, affect landslides indirectly. (Öz&Günek, 2021). The elevation values of our study area were determined to be between 1100 m and over 1900 m (Figure 8). When the elevation factor was analyzed, it was determined that 6% of the study area was very highly susceptible (Table 5).

Figure 8

Elevation to Fault Landslide Map of the Study Area

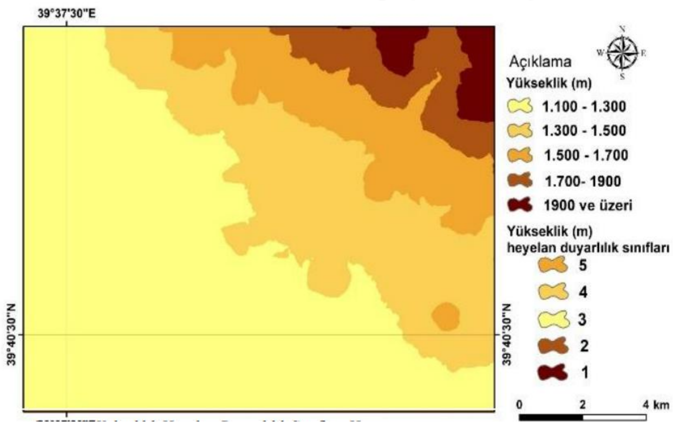


Table 5

Elevation Landslide Susceptibility Classes

Elevation Landslide Susceptibility Classes	**%**
Very high sensitivity	6
High sensitivity	7,50
Sensitive	50,70
Less sensitivity	21,70
Very little sensitivity	13,70
Total area	100

When combined with other factors, precipitation plays an important role in the formation of landslides. Before the landslide susceptibility analysis of the study area, the precipitation values of the region between 2013 and 2022 were determined (Figure 9). It was determined that 14.60% of the area is very sensitive to precipitation (Table 6).

Figure 9

Map of Precipitation Landslide

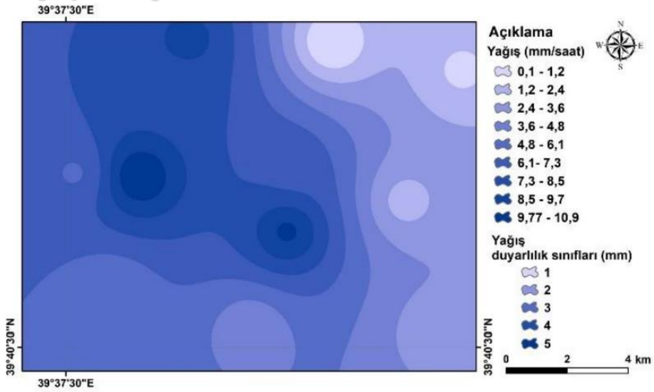


Table 6

Precipitation Landslide Susceptibility Classes

Precipitation Landslide Susceptibility Classes	%
Very high sensitivity	14,60
High sensitivity	40,20
Sensitive	23,40
Less sensitivity	12,30
Very little sensitivity	9,50
Total area	100

Slopes located at the intersections of river networks are affected by rivers. Streams erode the heel of the slope, and the slope becomes saturated with water up to the river level. Therefore, streams increase landslide susceptibility (Öz&Günek, 2021), (Figure 10). 1.10% of the rivers in the study area have very high susceptibility (Table 7).

Figure 10

Map of River Landslide Susceptibility Classes

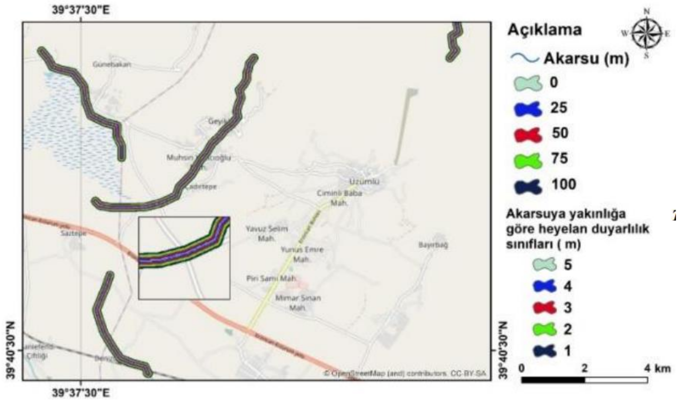


Table 7

River Landslide Susceptibility Classes

River Landslide Susceptibility Classes	%
Very high sensitivity	7,70
High sensitivity	7,50
Sensitive	7,10
Less sensitivity	6,80
Very little sensitivity	6,60
Total area	35,70

Since proximity to the road disrupts the slope balance, movement in the direction of the slope accelerates and affects landslide formation (Hepdeniz and Soyaslan, 2018). The landslide susceptibility class map of the study area was created (Figure 11) and it was determined that 7.70% of the area was very high susceptible (Table 8).

Figure 11
Road Proximity Landslide Susceptibility Classes

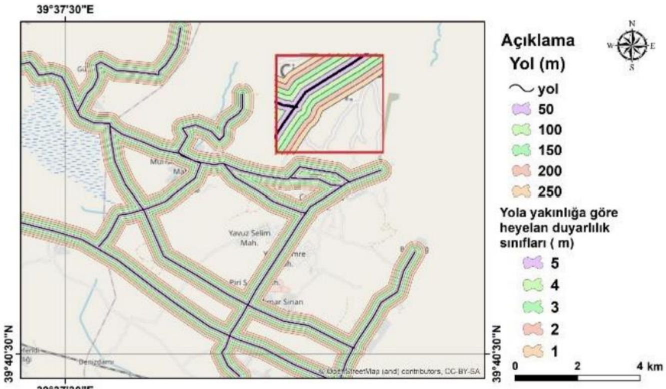


Table 8
Road Proximity Susceptibility Classes

Road Proximity Landslide Susceptibility Classes	%
Very high sensitivity	7,70
High sensitivity	7,50
Sensitive	7,10
Less sensitivity	6,80
Very little sensitivity	6,60
Total area	35,70

NDVI; areas with no or sparse vegetation cover are more susceptible to landslides. Generally, the decrease in the effect of degradation and erosion in areas covered with vegetation reduces landslide susceptibility (Nasery, 2022). In the study area, it was determined that plant density decreased in areas susceptible to landslides (Figure 12). It was determined that 30.80% of the area is very highly susceptible to landslides (Table 9).

Figure 12
NDVI Landslide Susceptibility Classes

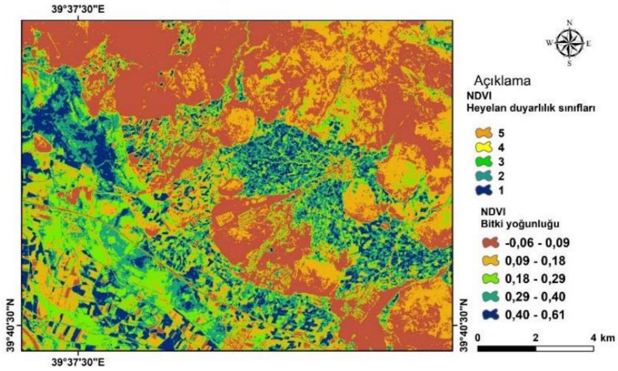


Table 9
NDVI Landslide Susceptibility Classes

NDVI Landslide Susceptibility Classes	%
Very High Sensitivity	30,80
High Sensitivity	26,40
Sensitive	16,70
Less sensitivity	15,10
Very little sensitivity	10,70
Total area	99,70

Slope curvature is classified into 3 groups as concave, flat, and convex (Çellek, 2013), (Figure 13), (Table 11). Although there is a tendency that especially convex slopes are more susceptible to landslides than concave slopes (Van Westen and Bonilla, 1999; Guzzetti et al., 1999). The convex part of the area with a rate of 25.10% is very highly susceptible to landslides (Figure 13), (Table 10).

Figure 13

Slope Curvature Landslide Susceptibility Classes

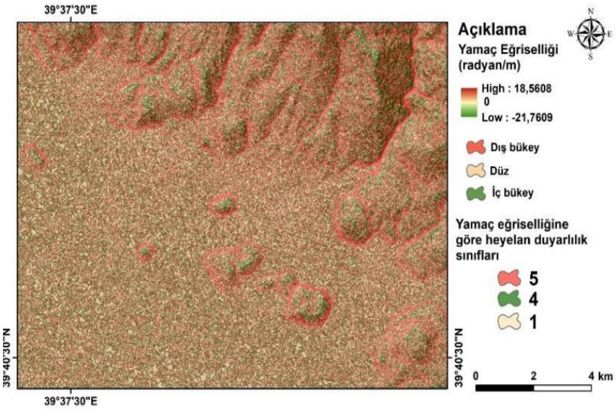


Table 10

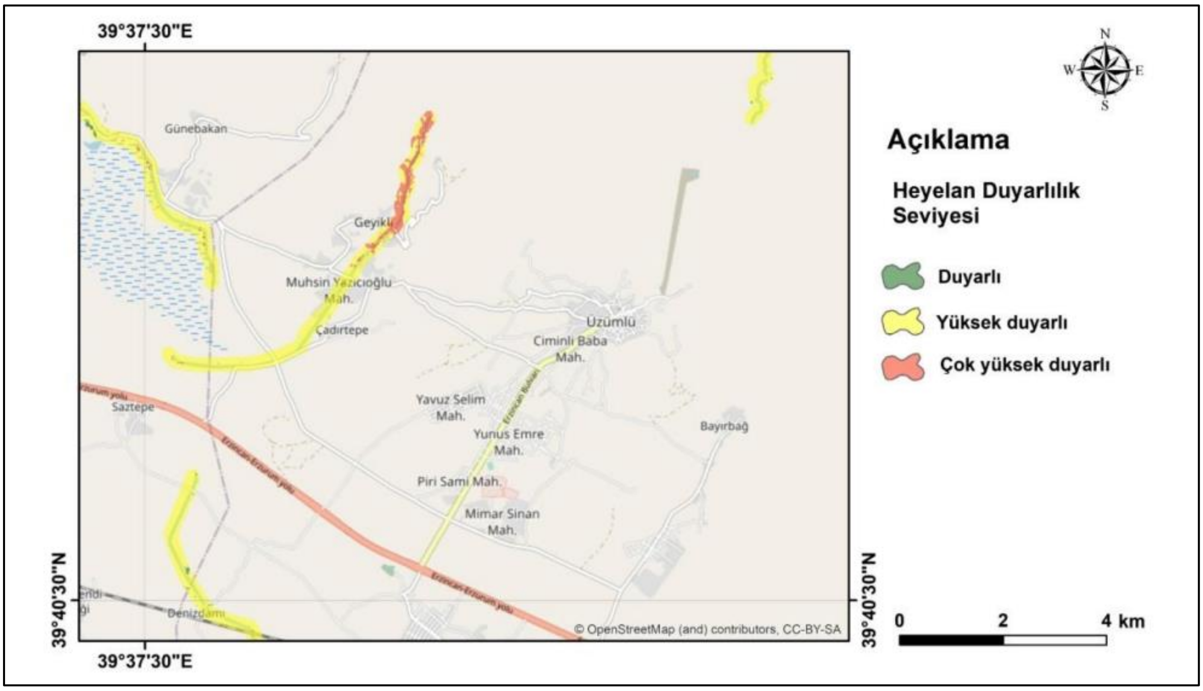
Slope Curvature Landslide Susceptibility Classes

Slope Curvature Sensitivity Classes	%
Very highly sensitive (convex)	25,10
Highly sensitive (Concave)	15,70
Total area	63,90

Slope, aspect, elevation, precipitation, rainfall, river, road, fault, lithology, slope curvature, and NDVI data of the study area, which are converted into raster data and reclassified according to their importance, can be combined by giving weight percentages in ArcGIS software>Spatial Analyst Tools>Overlay>Weighted Overlay tool and a landslide susceptibility class map can be created. The map created within the scope of this research is given below (Figure 14).

Figure 14

Landslide Susceptibility Map of the Study Area



When Figure 14 is examined, it is seen that landslide susceptibility increases in the areas with detailed pictures on the map. The study area consists of very high susceptibility, high susceptibility, and susceptibility classes. Table 11 shows the hectare values of the susceptibility classes belonging to the landslide susceptibility map and their areal values as % of the total area.

Table 11

Susceptibility Classes and Areas of Landslide

Sensitivity Analysis	ha	%
Very High Sensitivity	1,71	0,15
Highly sensitive	158,09	1,50
Sensitive	15,86	0,01

When Table 11 is examined, it is determined that the area with very high sensitivity in the study area is 1.71 ha, occupying an area of 0.15% of the total area, while the area of 158.09 ha with high sensitivity corresponds to a value of 1.50%.

Conclusion, Discussion and Suggestions

Even though the subject of project-based learning in geography education is emphasized in the literature (Sakallı, Artvinli, Dönmez, 2022; Artvinli, Dönmez, 2021a, Artvinli, Dönmez, 2021b), there are few studies on the more effective use of project-based learning with GIS technology and addressing student motivation. As can be seen, by using GIS and RS technology, maps and analyses were made within the parameters that are closely related to the landslide natural disaster, and the importance of the factors that are effective in the occurrence of landslides was revealed. Thus, thanks to GIS technology, within the scope of "Relevance and commitment", which is one of the basic principles of geography, students were taught how landslides, a real-life problem, can be prevented or minimized. GIS technology has the capacity to solve real-life problems with its superior features. It does this by effectively managing, analyzing, and visualizing geographical data. While designing a teaching process related to landslides, one of the natural disasters, which is the subject of learning outcome 10.4.1. determined within the scope of this research and also included in the GLC implemented in Turkey, it was emphasized that GIS is a decision support system. According to the results obtained from the research, the following recommendations are given:

- GIS should be used as a "decision support system" in the teaching process of geography course.
- Guidance documents should be created for teachers on the use of GIS in the teaching process in accordance with the learning outcomes in GLC.
- In-service trainings should be organized to enable geography teachers to use GIS as project based.
- Hardware and software problems related to the use of GIS in schools should be solved.

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Conflict of Interest

There are no personal or financial conflicts of interest between the authors of this article.

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Ethical Standards

Since there was no data collection from the participants within the scope of the study, there is no need for ethics committee permission.