LANDSLIDE SUSCEPTIBILITY ASSESSMENT OF TURKEY USING QUALITATIVE AND SEMI-QUANTITATIVE METHODS

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ABSTRACT

LANDSLIDE SUSCEPTIBILITY ASSESSMENT OF TURKEY USING QUALITATIVE AND SEMI-QUANTITATIVE METHODS

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Landslides have been studied by using several methods like inventory, heuristic, statistic, and deterministic methods in the recent years; these studies have also been integrated into geographic information systems with the help of technological developments. However, there has not been any nationwide landslide susceptibility zoning map produced for entire Turkey. In this study, assessing the landslide susceptibility of Turkey at a national scale using publicly available datasets was aimed. Two different scaled (1:2,000,000 and 1:500,000) and also two different pixel sized (500 m and 90 m) landslide susceptibility maps have been obtained for entire Turkey using qualitative and semi-quantitative techniques. The larger scaled approach that is composed of different landslide susceptibility maps of the watersheds has been selected after modeling 8-factor and 10-factor based AHP approach that were classified synthetically in a standard procedure developed for this study. Semi-quantitative modeling gives better results than heuristic modeling for the landslide susceptibility assessment of entire Turkey. The governing factors used in semi-quantitative modeling are curvature, landform and earthquake. It is observed that the huge percentage of historical landslides occurred in the topographic wetness index (TWI) layer possessing values of 12 and 13 that were derived from the 90 m resolution DEM. According to the findings Amasya, Sakarya, Muş, Çankırı and Bartın are the most landslide prone provinces of Turkey. The end product of this dissertation can be accepted to be a milestone for producing a final landslide susceptibility map of Turkey.

Keywords: Landslide, Nationwide, Susceptibility, AHP, Turkey

ÖZ

KALİTATİF VE YARI-KANTİTATİF YÖNTEMLERLE TÜRKİYE'NİN HEYELAN DUYARLILIK ÇALIŞMASI

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Heyelanlar son dönemde envanter, sezgisel, istatistiksel ve deterministik gibi farklı yöntemlerle çalışılmış, teknolojik gelişmeler ışığında bu çalışmalar coğrafi bilgi sistemlerine de entegre edilmiştir. Bununla birlikte, bugüne kadar Türkiye için ülke genelini kapsayan herhangi bir heyelan duyarlılık haritası üretilmemiştir. Bu çalışmada herkesin kullanımına açık veri setlerinin kullanılarak Türkiye'nin heyelan duyarlılık çalışmasının ulusal ölçekte yapılması amaçlanmıştır. Kalitatif ve yarı-kantitatif teknikler kullanılarak iki farklı ölçek (1:2,000,000 ve 1:500,000) ve iki farklı hücresel çözünürlük (500 m ve 90 m) için tüm Türkiye'yi kapsayan heyelan duyarlılık haritaları oluşturulmuştur. Bu haritalardan, 8 ve 10 faktörlü AHP yaklaşımıyla havza bazında modellenen ve bu çalışma için geliştirilen standart prosedür ile sentetik biçimde sınıflandırılan farklı su havzalarının heyelan duyarlılık haritalarından oluşan büyük ölçekli yaklaşım seçilmiştir. Heyelan duyarlılık çalışmasında yarı-kantitatif modelleme sezgisel modellemeye kıyasla Türkiye geneli için daha iyi sonuçlar vermiştir. Yarı-kantitatif modellemede baskın olan faktörler eğrilik, arazi şekli ve depremdir. 90 m çözünürlüklü sayısal arazi modelinden üretilmiş topoğrafik nemlilik indeksi tabakasının 12 ile 13 değerleri arasında kalan alanlarında tarihsel heyelanların oldukça büyük bir bölümünün meydana geldiği gözlemlenmiştir. Bulunan sonuçlara göre Amasya, Sakarya, Muş, Çankırı ve Bartın ülkemizin heyelana en fazla duyarlı olan illeridir. Bu doktora tezinin ürünü Türkiye'nin nihai heyelan duyarlık haritasının üretilmesi için kilometre taşı olarak kabul görebilir.

Anahtar Kelimeler: Heyelan, Ülke Geneli, Duyarlılık, AHP, Türkiye

Dedicated to my lovely family

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CHAPTER 1

INTRODUCTION

1.1 General

Mass movements in complex terrains like Turkey are natural degradational processes. Under the influence of a variety of causal factors, and triggered by events such as earthquakes or extreme rainfall, most of the terrains in mountainous areas have been subjected to slope failure at least once (Naranjo and van Westen, 1994).

In recent years, growing population and expansion of settlement and life-lines have largely increased the impact of natural hazards both in industrialized and developing countries. In many countries, the economic losses and causalities due to landslides generate a loss of property larger than any other natural hazards, including earthquakes, floods and windstorms.

Landslides are considered the second most significant natural hazard among those identified by the United Nations Development Program (UNEP, 1997). The full awareness of the effects produced by natural hazards led the United Nations, in 1989, to sponsor a resolution that declared the years 1990-2000 the "International Decade for Natural Disaster Reduction". Damage caused by catastrophic events is too costly even for industrialized societies. In other words, natural catastrophes occur with higher frequency than our resilience or ability to recover from previous events. The recent trend is towards the development of warning systems and land utilization regulations aimed at minimizing the loss of lives and property damage.

The best method for any landslide mitigation project is the zonation of landslide hazard. It can be considered one of the most powerful tools to improve land-use planning and to avoid the development of threatened areas, the most efficient and economic way to reduce future damage and loss of lives (Cascini, 2002; Cascini, 2005). Hence, it should supply planners and decision makers with adequate and understandable information.

Many methods and techniques have been proposed in the literature to evaluate the landslide hazard and produce a map portraying its spatial distribution (landslide hazard zonation). The first term means "the probability of occurrence within a specific period of time and within a given area of potentially damaging phenomena" e.g, a landslide. The second term refers to the division of the land surface into homogenous areas or domains and their ranking according to different degrees of hazard due to mass-movement. According to this definition, hazard maps should both display the location of actual and potential slope-failure, and provide information on the time or probability of their future occurrence (return period).

However, on a regional scale the temporal dimension of landsliding is essentially a function of the triggering mechanisms which are climatic (due to extreme rainfall) or geodynamic (earthquakes) in nature (Dewitte et al., 2006). The timing of such triggers cannot readily be linked to a model of spatial instability which is essentially founded upon the geomorphological and geological features of a region.

Hence, most of the current hazard maps aim to predict where failures are most likely to occur without any clear indication of when they are likely to take place. These should be better defined as landslide susceptibility maps (Brabb, 1984).

Landslide susceptibility is defined as the proneness of the terrain to produce slope failures. Susceptibility is usually expressed in a cartographic way. A landslide susceptibility map depicts areas likely to have landslides in the future by correlating some of the principal factors that contribute to landsliding with the past distribution of slope failure (Brabb, 1984). Because many factors can play a role in the occurrence of mass movements, the analysis is complex. It requires not only a large number of input variables, but techniques of analysis may be very costly and time-consuming.

Consequently, attention was given to seeking and developing methods and techniques to enable a faster and more efficient acquisition and processing of those geological-geomorphological data which are both relevant in assessing landslide susceptibility and mappable at effective cost over wide regions (Carrara et al., 1988).

Moreover, during the last decades, the increasing availability of computers has created opportunities for more detailed and rapid analyses. It is proved that the development of Geographic Information Systems (GIS) has enhanced the capabilities for susceptibility assessment over large regions (Van Westen, 1993). The performance of neighborhood operations with the GIS allows extraction of morphological and hydrological parameters from Digital Elevation Models (DEM), that otherwise would be difficult to obtain. The main goal is the automatic capture of most of the parameters or causative factors in relation to the occurrence of landslides.

1.2 Objectives

The aim of this study is to assess the landslide susceptibility of Turkey at a national scale using publicly available datasets. On this scale, qualitative and semi-quantitative techniques are considered the most appropriate approaches for landslide susceptibility mapping. In particular, among the different techniques developed in the literature during the years, index based and Analytical Hierarchy Process (AHP) based approaches have been applied on different scales.

Two different scaled (1:2,000,000 and 1:500,000) and also two different pixel sized (500 m and 90 m) landslide susceptibility maps have been obtained for entire Turkey in this study. The larger scaled approach that is composed of different landslide susceptibility maps of watersheds has been selected after modeling 8 factors and 10 factors based AHP approach that were classified synthetically in a standard procedure developed for this study.

The study is targeted towards individuals and organizations that are interested in nationwide landslide susceptibility zoning in Turkey, which lacks a landslide susceptibility map of the entire country. In this respect, the maps developed in this study can be considered as a milestone for the further nationwide landslide susceptibility assessments that would be carried out in Turkey.

Hence, the objectives of the study can be listed as follows:

- To obtain landslide susceptibility map of Turkey at a national scale by using publicly available datasets.
- To select appropriate scale or scales in order to assess landslide susceptibility of entire Turkey.
- To selecting the most appropriate techniques for the nationwide landslide susceptibility mapping of Turkey.
- To validate the proposed landslide susceptibility map of Turkey by using ROC curves.

1.3 Thesis Outline

The subjects described in the following chapters are given below:

In Chapter 2, landslide susceptibility mapping considering selection of causative factors, scale and techniques are introduced. Appropriate heuristic analysis and quantitative techniques used for nationwide landslide susceptibility assessments are discussed.

In Chapter 3, the landslide susceptibility assessment of Turkey is performed only by using a simple mathematical equation for Turkey in its entirety on a 1:2,000,000 scale using a qualitative method (Landslide Susceptibility Index) suitable for a GIS-based country-wide analysis from publicly available datasets. It is also intended to tackle the main factors for landsliding and to identify the most susceptible regions for landsliding as a basis for further detailed hazard or risk studies.

In Chapter 4, Turkey is divided into the 26 main watersheds with increased spatial resolution (90 m) in a larger scale (1:500,000) in order to overcome some of the shortcomings of the previous chapter. Every watershed is modeled by 8 and 10 causative factors on its own using a semi-quantitative method (AHP).

In Chapter 5, all of the results are compared, evaluated and synthetically classified into susceptibility zones. The validation of the produced maps is performed and the standard procedure during performance tests is explained in detail. These 26 watershed zones are merged and a more detailed landslide susceptibility map is presented for entire Turkey.

Finally, Chapter 6 summarizes the main results of the study, discusses the implications of the work within the context of existing literature and presents recommendations for further research.

CHAPTER 2

SUSCEPTIBILITY ZONING

Destitution and demographic pressure have led lots of people to live in areas that are prone to landslides. Poor land-use planning, environmental mismanagement and a lack of regulatory mechanism increase the risk and exacerbate the effects of disasters. Several cases of the negative role played by demographic pressure on the increasing number of disasters can be mentioned (Brand, 1988). In similar cases, a reliable risk zoning for urban planning and development is an urgent need. Within the landslide risk management framework proposed by Fell et al. (2005), hazard zoning turns out to be a part of both risk analysis and risk assessment since the hazard distribution must be compared with the urban plan.

Landslide hazard zoning has been developed since the 1970's (Brabb et al., 1972; Nilsen et al., 1979; Kienholz, 1978) to face practical problems at different scales. The scientific literature highlights the extensive development during the last few decades of landslide hazard zoning, which nowadays is a powerful tool to improve land-use planning and to avoid the development of threatened areas. It represents the most efficient and economic way to reduce future damage and loss of lives (Cascini, 2002; Cascini, 2005).

Hazard maps should provide information about the location of actual and potential slope failure and about the return period. However, on a national or regional scale the temporal dimension of landsliding is essentially a function of the triggering mechanisms which are climatic (due to extreme rainfall) or geodynamic (earthquakes) in nature (Dewitte et al., 2006). The timing of such triggers cannot readily be linked to a model of spatial instability which is essentially founded upon the geomorphological and geological features of a region. Hence, most of the current hazard maps aim to predict where failures are most likely to occur without any clear indication of when they are likely to take place. These should be better defined as landslide susceptibility maps (Brabb, 1984).

Actually, susceptibility, hazard and risk are often used interchangeably in landslide zoning maps. However, a review of the recent experience in landslide susceptibility and hazard zoning (Cascini et al., 2005) highlights the fact that these maps have different accuracy and reliability. The amount of information supplied and the degree of detail constitute the greatest difference between susceptibility, hazard and risk maps.

In order to avoid confusion about the terminology, some definitions have to be supplied. According to the International Guidelines currently being developed by JTC-1 (Joint

Technical Committee on Landslides and Engineered Slopes), different types of landslides mapping/zoning are possible, respectively defined below.

Landslide inventory mapping involves the location, classification, volume, activity, date of occurrence and other characteristics of landslides which exist or potentially may occur in an area. However in some cases there may be a degree of interpretation because they may be based on geomorphologic attributes seen on air photographs or mapped on the ground.

Landslide susceptibility zoning involves the classification, volume (or area) and spatial distribution of existing and potential landslides in the study area. Landslide susceptibility zoning usually involves developing an inventory of landslides which have occurred in the past together with an assessment of the areas with a potential to experience landsliding in the future, but with no assessment of the frequency (annual probability) of the occurrence of landslides.

Landslide hazard zoning takes the outcomes of landslide susceptibility mapping and assigns an estimated frequency (annual probability) to the potential landslides. The hazard may be expressed as the frequency of a particular type of landslide of a certain volume, or landslides of a particular type, volume and velocity (which may vary with distance from the landslide source), or in some cases as the frequency of landslides with a particular intensity, where intensity may be a measure in kinetic energy terms. Intensity measures are most useful for rock falls and debris flows (e.g., depth x velocity). Hazard zoning should be done for the area in its condition at the time of the zoning study. Hazard zoning may be quantitative or qualitative.

Landslide risk zoning takes the outcomes of hazard mapping, and assesses the potential damage to persons (annual probability of loss of life), and/or to property (annual value of property loss) for the elements at risk, accounting for temporal and spatial probability and vulnerability. Risk zoning depends on the elements at risk, their temporal spatial probability and vulnerability. Several risk zoning maps may be developed for a single hazard zoning study to show the effects of different development plans on managing risk.

It can be observed that landslide inventory is the basis for all the mapping, and it is important that this activity be done thoroughly. With this aim, the inventory should be mapped at a larger scale than the susceptibility and hazard zoning maps. Landslide inventory maps published by Mineral Research and Exploration Institute (MTA) during the last decade was prepared in 1:25,000 scale, but a hardcopy format of these maps are only available in 1:500,000 scale. After the purchasing procedure, these hardcopy maps were digitized in 1:500,000 scale and used in evaluation/validation stages of this study.

As previously mentioned, the purpose of landslide susceptibility maps is the identification of areas threatened by present and potential slope instability. Their reliability depends mostly on the amount and quality of available data used as well as on the selection of the appropriate methodology. The availability of data determines the type of analysis that can be performed. On the other hand, the working scale also affects the quality of the results (Van Westen, 1994). To be profitably used for urban planning and development, the maps must be performed at an appropriate scale, in order to avoid controversy in delivering building permits, expropriation and compensating measures (Leroi, 1996). Actually, before starting a study, an earth scientist should be aware of the desired degree of detail of the map, given the requirements of the study. When a degree of detail and a working scale have been defined, the cost-effectiveness of obtaining input data must be considered (Naranjo et al., 1994).

2.1 Scales

In preparing a susceptibility map, the influence of a certain number of factors on the slope instability must be evaluated. The more detailed the map is, the greater will be the number of factors to be considered. The working scale is one of the first points to define. Different choices depend on the working scale, such as the adopted methodology, the factors to be selected, the mapping unit, etc. Referring to Soeters and van Westen (1996) and to Cascini et al. (2005), the suggested landslide zoning scales are summarized in Table 2.1.

Table 2.1 Landslide zoning mapping scales (International Guidelines; JTC-1, 2007).

Scale Description	Indicative Range of Scales	Typical Area of Zoning
Small	< 1:100,000	< 10,000 km^2
Medium	1:100,000 to 1:25,000	1000 – 10,000 km^2
Large	1:25,000 to 1:5,000	10 - 1000 km^2
Detailed	> 1:5000	Several hectares

In practical terms the scale of mapping may be controlled by the scale of the available topographic maps. On the basis of the table, it can be observed that:

a. The input data used to produce landslide zoning maps must have the appropriate resolution and quality. Generally speaking, the inputs to the zoning should be at larger scales than the zoning map, not smaller. Reliable zoning cannot be produced if, for instance, a landslide hazard zoning map prepared at a scale of

1:5,000 is based on 1:25,000 geomorphological or topographic maps because the accuracy of boundaries will be potentially misleading.

b. The use of larger scale zoning maps must be accompanied by a greater detail of input data and understanding of the slope processes involved.
c. In practice, only limited detail can be shown on small, medium and even large scale maps. Most examples of municipal (local government) landslide hazard or risk zoning maps which assign a hazard or risk classification on an individual property level should be prepared at the detailed level on large scale landslide zoning maps.
d. The usefulness and reliability of small scale landslide zoning mapping is considered by some to be questionable, even for regional development planning.

Several papers review the numerous quantitative and qualitative methods of landslide susceptibility and hazard assessment and their applicability at different scales (e.g., Aleotti and Chowdhury, 1999; Şeker et al., 2004; Chacon et al., 2006; Thiery et al., 2007). Statistical methods are more suitable for analyzing susceptibility at medium scales (1:25,000–1:100,000) because they reduce the subjectivity involved in expert judgments (Van Western et al., 2006; Thiery et al., 2007). Qualitative methods based on inventorying and heuristic analysis that are the only feasible options for this study are widely used to produce susceptibility maps at small-scales (< 1:100,000) (Glade and Crozier, 2005).

2.2 Susceptibility assessment methods

Classifications of the methods developed in the literature to assess landslide susceptibility are distinguished below.

Qualitative methods are subjective and portray the zoning in descriptive terms.

Quantitative methods produce numerical values to define the susceptibility degree. The typology of the adopted method is also related to the working scale. Concerning the intermediate scale (1:25000), present knowledge suggests that zoning must be produced using a qualitative approach. On the contrary, at a large scale (1:5000 or larger, as well as a site-scale) the quantitative approach must be preferred, where good and extensive knowledge is available.

Direct methods consist of the geomorphological mapping of landslide susceptibility, based on the geomorphological experience and knowledge of the terrain conditions (Duman et al., 2006). *Indirect* methods are based on information obtained from the interrelation between landscape factors and landslide distribution and are essentially stepwise: they require first the recognition and mapping of landslide distribution over an area, then the identification of a group of physical factors which are related to slope instability, then the estimate of the relative contribution of the instability factors in generating slope-failures. These indirect methods involve analysis techniques of various types (Soeters and van Westen, 1996):

(i) Heuristic Analysis

In heuristic methods the expert opinion of the person carrying out the zoning is used to assess the susceptibility. They are based on the *a priori* knowledge of all the causes and instability factors of landsliding in the area under investigation. The instability factors are ranked and weighed according to their assumed or expected importance in causing mass movements (Carrara et al., 1995). These methods combine the mapping of the landslides and their geomorphologic setting as the main input factors for assessing the hazard. Two main types of heuristic analysis can be distinguished: geomorphic analysis and qualitative map combination. In *geomorphic analysis* the susceptibility is determined directly by the person carrying out the study based on individual experience and the use of reasoning by analogy. The decision rules are therefore difficult to formulate because they vary from place to place. In *qualitative map combination* the person carrying out the study uses expert knowledge to assign weighting values to a series of input parameters. These are summed according to these weights, leading to susceptibility and hazard classes. These methods are common, but it is difficult to determine the weighting of the input parameters. The principal disadvantage of these methods is their dependence on how well and how much the investigator understands the geomorphological processes acting upon the terrain.

(ii) Knowledge based analysis

Knowledge based analysis or heuristic "data mining" is the science of computer modeling of a learning process (Quinlan, 1993). The data mining learning process extracts patterns from the databases of landslides (Flentje et al., 2007). Pixels with attributed characteristics (from the input data layers) matching those for known landslides are used to define classes of landslide zoning. The percentage distributions of landslides within the zones are then used to help define the zones.

(iii) Statistical analysis

The statistical or probabilistic approach is based on the functional relationships between some of the main factors that contribute to the occurrence of slope failure, such as steep slope or presence of weak lithological units, and the past distribution of landslides (Carrara et al., 1995). This approach usually involves the mapping of the existing landslides, the mapping of a set of factors that are supposed be directly or indirectly linked to the stability of the slopes, and the establishment of the statistical relationships between these factors and the instability process. A statistical model of slope instability is built on the assumption that the factors which caused slope failure in a region are the same as those which will generate landslides in the future. Hence susceptibility zoning is conducted in a largely objective manner whereby factors and their interrelationships are evaluated on a statistical basis. Various methods exist for the development of the rules for and relationships between variables and these include bivariate analysis (Brabb et al., 1972), multivariate analysis, particularly the discriminant analysis (Neuland, 1976; Carrara, 1983; Carrara et al., 1995), Boolean approaches using logistic regression (Atkinson and Massari, 1998; Dai and Lee, 2001; Ayalew and Yamagishi, 2005), Bayesian methods using weights of evidence and neural networks (Gomez and Kavzoğlu, 2005; Lee et al., 2006). These methods can be used when a large amount of information is available, in the form of both quantitative and qualitative data. The principal advantage is the objectivity of the model, while the greater disadvantage is the cost of the acquisition of some factors that are related to the slope instability. Limitations with such methods result from data quality such as errors in mapping, incomplete inventory and poor resolution of some data sets as the models are essentially data trained. In addition, the results of such models are not readily transferable from region to region. Moreover, all the statistical methods are very sensitive to the type and quality of the factors chosen for the susceptibility analysis.

(iv) Deterministic Analysis

Deterministic methods are used in order to study the instability of a slope in a detailed study. They apply classical slope stability theory and principles such as infinite slope, limit equilibrium (e.g., Bishop, Sarma methods, etc.) and less commonly finite element, 3D techniques and take into account the physical laws controlling slope instability; they offer a great advantage with respect to the other methods. These models require standard soil parameter inputs such as soil thickness, soil strength, groundwater pressures, slope geometry, etc. The resultant map details the average factor of safety and boundaries while susceptibility and hazard classes can be set according to factor of safety ranges (i.e., inunfailed<1.0, metaunfailed 1.0 to 1.1, etc). One-dimensional deterministic slope stability models have been used to calculate average safety factors of the slopes (van Westen and Terlien, 1996; Zhou et al., 2003) in which a hydrological model may also be incorporated into (Montgomery and Dietrich, 1994; Montgomery et al. 1998). Three-dimensional deterministic models integrated in a GIS environment have been performed by Xie et al. (2004). Deterministic distributed models require maps that give the spatial distribution of the input data. The variability of the input data can be further used to calculate the probability of failure in conjunction with the return periods of triggers (Savage et al., 2004, and

Baum et al., 2005). The main advantage of these methods are their great reliability, if the input data are correct. However, the large amount of data that is required can only be afforded in the case of individual slopes or small areas, so they are not suitable when analyzing large areas. Moreover, another problem with these methods is the oversimplification of the geological and geotechnical model, and difficulties in predicting groundwater pore pressures and their relationship to rainfall and/or snow melt.

As already mentioned, the susceptibility models and the mapping scales are conceptually and operationally interrelated (Carrara et al., 1995). The selection of the most appropriate zoning method depends on several factors. Table 2.2 summarizes the activities necessary to map the existing landslide and to assess the areas with a potential to experience landsliding in the future, by relating methods, input data and procedures.

Table 2.2 Landslide zoning methods and procedures.

Method	Input / Procedure	Topography, landslide inventory, geology, geomorphology	Adding soil classess and depth, terrain units	Adding hydrogeology, geotechnics
Basic	Heuristic and empirical methods	+		
Intermediate	Statistical analyses	+	+	
Sophisticated	Deterministic (physically based or geotechnical) models	+	+	+

For instance, methods using heuristic or empirical procedures (Brabb, 1984; Cascini et al., 2005; Evans and King, 1998; Hungr et al., 2005; Nilsen et al., 1979) to process essentially topographic, geological and geomorphological data are considered basic methods for the inventory of existing landslides and characterization of potential landslides. The method can be defined as intermediate when further details on the input data and procedures based on statistical analyses are added (Baynes and Lee, 1998; Carrara et al., 1995; Sanctana et al., 2003; van Westen, 1994). Finally, sophisticated methods necessarily need hydrogeological and geotechnical data, and deterministic or probabilistic procedures (Baum et al., 2005; Duncan, 1992; Goodman and Shi, 1985).

2.3 Zoning levels

On the basis of any adopted method mentioned above, three different zoning levels can be obtained:

- preliminary
- intermediate
- advanced.

For instance, when using basic methods exclusively, only a preliminary zoning level can be obtained; while intermediate and sophisticated methods can allow the improvement of the zoning level according to the combination shown in Table 2.3.

Table 2.3 Levels of activity required for susceptibility, hazard and risk zoning levels (International Guidelines; JTC-1, 2007).

Type of Zoning	Inventory Mapping	Susceptibility Zoning	
Zoning Level	**Inventory of existing landslides**	**Characterization of potential landslides**	**Travel distance and velocity of potential landslides**
Preliminary	Basic [1, 2]	Basic [1, 2]	Basic [1] Intermediate [2]
Intermediate	Intermediate	Intermediate	Intermediate
Advanced	Sophisticated	Sophisticated to intermediate	Intermediate to sophisticated

Notes: [1] For qualitative zoning
[2] For quantitative zoning

Table 2.3 defines the levels of landslide inventory and susceptibility zoning in terms of geotechnical and other input data. It is important to match the level of the zoning to the required usage (purpose), the scale of mapping and in turn match these to the level of the input data. It is not possible, for example, to produce a satisfactory advanced level hazard zoning without at least an intermediate level assessment of frequency of landsliding. If only a basic level assessment of frequency can be made, then the result will be no better than a preliminary level, and there is no point in spending large resources for bringing the other inputs to an intermediate or, in particular, to a sophisticated level. On the other hand, if a preliminary level hazard zoning is required then the inputs may be at the basic level. The current practice shows that due to both the scarcity of available data and cost restrictions, only basic or intermediate inputs and methods are mostly used.

2.4 Purposes

Landslide zoning that is mainly used for land use planning can be carried out for different purposes. It is most commonly required at the local government level for planning urban development, but may be required by state or federal governments for regional land use planning or disaster management planning. It may also be required by land developers, those managing recreational areas, or those developing major infrastructures such as highways and railways. It is the combination of having an area which is potentially subject to landsliding, and the scale and type of development of the area that will determine whether landslide zoning is needed for land use planning.

The type and level of detail of the zoning and the scale of the maps depend principally on the purpose to which landslide zoning is to be applied (regional, local and site specific planning).

It will usually be appropriate to carry out landslide susceptibility zoning as a first stage in the development of landslide hazard or risk zoning for planning purposes. Staging will allow better control of the process and may reduce the costs of the zoning by limiting the more detailed zoning only to areas where it is necessary. It should be noted that it will seldom be necessary to carry out landslide zoning at an advanced level because the costs will potentially be so much larger than the costs for intermediate level zoning and this will potentially outweigh the benefits. It is important to link all the elements described up to now: type of zoning, scale of zoning, zoning methods, zoning level and purpose of zoning. Table 2.4 provides all the connections with reference to landslide susceptibility.

At a small scale, considering that only basic methods can be used (i.e., methods based on geological data and heuristic procedures), only a preliminary zoning level can be pursued and obtained. At a medium scale, where statistical procedures can be used, two zoning levels may be defined. At a large and detailed scale, three zoning levels are possible, respectively, based on basic, intermediate and sophisticated methods. However, the type of analysis, level and scale of zoning also depend on the complexity of the landslide features, the homogeneity of the terrain, the spatial variability of the important causal factors, geotechnical parameters and the amount of available data and expertise.

Table 2.4 Landslide zoning mapping scales, methods, levels and purposes for susceptibility assessment (International Guidelines; JTC-1, 2007).

Scale description	Indicative range of scales	Zoning methods			Zoning levels			Type of zoning	Purpose
		Basic	Intermediate	Sophisticated	Preliminary	Intermediate	Advanced	Susceptibility	
Small	< 1:100,000	A			A			A	Regional zoning - *Information*
Medium	1:100,000 to 1:25,000	A	M		A	M		A	Regional zoning - *Information* - *Advisory*
Large	1:25,000 to 1:5,000	A	A	A	A	A	A	A	Local zoning - *Information* - *Advisory* - *Statutory*
Detailed	> 1:5,000	N	M	A	N	M	A	N	Site specific zoning - *Information* - *Advisory* - *Statutory* - *Design*

Notes: (A) applicable; (M) may be applicable; (N) not recommended or not commonly used

CHAPTER 3

NATIONAL LEVEL LANDSLIDE SUSCEPTIBILITY ASSESSMENT

3.1 Introduction

Landslide is one of the most frequently encountered natural disasters in the world. According to recent studies, floods account for about 46% of all natural disasters that is followed by hurricanes (26%) and landslides (10%) (CRED, 2010). Turkey is one of the European countries most affected by natural hazards with strong socio-economic impacts. Landslide is the second most destructive disasters in Turkey after earthquakes (Reis and Yomralıoğlu, 2005; Baltacı et al., 2010). It is clear that landslides are the most frequent disasters that have caused the most suffering and loss amongst all disasters that have occurred in Turkey during last 50 years (Gökçe et al., 2008; Dağ and Bulut, 2012). Most of the landslides that have occurred in Turkey are typically associated with heavy rainfall; hence landslide and flood have typically occurred simultaneously. This is the main reason why experts cannot separate how much damage or loss has been caused by the landslide on its own.

Mountainous environments having heavy rainfall and plateaus that cover more than half of Turkey's area are especially susceptible to landsliding. Landslides generally occur in areas where they have occurred in the past. This means that landslide inventory is a must study for landslide susceptibility assessments. In Turkey, landslide related damage information has been collected by the General Directorate of Disaster Affairs since the mid 20th century. Mineral Research and Exploration Institute has published landslide inventory maps of the country during the last decade. 4,250 settlements were affected and 197 people lost their lives during landslides in Turkey that have occurred in the period between 1958-2000. According to the General Directorate of Disaster Affairs, a total of 63,000 residentials have been relocated to safer places in this period.

Recent landslide studies in Turkey have focused on the application of quantitative or qualitative methods to develop susceptibility and hazard assessments in small regions of the country. However, a landslide susceptibility assessment of the entire country, considering as many causal factors as reasonably possible, and which could be used in a GIS environment by the institutions involved in risk assessment and management, is still missing.

The aim of this chapter is to assess landslide susceptibility in Turkey through using a qualitative method (Landslide Susceptibility Index) suitable for a GIS-based country-wide analysis from publicly available datasets. It is also intended to tackle the main factors for landsliding and to identify the most susceptible regions for landsliding as a basis for further detailed hazard or risk studies.

3.2 The study area

Turkey is a mountainous Eurasian country with a strategic location situated in the Anatolian peninsula in western Asia, eastern Thrace and south-eastern Europe (Figure 3.1). Turkey is the world's 37th largest country and covers an area of 783,562 km^2 that forms a roughly rectangular shaped bridge between Europe and Asia. Turkey borders the Black sea (to the north), the Mediterranean (to the south), the Aegean (in the west) and the Marmara sea (in the northwest separating Europe and Asia) and has a total sea coastline length of 7,200 kilometers (CIA, 2002). Ankara is the capital of Turkey and the country's second largest city after Istanbul.

Figure 3.1 Map of Turkey (source: www.nationsonline.org).

The Anatolian part of Turkey accounts for 97% of the country's total footprint area. It is also known as Asia Minor, Asiatic Turkey or the Anatolian Plateau. The term Anatolia is most frequently used in specific reference to the large, semiarid central plateau, which is rimmed by hills and mountains that in many places limit access to the fertile, densely settled coastal regions. The European portion of Turkey, known as Thrace, encompasses

3% of the total area but is home to more than 10% of the total population. Istanbul, the largest city of Thrace and Turkey, has a population of 13,854,740 (TUIK, 2012). Thrace is separated from Anatolia by the Bosphorus, the Sea of Marmara, and the Dardanelles; which collectively form the strategic Turkish Straits that link the Aegean sea with the Black sea. Mount Ararat, Turkey's tallest mountain with an elevation of 5,166 m, is the legendary landing place of Noah's ark and is located in the far eastern portion of the country.

3.2.1 A general review of the geology of Turkey

Turkey is characterized by a very complex geology, whose main features are still poorly understood despite an increasing amount of geological data that have become available in the last 25 years. The complex geology has resulted in widely different views on the geological evolution of Turkey.

The Anatolian peninsula is surrounded on three sides by seas, which exhibit widely different geological features. The Black sea in the north is an oceanic backarc basin. It has formed during the Cretaceous, behind and towards the north of the Pontide magmatic arc as a result of the subduction of the northern Neo-Tethys Ocean. In the pre-Cretaceous times, the Pontides were adjacent to Dobrugea and Crimea. The Aegean sea is a geologically young sea, which started to develop during the Oligo-Miocene as a result of north-south extension above the retreating Hellenic subduction zone. The Eastern Mediterranean represents a relic of the southern branch of the Neo-Tethys, and is much older than the other seas (Garfunkel, 2004).

Turkey is geologically divided into three main tectonic units: the Pontides, the Anatolides-Taurides and the Arabian platform (Figure 3.2). These tectonic units, which were once surrounded by oceans, are now separated by sutures, which mark the tectonic lines or zones along which these oceans have disappeared. The Pontides exhibit Laurussian affinities and are comparable to the tectonic units in the Balkans and the Caucasus, as well as those in central Europe. They all were located north of the northern branch of the Neo-Tethys. The complete closure of this ocean resulted in the İzmir-Ankara-Erzincan suture, which marks the boundary between the Pontides and the Anatolides-Taurides. The Anatolides-Taurides show Gondwana affinities but were separated from the main mass of Gondwana by the southern branch of Neo-Tethys. They are in contact with the Arabian platform along the Assyrian suture. The northern margin of the Arabian platform is represented by southeast Anatolia south of the Assyrian suture.

The Pontides comprise the region north of the İzmir-Ankara-Erzincan suture. They were folded and thrust faulted during the Alpide orogeny but were not metamorphosed. In contrast to the Anatolides-Taurides, they bear evidence for Variscan (Carboniferous) and Cimmeride (Triassic) orogenies. The Pontides consist of three terranes, which show markedly different geological evolutions. These are the Strandja, İstanbul and Sakarya terranes (Figure 3.3).

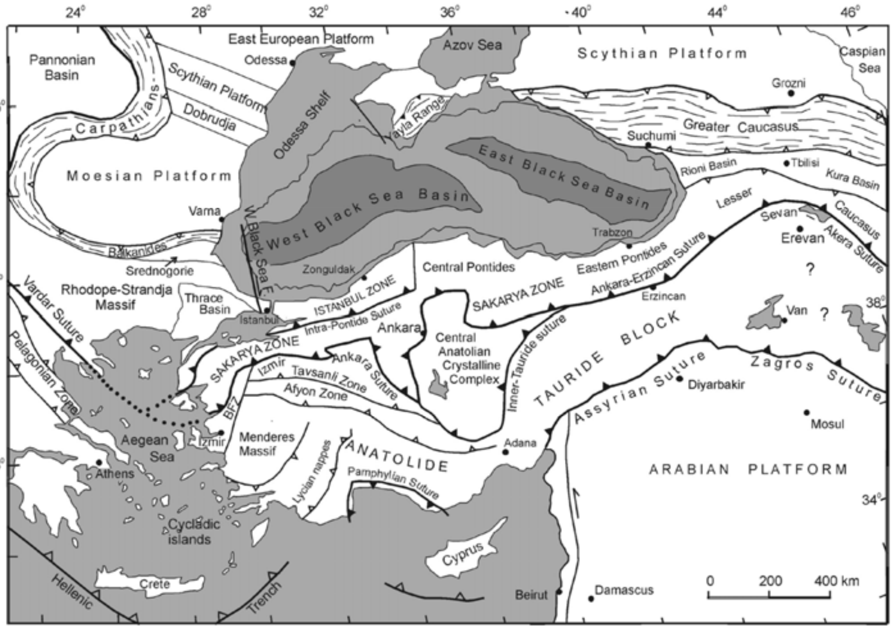

Figure 3.2 Tectonic map of north-eastern Mediterranean region showing the major sutures and continental blocks. Sutures are shown by heavy lines with the polarity of former subduction zones indicated by filled triangles. Heavy lines with open triangles represent active subduction zones. The Late Cretaceous oceanic crust in the Black sea is shown by grey tones. Small open triangles indicate the vergence of the major fold and thrust belts. BFZ denotes the Bornova flysch zone (Okay, 2008).

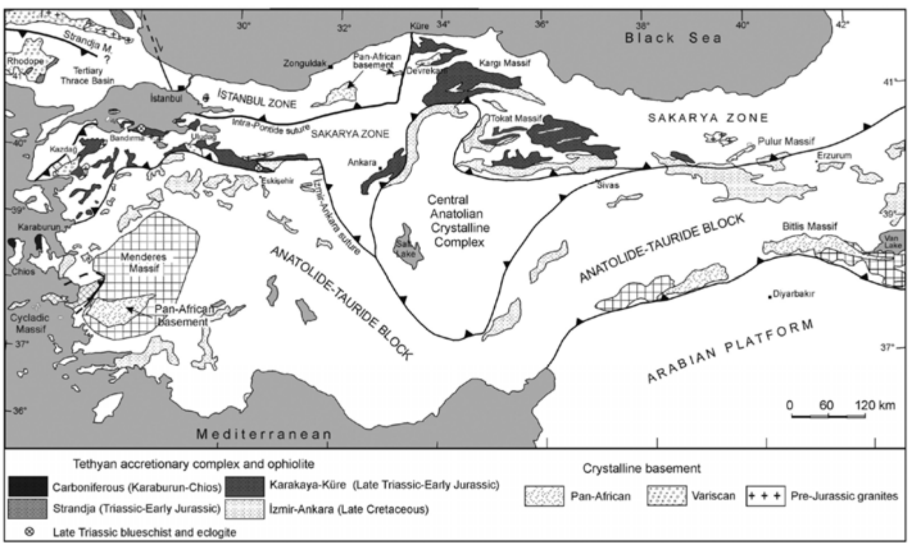

Figure 3.3 Distribution of different basement types and accretionary complexes in Turkey (Okay et al., 2006).

The Anatolide-Tauride terrane forms the bulk of southern Turkey and in contrast to the Pontic continental fragments shows a Palaeozoic stratigraphy similar to the Arabian platform, including common glacial deposits of Late Ordovician age (Monod et al., 2003). During the obduction, subduction and continental collision episodes in the Late Cretaceous and Palaeocene, the Anatolide-Tauride terrane was in the footwall position and therefore underwent much stronger Alpide deformation and regional metamorphism than that observed in the Pontic zones. During the mid Cretaceous a very large body of ophiolite and underlying tectonic slices of ophiolitic melange were emplaced over the Anatolide-Tauride terrane. The northern margin of the Anatolide-Tauride terrane underwent HP/LT (high pressure/low temperature) metamorphism at depths of over 70 km under this oceanic thrust sheet. Erosional remnants of this thrust sheet of ophiolite and ophiolitic melange occur throughout the Anatolide-Taurides. Although widely called a melange, it generally lacks all encompassing matrix, and represents a highly sheared Cretaceous accretionary complex. With the inception of continental collision in the Palaeocene, the Anatolide-Tauride terrane was internally sliced and formed a south to southeast vergent thrust pile. The contraction continued until the Early to Mid-Miocene in the western Turkey and is still continuing in eastern Anatolia. The lower parts of the thrust pile in the north were regionally metamorphosed, while the upper parts in the south form large cover nappes. The different types and ages of Alpide metamorphism led to the subdivision of the Anatolide-Taurides into zones with different metamorphic features, in a similar manner to the subdivision of the Western Alps into Helvetics and Penninic zones, albeit with a different polarity. There are three main regional metamorphic zones in the Anatolide-Taurides in western Anatolia: A Cretaceous blueschist belt, namely the Tavşanlı zone in the north, a lower grade high-pressure metamorphic belt, the Afyon zone in the center and the Barrovian-type Eocene metamorphic belt, the Menderes Massif in the south. To the northwest of Menderes Massif there is a belt of chaotically deformed uppermost Cretaceous-Palaeocene flysch with Triassic to Cretaceous limestone blocks. This Bornova flysch zone has an anomalous position between the İzmir-Ankara suture and the Menderes Massif. Taurides, which lie south of the metamorphic regions, consist of a stack of thrust sheets of Palaeozoic and Mesozoic sedimentary rocks (Gutnic et al., 1979; Özgül, 1984). The Central Anatolian Crystalline Complex north of the Taurides is a region of metamorphic and plutonic rocks with Cretaceous isotopic ages. The question of the affinity of the Central Anatolian Crystalline Complex, whether part of the Anatolide-Tauride terrane, or a single terrane on its own, is not yet solved.

The southeast Anatolia forms the northernmost extension of the Arabian platform. During the Mesozoic and Tertiary the Arabian platform was separated from the Anatolide-Taurides by the southern branch of the Neo-Tethys, which today is represented by the Assyrian suture (Şengör and Yılmaz, 1981). The Arabian platform has a Pan-African crystalline basement overlain by a Palaeozoic to Tertiary sedimentary sequence. In most areas of the southeast Anatolia only the Cretaceous and younger deposits crop out on the surface. The lower parts of the sequence are exposed in a number of anticlines (Rigo de Righi and Cortesini, 1964). These include the Amanos mountains west of Gaziantep, the

Derik and Hazro anticlines south and north of Diyarbakır respectively, and the Zap anticlines south of Hakkari. In the Zap anticline between Hakkari and Çukurca the Cambrian to Carboniferous sequence is dominated by clastic rocks, whereas the Permian to Eocene sequence is largely shallow marine carbonates.

During the Late Cretaceous and Tertiary ophiolites, ophiolitic melanges and thrust sheets were emplaced over the Arabian platform, which are denoted as the "Lower Nappe". This was part of an extensive emplacement of the oceanic lithosphere over the continent extending from Antakya on the Mediterranean coast to Oman in Arabia. The continental collision with the Anatolides-Taurides occurred later during the Miocene, when a second set of allochthonous units including the Bitlis Massif and the underlying melange units were emplaced over the Arabian platform.

The final amalgamation of the terranes in the Oligo-Miocene ushered a new tectonic era characterized by continental sedimentation, calcalkaline magmatism, extension and strike-slip faulting. Most of the present active structures, such as the North Anatolian Fault, and most of the present landscape are a result of this neotectonic phase.

3.2.2 Climate of Turkey

The coastal areas of Turkey bordering the Aegean sea and the Mediterranean sea have a temperate Mediterranean climate, with hot, dry summers and mild to cool, wet winters. The coastal areas of Turkey bordering the Black sea have a temperate Oceanic climate with warm, wet summers and cool to cold, wet winters. The Turkish Black sea coast receives the greatest amount of precipitation and is the only region of Turkey that receives high precipitation throughout the year (Figure 3.4). The eastern part of that coast averages 2,200 mm annually which is the highest precipitation in the country (Şensoy et al., 2013).

The coastal areas of Turkey bordering the Sea of Marmara (including Istanbul), which connects the Aegean sea and the Black sea, have a transitional climate between a temperate Mediterranean climate and a temperate Oceanic climate with warm to hot, moderately dry summers and cool to cold, wet winters. Snow does occur on the coastal areas of the Sea of Marmara and the Black sea almost every winter, but it usually lies no more than a few days. Snow on the other hand is rare in the coastal areas of the Aegean sea and very rare in the coastal areas of the Mediterranean sea.

Conditions can be much harsher in the more arid interior. Mountains close to the coast prevent maritime influences from extending inland, giving the central Anatolian plateau of the interior of Turkey a continental climate with sharply contrasting seasons.

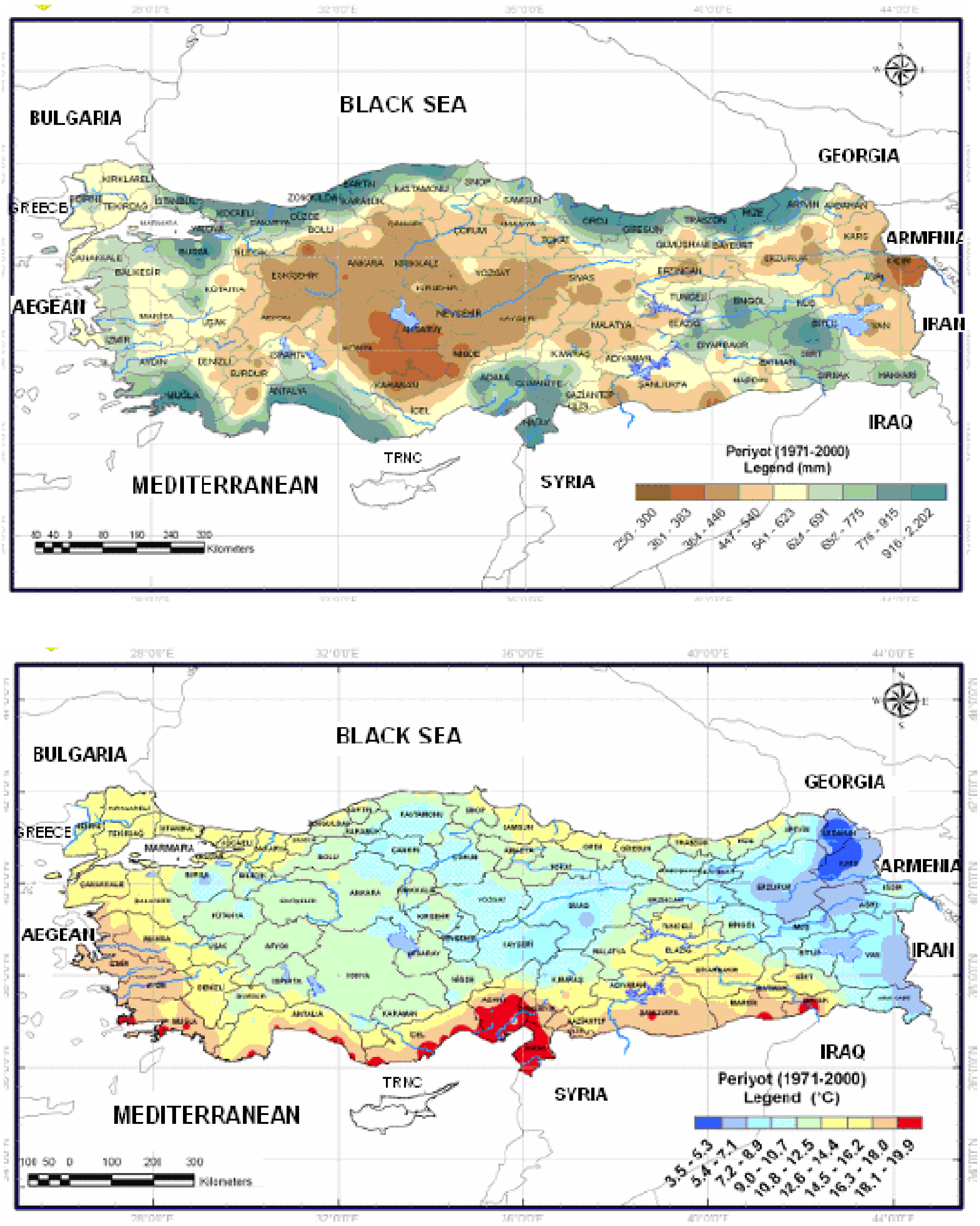

Figure 3.4 Mean annual precipitation (upper figure) and mean annual temperature (lower figure) map of Turkey (Şensoy et al., 2013).

Winters on the plateau are especially severe. Temperatures of -30 °C to -38 °C can occur in eastern Anatolia, and snow may lie on the ground for a period of at least 120 days during the year. In the west, winter temperatures average below 1 °C. Summers are hot and dry, with temperatures generally above 30 °C in the day. Annual average precipitation of Turkey for the 1971-2000 climatic period is about 640 mm and has a decreasing trend of about 29 mm/100 years (Şensoy et al., 2013). The driest regions are the Konya plain and the Malatya plain, where annual rainfall frequently is less than 300 mm. May is generally the wettest month, whereas July and August are the driest.

3.3 Methodology

The very large number of variable sets that drives and triggers landslides (i.e., geology, internal relief, rainfall, aspect, slope, land cover, seismicity, soil type, groundwater level, floods, and human activity) and the difficulties of processing and analyzing large volume of datasets required for a large country like Turkey, comprise limiting factors for the development of landslide susceptibility assessments after implementing some approaches like probabilistic methods. Geographical Information Systems (GIS) simplify the analysis of spatial variables through modeling the real world by representing it in the form of data layers, and use of spatial analysis algorithms based on raster data sets.

Raster overlay and map algebra techniques were used for the processing (geoprocessing) of geographical data. The maps (variables) were expressed as raster layers and were regarded as parts of some mathematical operations leading to derive new maps in this stage (Tomlin, 1990). ArcGIS Spatial Analyst and its Raster Calculator package were mainly used to develop nationwide landslide susceptibility assessment.

In order to develop the landslide susceptibility map of Turkey at the scale of 1:2,000,000, an index based calculation which considers six factors that controls the occurrence of landslides was applied. The selected resolution for index layers (i.e., slope, lithology, local relief, rainfall, land use, seismicity) was 500 m x 500 m. This resolution is deemed to be sufficient for representing and analyzing the landslide susceptibility of Turkey at a scale of 1:2,000,000. These index layers were selected by considering the availability of the data that covers entire Turkey.

These six layers could be expanded and index calculation method could also be enhanced if country wide datasets would become available. Unfortunately, some datasets like water level variations, soil map, intensity of precipitation, sinkholes, etc., are only locally available and these limited datasets are not suitable for studying country wide landslide susceptibility assessment. Therefore, this chapter has been studied by using only country wide available datasets.

Digital elevation model (DEM) of SRTM (NASA Shuttle Radar Topographic Mission) which is a joint international project developed by the National Imagery and Mapping Agency (NIMA) and the National Aeronautics and Space Administration (NASA) was used as the data source for the slope angle and local relief analyses. Producing elevation data of about 80% of the Earth's surface was the main purpose of this project.

Different versions of SRTM DEM were published by NASA. A version 3 (V3) set of SRTM DEM which has 500 m pixel resolution was selected for this study (Figure 3.5). The main problem for analyzing this DEM throughout Turkey was selecting appropriate projection. Turkey has four different UTM projections and those are not suitable for country wide landslide susceptibility assessment. Another alternative is Lambert Conformal Conic Projection (LCC) that possesses metric system. All layers used in this study were projected as LCC. During SRTM DEM projection transformation from geographic (lat-long) to LCC bilinear interpolation resampling method was selected.

Resampling methods that are generally used are nearest neighbor, bilinear interpolation and cubic convolution. Bilinear interpolation method yields the most appropriate results after testing these methods. The interpolation as a whole is not linear but rather quadratic, it uses the elevation values of four neighboring cells to calculate a new value by a linear interpolation on both x and y. The elevation errors (originally comes from SRTM DEM, like pits, etc.) at pixel level were improved by using void filling algorithm during DEM preprocessing.

Slope angle calculation was processed using the methodology proposed by Hickey (Dunn and Hickey, 1998; Hickey, 2000; Van Remortel et al., 2001) in an "AML" application running over ArcGIS. The slope angle is actually calculated as part of RUSLE equation for soil erosion estimation, in conjunction with other factors like slope length. This method is the maximum downhill slope angle which constrains the slope angle calculations to one cell length (or 1.4 cell lengths in the diagonal) in a downhill direction.

It is recognized that there exist large differences between slope angle calculation methodologies (Dunn and Hickey, 1998; Guth, 1995; Skidmore, 1989). A comparison of Hickey's and ArcGIS application slope angle methods over SRTM data confirmed that only the 45 % of the area has equal values. The slope angle map selected for this study was the maximum downhill slope angle, as it represents the worst situation and not an "averaging" value as ArcGIS uses (Figure 3.6).

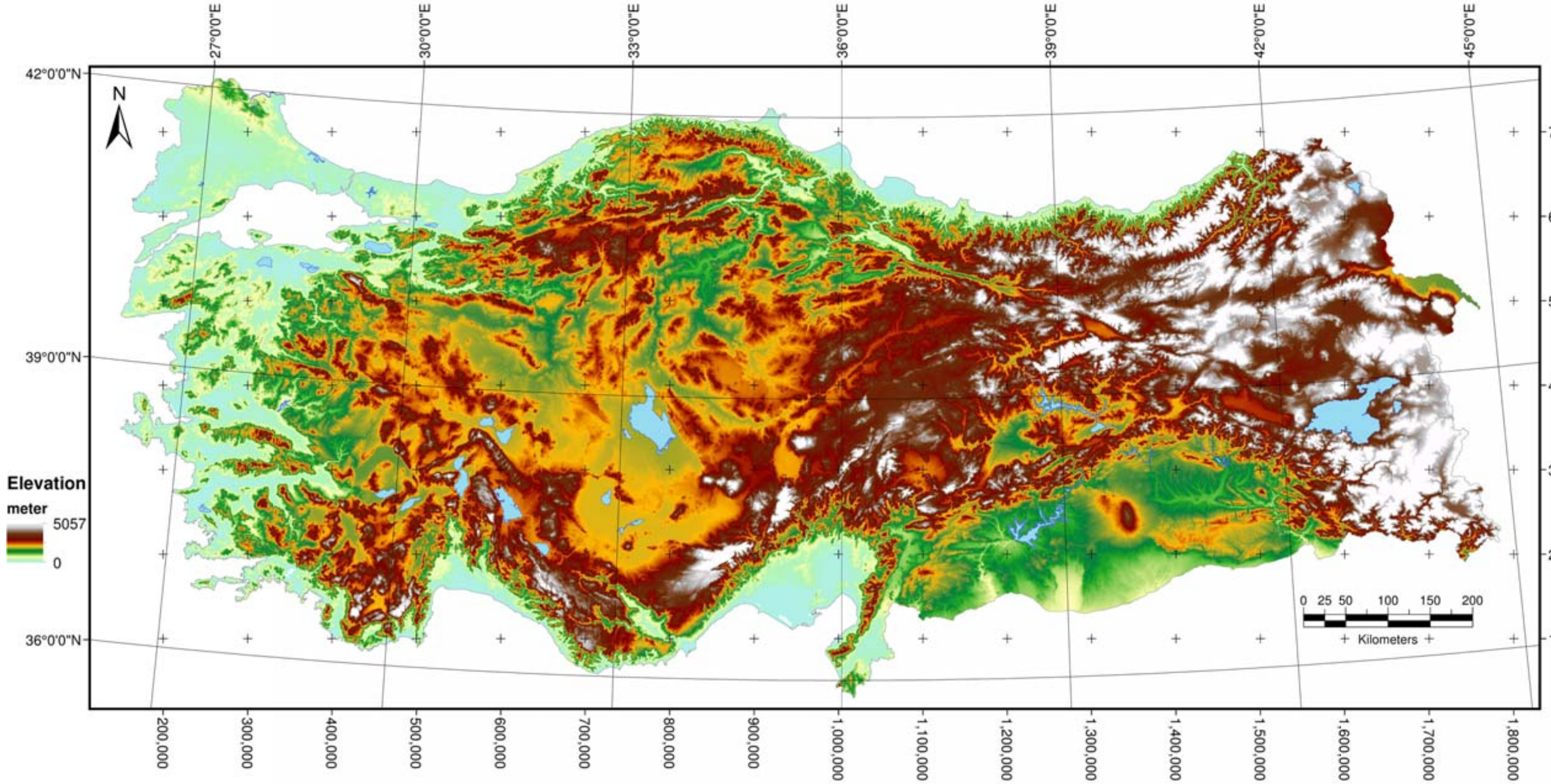

Figure 3.5 Elevation map of Turkey (based on SRTM DEM).

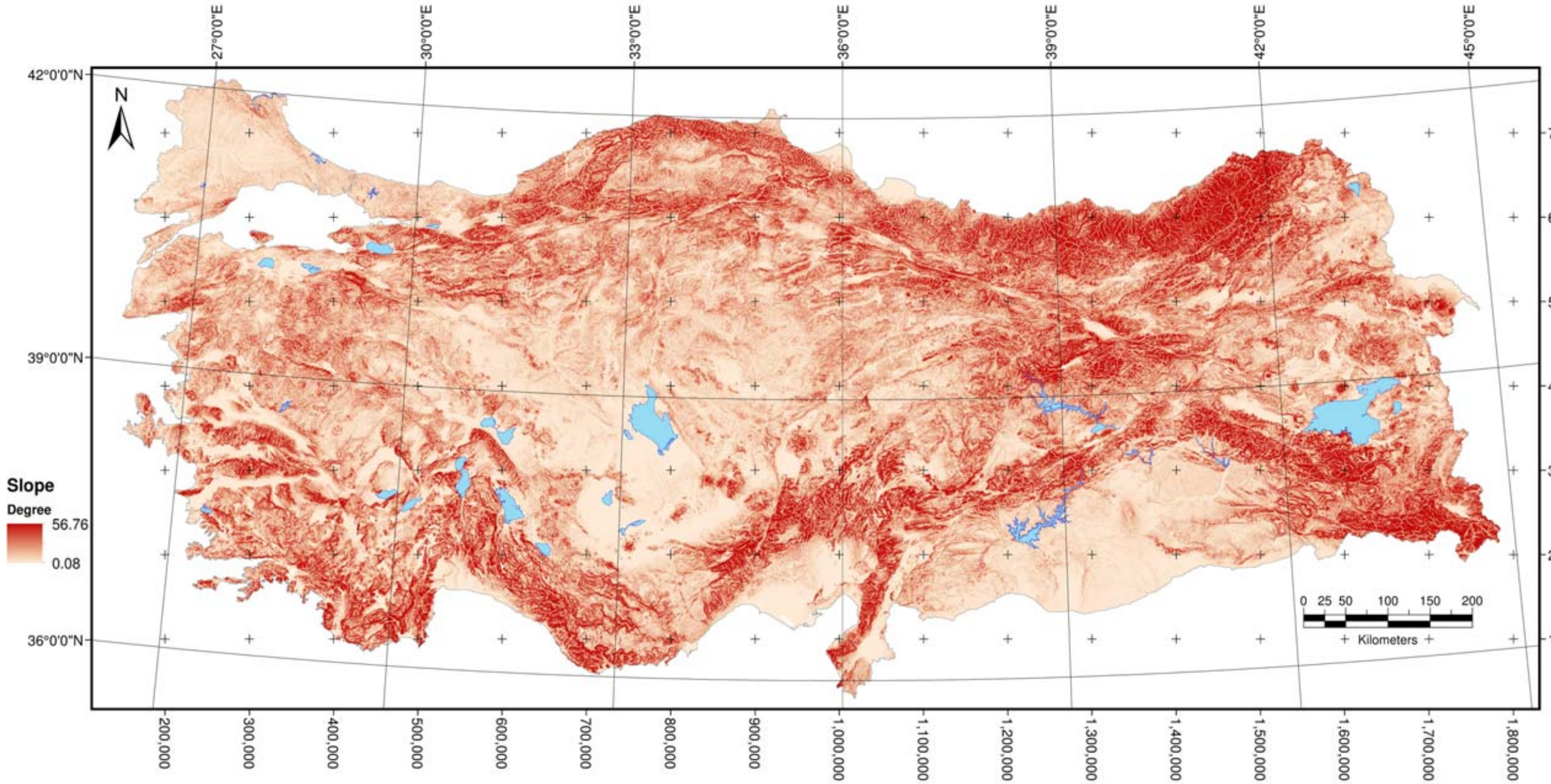

Figure 3.6 Slope angle map of Turkey (based on SRTM. DEM).

The local relief is defined as the height difference per square kilometer or per hectare. This variable, also called internal relief or amplitude of relief, represents an addition to slope gradient since it reflects the topography of a wider area, thus allowing the incorporation in the modeling process of the topographical factors in a more comprehensive way, especially related to the capacity of moving loosened rock masses. This factor has a special importance in the case of landslides induced by earthquakes (Paus, 2005). For generating the local relief layer, a square of 1 km in side was used to define the neighborhood area and focal range function Spatial Analyst was used. Due to the fact that SRTM DEM used in this study has a spatial resolution of 500 m, a window of 2 x 2 pixels (1 km^2) was selected for calculating the local relief. The local relief map calculated showed that this value changes between 0 to 869 m/km^2. The area with higher concentrations is located in north-east and south-east parts of Turkey (Figure 3.7).

Land use was processed from Corine Land Cover 2006 database (Coordination of Information on the Environment, source: http://www.eea.europa.eu/data-and-maps/data/clc-2006-vector-data-version-2), a harmonised and comparable snapshot of land cover for entire Europe in the year 2006, based on high resolution satellite data (Nunes de Lima, 2005). This European reference dataset was based on Landsat ETM+satellite images (30 m resolution for multispectral images and 12.5 m for panchromatic images) and contains 49 land cover classes grouped on 3 hierarchical levels. For the proposed landslide susceptibility model, a synthetic classification was designed, representing a combination between Corine levels 2 and 3 (Figure 3.8).

Lithology was obtained from 1:500,000 scale geological maps produced by the Turkish Mineral Research and Exploration General Directorate during the last decade. The attributes derived from this map are mainly the historical units and their lithological description. Large number of lithologic units were digitized and grouped into 24 synthetic lithologic classes (Figure 3.9).

The seismicity data layer was derived from the Earthquake Zoning Map of Turkey prepared by the Ministry of Public Works and Settlement considering the latest knowledge and approved by the Government of Turkey and published in 1996., which differentiates five classes, representing peak ground acceleration with 10% probability of exceedance in 50 years (Figure 3.10).

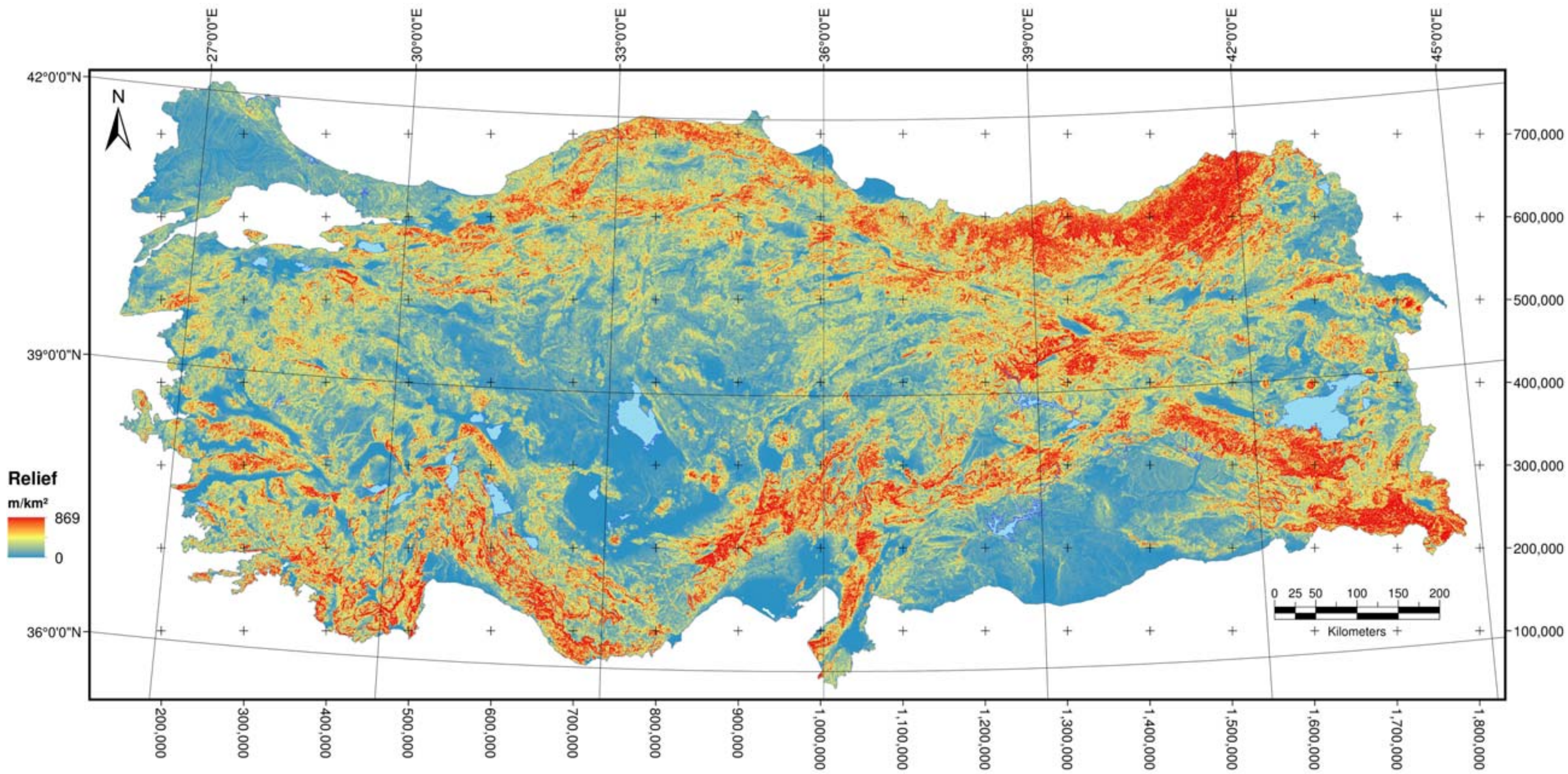

Figure 3.7 Local relief map of Turkey (based on SRTM DEM).

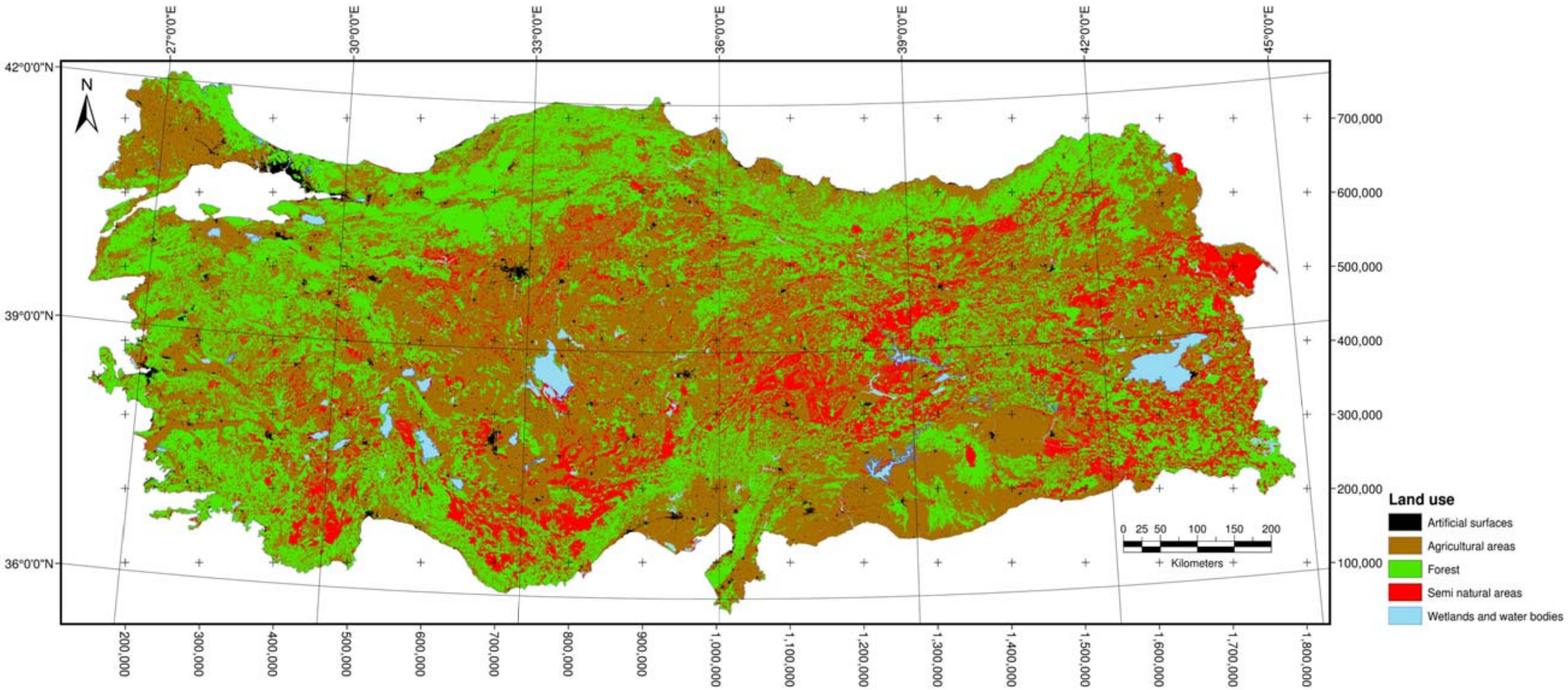

Figure 3.8 Land use map of Turkey (based on CLC2006).

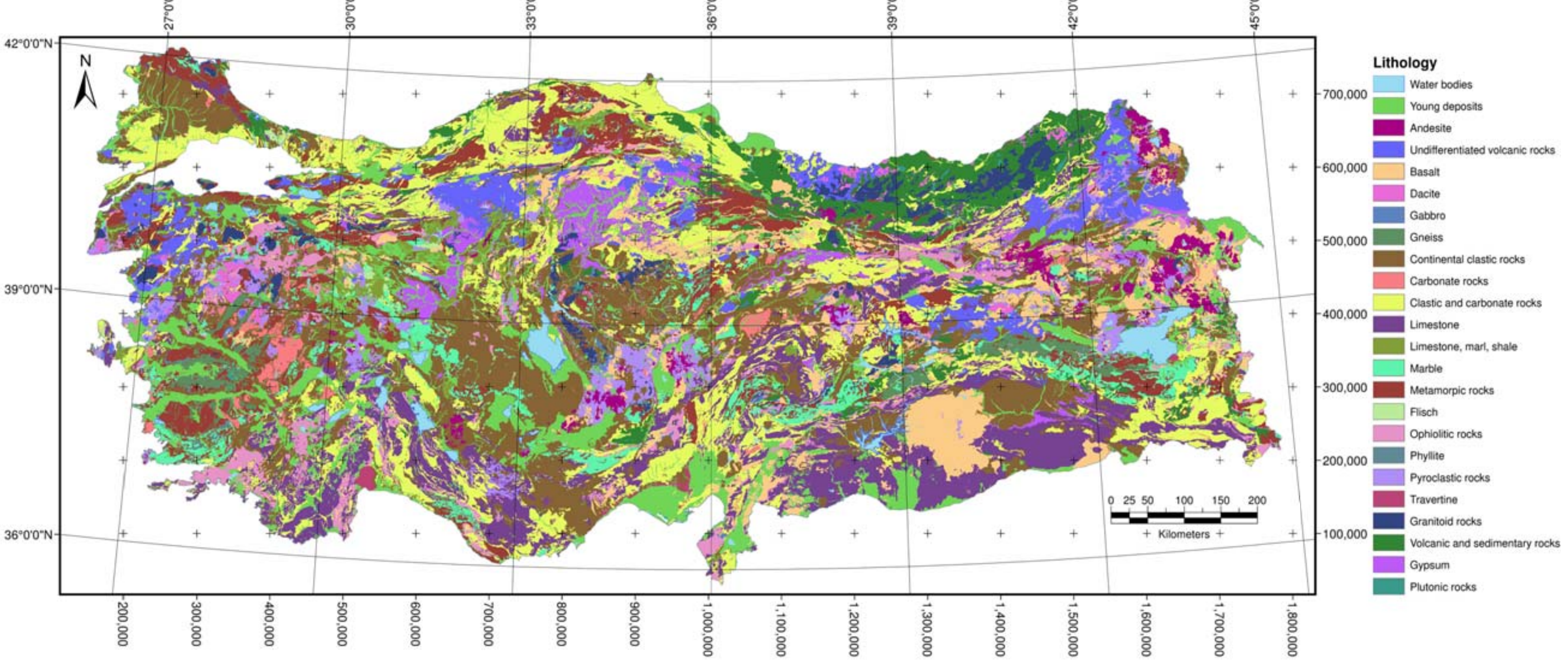

Figure 3.9 Lithology map of Turkey (based on 1:500,000 scaled geological maps).

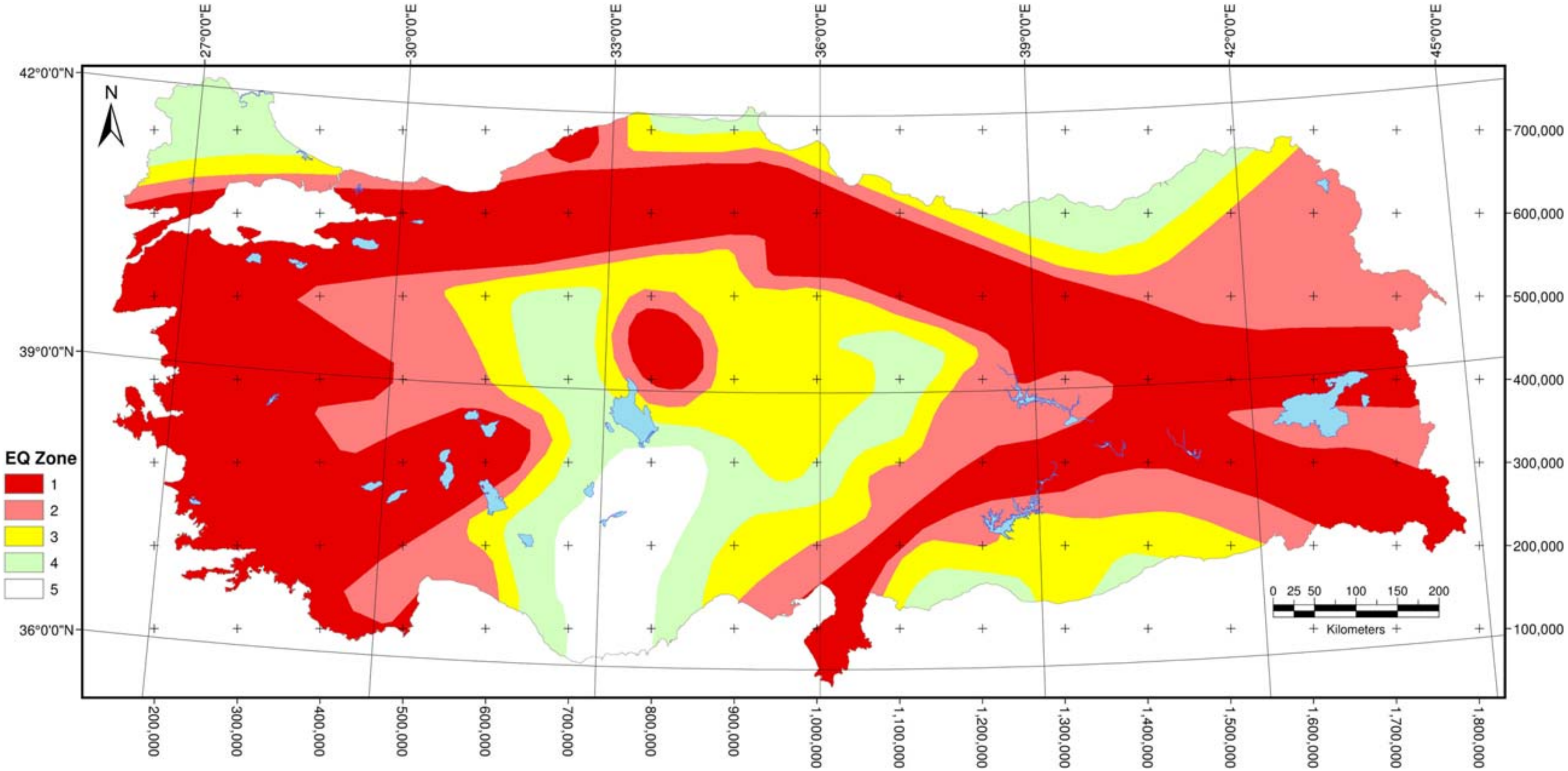

Figure 3.10 Earthquake zoning map of Turkey (source: Ministry of Public Works and Settlement, 1996).

The map of annual mean total rainfall was based on monthly total rainfall records from 823 meteorological stations that kept a record for a period of 65 years. Unfortunately, most of the stations did not operate for a period of 12 months in some years. For this reason, years that had 12 month recorded values were selected. For example, Station-A has been operated for 65 years, but 25 of those years had missing monthly records. For this station, the remainder 40 years were selected, every monthly total rainfall value were summed and then divided by 40. This procedure was carried out for each and every station where each station was represented with only one annual mean total rainfall value. These values were interpolated by using the Inverse Distance Weighting (IDW) method where eventually the mean total rainfall map for Turkey was developed (Figure 3.11).

The factors used in this study were classified into a number of classes and each of them was rated by means of expert judgment from 1 to 10, according to their relevance for landslide susceptibility. These classifications were aimed at estimating susceptibility to slope movements of the sliding type, excluding other types of slope movements like rock-falls. Slopes with gradients between 6° and 12° have the greatest susceptibility for both rotational and translational slide development. Slopes with higher gradients tend to be affected by other types of mass movements. The local relief of areas more prone to landslide activity typically have values ranging between 50 and 110 m/km^2. These ranges and rating values were summarized in Table 3.1.

Table 3.1 Distribution of slope angle and local relief classes in Turkey.

Slope				*Local relief*			
Class (°)	Rating	Area (km²)	%	Class (m/km²)	Rating	Area (km²)	%
< 2	0	154,615	19.732	0 - 50	6	63,939.00	8.16
2 - 4	4	171,282	21.859	50 - 70	8	159,298.00	20.33
4 - 6	6	111,864	14.276	70 - 90	10	127,799.00	16.31
6 - 8	9	86,814	11.079	90 - 110	9	102,255.00	13.05
8 - 10	10	66,346	8.467	110 - 130	7	79,688.00	10.17
10 - 12	8	51,098	6.521	130 - 150	4	62,215.00	7.94
12 - 14	5	38,537	4.918	150 - 180	3	66,838.00	8.53
14 - 20	7	73,239	9.350	180 - 270	5	92,539.00	11.81
20 - 30	3	27,365	3.492	270 - 600	2	28,913.00	3.69
30 - 45	2	2,377	0.303	> 600	1	78.00	0.01
> 45	1	25	0.003				

Concerning land use, the lowest landslide susceptibility ratings were assigned to wetlands and water bodies, while agricultural areas, and forest areas have the highest ratings. Seismicity and annual mean total rainfall rating values were determined according to the intensity of the phenomenon.

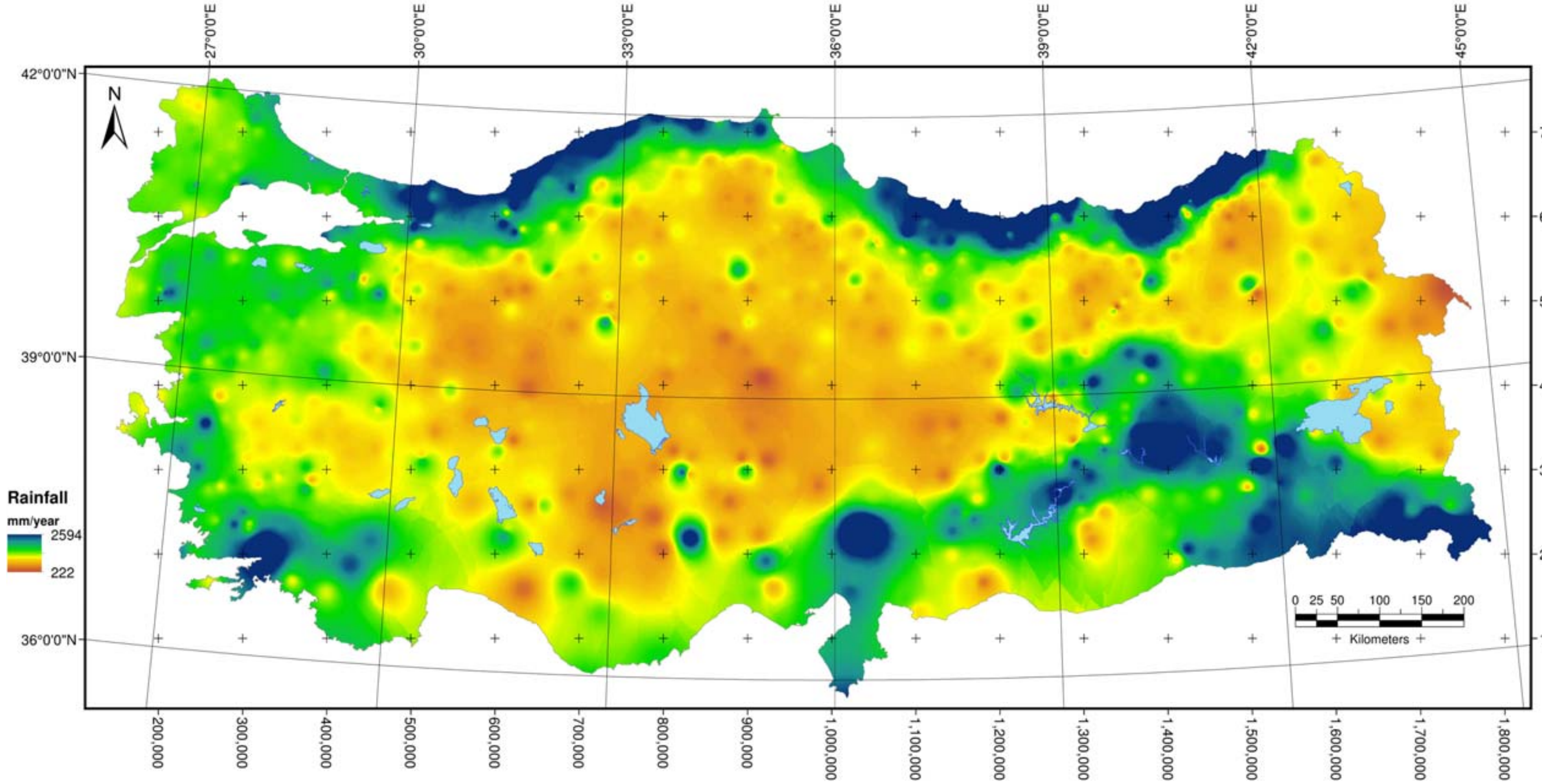

Figure 3.11 Mean total rainfall map of Turkey.

Since the geological factors have a crucial control on the spatial distribution of landslides, a description of the lithological classes differentiated in the present analysis is indicated below. The main criteria taken into consideration for rating the lithological classes were the genesis of the geological formations (metamorphic, igneous or sedimentary rocks) and their geotechnical properties. In the case of sedimentary terrains, the following elements were considered: genesis (clastic, organic, and chemical), texture (coarse, medium, fine and very fine), as well as the mechanical strength (Hoek et al., 1998; Marinos and Hoek, 2001) according to the Geological Strength Index (Hoek et al., 1998). The analysis of these natural factors led to differentiating 9 subclasses, the assigned rates to compute intrinsic susceptibility to landsliding is given in Table 3.2 below.

Table 3.2 Rating values assigned for different lithology classes in Turkey.

Lithology	***Rating***
Clastic and carbonate rocks	10
Continental clastic rocks	8
Limestone	6
Undifferentiated volcanic rocks, basalt	5
Volcanic and sedimentary rocks	4
Metamorpic rocks, ophiolitic rocks, gypsum	3
Young deposits, andesite, pyroclastic rocks	2
Dacite, gabbro, gneiss, carbonate rocks, limestone, marl, shale, marble, flysch, phyllite, travertine, granitoid rocks, plutonic rocks	1
Water bodies	0

After having obtained the values from 1 to 10 for each of the six factors by re-classifications, data layers have been converted to 500 m resolution grids, assumed to be sufficient for a final map on the scale of 1:2,000,000. Each factor was considered to have a different influence on landslide susceptibility, incorporated in the model as an assigned weight established through expert judgment. In this stage, 4 different weight groups were assigned to layer sets to capture the layer variability for landslide susceptibility in Turkey (Table 3.3).

All the preliminary maps were integrated into a final map of landslide susceptibility by weighting in each cell the value of the different causal factors. Equation (3.1) was used to calculate a Landslide Susceptibility Index (LSI):

$$LSI = \frac{L_1 * W_i + L_2 * W_i + L_3 * W_i + L_4 * W_i + L_5 * W_i + L_6 * W_i}{100} \qquad (3.1)$$

Table 3.3 Assigned weights in the landslide susceptibility assessments.

Layer	*Layer No*	W_1 *(%)*	W_2 *(%)*	W_3 *(%)*	W_4 *(%)*
Slope	L_1	25	35	30	25
Local relief	L_2	5	5	5	10
Land use	L_3	10	10	10	10
Rainfall	L_4	15	20	15	15
Earthquake	L_5	10	10	10	10
Lithology	L_6	35	20	30	30

The LSI was computed by using ArcGIS software and a series of functions of Spatial Analyst. Figure 3.12 presents a flowchart for obtaining the landslide susceptibility map of Turkey.

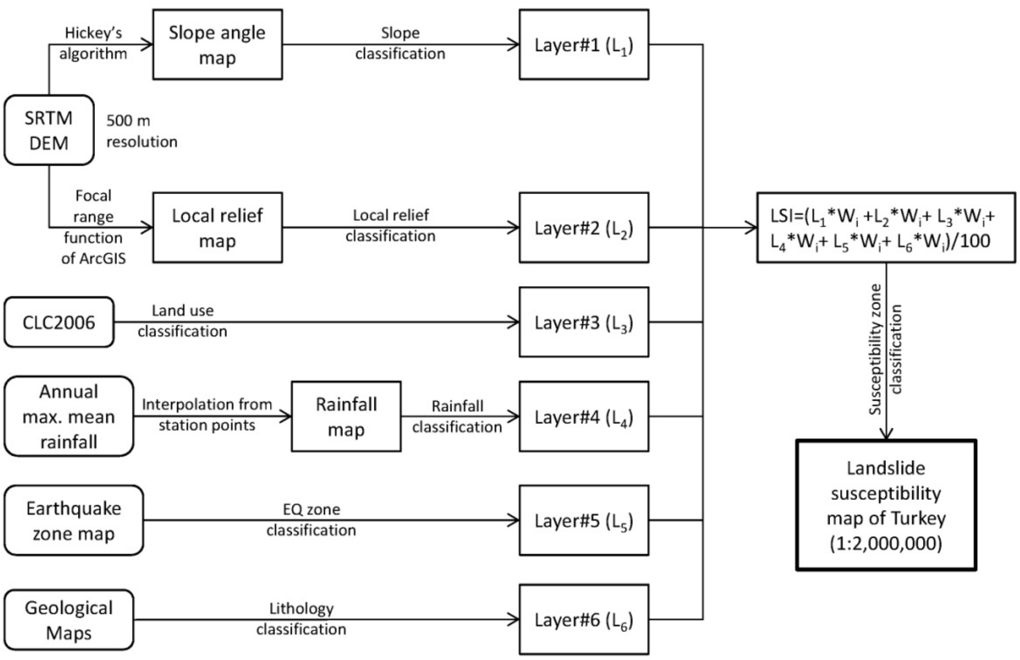

Figure 3.12 Flow chart of the study.

It was assumed that no landslides may occur in the areas with lower slope class (0–1°), and in water bodies, water courses and wetlands surfaces. For those areas, the LSI value should be 0, regardless of the values of local relief, earthquake or precipitation factors. Therefore, a restriction has been established for slope, land use and lithology layers, assigning a value of 0 for those classes. Whenever the value of the cell from the computed grid was equal to 0, at least one of the three restrictions was fulfilled. By applying a “Query Map” function, which yields values greater than 0, another grid was obtained having a “0” value for those cells that did not meet the query condition but the restriction set, so that no landslides were likely to occur; and a value “1” for all the other values, representing landslide-prone cells. The initial LSI grid was multiplied by this grid mask (0, 1) in order to obtain the final LSI map.

Four different weight groups given in Table 3.3 were applied to the layers and the performance of resulting maps were compared with each other in Chapter 5. According to the preliminary findings the 3rd weight group (W_3) provides better results for the nationwide landslide susceptibility assessment of Turkey. Unfortunately, the landslide susceptibility map of the proposed study represents fair results considering the very large extent of the study area. The proposed study has not led to a reasonably well predictive capability, considering the size of the area, its complexity and the limited number of parameters. Landslide susceptibility of Turkey would be studied on the next chapter using larger scale (90 m pixel resolution) data sets by dividing Turkey into 26 different zones. These zones would be main watersheds that were defined by highpoints and ridgelines that descend into lower elevations and main stream valleys. After analyzing these 26 main watersheds one by one, entire landslide susceptibility map of Turkey would be obtained by merging these 26 zones.

CHAPTER 4

REGIONAL LEVEL LANDSLIDE SUSCEPTIBILITY ASSESSMENT

4.1 Introduction

Landslides cause a significant amount of damage in the mountainous environments of Turkey that cover more than half of the country. Most landslide studies in Turkey have concentrated on landslide inventory mapping, landslide descriptions and qualitative hazard assessment and do not cover the country as a whole. Most of these investigations were carried out in the northern part of the country. The aim of this dissertation is to assess landslide susceptibility in Turkey using qualitative methods for country-wide analysis with publicly available datasets.

As a component of the study, the necessity of this chapter came up after outputs of the previous chapter. For large-scale landslide susceptibility assessment, a range of methodologies have been published (Bonnard et al., 2004; Lee and Jones, 2004; Eberhardt et al., 2005; Glade et al., 2005), but only a limited amount of research has been done on landslide susceptibility assessment for large areas such as countries in their entirety (Guzzetti, 2000; Yoshimatsu and Abe, 2006). At such small scales, the aim is generally to produce a landslide susceptibility index, locating high susceptible areas for more detailed studies. Susceptibility indices have been applied in small-scale studies either for specific countries (Davidson, 1997; Carreno et al., 2007) or at a global level (Evans and Roberts, 2006; Nadim et al., 2006a; Nadim et al., 2006b). The results are intended to support national decision makers in prioritizing funding for risk assessments at local, municipal and provincial levels. With the outcomes of the study in Turkey, the Civil Defense organization will be able to alert the local authorities about the risk levels, therefore allowing for early warning and evacuation of landslide-prone areas.

The landslide susceptibility map of Turkey generated in the previous chapter constitutes a preliminary step considering a very large extent of the study area. In this chapter, Turkey was divided into the main 26 watersheds with increased spatial resolution (90 m) in a larger scale (1:500,000). Every watershed was modeled by 8 and 10 causative factors on its own, through not using a simple mathematical equation for Turkey in its entirety. Finally, these 26 zones were merged and a more detailed landslide susceptibility map of Turkey was obtained.

4.2 Methodology

Even though there has been an increasing international interest in landslide susceptibility assessments in the last two decades, no standard procedure for the production of landslide susceptibility maps has been developed (Ercanoğlu and Gökçeoğlu, 2004). The process of creating landslide susceptibility maps can follow several qualitative or quantitative approaches (Soeters and van Westen, 1996). The qualitative or direct mapping approach includes the landslide inventory and heuristic analyses which are generally based on personal experience or knowledge and can be considered as subjective. Some qualitative approaches, however, rank and weight the observed occurrences and may evolve to be semi-quantitative in nature. The quantitative methods such as statistical methods and deterministic approaches can be considered as more objective due to the data-dependent character of the methodologies rather than experience driven knowledge. According to Soeter and Van Westen (1996), conventional well developed landslide susceptibility methods can be classified into four broad categories: (a) Landslide inventories; (b) Heuristic approaches; (c) Statistical methods; and, (d) Deterministic approaches.

(a) Landslide inventory is the most elementary approach giving the spatial distribution of the mass movement deposits. It involves the compilation of a database of pre-existing landslides whereby the susceptibility map is derived directly from the landslide inventory map.

(b) Heuristic analysis consists of two main types:

(i) Geomorphic analysis involves the determination of the hazard by drawing on individual experience, field observations and reasoning by analogy with similar sites elsewhere.

(ii) Qualitative map combination entails the assigning of weighting values to a series of thematic maps based on the skills and experience of the scientist which are summed at various locations and hence the area is classified into a hazard class.

(c) Statistical approach or indirect mapping includes:

(i) Bivariate statistical analysis which combines each factor map with the landslide distribution map and weighting values. Each parameter class is based on cross tabulation data defining their spatial correlation.

(ii) Multivariate statistical analysis is based on the presence or absence of landslides within a defined land unit (e.g., catchment areas, geomorphic units, or other terrain units). The analysis entails the sampling of all relevant factors either on a large–grid basis or in morphometric units. For each sampling unit, the presence or absence of landslides is also determined. The resulting matrix is then analyzed using multiple regression or discriminant analysis.

(d) Deterministic approaches require detailed geotechnical and hydrological data and are expressed in terms of the factor of safety. This method is only applicable when the geomorphic and geological conditions are fairly homogeneous over the entire study area and is used in the analysis of large scale areas.

Not all methods of landslide susceptibility are equally applicable at each working scale (Soeters and van Western, 1996). An overview of the various methodologies and recommendations of their use at three most relevant scales are provided in Table 4.1.

Table 4.1 Overview of methodologies and recommendations of their use at three most relevant scales (Soeter and Van Westen, 1996).

Scale of use recommended					
Type of analysis	**Technique**	**Characteristics**	**Regional**	**Medium**	**Large**
Inventory	Landslide distribution analysis	Analyze distribution and classification of landslides	+	+	+
	Landslide activity analysis	Analyze temporal changes in landslide pattern	-	+	+
	Landslide density analysis	Calculate landslide density in terrain units	+	-	-
Heuristic	Geomorphological analysis	Use in-field expert opinion in zonation	+	+	+
	Qualitative map combination	Use expert-based weight values of parameter maps	+	+	-
Statistical	Bivariate statistical analysis	Calculate importance of contributing factor combination	-	+	-
	Mutivariate statistical analysis	Calculate prediction formula from data matrix	-	+	-
Deterministic	Safety of factor analysis	Apply hydrological and slope stability models	-	-	+

When considering the objectives for the assessment of a national landslide susceptibility map, in combination with a large study area and limitations in available data, a semi-quantitative approach was selected. The main difference between qualitative and semi-quantitative approaches is the assignment of weights to given certain criteria. The semi-quantitative estimation for landslide susceptibility assessment is considered useful when the level of susceptibility does not justify the time.

For implementing the semi-quantitative model, the Spatial Analyst extension of ArcGIS was used. The input is a set of maps that are the spatial representation of the criteria, which are grouped, standardized and weighted in a "criteria tree". The output is one or more "composite index map(s)", which indicates the realization of the model implemented. The theoretical background for the multi-criteria evaluation is based on the Analytical Hierarchical Process (AHP) developed by Saaty (1980). The AHP has been extensively applied in decision-making problems (Saaty and Vargas, 2001), and only recently, some research has been carried out to apply AHP to landslide susceptibility assessment.

4.2.1 Analytical Hierarchy Process for landslide susceptibility mapping

In the early 1970s, Dr Thomas Saaty formulated the analytical hierarchy process (AHP) as a generalized quantitative method for dealing with multi-criteria decision making (Saaty 1980, 1986, 1995). It is a decision-aiding tool for dealing with complex, unstructured, and multi-criteria decisions. It provides a flexible and easily understandable way of analyzing complicated problems, and allows shaping ideas and solving problems by making approximate assumptions. Therefore, it has a very high ability to structure complexity and exercise judgment.

The AHP overcomes the problems with arbitrary weights and scores approaches, by its ability to enable decision-makers to derive ratio scale priorities or weights as opposed to arbitrarily assign them (Yalçın, 2007). Moreover, this is done by structuring complexity as a hierarchy and by deriving ratio scale measures through pairwise relative comparisons. The pairwise comparison typically incorporates redundancy, which results in a reduction of measurement error as well as producing a measure of consistency of the comparison judgments. Thus, it allows incorporating both objective and subjective considerations in the decision process.

AHP is based on three principles: decomposition, comparative judgment and synthesis of priorities (Malczewski, 1999). Concepts and techniques in AHP include: hierarchical structuring of complexity, pairwise comparisons, redundant judgments, an eigenvector method for deriving weights, and consistency considerations.

AHP application for landslide susceptibility can be found in many applications (Chung and Leclerc, 1994; Barredo et al., 2000; Ayalew et al., 2004; Komac, 2006; Akgün and Bulut, 2007; Yalçın, 2007). The landslide susceptibility index based on the AHP approach is also calculated on the basis of the weighted linear combination (Equation 4.1) given by Voogd (1983), but, the weights W_j and rating values w_{ij} values are quantitatively determined by pairwise comparisons and eigenvector calculations (Saaty, 1977). The W_j values are obtained as the eigenvalues of the matrix that portrays the relationship between different factors, and the w_{ij} values are the eigenvalues of the matrix that portrays the relationship between all classes in a factor.

$$LSI = \sum_{j=1}^{n} W_j w_{ij} \tag{4.1}$$

where:

LSI: Landslide susceptibility index
W_j: weight value of parameter j
w_{ij}: rating value or weight value of class i in parameter j
n: number of parameters.

The AHP method is used in this study to systematically assign preferences based on Saaty's proposal (Saaty, 2000). When comparing two attributes (layer classes or parameters in a layer), the following numerical relational scale is used (Table 4.2).

Table 4.2 Scale of preference between two parameters in AHP (Saaty, 2000).

Scale	***Degree of preference***	***Explanation***
1	Equally	Two activities contribute equally to the objective
3	Moderately	Experience and judgment slightly to moderately favor one activity over another
5	Strongly	Experience and judgment strongly or essentially favor one activity over another
7	Very strongly	An activity is strongly favored over another and its dominance is showed in practice
9	Extremely	The evidence of favoring one activity over another is of the highest degree possible of an affirmation
2, 4, 6 ,8	Intermediate values	Used to represent compromises between the references in weights 1, 3, 5, 7 and 9
Reciprocals	Opposites	Used for inverse comparison

Another appealing feature of the AHP is the ability to evaluate pairwise rating inconsistency. The eigenvalues enable to quantify a consistency measure which is an indicator of the inconsistencies or intransitivities in a set of pairwise ratings. Saaty (2000) proved that for a consistent reciprocal matrix, the largest eigenvalue λ_{Max} is equal to the number of comparisons n. A measure of consistency, called consistency index CI, is defined as follows:

$$CI = \frac{\lambda_{Max} - n}{n - 1} \qquad (4.2)$$

Saaty (2000) randomly generated reciprocal matrixes using scales 1/9, 1/8,…, 1, …, 8, 9 to evaluate a so called random consistency index *RI*. The average random consistency index of matrices is shown in Table 4.3.

Table 4.3 Random Consistency Index (RI).

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.53	1.56	1.57	1.59

Saaty (1977) introduced a consistency ratio *CR*, which is a comparison between the consistency index and the random consistency index as expressed by Equation 4.3.

$$CR = \frac{CI}{RI} \tag{4.3}$$

If the value of the consistency ratio is smaller or equal to 10%, the inconsistency is acceptable, but if the consistency ratio is greater than 10%, the subjective judgment needs to be revised (Saaty, 1977).

The landslide susceptibility index is calculated by equation 4.1, based on weights and rating values obtained from the Eigen values of the AHP matrixes that express the relationship between different factors, and of the matrixes that express the relationship between classes in a factor. Finally, the map of landslide susceptibility zonation is obtained by separating the scale of LSI values into different landslide susceptibility classes.

4.2.2 Selection of landslide causative factors and watershed boundaries

Many studies that involve natural (e.g., lithology, lineament, etc.) and artificial (e.g., roads and other engineering structures, etc.), or causal (e.g., slope, lithology, etc.) and triggering (e.g., rain, seismicity, etc.) factors together have been previously performed by researchers for landslide susceptibility assessment studies. From the different kind of factors, causative factors are the basis of a landslide susceptibility assessment; as many as 40 factors have been used in the building of discriminant landslide susceptibility analysis models (Guzzetti et al., 1999). However, to make the landslide susceptibility assessment study more compact and effective, availability, effectiveness, and independence of each factor must be considered. In this chapter, because of the reason that some data of the factors are very hard to get and some factors are not very important for analyzing the susceptibility, ten factors were selected to analyze the landslide susceptibility. The slope, internal relief, lithology, land cover, aspect, topographic wetness index (TWI), classified landforms and classified curvature were selected as casual factors and rainfall intensity and earthquake were selected as triggering factors.

The main reason for selecting the factors mentioned above is their publicly availability and all of them are largely used in landslide susceptibility research studies as causative factors. The preferred resolution in this chapter for causative factors (layers) was 90 m x 90 m that would be sufficient enough for representing and analyzing the landslide susceptibility of Turkey at a scale of 1:500,000. A version 4.1 (V4.1) set of SRTM DEM published by NASA and having 90 m pixel resolution was selected for this study. All layers used in this chapter were projected as Lambert Conformal Conic that covers the entire Turkey, as preferred in the previous chapter. Selection and quality of digital elevation model (DEM) is one the most important procedure for landslide susceptibility assessments. Most of factors (slope, relief, aspect, curvature, etc.) used in these studies are mainly derived from DEM. Slope, internal relief, aspect, topographic wetness index, classified landforms and classified curvature factors are produced using DEM in this study. More than half of the factors used in this chapter derived from DEM, this shows that why DEM is very important for landslide susceptibility assessments.

Slope angle calculation was processed using the methodology proposed by Hickey (Dunn and Hickey, 1998; Hickey, 2000; Van Remortel et al., 2001) in an “AML” application running over ArcGIS as mentioned in the previous chapter.

The internal relief or local relief that is the height difference per square kilometer was calculated using Spatial Analyst extension of ArcGIS. SRTM DEM used in this study has a spatial resolution of 90 m, a window of 11 x 11 pixels (0.9801 km^2) was selected for calculating the internal relief. Other DEM derivatives (aspect, TWI, landforms and curvature) were calculated in SAGA GIS environment.

Aspect or slope aspect identifies the downslope direction of the maximum rate of change in value from each cell to its neighbors. Aspect fits a plane to elevation values of a 3 x 3 cell neighborhood around the processing or center cell. The direction the plane faces is the aspect for the processing cell. Aspect can be thought of as the slope direction. The values of the output raster will be the compass direction of the aspect. The resulting aspect layer resolution is the same with DEM which is 90 m.

Topography is the major actor that controls the spatial variation of hydrological conditions and slope stabilities. It affects the spatial distribution of soil moisture, and groundwater flow often follows surface topography (Burt and Butcher, 1986; Seibert et al., 1997; Rodhe and Seibert, 1999; Zinko et al., 2005). Topographic indices have therefore been used to describe spatial soil moisture patterns (Burt and Butcher, 1986; Moore et al., 1991). One such index is the topographic wetness index developed by Beven and Kirkby (1979) within the runoff model. It is defined as;

$$TWI = \ln\left(\frac{a}{\tan\beta}\right) \tag{4.4}$$

where a is the local upslope area draining through a certain point per unit contour length and $tan\beta$ is the local slope. The TWI has been used to study spatial scale effects on hydrological processes. Water infiltration to slope material causes the pore water pressures and decreases the soil strength. In this study TWI was considered as another causative factor having the same resolution with DEM.

The Topographic Position Index (TPI) compares the elevation of each cell in a DEM to the mean elevation of a neighborhood around that cell. Positive TPI values represent locations that are higher than the average of their surroundings, as defined by the neighborhood (ridges). Negative TPI values represent locations that are lower than their surroundings (valleys). TPI values near zero are either flat areas (where the slope is near zero) or areas of constant slope (where the slope of the point is significantly greater than zero). Combining TPI at a small allows a variety of nested landforms to be distinguished. This procedure was implemented in SAGA GIS environment through TPI based landform classification analysis. The result of this analysis was used as causative factor with 90 m resolution. Classification variables were given in Table 4.4.

Table 4.4 Assigned pixel values for TPI based classified landforms.

Pixel Value	TPI Based Classfied Landforms
1	Canyons, deeply incised streams
2	Midslope drainages, shallow valleys
3	Upland drainages, headwaters
4	U-shaped valleys
5	Plains
6	Open slopes
7	Upper slopes, mesas
8	Local ridges/hills in valleys
9	Midslope ridges, small hills in plains
10	Mountain tops, high ridges

Profile curvature is the curvature in the vertical plane parallel to the slope direction. It measures the rate of change of slope and therefore influences the flow velocity of water draining the surface and thus erosion or landslide and the resulting downslope movement of soil. Plan curvature (or tangential curvature) is the curvature of a contour line formed by intersecting a horizontal plane with the surface. Plan curvature influences the convergence or divergence of water during downhill flow. Curvature is the combination of both plan and profile curvature that is a complex terrain derivative to compute. Curvature factor analysis performed in SAGA GIS and classified according to Dikau (1988). Classification criteria were given in Figure 4.1. The resulting layer has a resolution of 90 m and used as causative factor.

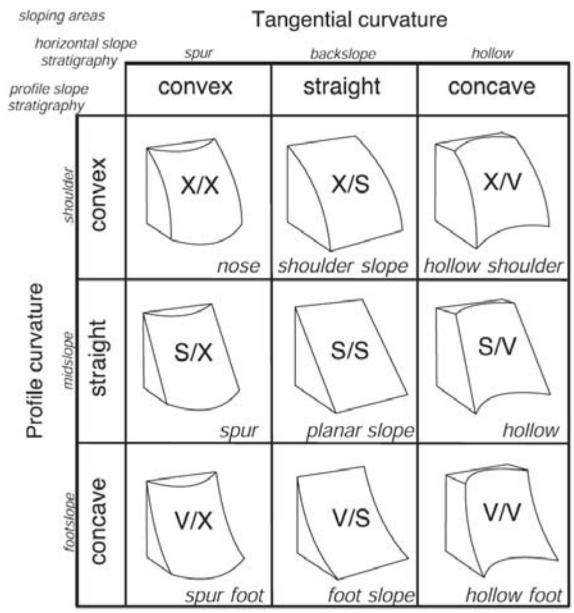

Figure 4.1 Classified curvature forms based on Dikau (1998) (source: Schmidt and Hewitt, 2004).

Land use was processed using Corine Land Cover 2006 database (Coordination of Information on the Environment, source: http://www.eea.europa.eu/data-and-maps/data/clc-2006-vector-data-version-2). This European reference dataset was based on Landsat ETM+ satellite images (30 m resolution for multispectral images and 12.5 m for panchromatic images) and contains 49 land cover classes grouped on 3 hierarchical levels. For the proposed study, a synthetic classification was designed that was previously implemented in Chapter-3 and given in Table 4.5. The resulting layer resolution is the same with DEM which is 90 m.

Table 4.5 Reclassified land covers based on CORINE Level-3 classification.

CORINE Level-3 Classification Name	Reclassed Name
Continuous urban fabric Discontinuous urban fabric Industrial or commercial units Road and rail networks and associated land Port areas Airports Mineral extraction sites Dump sites Construction sites Green urban areas Sport and leisure facilities	Artificial surfaces
Non-irrigated arable land Permanently irrigated land Rice fields Vineyards Fruit trees and berry plantations Olive groves Pastures Complex cultivation patterns Land principally occupied by agriculture, with significant areas of natural vegetation	Agricultural areas
Broad-leaved forest Coniferous forest Mixed forest Natural grasslands Sclerophyllous vegetation Transitional woodland-shrub	Forest
Beaches, dunes, sands Bare rocks Sparsely vegetated areas Burnt areas Glaciers and perpetual snow	Semi natural areas
Inland marshes Peat bogs Salt marshes Salines Water courses Water bodies Coastal lagoons Estuaries Sea and ocean	Wetlands and water bodies

Lithology layer was obtained from 1:500,000 scaled geological maps by digitizing process. Database was created for digitized lithology boundary polygons on ArcGIS environment considering their geological units and lithological descriptions. This digital map was rasterized in 90 m pixel resolution and lithological units were grouped into 24 synthetic lithologic classes (Table 4.6). Detailed table for this classification was given in Appendix C.

Table 4.6 Assigned pixel values based on reclassified lithologies.

Lithology Class Name	*No*
Water bodies	0
Young deposits	1
Andesite	2
Undifferentiated volcanic rocks	3
Basalt	4
Dacite	5
Gabbro	6
Gneiss	7
Continental clastic rocks	8
Carbonate rocks	9
Clastic and carbonate rocks	10
Limestone	11
Limestone, marl, shale	12
Marble	13
Metamorpic rocks	14
Flisch	15
Ophiolitic rocks	16
Phyllite	17
Pyroclastic rocks	18
Travertine	19
Granitoid	20
Volcanic and sedimentary rocks	21
Gypsum	22
Plutonic rocks	23

Earthquake layer was derived from the Earthquake Zoning Map of Turkey (1996) which differentiates five classes, representing peak ground acceleration with 10% probability of exceedance in 50 years. These five classes were digitized in ArcGIS environment and rasterized with the same resolution with DEM.

The map of annual mean total rainfall was prepared in previous chapter. Unfortunately the resolution of this layer was 500 m that is rough for local based landslide susceptibility assessment. In order to overcome this problem station values were interpolated again with higher resolution (90 m) by using the Inverse Distance Weighting (IDW) method where eventually the mean total rainfall map was developed.

The process of creating the susceptibility map involves several qualitative or quantitative approaches. Early attempts defined susceptibility classes by qualitative overlaying of geological and morphological slope-attributes to landslide inventories (Nielsen et al., 1979). More sophisticated assessments involve AHP, bivariate, multivariate, logistic regression, fuzzy logic, artificial neural network, etc. (Carrara, 1983; van Westen, 1997; Dai et al., 2001; Lee and Min, 2001; Ercanoğlu and Gökçeoğlu, 2004; Lee et al., 2004; Komac, 2006). In this chapter, for the reason mentioned in the introduction part, AHP was used for the landslide susceptibility assessment.

A watershed is a topographic region from which a stream receives runoff, through flow, and groundwater flow that is divided from each other by topographic barriers. It is really hard work to handle and analyze data layers of Turkey with higher spatial resolution for landslide susceptibility assessment in one extent. Problems that have been faced on this topic were discussed in the previous chapter. In order to obtain a landslide susceptibility map of Turkey with higher resolution one must decrease the file size of the datasets. The only way to perform this is dividing entire Turkey into meaningful zones. The "zone" was selected as the watershed boundary. A watershed is the topographic region from which a stream receives runoff, throughflow, and groundwater flow that is divided from each other by topographic barriers.

In this chapter, Turkey was divided into 26 main watersheds with increased spatial resolution (90 m) in a larger scale (1:500,000). Every watershed was modeled on its own, through not using a simple mathematical equation for entire Turkey. Analytical hierarchy process was performed with 10 factors for the each watershed. After these analyses, two least effective factors which were aspect and rainfall intensity were separated from these 10 factors and each watershed was modeled again with only 8 factors. Briefly, every watershed was modeled with AHP by using two different sets of factors, finally results, comparative graphs and ROC curves were given for each watershed. Finally, these 26 zones were merged and a more detailed landslide susceptibility map of Turkey was obtained. Boundaries of these main watersheds are given in Figure 4.2 and historical landslide footprint areas were also given in Table 4.7.

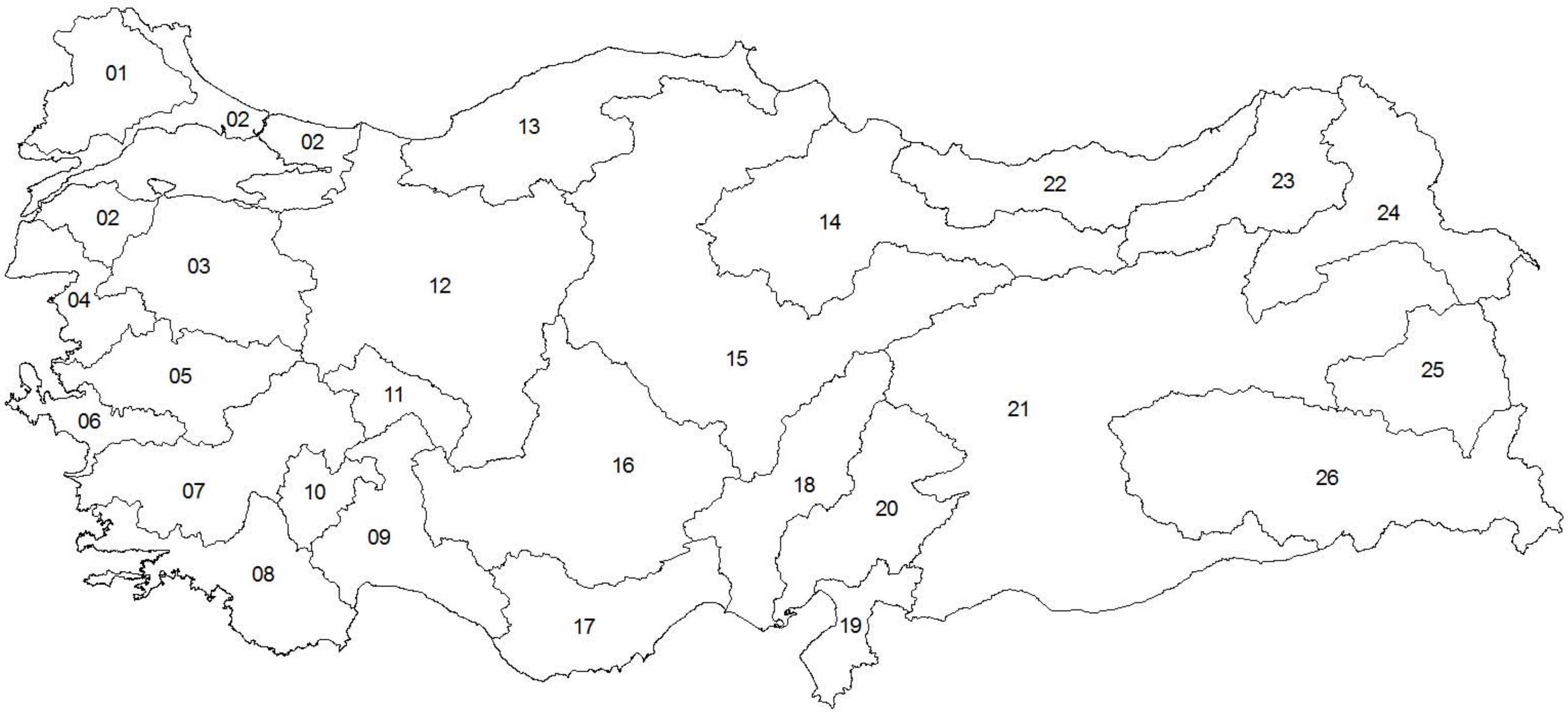

Figure 4.2 Main watershed boundaries for Turkey (source: State Water Works, DSİ).

Table 4.7 Watershed characteristics based on historical landslides (source: DSİ and MTA).

No	Name	Landslide Area (A)	Watershed Area (B)	Landslide Ratio (A/B)
1	Meriç-Ergene	5.320 km²	14464.814 km²	0.04%
2	Marmara	436.866 km²	23113.869 km²	1.89%
3	Susurluk	143.094 km²	24293.385 km²	0.59%
4	Kuzey Ege	53.812 km²	9952.334 km²	0.54%
5	Gediz	84.900 km²	16976.216 km²	0.50%
6	Küçük Menderes	5.805 km²	7029.945 km²	0.08%
7	Büyük Menderes	209.229 km²	26010.286 km²	0.80%
8	Batı Akdeniz	299.530 km²	21084.725 km²	1.42%
9	Antalya	141.059 km²	20213.399 km²	0.70%
10	Burdur	9.117 km²	6273.775 km²	0.15%
11	Akarçay	223.518 km²	7954.481 km²	2.81%
12	Sakarya	1077.202 km²	63256.975 km²	1.70%
13	Batı Karadeniz	3060.300 km²	28967.667 km²	10.56%
14	Yeşilırmak	1734.562 km²	39614.187 km²	4.38%
15	Kızılırmak	1652.320 km²	82100.076 km²	2.01%
16	Konya Kapalı	24.241 km²	49805.341 km²	0.05%
17	Doğu Akdeniz	484.859 km²	21657.879 km²	2.24%
18	Seyhan	58.305 km²	22135.942 km²	0.26%
19	Asi	27.280 km²	7856.754 km²	0.35%
20	Ceyhan	165.300 km²	21487.635 km²	0.77%
21	Fırat	6058.294 km²	121677.479 km²	4.98%
22	Doğu Karadeniz	665.532 km²	22852.488 km²	2.91%
23	Çoruh	1014.108 km²	20251.609 km²	5.01%
24	Aras	1276.114 km²	28099.522 km²	4.54%
25	Van Gölü	373.357 km²	17916.731 km²	2.08%
26	Dicle	1304.693 km²	54278.689 km²	2.40%

4.3 Results

In this section each watershed would be analyzed on its own and the results for the related watershed would also be given separately as a section. The validation of the produced landslide susceptibility maps using the ROC curves, the selection process of the 8 factors based or 10 factors based approach and the sythetic classficiation process of the selected map would be presented in Chapter 5.

4.3.1 Watershed No: 1 (Meriç-Ergene)

The Study Area

Meriç-Ergene watershed is located on the northwest part of Turkey. Elevation ranges between 0 m and 1021 m in this region. Landslide activity of this watershed is very low according to landslide inventory map.

Historical landslides occurred in this region mostly located on the southern part of the watershed which is also overlays with Zone 1 and Zone 2 of earthquake zoning map of Turkey. Clastic and carbonate rocks and continental clastic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 32° in the region, most of historical landslides occurred between 5° and 10°. Most of landslides were occurred in east (E) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 496 mm and 798 mm. Historical landslides mainly occurred on the range between 600 mm to 700 mm. TWI values ranges between 0 to 22 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 355 m/km^2 in the watershed area, most of the landslides were occurred between 50 m/km^2 and 150 m/km^2. Agricultural areas and forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

AHP was firstly introduced by the Saaty (1980) and gained wide application in site selection, suitability analysis, regional planning, and landslide susceptibility analysis (Ayalew et al., 2005). For the landslide susceptibility analysis, the weight value and rating value of factors should be known. The weight value was relatively important in factors such as slope, lithology, and land cover. The rating value was relatively important in classes of each factor. For example, if slope is more important than land cover in a landslide occurrence, a relatively important value was the weight; if a 15° slope was more hazardous than a 10° slope, a relatively important value was the rating. Because there were no fixed or standard values of weight and rating for a landslide related to the factors, a determination of a weight and rating value proved to be very important in a landslide susceptibility analysis. The weight and rating should be determinate based on an objective analysis, not on subjective experts' opinions (Lee et al., 2004).

Obtaining factor weights in AHP, a pairwise comparison matrix should be built with scores given in Table 4.2. When the factor on the vertical axis is more important than the factor on the horizontal axis, this value varies between 1 and 9. Conversely, the value varies between the reciprocals 1/2 and 1/9 as shown in Table 4.8 (for 8 factors) and Table 4.9 (for 10 factors). The diagonal boxes of a pairwise comparison matrix always take a value of 1. The selection of the appropriate scores was guided by data shown in Table 4.10. For example, from Table 4.10, curvature was a more effective factor than aspect. In Table 4.9, the score 3 was given to curvature. Conversely, a 1/3 score was given to aspect, which implied that for this watershed curvature was 9 times more important than aspect. Once the matrix was constructed, the weight values for each factor could be derived by a series of simple summation and division processes. The consistencies of these matrixes were summarized with a consistency value ratio (CR). The value of the consistency ratio must be smaller or equal to 10%, unless scores given in the matrix needs to be revised (Saaty, 1977).

Table 4.8 Reciprocal matrix and weight values between 8 factors for Watershed-1.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1	1	1	1	1/2
Int. Relief	1/2	1	1	1	1	1	1/2	1/2
Lithology	1	1	1	1	1	1	1/2	1/2
Land Cover	1	1	1	1	2	1	1/2	1/2
Earthquake	1	1	1	1/2	1	1	1/2	1/2
TWI	1	1	1	1	1	1	1/2	1
Landforms	1	2	2	2	2	2	1	1
Curvature	2	2	2	2	2	1	1	1
Weight	*0.1224*	*0.0924*	*0.0997*	*0.1111*	*0.0931*	*0.1111*	*0.1847*	*0.1855*

Consistency Ratio (CR) = 1.71%

Table 4.9 Reciprocal matrix and weight values between 10 factors for Watershed-1.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	1	1/2	1	1	1	2	1	1/2	1/2
Int. Relief	1	1	1/2	1	1	1	2	1	1/2	1/2
Rainfall	2	2	1	2	2	2	3	1	1	1
Lithology	1	1	1/2	1	1	1	2	1	1/2	1/2
Land Cover	1	1	1/2	1	1	1	2	1	1/2	1/2
Earthquake	1	1	1/2	1	1	1	2	1	1/2	1/2
Aspect	1/2	1/2	1/3	1/2	1/2	1/2	1	1/2	1/3	1/3
TWI	1	1	1	1	1	1	2	1	1/2	1/2
Landforms	2	2	1	2	2	2	3	2	1	1
Curvature	2	2	1	2	2	2	3	2	1	1
Weight	*0.0809*	*0.0809*	*0.1485*	*0.0809*	*0.0809*	*0.0809*	*0.0443*	*0.0882*	*0.1572*	*0.1572*

Consistency Ratio (CR) = 0.38%

Table 4.10 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-1.

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	14.29%	0.2368	0.0290	0.0192
	5° - 10°	60.32%	1.0000	0.1224	0.0809
	10° - 15°	25.40%	0.4211	0.0516	0.0341
	> 15°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	11.11%	0.2692	0.0249	0.0218
	50 - 100	41.27%	1.0000	0.0924	0.0809
	100 - 150	39.68%	0.9615	0.0888	0.0778
	150 - 200	7.94%	0.1923	0.0178	0.0156
	> 200	0.00%	0.0000	0.0000	0.0000
Rainfall	< 600	0.00%	0.0000	-	0.0000
	600 - 700	85.71%	1.0000	-	0.1485
	700 - 800	14.29%	0.1667	-	0.0248
	> 800	0.00%	0.0000	-	0.0000
Lithology	Young deposits	7.94%	0.1724	0.0172	0.0139
	Basalt	7.94%	0.1724	0.0172	0.0139
	Continental clastic rocks	38.10%	0.8276	0.0825	0.0669
	Clastic and carbonate rocks	46.03%	1.0000	0.0997	0.0809
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	1.59%	0.0294	0.0033	0.0024
	Agricultural areas	53.97%	1.0000	0.1111	0.0809
	Forest	44.44%	0.8235	0.0915	0.0666
	Others	0.00%	0.0000	0.0000	0.0000
Earthquake	Zone 1	23.81%	0.5357	0.0499	0.0433
	Zone 2	22.22%	0.5000	0.0466	0.0404
	Zone 3	44.44%	1.0000	0.0931	0.0809
	Zone 4	9.52%	0.2143	0.0200	0.0173
	Zone 5	0.00%	0.0000	0.0000	0.0000
Aspect	N	3.17%	0.1176	-	0.0052
	NE	20.63%	0.7647	-	0.0339
	E	26.98%	1.0000	-	0.0443
	SE	17.46%	0.6471	-	0.0287
	S	14.29%	0.5294	-	0.0235
	SW	4.76%	0.1765	-	0.0078
	W	3.17%	0.1176	-	0.0052
	NW	9.52%	0.3529	-	0.0156

Table 4.10 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-1 (continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
TWI	< 11	0.00%	0.0000	0.0000	0.0000
	11 - 12	30.16%	0.5938	0.0659	0.0524
	12 - 13	50.79%	1.0000	0.1111	0.0882
	13 - 14	15.87%	0.3125	0.0347	0.0276
	14 - 15	1.59%	0.0313	0.0035	0.0028
	15 - 16	1.59%	0.0313	0.0035	0.0028
	> 16	0.00%	0.0000	0.0000	0.0000
Landforms	Midslope drainages, shallow valleys	4.76%	0.0556	0.0103	0.0087
	Plains	9.52%	0.1111	0.0205	0.0175
	Open slopes	85.71%	1.0000	0.1847	0.1572
	Others	0.00%	0.0000	0.0000	0.0000
Curvature	V / V	3.17%	0.0357	0.0066	0.0056
	V / S	3.17%	0.0357	0.0066	0.0056
	S / V	4.76%	0.0536	0.0099	0.0084
	S / S	88.89%	1.0000	0.1855	0.1572
	Others	0.00%	0.0000	0.0000	0.0000

To objectively determine a rating value, the following statistical data extracted from historical landslide records was used (Table 4.10). Each factor was divided into classes, and values of these classes were normalized. For example, from Table 4.10, it was inferred that the landslides frequently occurred in areas possessing slopes between 5°-10°. Then, the normalized value of 1 was given to this slope class. To get a slope rating value in AHP, normalized value of each class and weight values obtained from Tables 4.8 and 4.9 were multiplied and written in the columns that read "*Rating Value[8]*" and "*Rating Value[10]*" in Table 4.10. The rating value of the other factors, which had an influence on landslide susceptibility were also calculated by the same way as that in the slope map. Finally, the rating values for two different approaches (8 factors and 10 factors) were obtained as shown in Table 4.10.

Rating values represent cell values for the corresponding factor map. The sum of these values for different layers gives a landslide susceptibility index value that varies between 0 and 1. An example for this calculation is presented in Table 4.11.

Table 4.11 Sample calculation of landslide susceptibility using AHP rating values.

Data Layers	Classes	Rating Value[8]	Rating Value[10]
Slope	5° - 10°	0.1224	0.0809
Internal Relief	150 - 200	0.0178	0.0156
Rainfall	600 - 700	-	0.1485
Lithology	Clastic and carbonate rocks	0.0997	0.0809
Land Cover	Forest	0.0915	0.0666
Earthquake	Zone 1	0.0499	0.0433
Aspect	S	-	0.0235
TWI	12 - 13	0.1111	0.0882
Landforms	Open slopes	0.1847	0.1572
Curvature	S / S	0.1855	0.1572
		0.8626	**0.8620**

After the sum of all related layers for the 8 factor and 10 factor approaches were computed, two different landslide susceptibility maps were obtained (Figure 4.3 and Figure 4.4). Pixel values for these maps varied between 0 and 1.

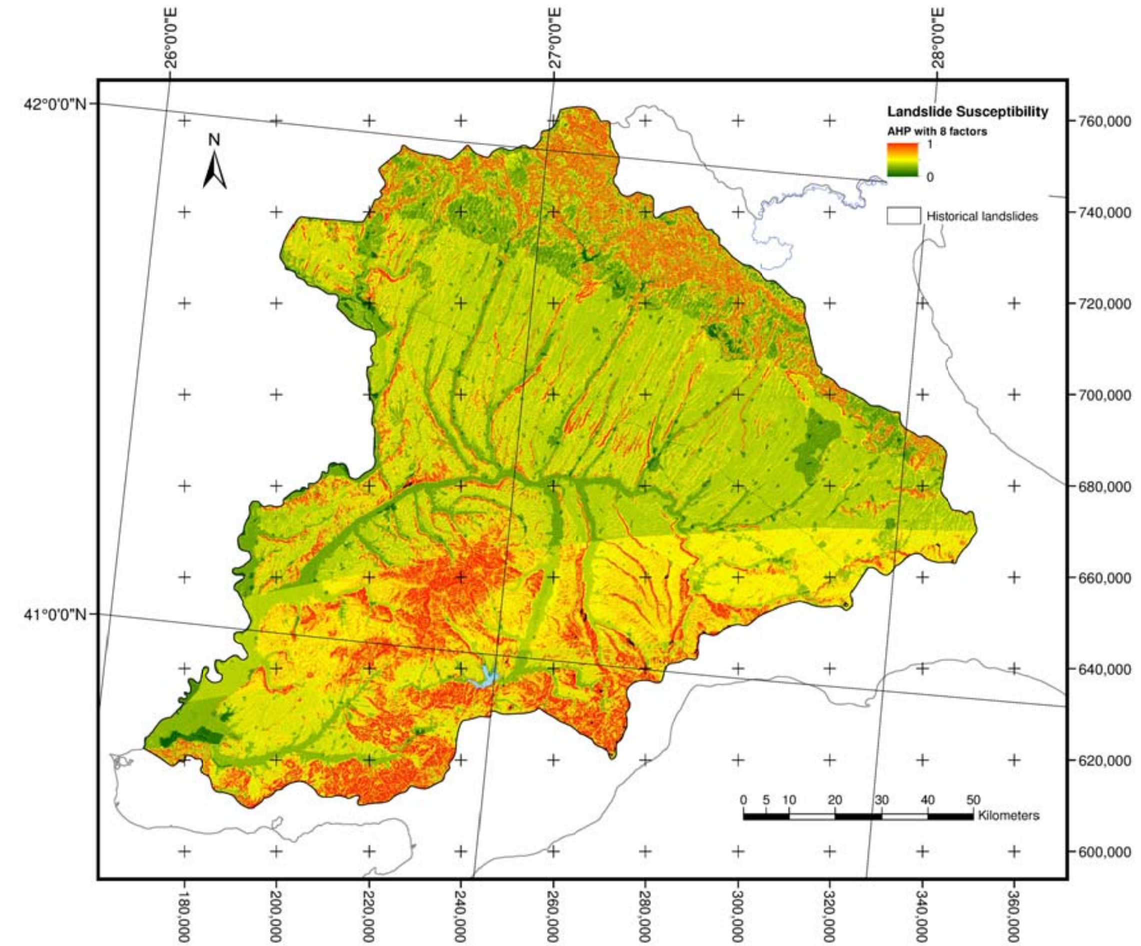

Figure 4.3 Unclassified landslide susceptibility map for Watershed-1 (with 8 factors).

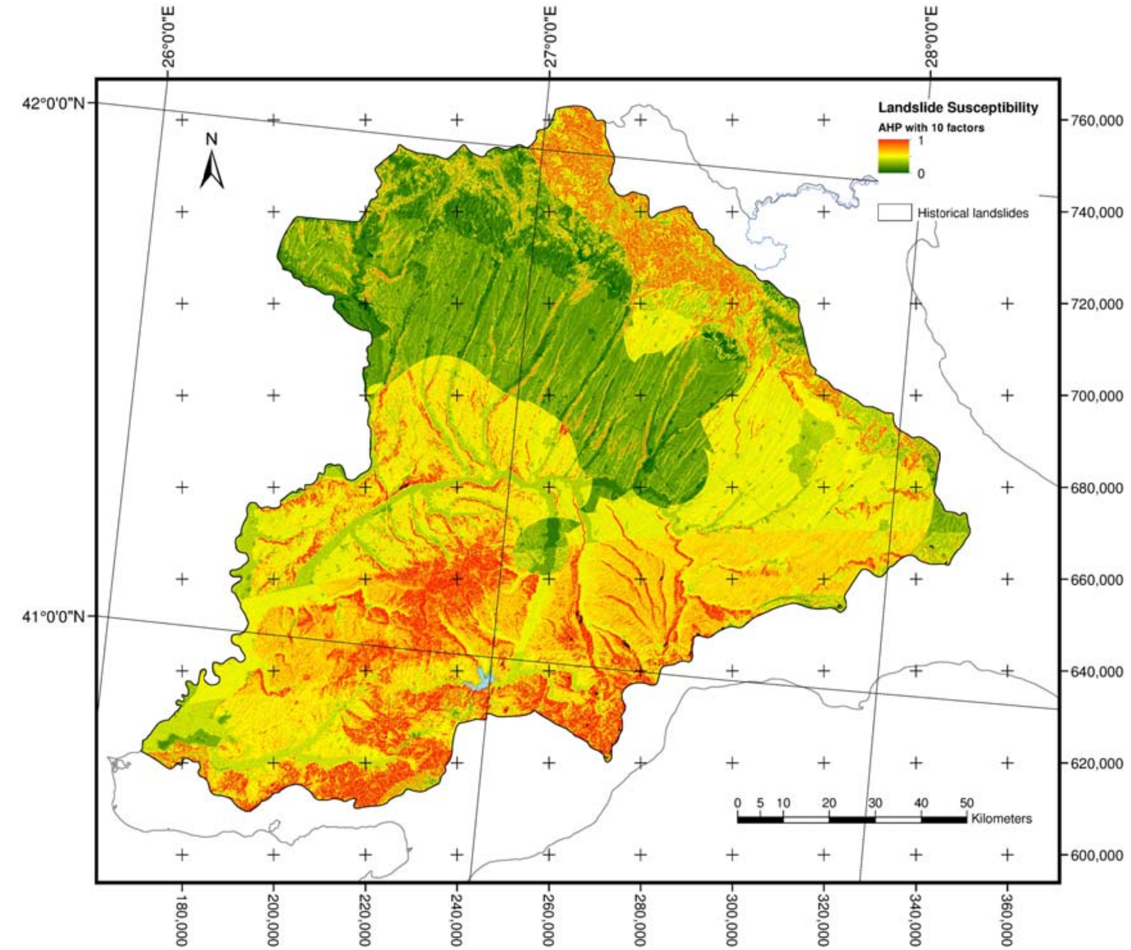

Figure 4.4 Unclassified landslide susceptibility map for Watershed-1 (with 10 factors).

4.3.2 Watershed No: 2 (Marmara)

The Study Area

Marmara watershed is located on the northwest part of Turkey and surrounds Marmara Sea. Elevation ranges between 0 m and 1538 m in this region. Landslide activity of this watershed is moderate according to landslide inventory map.

Historical landslides occurred in this region mostly located on the middle part of the watershed which is also overlays with Zone 1 of earthquake zoning map of Turkey. Continental clastic rocks and clastic and carbonate rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 59° in the region, most of historical landslides occurred between 5° and 10°. Most of landslides were occurred in east (E) and west (W) directions of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 533 mm and 1263 mm. Historical landslides mainly occurred on the range between 600 mm to 800 mm. TWI values ranges between 9 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 700 m/km^2 in the watershed area, most of the landslides were occurred between 50 m/km^2 and 150 m/km^2. Agricultural areas are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.12 (for 8 factors) and Table 4.13 (for 10 factors). The selection of the appropriate scores was summarized in Table A.1. Produced landslide susceptibility maps for this watershed were given in Figure B.1 (or 8 factors) and Figure B.2 (for 10 factors).

Table 4.12 Reciprocal matrix and weight values between 8 factors for Watershed-2.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1	1	1	1	1
Int. Relief	1/2	1	1	1/2	1/2	1	1/2	1/3
Lithology	1	1	1	1/2	1/2	1	1/2	1/2
Land Cover	1	2	2	1	1/2	1	1	1
Earthquake	1	2	2	2	1	2	1	1
TWI	1	1	1	1	1/2	1	1/2	1/2
Landforms	1	2	2	1	1	2	1	1
Curvature	1	3	2	1	1	2	1	1
Weight	*0.1317*	*0.0735*	*0.0851*	*0.1317*	*0.1691*	*0.0929*	*0.1535*	*0.1624*

Consistency Ratio (CR) = 1.57%

Table 4.13 Reciprocal matrix and weight values between 10 factors for Watershed-2.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	1	1	1	1/2	4	1	1	1
Int. Relief	1/2	1	1	1	1/2	1/2	2	1	1/2	1/2
Rainfall	1	1	1	1	1/2	1/2	3	1	1/2	1/2
Lithology	1	1	1	1	1/2	1/2	3	1	1/2	1/2
Land Cover	1	2	2	2	1	1	4	1	1	1
Earthquake	2	2	2	2	1	1	5	2	1	1
Aspect	1/4	1/2	1/3	1/3	1/4	1/5	1	1/3	1/5	1/5
TWI	1	1	1	1	1	1/2	3	1	1/2	1/2
Landforms	1	2	2	2	1	1	5	2	1	1
Curvature	1	2	2	2	1	1	5	2	1	1
Weight	*0.1067*	*0.0687*	*0.0766*	*0.0766*	*0.1292*	*0.1504*	*0.0283*	*0.0831*	*0.1402*	*0.1402*

Consistency Ratio (CR) = 0.92%

4.3.3 Watershed No: 3 (Susurluk)

The Study Area

Susurluk watershed is located on the northwest part of Turkey and on the south of Marmara Sea. Elevation ranges between 0 m and 2529 m in this region. Landslide activity of this watershed is low according to landslide inventory map.

Historical landslides occurred in this region distributed through the watershed and mostly overlays with Zone 1 of earthquake zoning map of Turkey. Continental clastic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 61° in the region, most of historical landslides occurred between 5° and 10°. Most of landslides were occurred in west (W) and east (E) directions of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 435 mm and 834 mm. Historical landslides mainly occurred on the range between 600 mm to 700 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 806 m/km^2 in the watershed area, most of the landslides were occurred between 100 m/km^2 and 200 m/km^2. Agricultural areas are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.14 (for 8 factors) and Table 4.15 (for 10 factors). The selection of the appropriate scores was summarized in Table A.2. Produced landslide susceptibility maps for this watershed were given in Figure B.3 (or 8 factors) and Figure B.4 (for 10 factors).

Table 4.14 Reciprocal matrix and weight values between 8 factors for Watershed-3.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1	1	1	1	1/2
Int. Relief	1/2	1	1/2	1/2	1/3	1/2	1/3	1/2
Lithology	1	2	1	1	1/2	1	1	1
Land Cover	1	2	1	1	1	1	1	1
Earthquake	1	3	2	1	1	2	1	1
TWI	1	2	1	1	1/2	1	1/2	1/2
Landforms	1	3	1	1	1	2	1	1
Curvature	2	2	1	1	1	2	1	1
Weight	***0.1203***	***0.0586***	***0.1201***	***0.1299***	***0.1639***	***0.1013***	***0.1492***	***0.1566***

Consistency Ratio (CR) = 1.56%

Table 4.15 Reciprocal matrix and weight values between 10 factors for Watershed-3.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	1	1	1	1	3	1	1	1
Int. Relief	1/2	1	1/2	1/2	1/2	1/3	2	1/2	1/3	1/3
Rainfall	1	2	1	1	1/2	1/2	3	1	1/2	1/2
Lithology	1	2	1	1	1	1/2	3	1	1	1/2
Land Cover	1	2	2	1	1	1	4	1	1	1
Earthquake	1	3	2	2	1	1	5	2	1	1
Aspect	1/3	1/2	1/3	1/3	1/4	1/5	1	1/3	1/5	1/5
TWI	1	2	1	1	1	1/2	3	1	1/2	1/2
Landforms	1	3	2	1	1	1	5	2	1	1
Curvature	1	3	2	2	1	1	5	2	1	1
Weight	***0.1092***	***0.0491***	***0.0823***	***0.0950***	***0.1199***	***0.1454***	***0.0290***	***0.0884***	***0.1362***	***0.1454***

Consistency Ratio (CR) = 1.12%

4.3.4 Watershed No: 4 (Kuzey Ege)

The Study Area

Kuzey Ege watershed is located on the northwest part of Turkey and on the east of Aegean Sea. Elevation ranges between 0 m and 1759 m in this region. Landslide activity of this watershed is very low according to landslide inventory map.

Historical landslides occurred in this region mostly located on Çandarlı peninsula which is also overlays with Zone 1 of earthquake zoning map of Turkey. Undifferentiated volcanic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 66° in the region, most of historical landslides occurred between 5° and 10°. Most of landslides were occurred in south-west (SW) direction of slope aspect.

Annual mean total rainfall distribution in the area ranges between 518 mm and 946 mm. Historical landslides mainly occurred on the range between 600 mm to 700 mm. TWI values ranges between 0 to 22 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 710 m/km^2 in the watershed area, most of the landslides were occurred between 150 m/km^2 and 200 m/km^2. Forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.16 (for 8 factors) and Table 4.17 (for 10 factors). The selection of the appropriate scores was summarized in Table A.3. Produced landslide susceptibility maps for this watershed were given in Figure B.5 (or 8 factors) and Figure B.6 (for 10 factors).

Table 4.16 Reciprocal matrix and weight values between 8 factors for Watershed-4.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	1	1	1	1/2	1	1/2	1/2
Int. Relief	1	1	1/3	1/3	1/2	1	1/2	1/2
Lithology	1	3	1	1	1/2	1	1	1/2
Land Cover	1	3	1	1	1/2	1	1	1/2
Earthquake	2	2	2	2	1	2	1	1
TWI	1	1	1	1	1/2	1	1/2	1
Landforms	2	2	1	1	1	2	1	1
Curvature	2	2	2	2	1	1	1	1
Weight	***0.0904***	***0.0725***	***0.1167***	***0.1167***	***0.1808***	***0.1008***	***0.1540***	***0.1683***

Consistency Ratio (CR) = 2.76%

Table 4.17 Reciprocal matrix and weight values between 10 factors for Watershed-4.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	1	1	1	1	1/2	1	1	1/2	1/2
Int. Relief	1	1	1/2	1/2	1/2	1/2	1	1	1/2	1/2
Rainfall	1	2	1	1	1	1/2	2	1	1/2	1/2
Lithology	1	2	1	1	1	1/2	2	1	1	1/2
Land Cover	1	2	1	1	1	1/2	2	1	1	1/2
Earthquake	2	2	2	2	2	1	3	2	1	1
Aspect	1	1	1/2	1/2	1/2	1/3	1	1/2	1/2	1/2
TWI	1	1	1	1	1	1/2	2	1	1/2	1/2
Landforms	2	2	2	1	1	1	2	2	1	1
Curvature	2	2	2	2	2	1	2	2	1	1
Weight	***0.0763***	***0.0630***	***0.0881***	***0.0947***	***0.0947***	***0.1581***	***0.0564***	***0.0818***	***0.1344***	***0.1525***

Consistency Ratio (CR) = 1.33%

4.3.5 Watershed No: 5 (Gediz)

The Study Area

Gediz watershed is located on the western part of Turkey. Elevation ranges between 0 m and 2298 m in this region. Landslide activity of this watershed is very low according to landslide inventory map.

Historical landslides occurred in this region mostly located on the north-east part of the watershed which is also overlays with Zone 1 of earthquake zoning map of Turkey. Continental clastic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 67° in the region, most of historical landslides occurred between 5° and 10°. Most of landslides were occurred in south (S) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 446 mm and 1044 mm. Historical landslides mainly occurred on the range between 400 mm to 500 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 856 m/km^2 in the watershed area, most of the landslides were occurred between 150 m/km^2 and 200 m/km^2. Agricultural areas are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.18 (for 8 factors) and Table 4.19 (for 10 factors). The selection of the appropriate scores was summarized in Table A.4. Produced landslide susceptibility maps for this watershed were given in Figure B.7 (or 8 factors) and Figure B.8 (for 10 factors).

Table 4.18 Reciprocal matrix and weight values between 8 factors for Watershed-5.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	1	2	1	1/2	1	1/2	1/2
Int. Relief	1	1	1/2	1/2	1/2	1	1/2	1/2
Lithology	1/2	2	1	1	1/2	1	1	1
Land Cover	1	2	1	1	1/2	1	1	1
Earthquake	2	2	2	2	1	2	1	1
TWI	1	1	1	1	1/2	1	1/2	1/2
Landforms	2	2	1	1	1	2	1	1
Curvature	2	2	1	1	1	2	1	1
Weight	*0.1045*	*0.0774*	*0.1142*	*0.1202*	*0.1827*	*0.0913*	*0.1548*	*0.1548*

Consistency Ratio (CR) = 2.36%

Table 4.19 Reciprocal matrix and weight values between 10 factors for Watershed-5.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	1	1	1	1	1/2	3	1	1/2	1/2
Int. Relief	1	1	1/2	1/2	1/2	1/2	2	1	1/2	1/2
Rainfall	1	2	1	1	1	1/2	3	1	1	1
Lithology	1	2	1	1	1	1/2	3	1	1	1
Land Cover	1	2	1	1	1	1/2	3	1	1	1
Earthquake	2	2	2	2	2	1	5	2	1	1
Aspect	1/3	1/2	1/3	1/3	1/3	1/5	1	1/3	1/4	1/4
TWI	1	1	1	1	1	1/2	3	1	1/2	1/2
Landforms	2	2	1	1	1	1	4	2	1	1
Curvature	2	2	1	1	1	1	4	2	1	1
Weight	*0.0838*	*0.0653*	*0.1032*	*0.1032*	*0.1032*	*0.1644*	*0.0317*	*0.0838*	*0.1307*	*0.1307*

Consistency Ratio (CR) = 1.13%

4.3.6 Watershed No: 6 (Küçük Menderes)

The Study Area

Küçük Menderes watershed is located on the western part of Turkey. Elevation ranges between 0 m and 2134 m in this region. Landslide activity of this watershed is very low according to landslide inventory map.

Historical landslides occurred in this region mostly located on northern and southern part of the watershed which is also overlays with Zone 1 of earthquake zoning map of Turkey. Carbonate rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 59° in the region, most of historical landslides occurred between 5° and 10°. Most of landslides were occurred in west (W) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 483 mm and 926 mm. Historical landslides mainly occurred on the range between 700 mm to 800 mm. TWI values ranges between 9 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 804 m/km^2 in the watershed area, most of the landslides were occurred between 100 m/km^2 and 150 m/km^2. Agricultural areas are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.20 (for 8 factors) and Table 4.21 (for 10 factors). The selection of the appropriate scores was summarized in Table A.5. Produced landslide susceptibility maps for this watershed were given in Figure B.9 (or 8 factors) and Figure B.10 (for 10 factors).

Table 4.20 Reciprocal matrix and weight values between 8 factors for Watershed-6.

Factors^{8}	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1	1/2	1	1	1
Int. Relief	1/2	1	1	1	1/2	1	1/2	1/2
Lithology	1	1	1	1	1/2	1	1/2	1/2
Land Cover	1	1	1	1	1/2	1	1	1
Earthquake	2	2	2	2	1	2	1	1
TWI	1	1	1	1	1/2	1	1	1/2
Landforms	1	2	2	1	1	1	1	1
Curvature	1	2	2	1	1	2	1	1
Weight	***0.1217***	***0.0854***	***0.0928***	***0.1113***	***0.1856***	***0.1017***	***0.1445***	***0.1570***

Consistency Ratio (CR) = 1.54%

Table 4.21 Reciprocal matrix and weight values between 10 factors for Watershed-6.

Factors^{10}	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	1	1	1	1	1/2	3	1	1	1
Int. Relief	1	1	1	1	1	1/2	2	1	1/2	1/2
Rainfall	1	1	1	1	1	1/2	3	1	1	1
Lithology	1	1	1	1	1	1/2	2	1	1/2	1/2
Land Cover	1	1	1	1	1	1/2	3	1	1	1
Earthquake	2	2	2	2	2	1	5	2	1	1
Aspect	1/3	1/2	1/3	1/2	1/3	1/5	1	1/2	1/4	1/4
TWI	1	1	1	1	1	1/2	2	1	1/2	1/2
Landforms	1	2	1	2	1	1	4	2	1	1
Curvature	1	2	1	2	1	1	4	2	1	1
Weight	***0.0972***	***0.0809***	***0.0972***	***0.0809***	***0.0972***	***0.1652***	***0.0348***	***0.0809***	***0.1328***	***0.1328***

Consistency Ratio (CR) = 1.04%

4.3.7 Watershed No: 7 (Büyük Menderes)

The Study Area

Büyük Menderes watershed is located on the southwest part of Turkey. Elevation ranges between 0 m and 2519 m in this region. Landslide activity of this watershed is low according to landslide inventory map.

Historical landslides occurred in this region mostly located on the middle part of the watershed which is also overlays with Zone 1 of earthquake zoning map of Turkey. Continental clastic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 67° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in east (E) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 421 mm and 1213 mm. Historical landslides mainly occurred on the range between 500 mm to 700 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 827 m/km^2 in the watershed area, most of the landslides were occurred between 150 m/km^2 and 200 m/km^2. Agricultural areas and forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.22 (for 8 factors) and Table 4.23 (for 10 factors). The selection of the appropriate scores was summarized in Table A.6. Produced landslide susceptibility maps for this watershed were given in Figure B.11 (or 8 factors) and Figure B.12 (for 10 factors).

Table 4.22 Reciprocal matrix and weight values between 8 factors for Watershed-7.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	1	1	1	1/2	1	1/2	1/2
Int. Relief	1	1	1/2	1	1/2	1	1/2	1/2
Lithology	1	2	1	1	2	1	1	1
Land Cover	1	1	1	1	1/2	1	1/2	1/2
Earthquake	2	2	1/2	2	1	2	2	1
TWI	1	1	1	1	1/2	1	1	1/2
Landforms	2	2	1	2	1/2	1	1	2
Curvature	2	2	1	2	1	2	1/2	1
Weight	***0.0910***	***0.0820***	***0.1481***	***0.0910***	***0.1730***	***0.0999***	***0.1598***	***0.1552***

Consistency Ratio (CR) = 3.56%

Table 4.23 Reciprocal matrix and weight values between 10 factors for Watershed-7.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	1	1	1/2	1	1/2	2	1	1/2	1/2
Int. Relief	1	1	1	1/2	1	1/2	2	1	1/2	1/2
Rainfall	1	1	1	1/2	1/2	1/3	2	1	1/2	1/2
Lithology	2	2	2	1	1	1/2	3	1	1	1
Land Cover	1	1	2	1	1	1/2	2	1	1/2	1/2
Earthquake	2	2	3	2	2	1	4	2	1	1
Aspect	1/2	1/2	1/2	1/3	1/2	1/4	1	1/2	1/3	1/3
TWI	1	1	1	1	1	1/2	2	1	1/2	1/2
Landforms	2	2	2	1	2	1	3	2	1	1
Curvature	2	2	2	1	2	1	3	2	1	1
Weight	***0.0744***	***0.0744***	***0.0675***	***0.1202***	***0.0866***	***0.1667***	***0.0406***	***0.0801***	***0.1447***	***0.1447***

Consistency Ratio (CR) = 0.93%

4.3.8 Watershed No: 8 (Batı Akdeniz)

The Study Area

Batı Akdeniz watershed is located on the southwest part of Turkey. Elevation ranges between 0 m and 3039 m in this region. Landslide activity of this watershed is moderate according to landslide inventory map.

Historical landslides occurred in this region mostly located on the eastern part of the watershed which is also overlays with Zone 1 and Zone 2 of earthquake zoning map of Turkey. Clastic and carbonate rocks and continental clastic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 71° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in west (W) and south-east (SE) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 420 mm and 1317 mm. Historical landslides mainly occurred on the range between 500 mm to 700 mm. TWI values ranges between 8 to 22 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 1044 m/km^2 in the watershed area, most of the landslides were occurred between 200 m/km^2 and 300 m/km^2. Agricultural areas and forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.24 (for 8 factors) and Table 4.25 (for 10 factors). The selection of the appropriate scores was summarized in Table A.7. Produced landslide susceptibility maps for this watershed were given in Figure B.13 (or 8 factors) and Figure B.14 (for 10 factors).

Table 4.24 Reciprocal matrix and weight values between 8 factors for Watershed-8.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	2	1	1	1	1/2	1/2
Int. Relief	1/2	1	1	1/2	1/2	1/2	1/2	1/3
Lithology	1/2	1	1	1/2	1/2	1/2	1/2	1/3
Land Cover	1	2	2	1	1/2	1	1/2	1
Earthquake	1	2	2	2	1	1	1	2
TWI	1	2	2	1	1	1	1/2	1/2
Landforms	2	2	2	2	1	2	1	1/2
Curvature	2	3	3	1	1/2	2	2	1
Weight	*0.1156*	*0.0643*	*0.0643*	*0.1153*	*0.1695*	*0.1156*	*0.1669*	*0.1886*

Consistency Ratio (CR) = 3.16%

Table 4.25 Reciprocal matrix and weight values between 10 factors for Watershed-8.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	2	2	1	1	3	1	1/2	1/2
Int. Relief	1/2	1	1	1	1/2	1/2	1	1/2	1/2	1/3
Rainfall	1/2	1	1	1	1/2	1/2	2	1/2	1/2	1/2
Lithology	1/2	1	1	1	1/2	1/2	1	1/2	1/2	1/3
Land Cover	1	2	2	2	1	1/2	2	1	1/2	1/2
Earthquake	1	2	2	2	2	1	3	1	1	1
Aspect	1/3	1	1/2	1	1/2	1/3	1	1/2	1/4	1/4
TWI	1	2	2	2	1	1	2	1	1/2	1/2
Landforms	2	2	2	2	2	1	4	2	1	1
Curvature	2	3	2	3	2	1	4	2	1	1
Weight	*0.1088*	*0.0576*	*0.0648*	*0.0576*	*0.0977*	*0.1344*	*0.0450*	*0.1045*	*0.1589*	*0.1706*

Consistency Ratio (CR) = 1.32%

4.3.9 Watershed No: 9 (Antalya)

The Study Area

Antalya watershed is located on the southwest part of Turkey and on the north of Mediterranean Sea. Elevation ranges between 0 m and 2972 m in this region. Landslide activity of this watershed is low according to landslide inventory map.

Historical landslides occurred in this region mostly located on the south-west and northern part of the watershed which is also overlays with Zone 1 and Zone 2 of earthquake zoning map of Turkey. Clastic and carbonate rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 78° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in east (E) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 300 mm and 763 mm. Historical landslides mainly occurred on the range between 700 mm to 800 mm. TWI values ranges between 0 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 1255 m/km^2 in the watershed area, most of the landslides were occurred between 200 m/km^2 and 300 m/km^2. Forests and agricultural are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.26 (for 8 factors) and Table 4.27 (for 10 factors). The selection of the appropriate scores was summarized in Table A.8. Produced landslide susceptibility maps for this watershed were given in Figure B.15 (or 8 factors) and Figure B.16 (for 10 factors).

Table 4.26 Reciprocal matrix and weight values between 8 factors for Watershed-9.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1	1	1	1	1/2
Int. Relief	1/2	1	1/2	1/2	1/2	1/2	1/2	1/3
Lithology	1	2	1	1	1	1	1	1/2
Land Cover	1	2	1	1	1	1	1	1/2
Earthquake	1	2	1	1	1	1	1	1
TWI	1	2	1	1	1	1	1	1
Landforms	1	2	1	1	1	1	1	2
Curvature	2	3	2	2	1	1	1/2	1
Weight	***0.1201***	***0.0616***	***0.1201***	***0.1201***	***0.1292***	***0.1292***	***0.1475***	***0.1722***

Consistency Ratio (CR) = 1.98%

Table 4.27 Reciprocal matrix and weight values between 10 factors for Watershed-9.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	1/2	1	1	1	2	1	1	1/2
Int. Relief	1/2	1	1/3	1/2	1/2	1/2	1	1/2	1/2	1/3
Rainfall	2	3	1	2	2	1	3	1	1	1
Lithology	1	2	1/2	1	1	1	2	1	1	1/2
Land Cover	1	2	1/2	1	1	1	2	1	1	1/2
Earthquake	1	2	1	1	1	1	2	1	1	1
Aspect	1/2	1	1/3	1/2	1/2	1/2	1	1/2	1/3	1/3
TWI	1	2	1	1	1	1	2	1	1	1/2
Landforms	1	2	1	1	1	1	3	1	1	1
Curvature	2	3	1	2	2	1	3	2	1	1
Weight	***0.0937***	***0.0493***	***0.1452***	***0.0937***	***0.0937***	***0.1082***	***0.0474***	***0.1007***	***0.1129***	***0.1552***

Consistency Ratio (CR) = 0.94%

4.3.10 Watershed No: 10 (Burdur)

The Study Area

Burdur watershed is located on the southwest part of Turkey. Elevation ranges between 821 m and 2738 m in this region. Landslide activity of this watershed is very low according to landslide inventory map.

Historical landslides occurred in this region mostly located on the middle part of the watershed which is also overlays with Zone 1 of earthquake zoning map of Turkey. Continental clastic rocks and ophiolitic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 62° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in west (W) and northwest (NW) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 488 mm and 887 mm. Historical landslides mainly occurred on the range between 500 mm to 600 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 901 m/km^2 in the watershed area, most of the landslides were occurred between 200 m/km^2 and 300 m/km^2. Forests and semi-natural areas are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.28 (for 8 factors) and Table 4.29 (for 10 factors). The selection of the appropriate scores was summarized in Table A.9. Produced landslide susceptibility maps for this watershed were given in Figure B.17 (or 8 factors) and Figure B.18 (for 10 factors).

Table 4.28 Reciprocal matrix and weight values between 8 factors for Watershed-10.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	2	1	1/2	1	1/2	1/2
Int. Relief	1/2	1	1/2	1/2	1/4	1/2	1/3	1/3
Lithology	1/2	2	1	1/2	1/4	1/2	1/3	1/3
Land Cover	1	2	2	1	1/2	1	1/2	1/2
Earthquake	2	4	4	2	1	2	1	2
TWI	1	2	2	1	1/2	1	1/2	1/2
Landforms	2	3	3	2	1	2	1	1/2
Curvature	2	3	3	2	1/2	2	2	1
Weight	***0.1000***	***0.0500***	***0.0601***	***0.1000***	***0.2221***	***0.1000***	***0.1752***	***0.1927***

Consistency Ratio (CR) = 1.75%

Table 4.29 Reciprocal matrix and weight values between 10 factors for Watershed-10.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	1	2	1	1/2	3	1	1/2	1/2
Int. Relief	1/2	1	1/2	1	1/2	1/4	1	1/2	1/3	1/3
Rainfall	1	2	1	2	1	1/2	3	1/2	1	1/2
Lithology	1/2	1	1/2	1	1/2	1/4	1	1/2	1/3	1/3
Land Cover	1	2	1	2	1	1/2	2	1	1/2	1/2
Earthquake	2	4	2	4	2	1	5	2	1	1
Aspect	1/3	1	1/3	1	1/2	1/5	1	1/3	1/4	1/4
TWI	1	2	2	2	1	1/2	3	1	1/2	1/2
Landforms	2	3	1	3	2	1	4	2	1	1
Curvature	2	3	2	3	2	1	4	2	1	1
Weight	***0.0907***	***0.0462***	***0.0939***	***0.0462***	***0.0870***	***0.1778***	***0.0382***	***0.0996***	***0.1557***	***0.1646***

Consistency Ratio (CR) = 0.98%

4.3.11 Watershed No: 11 (Akarçay)

The Study Area

Akarçay watershed is located on the midwest part of Turkey. Elevation ranges between 949 m and 2576 m in this region. Landslide activity of this watershed is high according to landslide inventory map.

Historical landslides occurred in this region mostly located on the western part of the watershed which is also overlays with Zone 1 and Zone 2 of earthquake zoning map of Turkey. Continental clastic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 57° in the region, most of historical landslides occurred between 5° and 15°. Most of landslides were occurred in east (E) and north-east (NE) directions of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 314 mm and 621 mm. Historical landslides mainly occurred on the range between 500 mm to 600 mm. TWI values ranges between 9 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 749 m/km^2 in the watershed area, most of the landslides were occurred between 150 m/km^2 and 200 m/km^2. Forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.30 (for 8 factors) and Table 4.31 (for 10 factors). The selection of the appropriate scores was summarized in Table A.10. Produced landslide susceptibility maps for this watershed were given in Figure B.19 (or 8 factors) and Figure B.20 (for 10 factors).

Table 4.30 Reciprocal matrix and weight values between 8 factors for Watershed-11.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	1	1	1/2	1/2	1	1/2	1/2
Int. Relief	1	1	1/2	1/2	1/2	1/2	1/2	1/2
Lithology	1	2	1	1	1	1	1/2	1/2
Land Cover	2	2	1	1	1	1/2	1	2
Earthquake	2	2	1	1	1	1	1	2
TWI	1	2	1	2	1	1	1/3	1/3
Landforms	2	2	2	1	1	3	1	1/2
Curvature	2	2	2	1/2	1/2	3	2	1
Weight	***0.0795***	***0.0672***	***0.1064***	***0.1458***	***0.1515***	***0.1171***	***0.1618***	***0.1707***

Consistency Ratio (CR) = 6.38%

Table 4.31 Reciprocal matrix and weight values between 10 factors for Watershed-11.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	1	1/2	1	1/2	1/2	2	1	1/2	1/2
Int. Relief	1	1	1/2	1/2	1/2	1/2	2	1/2	1/2	1/2
Rainfall	2	2	1	1	1	1	3	1	1	1
Lithology	1	2	1	1	1/2	1/2	2	1	1/2	1/2
Land Cover	2	2	1	2	1	1	3	1	1	1
Earthquake	2	2	1	2	1	1	3	1	1	1
Aspect	1/2	1/2	1/3	1/2	1/3	1/3	1	1/2	1/3	1/4
TWI	1	2	1	1	1	1	2	1	1/2	1/2
Landforms	2	2	1	2	1	1	3	2	1	1
Curvature	2	2	1	2	1	1	4	2	1	1
Weight	***0.0702***	***0.0618***	***0.1197***	***0.0823***	***0.1274***	***0.1274***	***0.0394***	***0.0950***	***0.1364***	***0.1404***

Consistency Ratio (CR) = 1.11%

4.3.12 Watershed No: 12 (Sakarya)

The Study Area

Sakarya watershed is located on the midwest part of Turkey. Elevation ranges between 0 m and 2460 m in this region. Landslide activity of this watershed is moderate according to landslide inventory map.

Historical landslides occurred in this region mostly located on the northern part of the watershed which is also overlays with Zone 1 of earthquake zoning map of Turkey. Clastic and carbonate rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 74° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in west (W) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 286 mm and 1319 mm. Historical landslides mainly occurred on the range between 300 mm to 400 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 837 m/km^2 in the watershed area, most of the landslides were occurred between 150 m/km^2 and 200 m/km^2. Agricultural areas and forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.32 (for 8 factors) and Table 4.33 (for 10 factors). The selection of the appropriate scores was summarized in Table A.11. Produced landslide susceptibility maps for this watershed were given in Figure B.21 (or 8 factors) and Figure B.22 (for 10 factors).

Table 4.32 Reciprocal matrix and weight values between 8 factors for Watershed-12.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1	1/2	1	1/2	1/2
Int. Relief	1/2	1	1	1/2	1/2	1/2	1/3	1/3
Lithology	1	1	1	1/2	1/2	1/2	1/2	1/2
Land Cover	1	2	2	1	1	1	1	1
Earthquake	2	2	2	1	1	1	1	1
TWI	1	2	2	1	1	1	1/2	1/2
Landforms	2	3	2	1	1	2	1	2
Curvature	2	3	2	1	1	2	1/2	1
Weight	***0.0994***	***0.0628***	***0.0757***	***0.1395***	***0.1514***	***0.1186***	***0.1914***	***0.1614***

Consistency Ratio (CR) = 1.85%

Table 4.33 Reciprocal matrix and weight values between 10 factors for Watershed-12.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	1	1	1	1/2	3	1	1/2	1/2
Int. Relief	1/2	1	1/2	1	1/2	1/2	2	1/2	1/3	1/3
Rainfall	1	2	1	1	1/2	1/2	2	1/2	1/2	1/2
Lithology	1	1	1	1	1/2	1/2	2	1/2	1/2	1/2
Land Cover	1	2	2	2	1	1	3	1	1	1
Earthquake	2	2	2	2	1	1	3	1	1	1
Aspect	1/3	1/2	1/2	1/2	1/3	1/3	1	1/3	1/4	1/4
TWI	1	2	2	2	1	1	3	1	1/2	1/2
Landforms	2	3	2	2	1	1	4	2	1	1
Curvature	2	3	2	2	1	1	4	2	1	1
Weight	***0.0894***	***0.0559***	***0.0742***	***0.0688***	***0.1254***	***0.1339***	***0.0360***	***0.1102***	***0.1531***	***0.1531***

Consistency Ratio (CR) = 1.23%

4.3.13 Watershed No: 13 (Batı Karadeniz)

The Study Area

Batı Karadeniz watershed is located on the northern part of Turkey. Elevation ranges between 0 m and 2397 m in this region. Landslide activity of this watershed is very high according to landslide inventory map.

Historical landslides occurred in this region located on every part in the watershed which is also overlays with every zone (1, 2, 3 and 4) of earthquake zoning map of Turkey. Clastic and carbonate rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 77° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in west (W) north-west (NW) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 382 mm and 1275 mm. Historical landslides mainly occurred on the range between 800 mm to 1000 mm. TWI values ranges between 0 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 970 m/km^2 in the watershed area, most of the landslides were occurred between 200 m/km^2 and 300 m/km^2. Agricultural areas and forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.34 (for 8 factors) and Table 4.35 (for 10 factors). The selection of the appropriate scores was summarized in Table A.12. Produced landslide susceptibility maps for this watershed were given in Figure B.23 (or 8 factors) and Figure B.24 (for 10 factors).

Table 4.34 Reciprocal matrix and weight values between 8 factors for Watershed-13.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1/2	1/2	1	1	1/2	1/2
Int. Relief	1/2	1	1/3	1/2	1/2	1/2	1/3	1/3
Lithology	2	3	1	2	2	2	1	1
Land Cover	2	2	1/2	1	1	1	1	1
Earthquake	1	2	1/2	1	1	1	1	1
TWI	1	2	1/2	1	1	1	1	1/2
Landforms	2	3	1	1	1	1	1	1
Curvature	2	3	1	1	1	2	1	1
Weight	*0.0912*	*0.0546*	*0.1910*	*0.1289*	*0.1180*	*0.1081*	*0.1475*	*0.1607*

Consistency Ratio (CR) = 1.39%

Table 4.35 Reciprocal matrix and weight values between 10 factors for Watershed-13.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	2	1/2	1/2	1	2	1	1/2	1/2
Int. Relief	1/2	1	1	1/3	1/2	1/2	1	1/2	1/3	1/3
Rainfall	1/2	1	1	1/3	1/3	1/2	1	2	1/3	1/3
Lithology	2	3	3	1	1	1	4	2	1	1
Land Cover	2	2	3	1	1	1	3	1	1	1
Earthquake	1	2	2	1	1	1	3	1	1	1
Aspect	1/2	1	1	1/4	1/3	1/3	1	1/3	1/4	1/4
TWI	1	2	1/2	1/2	1	1	3	1	1	1/2
Landforms	2	3	3	1	1	1	4	1	1	1
Curvature	2	3	3	1	1	1	4	2	1	1
Weight	*0.0841*	*0.0489*	*0.0594*	*0.1461*	*0.1288*	*0.1157*	*0.0397*	*0.0935*	*0.1377*	*0.1461*

Consistency Ratio (CR) = 2.39%

4.3.14 Watershed No: 14 (Yeşilırmak)

The Study Area

Yeşilırmak watershed is located on the midnorth part of Turkey. Elevation ranges between 0 m and 3288 m in this region. Landslide activity of this watershed is high according to landslide inventory map.

Historical landslides occurred in this region mostly located on the North Anatolia Fault Zone which is also overlays with Zone 1 and Zone 2 of earthquake zoning map of Turkey. Continental clastic rocks and clastic and carbonate rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 64° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in south-east (SE) and east (E) directions of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 346 mm and 1108 mm. Historical landslides mainly occurred on the range between 400 mm to 600 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 822 m/km^2 in the watershed area, most of the landslides were occurred between 150 m/km^2 and 250 m/km^2. Agricultural areas and forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.36 (for 8 factors) and Table 4.37 (for 10 factors). The selection of the appropriate scores was summarized in Table A.13. Produced landslide susceptibility maps for this watershed were given in Figure B.25 (or 8 factors) and Figure B.26 (for 10 factors).

Table 4.36 Reciprocal matrix and weight values between 8 factors for Watershed-14.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	2	1	1/2	1	1/2	1/2
Int. Relief	1/2	1	1	1/2	1/4	1/2	1/3	1/3
Lithology	1/2	1	1	1/3	1/5	1/2	1/4	1/4
Land Cover	1	2	3	1	1/2	1	1/2	1/2
Earthquake	2	4	5	2	1	2	1	1
TWI	1	2	2	1	1/2	1	1/2	1/2
Landforms	2	3	4	2	1	2	1	1/2
Curvature	2	3	4	2	1	2	2	1
Weight	*0.0995*	*0.0537*	*0.0464*	*0.1052*	*0.2047*	*0.0995*	*0.1784*	*0.2126*

Consistency Ratio (CR) = 0.86%

Table 4.37 Reciprocal matrix and weight values between 10 factors for Watershed-14.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	1	2	1	1/2	3	1	1/2	1/2
Int. Relief	1/2	1	1/2	1	1/2	1/4	1	1/2	1/3	1/3
Rainfall	1	2	1	2	1	1/2	3	1/2	1/2	1/2
Lithology	1/2	1	1/2	1	1/3	1/5	1	1/2	1/4	1/4
Land Cover	1	2	1	3	1	1/2	3	1	1/2	1/2
Earthquake	2	4	2	5	2	1	5	2	1	1
Aspect	1/3	1	1/3	1	1/3	1/5	1	1/3	1/4	1/4
TWI	1	2	2	2	1	1/2	3	1	1/2	1/2
Landforms	2	3	2	4	2	1	4	2	1	1
Curvature	2	3	2	4	2	1	4	2	1	1
Weight	*0.0893*	*0.0457*	*0.0847*	*0.0405*	*0.0933*	*0.1791*	*0.0362*	*0.0975*	*0.1668*	*0.1668*

Consistency Ratio (CR) = 0.74%

4.3.15 Watershed No: 15 (Kızılırmak)

The Study Area

Kızılırmak watershed is located on the middle part of Turkey. Elevation ranges between 0 m and 3857 m in this region. Landslide activity of this watershed is high according to landslide inventory map.

Historical landslides occurred in this region mostly located on the northern part of the watershed which is also overlays with Zone 1 and Zone 2 of earthquake zoning map of Turkey. Clastic and carbonate rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 70° in the region, most of historical landslides occurred between 5° and 15°. Most of landslides were occurred in east (E) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 221 mm and 845 mm. Historical landslides mainly occurred on the range between 400 mm to 500 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 772 m/km^2 in the watershed area, most of the landslides were occurred between 150 m/km^2 and 200 m/km^2. Agricultural areas and forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.38 (for 8 factors) and Table 4.39 (for 10 factors). The selection of the appropriate scores was summarized in Table A.14. Produced landslide susceptibility maps for this watershed were given in Figure B.27 (or 8 factors) and Figure B.28 (for 10 factors).

Table 4.38 Reciprocal matrix and weight values between 8 factors for Watershed-15.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	1	2	1	1	1	1/2	1/2
Int. Relief	1	1	1	1/2	1/2	1/2	1/3	1/3
Lithology	1/2	1	1	1/2	1/2	1/2	1/3	1/3
Land Cover	1	2	2	1	1	1	1/2	1/2
Earthquake	1	2	2	1	1	1	1/2	1
TWI	1	2	2	1	1	1	1	1
Landforms	2	3	3	2	2	1	1	1
Curvature	2	3	3	2	1	1	1	1
Weight	***0.1076***	***0.0684***	***0.0618***	***0.1159***	***0.1270***	***0.1391***	***0.1979***	***0.1823***

Consistency Ratio (CR) = 1.27%

Table 4.39 Reciprocal matrix and weight values between 10 factors for Watershed-15.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	1	1/2	2	1	1	3	1	1/2	1/2
Int. Relief	1	1	1/2	1	1/2	1/2	2	1/2	1/3	1/3
Rainfall	2	2	1	3	1	1	4	1/2	1	1
Lithology	1/2	1	1/3	1	1/2	1/2	2	1/2	1/3	1/3
Land Cover	1	2	1	2	1	1	3	1	1/2	1/2
Earthquake	1	2	1	2	1	1	3	1	1/2	1
Aspect	1/3	1/2	1/4	1/2	1/3	1/3	1	1/3	1/5	1/4
TWI	1	2	2	2	1	1	3	1	1/2	1/2
Landforms	2	3	1	3	2	2	5	2	1	1
Curvature	2	3	1	3	2	1	4	2	1	1
Weight	***0.0871***	***0.0579***	***0.1268***	***0.0518***	***0.0987***	***0.1065***	***0.0320***	***0.1103***	***0.1715***	***0.1575***

Consistency Ratio (CR) = 1.61%

4.3.16 Watershed No: 16 (Konya Kapalı)

The Study Area

Konya Kapalı watershed is located on the middle part of Turkey. Elevation ranges between 899 m and 3405 m in this region. Landslide activity of this watershed is very low according to landslide inventory map.

Historical landslides occurred in this region mostly located on the southern part of the watershed which is also overlays with Zone 4 and Zone 5 of earthquake zoning map of Turkey. Continental clastic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 68° in the region, most of historical landslides occurred between 5° and 15°. Most of landslides were occurred in south-west (SW) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 263 mm and 1113 mm. Historical landslides mainly occurred on the range between 400 mm to 500 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 862 m/km^2 in the watershed area, most of the landslides were occurred between 100 m/km^2 and 150 m/km^2. Semi-natural areas are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.40 (for 8 factors) and Table 4.41 (for 10 factors). The selection of the appropriate scores was summarized in Table A.15. Produced landslide susceptibility maps for this watershed were given in Figure B.29 (or 8 factors) and Figure B.30 (for 10 factors).

Table 4.40 Reciprocal matrix and weight values between 8 factors for Watershed-16.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1/2	1	1	1/2	1/2
Int. Relief	1/2	1	1	1	1	1	1/2	1/2
Lithology	1	1	1	1	1	1	1/2	1/2
Land Cover	2	1	1	1	1	1	1/2	1/2
Earthquake	1	1	1	1	1	1	1	1/2
TWI	1	1	1	1	1	1	1/2	1/2
Landforms	2	2	2	2	1	2	1	1
Curvature	2	2	2	2	2	2	1	1
Weight	*0.1040*	*0.0932*	*0.0992*	*0.1111*	*0.1105*	*0.0992*	*0.1845*	*0.1984*

Consistency Ratio (CR) = 1.59%

Table 4.41 Reciprocal matrix and weight values between 10 factors for Watershed-16.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	1	1	1	1	1	2	1	1/2	1/2
Int. Relief	1	1	1	1	1	1	2	1	1/2	1/2
Rainfall	1	1	1	1	1	1	2	1	1/2	1/2
Lithology	1	1	1	1	1	1	2	1	1/2	1/2
Land Cover	1	1	1	1	1	1	2	1	1/2	1/2
Earthquake	1	1	1	1	1	1	2	1	1	1/2
Aspect	1/2	1/2	1/2	1/2	1/2	1/2	1	1/2	1/3	1/3
TWI	1	1	1	1	1	1	2	1	1/2	1/2
Landforms	2	2	2	2	2	1	3	2	1	1
Curvature	2	2	2	2	2	2	3	2	1	1
Weight	*0.0877*	*0.0877*	*0.0877*	*0.0877*	*0.0877*	*0.0956*	*0.0466*	*0.0877*	*0.1611*	*0.1706*

Consistency Ratio (CR) = 0.36%

4.3.17 Watershed No: 17 (Doğu Akdeniz)

The Study Area

Doğu Akdeniz watershed is located on the southern part of Turkey. Elevation ranges between 0 m and 3487 m in this region. Landslide activity of this watershed is moderate according to landslide inventory map.

Historical landslides occurred in this region mostly located on the middle part of the watershed which is also overlays with Zone 5 of earthquake zoning map of Turkey. Continental clastic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 79° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in east (E) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 370 mm and 700 mm. Historical landslides mainly occurred on the range between 500 mm to 600 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 1395 m/km^2 in the watershed area, most of the landslides were occurred between 200 m/km^2 and 250 m/km^2. Agricultural areas are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.42 (for 8 factors) and Table 4.43 (for 10 factors). The selection of the appropriate scores was summarized in Table A.16. Produced landslide susceptibility maps for this watershed were given in Figure B.31 (or 8 factors) and Figure B.32 (for 10 factors).

Table 4.42 Reciprocal matrix and weight values between 8 factors for Watershed-17.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1	1	1	1	1/2
Int. Relief	1/2	1	1	1/2	1/2	1/2	1/2	1/3
Lithology	1	1	1	1/2	1/2	1	1/2	1/2
Land Cover	1	2	2	1	1	1	1	1
Earthquake	1	2	2	1	1	1	1	1
TWI	1	2	1	1	1	1	1/2	1/2
Landforms	1	2	2	1	1	2	1	1
Curvature	2	3	2	1	1	2	1	1
Weight	*0.1206*	*0.0673*	*0.0848*	*0.1417*	*0.1417*	*0.1110*	*0.1549*	*0.1779*

Consistency Ratio (CR) = 1.38%

Table 4.43 Reciprocal matrix and weight values between 10 factors for Watershed-17.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	1	1	1	1	3	1	1	1/2
Int. Relief	1/2	1	1/2	1	1/2	1/2	1	1/2	1/2	1/3
Rainfall	1	2	1	2	1	1	3	1	1	1
Lithology	1	1	1/2	1	1/2	1/2	2	1	1/2	1/2
Land Cover	1	2	1	2	1	1	3	1	1	1/2
Earthquake	1	2	1	2	1	1	3	1	1	1
Aspect	1/3	1	1/3	1/2	1/3	1/3	1	1/3	1/3	1/4
TWI	1	2	1	1	1	1	3	1	1/2	1/2
Landforms	1	2	1	2	1	1	3	2	1	1
Curvature	2	3	1	2	2	1	4	2	1	1
Weight	*0.1040*	*0.0548*	*0.1185*	*0.0709*	*0.1109*	*0.1185*	*0.0389*	*0.0976*	*0.1277*	*0.1580*

Consistency Ratio (CR) = 1.18%

4.3.18 Watershed No: 18 (Seyhan)

The Study Area

Seyhan watershed is located on the southern part of Turkey. Elevation ranges between 0 m and 3683 m in this region. Landslide activity of this watershed is very low according to landslide inventory map.

Historical landslides occurred in this region mostly located on the middle part of the watershed which is also overlays with Zone 3 and Zone 4 of earthquake zoning map of Turkey. Clastic and carbonate rocks and continental clastic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 77° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in north-west (NW) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 316 mm and 1062 mm. Historical landslides mainly occurred on the range between 300 mm to 600 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 1437 m/km^2 in the watershed area, most of the landslides were occurred between 200 m/km^2 and 250 m/km^2. Agricultural areas and forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.44 (for 8 factors) and Table 4.45 (for 10 factors). The selection of the appropriate scores was summarized in Table A.17. Produced landslide susceptibility maps for this watershed were given in Figure B.33 (or 8 factors) and Figure B.34 (for 10 factors).

Table 4.44 Reciprocal matrix and weight values between 8 factors for Watershed-18.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1	1/2	1	1	1/2
Int. Relief	1/2	1	1/2	1/2	1/2	1/2	1/2	1/3
Lithology	1	2	1	1	1/2	1	1	1/2
Land Cover	1	2	1	1	1	1	1	1/2
Earthquake	2	2	2	1	1	1	1	1
TWI	1	2	1	1	1	1	1	1/2
Landforms	1	2	1	1	1	1	1	1
Curvature	2	3	2	2	1	2	1	1
Weight	*0.1094*	*0.0614*	*0.1094*	*0.1190*	*0.1570*	*0.1190*	*0.1307*	*0.1942*

Consistency Ratio (CR) = 1.21%

Table 4.45 Reciprocal matrix and weight values between 10 factors for Watershed-18.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	1	1	1	1/2	2	1	1	1/2
Int. Relief	1/2	1	1/2	1/2	1/2	1/2	1	1/2	1/2	1/3
Rainfall	1	2	1	1	1/2	1/2	2	1	1/2	1/2
Lithology	1	2	1	1	1	1/2	2	1	1	1/2
Land Cover	1	2	2	1	1	1	3	1	1	1/2
Earthquake	2	2	2	2	1	1	3	1	1	1
Aspect	1/2	1	1/2	1/2	1/3	1/3	1	1/2	1/3	1/4
TWI	1	2	1	1	1	1	2	1	1	1/2
Landforms	1	2	2	1	1	1	3	1	1	1
Curvature	2	3	2	2	2	1	4	2	1	1
Weight	*0.0928*	*0.0512*	*0.0815*	*0.0928*	*0.1117*	*0.1381*	*0.0438*	*0.0997*	*0.1199*	*0.1684*

Consistency Ratio (CR) = 1.18%

4.3.19 Watershed No: 19 (Asi)

The Study Area

Asi watershed is located on the southern part of Turkey on the east of Mediterranean Sea. Elevation ranges between 0 m and 2201 m in this region. Landslide activity of this watershed is very low according to landslide inventory map.

Historical landslides occurred in this region mostly located on the southern part of the watershed which is also overlays with Zone 1 of earthquake zoning map of Turkey. Clastic and carbonate rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 74° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in west (W) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 493 mm and 980 mm. Historical landslides mainly occurred on the range between 700 mm to 900 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 1262 m/km^2 in the watershed area, most of the landslides were occurred between 100 m/km^2 and 150 m/km^2. Agricultural areas are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.46 (for 8 factors) and Table 4.47 (for 10 factors). The selection of the appropriate scores was summarized in Table A.18. Produced landslide susceptibility maps for this watershed were given in Figure B.35 (or 8 factors) and Figure B.36 (for 10 factors).

Table 4.46 Reciprocal matrix and weight values between 8 factors for Watershed-19.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	1	1	1/2	1/3	1	1/2	1/2
Int. Relief	1	1	1/2	1/2	1/3	1	1/2	1/2
Lithology	1	2	1	1/2	1/2	1	1/2	1/2
Land Cover	2	2	2	1	1/2	2	1	1
Earthquake	3	3	2	2	1	2	1	1
TWI	1	1	1	1/2	1/2	1	1/2	1/2
Landforms	2	2	2	1	1	2	1	1
Curvature	2	2	2	1	1	2	1	1
Weight	*0.0777*	*0.0722*	*0.0906*	*0.1513*	*0.1998*	*0.0817*	*0.1634*	*0.1634*

Consistency Ratio (CR) = 0.96%

Table 4.47 Reciprocal matrix and weight values between 10 factors for Watershed-19.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	1	1	1	1/2	1/3	2	1	1/2	1/2
Int. Relief	1	1	1	1/2	1/2	1/3	2	1	1/2	1/2
Rainfall	1	1	1	1	1/2	1/2	3	1	1/2	1/2
Lithology	1	2	1	1	1/2	1/2	3	1	1/2	1/2
Land Cover	2	2	2	2	1	1/2	4	2	1	1
Earthquake	3	3	2	2	2	1	6	2	1	1
Aspect	1/2	1/2	1/3	1/3	1/4	1/6	1	1/2	1/4	1/4
TWI	1	1	1	1	1/2	1/2	2	1	1/2	1/2
Landforms	2	2	2	2	1	1	4	2	1	1
Curvature	2	2	2	2	1	1	4	2	1	1
Weight	*0.0695*	*0.0656*	*0.0756*	*0.0820*	*0.1361*	*0.1774*	*0.0322*	*0.0723*	*0.1447*	*0.1447*

Consistency Ratio (CR) = 0.75%

4.3.20 Watershed No: 20 (Ceyhan)

The Study Area

Ceyhan watershed is located on the southern part of Turkey. Elevation ranges between 0 m and 3058 m in this region. Landslide activity of this watershed is low according to landslide inventory map.

Historical landslides occurred in this region mostly located on the middle part of the watershed which is also overlays with Zone 1, Zone 2 and Zone 3 of earthquake zoning map of Turkey. Clastic and carbonate rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 78° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in south-east (SE) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 317 mm and 1628 mm. Historical landslides mainly occurred on the range between 600 mm to 800 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 1147 m/km^2 in the watershed area, most of the landslides were occurred between 100 m/km^2 and 150 m/km^2. Agricultural areas are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.48 (for 8 factors) and Table 4.49 (for 10 factors). The selection of the appropriate scores was summarized in Table A.19. Produced landslide susceptibility maps for this watershed were given in Figure B.37 (or 8 factors) and Figure B.38 (for 10 factors).

Table 4.48 Reciprocal matrix and weight values between 8 factors for Watershed-20.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1/2	1/2	1	1/2	1/2
Int. Relief	1/2	1	1/3	1/4	1/4	1/3	1/4	1/4
Lithology	1	3	1	1/2	1	1	1	1
Land Cover	2	4	2	1	1	2	1	1
Earthquake	2	4	1	1	1	1	1	1
TWI	1	3	1	1/2	1	1	1/2	1/2
Landforms	2	4	1	1	1	2	1	1/2
Curvature	2	4	1	1	1	2	2	1
Weight	*0.0876*	*0.0393*	*0.1213*	*0.1752*	*0.1481*	*0.1018*	*0.1493*	*0.1774*

Consistency Ratio (CR) = 1.64%

Table 4.49 Reciprocal matrix and weight values between 10 factors for Watershed-20.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	2	1	1/2	1/2	2	1	1/2	1/2
Int. Relief	1/2	1	1	1/3	1/4	1/4	1	1/3	1/4	1/4
Rainfall	1/2	1	1	1/3	1/4	1/4	1	1	1/4	1/4
Lithology	1	3	3	1	1/2	1	3	1	1	1
Land Cover	2	4	4	2	1	1	4	2	1	1
Earthquake	2	4	4	1	1	1	4	1	1	1
Aspect	1/2	1	1	1/3	1/4	1/4	1	1/3	1/4	1/4
TWI	1	3	1	1	1/2	1	3	1	1/2	1/2
Landforms	2	4	4	1	1	1	4	2	1	1
Curvature	2	4	4	1	1	1	4	2	1	1
Weight	*0.0802*	*0.0368*	*0.0425*	*0.1133*	*0.1604*	*0.1407*	*0.0368*	*0.0905*	*0.1493*	*0.1493*

Consistency Ratio (CR) = 1.26%

4.3.21 Watershed No: 21 (Fırat)

The Study Area

Fırat watershed is located on the east part of Turkey. Elevation ranges between 317 m and 3838 m in this region. Landslide activity of this watershed is high according to landslide inventory map.

Historical landslides occurred in this region mostly located on the northern and the middle part of the watershed which is also overlays with Zone 1 and Zone 2 of earthquake zoning map of Turkey. Continental clastic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 74° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in west (W) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 254 mm and 1259 mm. Historical landslides mainly occurred on the range between 400 mm to 600 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 1114 m/km^2 in the watershed area, most of the landslides were occurred between 150 m/km^2 and 200 m/km^2. Agricultural areas and forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.50 (for 8 factors) and Table 4.51 (for 10 factors). The selection of the appropriate scores was summarized in Table A.20. Produced landslide susceptibility maps for this watershed were given in Figure B.39 (or 8 factors) and Figure B.40 (for 10 factors).

Table 4.50 Reciprocal matrix and weight values between 8 factors for Watershed-21.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1	1/2	1	1/2	1/2
Int. Relief	1/2	1	1	1/2	1/2	1/2	1/3	1/3
Lithology	1	1	1	1/2	1/2	1/2	1/3	1/3
Land Cover	1	2	2	1	1/2	1	1/2	1/2
Earthquake	2	2	2	2	1	1	1	1
TWI	1	2	2	1	1	1	1/2	1/2
Landforms	2	3	3	2	1	2	1	1
Curvature	2	3	3	2	1	2	1	1
Weight	*0.0969*	*0.0618*	*0.0678*	*0.1052*	*0.1642*	*0.1156*	*0.1942*	*0.1942*

Consistency Ratio (CR) = 1.10%

Table 4.51 Reciprocal matrix and weight values between 10 factors for Watershed-21.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	2	1	1	1/2	3	1	1/2	1/2
Int. Relief	1/2	1	1	1	1/2	1/2	2	1/2	1/3	1/3
Rainfall	1/2	1	1	1	1/2	1/3	2	1/2	1/3	1/3
Lithology	1	1	1	1	1/2	1/2	2	1/2	1/3	1/3
Land Cover	1	2	2	2	1	1/2	3	1	1/2	1/2
Earthquake	2	2	3	2	2	1	4	1	1	1
Aspect	1/3	1/2	1/2	1/2	1/3	1/4	1	1/3	1/5	1/5
TWI	1	2	2	2	1	1	3	1	1/2	1/2
Landforms	2	3	3	3	2	1	5	2	1	1
Curvature	2	3	3	3	2	1	5	2	1	1
Weight	*0.0917*	*0.0572*	*0.0547*	*0.0617*	*0.0977*	*0.1497*	*0.0321*	*0.1053*	*0.1749*	*0.1749*

Consistency Ratio (CR) = 0.81%

4.3.22 Watershed No: 22 (Doğu Karadeniz)

The Study Area

Doğu Karadeniz watershed is located on the northeast part of Turkey. Elevation ranges between 0 m and 3776 m in this region. Landslide activity of this watershed is high according to landslide inventory map.

Historical landslides occurred in this region located on every part of the watershed which is also overlays with every zone (1, 2, 3 and 4) of earthquake zoning map of Turkey. Volcanic and sedimentary rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 77° in the region, most of historical landslides occurred between 10° and 20°. Most of landslides were occurred in east (E) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 401 mm and 2594 mm. Historical landslides mainly occurred on the range between 900 mm to 1100 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 3 m/km^2 and 1102 m/km^2 in the watershed area, most of the landslides were occurred between 200 m/km^2 and 300 m/km^2. Agricultural areas are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.52 (for 8 factors) and Table 4.53 (for 10 factors). The selection of the appropriate scores was summarized in Table A.21. Produced landslide susceptibility maps for this watershed were given in Figure B.41 (or 8 factors) and Figure B.42 (for 10 factors).

Table 4.52 Reciprocal matrix and weight values between 8 factors for Watershed-22.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1/2	1	1	1/2	1/2
Int. Relief	1/2	1	1/2	1/3	1/2	1/2	1/2	1/2
Lithology	1	2	1	1/2	1	1	1	1
Land Cover	2	3	2	1	2	2	1	1
Earthquake	1	2	1	1/2	1	1	1/2	1/2
TWI	1	2	1	1/2	1	1	1	1
Landforms	2	2	1	1	2	1	1	1/2
Curvature	2	2	1	1	2	1	2	1
Weight	***0.0993***	***0.0610***	***0.1181***	***0.1908***	***0.0993***	***0.1181***	***0.1432***	***0.1703***

Consistency Ratio (CR) = 1.84%

Table 4.53 Reciprocal matrix and weight values between 10 factors for Watershed-22.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	1	1	1/2	1	2	1	1/2	1/2
Int. Relief	1/2	1	1	1/2	1/3	1/2	1	1/2	1/2	1/2
Rainfall	1	1	1	1/2	1/3	1/2	1	1	1/2	1/2
Lithology	1	2	2	1	1/2	1	2	1	1	1
Land Cover	2	3	3	2	1	2	3	2	1	1
Earthquake	1	2	2	1	1/2	1	2	1	1/2	1/2
Aspect	1/2	1	1	1/2	1/3	1/2	1	1/2	1/2	1/3
TWI	1	2	1	1	1/2	1	2	1	1	1
Landforms	2	2	2	1	1	2	2	1	1	1
Curvature	2	2	2	1	1	2	3	1	1	1
Weight	***0.0873***	***0.0549***	***0.0641***	***0.1070***	***0.1700***	***0.0935***	***0.0526***	***0.1007***	***0.1324***	***0.1376***

Consistency Ratio (CR) = 1.35%

4.3.23 Watershed No: 23 (Çoruh)

The Study Area

Çoruh watershed is located on the northeast part of Turkey. Elevation ranges between 53 m and 3893 m in this region. Landslide activity of this watershed is high according to landslide inventory map.

Historical landslides occurred in this region located on the every part of the watershed which is also overlays with Zone 1, Zone 2 and Zone 3 of earthquake zoning map of Turkey. Clastic and carbonate rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 75° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in west (W) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 311 mm and 2038 mm. Historical landslides mainly occurred on the range between 400 mm to 500 mm. TWI values ranges between 8 to 24 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 4 m/km^2 and 1027 m/km^2 in the watershed area, most of the landslides were occurred between 200 m/km^2 and 300 m/km^2. Forests and agricultural areas are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.54 (for 8 factors) and Table 4.55 (for 10 factors). The selection of the appropriate scores was summarized in Table A.22. Produced landslide susceptibility maps for this watershed were given in Figure B.43 (or 8 factors) and Figure B.44 (for 10 factors).

Table 4.54 Reciprocal matrix and weight values between 8 factors for Watershed-23.

Factors^{8}	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1	1	1	1	1/2
Int. Relief	1/2	1	1/2	1/2	1/2	1/2	1/2	1/3
Lithology	1	2	1	1/2	1/2	1	1/2	1/2
Land Cover	1	2	2	1	1/2	1	1	1/2
Earthquake	1	2	2	2	1	1	1	1
TWI	1	2	1	1	1	1	1/2	1/2
Landforms	1	2	2	1	1	2	1	1
Curvature	2	3	2	2	1	2	1	1
Weight	*0.1184*	*0.0612*	*0.0923*	*0.1197*	*0.1549*	*0.1088*	*0.1542*	*0.1906*

Consistency Ratio (CR) = 1.85%

Table 4.55 Reciprocal matrix and weight values between 10 factors for Watershed-23.

Factors^{10}	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	1	1	1	1	2	1	1	1/2
Int. Relief	1/2	1	1/2	1/2	1/2	1/2	1	1/2	1/2	1/3
Rainfall	1	2	1	1	1	1	2	1	1	1
Lithology	1	2	1	1	1/2	1/2	2	1	1/2	1/2
Land Cover	1	2	1	2	1	1	2	1	1	1/2
Earthquake	1	2	1	2	1	1	3	1	1	1
Aspect	1/2	1	1/2	1/2	1/2	1/3	1	1/2	1/3	1/3
TWI	1	2	1	1	1	1	2	1	1/2	1/2
Landforms	1	2	1	2	1	1	3	2	1	1
Curvature	2	3	1	2	2	1	3	2	1	1
Weight	*0.1007*	*0.0516*	*0.1082*	*0.0831*	*0.1084*	*0.1207*	*0.0475*	*0.0944*	*0.1298*	*0.1556*

Consistency Ratio (CR) = 1.25%

4.3.24 Watershed No: 24 (Aras)

The Study Area

Aras watershed is located on the east part of Turkey. Elevation ranges between 792 m and 5100 m in this region. Landslide activity of this watershed is high according to landslide inventory map.

Historical landslides occurred in this region mostly located on the southern part of the watershed which is also overlays with Zone 1 and Zone 2 of earthquake zoning map of Turkey. Continental clastic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 80° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in west (W) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 227 mm and 778 mm. Historical landslides mainly occurred on the range between 400 mm to 600 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 1961 m/km^2 in the watershed area, most of the landslides were occurred between 150 m/km^2 and 250 m/km^2. Semi-natural areas and forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.56 (for 8 factors) and Table 4.57 (for 10 factors). The selection of the appropriate scores was summarized in Table A.23. Produced landslide susceptibility maps for this watershed were given in Figure B.45 (or 8 factors) and Figure B.46 (for 10 factors).

Table 4.56 Reciprocal matrix and weight values between 8 factors for Watershed-24.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	2	1	1/2	1	1/2	1/2
Int. Relief	1/2	1	1	1/2	1/3	1/2	1/3	1/2
Lithology	1/2	1	1	1/2	1/4	1/2	1/4	1/3
Land Cover	1	2	2	1	1/2	1	1/2	1/2
Earthquake	2	3	4	2	1	3	1	1
TWI	1	2	2	1	1/3	1	1/2	1/2
Landforms	2	3	4	2	1	2	1	1
Curvature	2	2	3	2	1	2	1	1
Weight	*0.1019*	*0.0610*	*0.0529*	*0.1019*	*0.2073*	*0.0976*	*0.1959*	*0.1815*

Consistency Ratio (CR) = 0.76%

Table 4.57 Reciprocal matrix and weight values between 10 factors for Watershed-24.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	1	2	1	1/2	3	1	1/2	1/2
Int. Relief	1/2	1	1/2	1	1/2	1/3	2	1/2	1/3	1/2
Rainfall	1	2	1	2	1	1/2	3	1/2	1/2	1/2
Lithology	1/2	1	1/2	1	1/2	1/4	1	1/2	1/4	1/3
Land Cover	1	2	1	2	1	1/2	2	1	1/2	1/2
Earthquake	2	3	2	4	2	1	5	2	1	1
Aspect	1/3	1/2	1/3	1	1/2	1/5	1	1/3	1/5	1/4
TWI	1	2	2	2	1	1/2	3	1	1/2	1/2
Landforms	2	3	2	4	2	1	5	2	1	1
Curvature	2	2	2	3	2	1	4	2	1	1
Weight	*0.0906*	*0.0540*	*0.0860*	*0.0450*	*0.0872*	*0.1724*	*0.0348*	*0.0987*	*0.1724*	*0.1590*

Consistency Ratio (CR) = 0.88%

4.3.25 Watershed No: 25 (Van Gölü)

The Study Area

Van Gölü watershed is located on the east part of Turkey. Elevation ranges between 1638 m and 4029 m in this region. Landslide activity of this watershed is high according to landslide inventory map.

Historical landslides occurred in this region located on every part of the watershed which is also overlays with Zone 1 and Zone 2 of earthquake zoning map of Turkey. Clastic and carbonate rocks and continental clastic rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 61° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in north-west (NW) and west (W) directions of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 358 mm and 912 mm. Historical landslides mainly occurred on the range between 400 mm to 500 mm. TWI values ranges between 8 to 23 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 753 m/km^2 in the watershed area, most of the landslides were occurred between 150 m/km^2 and 200 m/km^2. Forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.58 (for 8 factors) and Table 4.59 (for 10 factors). The selection of the appropriate scores was summarized in Table A.24. Produced landslide susceptibility maps for this watershed were given in Figure B.47 (or 8 factors) and Figure B.48 (for 10 factors).

Table 4.58 Reciprocal matrix and weight values between 8 factors for Watershed-25.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	3	2	1	1/2	1	1/2	1/2
Int. Relief	1/3	1	2	1/2	1/3	1/2	1/3	1/3
Lithology	1/2	1/2	1	1/2	1/4	1/2	1/3	1/3
Land Cover	1	2	2	1	1/2	1	1/2	1/2
Earthquake	2	3	4	2	1	2	1	1
TWI	1	2	2	1	1/2	1	1/2	1/2
Landforms	2	3	3	2	1	2	1	2
Curvature	2	3	3	2	1	2	1/2	1
Weight	*0.1081*	*0.0609*	*0.0508*	*0.1010*	*0.1948*	*0.1010*	*0.2085*	*0.1748*

Consistency Ratio (CR) = 1.58%

Table 4.59 Reciprocal matrix and weight values between 10 factors for Watershed-25.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	1	2	1	1/2	2	1	1/2	1/2
Int. Relief	1/2	1	1/2	1	1/2	1/3	1	1/2	1/3	1/3
Rainfall	1	2	1	3	1	1/2	3	1/2	1	1
Lithology	1/2	1	1/3	1	1/2	1/4	1	1/2	1/3	1/3
Land Cover	1	2	1	2	1	1/2	2	1	1/2	1/2
Earthquake	2	3	2	4	2	1	3	2	1	1
Aspect	1/2	1	1/3	1	1/2	1/3	1	1/2	1/3	1/3
TWI	1	2	2	2	1	1/2	2	1	1/2	1/2
Landforms	2	3	1	3	2	1	3	2	1	1
Curvature	2	3	1	3	2	1	3	2	1	1
Weight	*0.0888*	*0.0484*	*0.1089*	*0.0453*	*0.0888*	*0.1678*	*0.0467*	*0.0986*	*0.1534*	*0.1534*

Consistency Ratio (CR) = 1.23%

4.3.26 Watershed No: 26 (Dicle)

The Study Area

Dicle watershed is located on the southeast part of Turkey. Elevation ranges between 333 m and 3935 m in this region. Landslide activity of this watershed is high according to landslide inventory map.

Historical landslides occurred in this region mostly located on every part of the watershed which is also overlays with Zone 1 and Zone 2 of earthquake zoning map of Turkey. Clastic and carbonate rocks are the most landslide prone lithologies according to historical landslide records. It is clear that planar slope (S/S) curvature and open slope landforms seems more prone to landslide rather than other curvature and landform classes in this region. Slope angle ranges between 0° and 78° in the region, most of historical landslides occurred between 10° and 15°. Most of landslides were occurred in east (E) direction of slope aspect but there is no significant difference with the consequent classes.

Annual mean total rainfall distribution in the area ranges between 299 mm and 1887 mm. Historical landslides mainly occurred on the range between 900 mm to 1000 mm. TWI values ranges between 8 to 24 and most of landslides occurred on the areas having value between 12 and 13. Internal relief is also varies between 0 m/km^2 and 1293 m/km^2 in the watershed area, most of the landslides were occurred between 150 m/km^2 and 300 m/km^2. Forests are the land cover types that historical landslides are mainly located on.

The Application of AHP Method

Pairwise comparison matrixes were built during AHP implementation for this region and factor weights were also given for both approaches in Table 4.60 (for 8 factors) and Table 4.61 (for 10 factors). The selection of the appropriate scores was summarized in Table A.25. Produced landslide susceptibility maps for this watershed were given in Figure B.49 (or 8 factors) and Figure B.50 (for 10 factors).

Table 4.60 Reciprocal matrix and weight values between 8 factors for Watershed-26.

Factors[8]	Slope	Int. Relief	Lithology	Land Cover	Earthquake	TWI	Landforms	Curvature
Slope	1	2	1	1/2	1/2	1	1/2	1/2
Int. Relief	1/2	1	1/2	1/3	1/4	1/2	1/3	1/3
Lithology	1	2	1	1	1/2	1	1	1
Land Cover	2	3	1	1	1/2	1	1	1
Earthquake	2	4	2	2	1	2	1	1
TWI	1	2	1	1	1/2	1	1	1
Landforms	2	3	1	1	1	1	1	1
Curvature	2	3	1	1	1	1	1	1
Weight	***0.0910***	***0.0499***	***0.1172***	***0.1343***	***0.1979***	***0.1172***	***0.1463***	***0.1463***

Consistency Ratio (CR) = 1.28%

Table 4.61 Reciprocal matrix and weight values between 10 factors for Watershed-26.

Factors[10]	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
Slope	1	2	1	1	1/2	1/2	3	1	1/2	1/2
Int. Relief	1/2	1	1/2	1/2	1/3	1/4	1	1/2	1/3	1/3
Rainfall	1	2	1	1	1	1/2	3	1	1/2	1/2
Lithology	1	2	1	1	1	1/2	3	1	1	1
Land Cover	2	3	1	1	1	1/2	3	1	1	1
Earthquake	2	4	2	2	2	1	5	2	1	1
Aspect	1/3	1	1/3	1/3	1/3	1/5	1	1/3	1/4	1/4
TWI	1	2	1	1	1	1/2	3	1	1	1
Landforms	2	3	2	1	1	1	4	1	1	1
Curvature	2	3	2	1	1	1	4	1	1	1
Weight	***0.0823***	***0.0426***	***0.0878***	***0.1010***	***0.1131***	***0.1722***	***0.0335***	***0.1010***	***0.1333***	***0.1333***

Consistency Ratio (CR) = 1.10%

CHAPTER 5

DISCUSSION OF THE RESULTS

5.1 National level landslide susceptibility assessment

The performances of four different weight groups given in Table 3.3 were compared and evaluated using a receiver operator characteristics (ROC) curve. The area under the ROC curve shows the global accuracy statistics for the each of the four maps. When the area under the ROC curves (Figure 5.1) is to be considered, it is observed that that the W_3 group is superior to the other W_i groups in prediction skills.

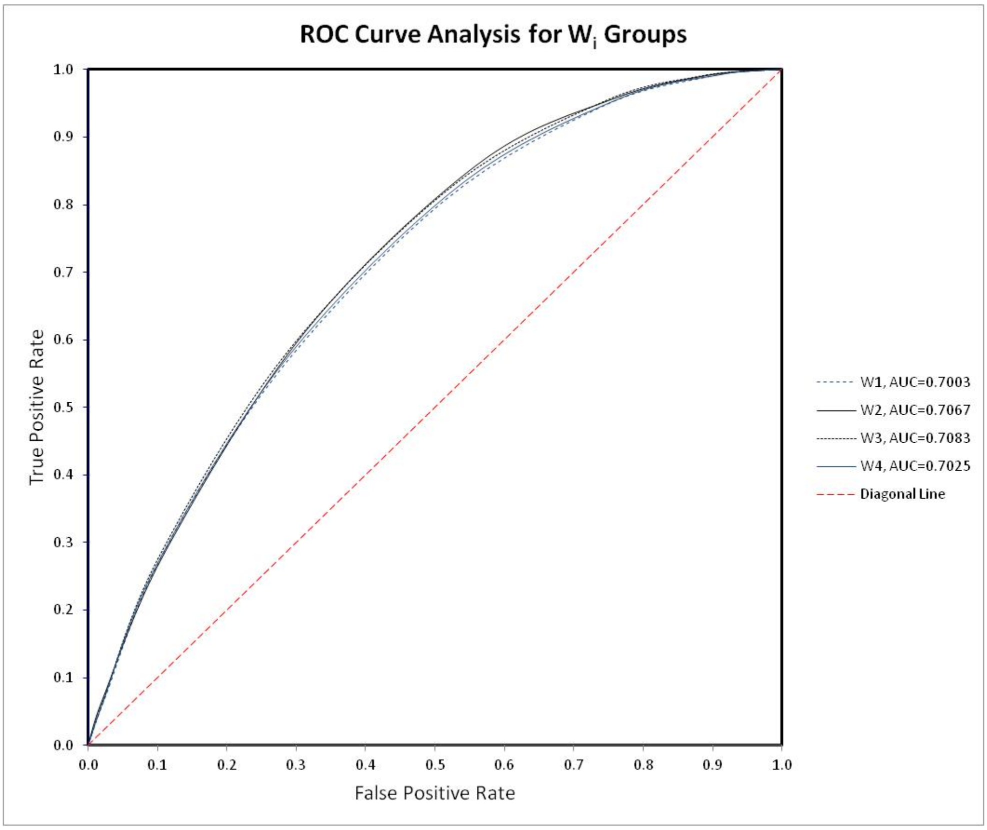

Figure 5.1 ROC curves for different weight groups in LSI.

The Landslide Susceptibility Index calculated by integrating the previously mentioned factors may range from 0 to 10. These values have been grouped into five susceptibility classes: no susceptibility (0–2), low (2–4), moderate (4–6), high (6–7) and very high (7–10) susceptibility (Figure 5.2). The no susceptibility class represents 4.2% of the Turkish territory (plains and low hills), low susceptibility class 36.4%, medium susceptibility 8.3%, high susceptibility 47.5% and very high susceptibility classes 3.6%, mostly in the western and middle Black Sea Region.

The reliability of the heuristic landslide susceptibility model based on the Landslide Susceptibility Index has been evaluated in nationwide scale using landslide inventories produced by MTA. In order to evaluate the predictive capability of the approach for Turkey, landslide inventory boundaries covering an area of approximately 30,000 km^2 has been used.

LSI values classified as “located in these boundaries” and also “located outside of these boundaries” are summarized in Table 5.1 and Figure 5.3. It is clear that the predicted LSI values located in real landslide boundaries has a left skewed graphic that implies that most of the real landslide areas were predicted by the approach. Distribution of off side real landslide boundaries represents an M shaped graphic. There is a clear cut located approximately on moderate class at the boundary between no-low class and high-very high class. Moderate class value could be used as a “threshold”, where values below this threshold could be assigned as “No Landslide” and others as “Landslide Susceptible”.

The reason for such an output could be modeling Turkey in its entirety in one simple mathematical expression with only six parameters. Each of these parameters has been weighed with a constant value for entire Turkey. Unfortunately, this approach has not led to consistent results for a nationwide study, owing to the small scale utilized.

According to Cascini (2008), preliminary zoning levels could be obtained by considering only basic methods (i.e., heuristic procedures) at small scaled landslide susceptibility assessments. The purpose of these studies that have small scales is only for information. In fact, 1:2,000,000 scale is very small in order to obtain detailed landslide susceptibility assessment for the entire Turkey. Pixel size was selected as large as 500 m for satisfying 1:2,000,000 scale. On the other hand, data sets (layers) used for this stage have approximately 3,134,248 pixels (in 500 m resolution) that is very large data file for analyzing on a tradition PC. If pixel size would be selected as 90 m, data sets would have approximately 96,736,049 pixels. This value is not a feasibly data file size for handling by any PC during analysis stages. The only reason for handling these huge data is not the capacity of PC, or the speed of processor; the main reason is architecture of GIS software on the market. Most of these software use only one core of the processor without considering other cores of the processor. Briefly, your GIS software is as powerful as your core speed of the processor that is the main limitation factor for handling huge datasets.

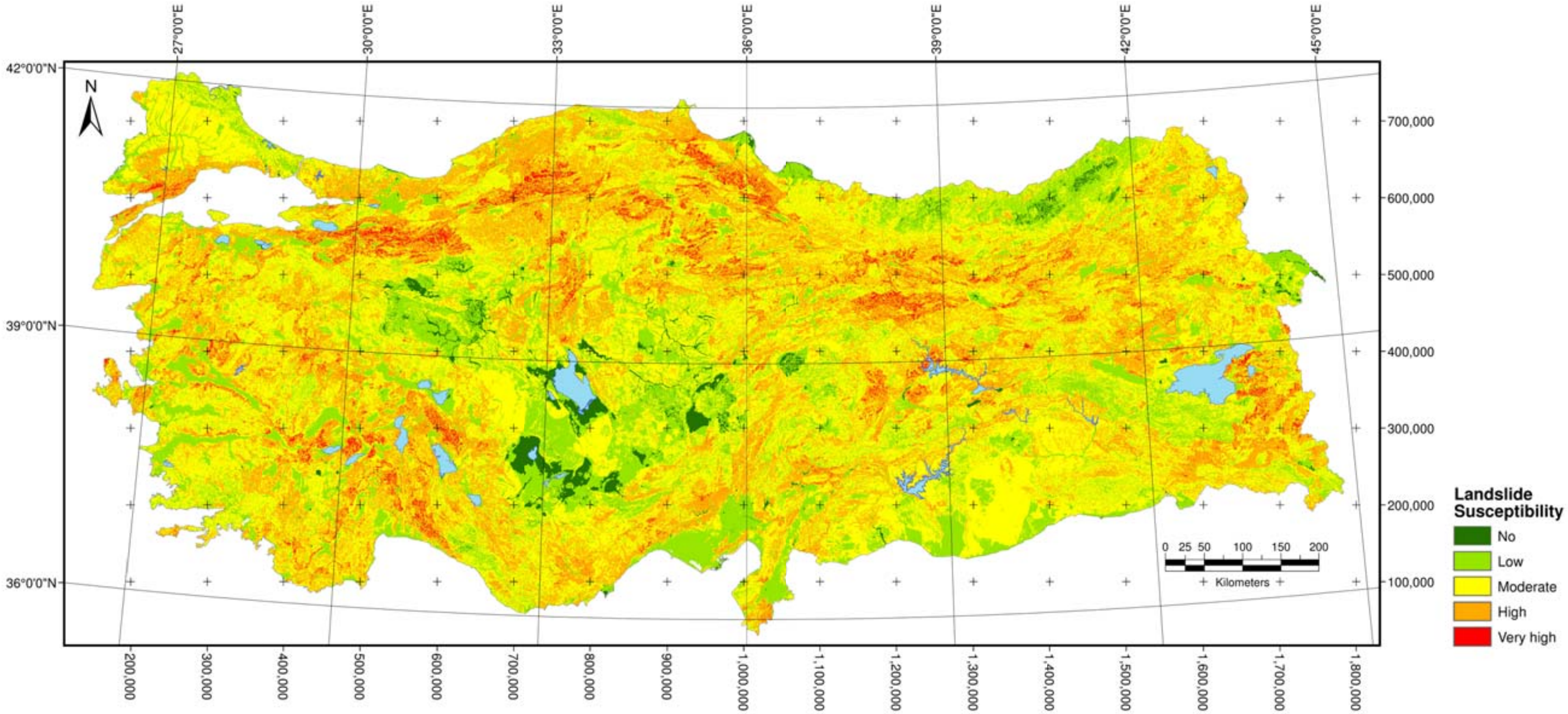

Figure 5.2 Landslide susceptibility assessment map of Turkey using LSI (W_3).

Table 5.1 Distribution of landslide susceptibility classes by test polygons.

Class	Areas in the Landslide Boundaries		Areas ouf of the Landslide Boundaries	
	Area (km^2)	%	Area (km^2)	%
No	38.7	0.13	32624.2	4.33
Low	1280.4	4.31	279880	37.13
Moderate	11401.6	38.34	63164.8	8.38
High	15241.4	51.25	351815.1	46.67
Very High	1777	5.98	26338.9	3.49
Totals	29739.1	100	753823.0	100

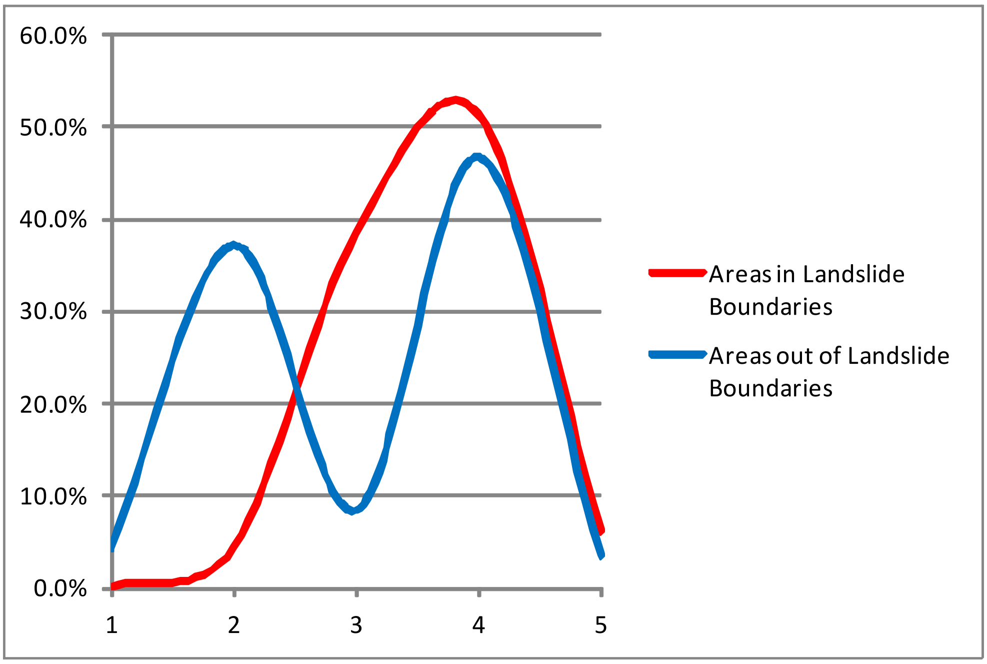

Figure 5.3 LSI class distributions through in-landslide and off-landslide areas.

Landslide susceptibility of Turkey was also studied on Chapter 4 using larger scale (90 m pixel resolution) data sets by dividing Turkey into 26 different zones. These zones were the main watersheds that were defined by highpoints and ridgelines that descend into lower elevations and main stream valleys. After analyzing these 26 main watersheds one by one, entire landslide susceptibility map of Turkey was obtained by merging these 26 zones.

5.2 Regional level landslide susceptibility assessment

Landslides are one of the most occurred natural hazards in our country. Stream channel incisions, seismic activity, heavy rainfall and anthropogenic effects are the main triggering factors of landslides. However, there is no nationwide study has been performed for obtaining the landslide susceptibility map of the entire Turkey. In the previous chapter, the landslide susceptibility map of Turkey was obtained with inadequate results considering its small scale (lower resolution) study. In this chapter, not only scale and the number of study regions are increased, but also study methodology is completely changed as well.

In Chapter 4, the entire Turkey was divided into main 26 watersheds with increased spatial resolution (90 m) in a larger scale (1:500,000). Every watershed was studied on its own, with two different factor sets processed in AHP method. The main reason was handling landslide susceptibly in each watershed uniquely with detailed resolution.

The slope, internal relief, lithology, land cover, aspect, topographic wetness index (TWI), classified landforms and classified curvature were selected as casual factors and rainfall intensity and earthquake were selected as triggering factors for AHP based studies carried out in Chapter 4. The reason for selecting these 10 factors is their publicly availability and their widely usage in landslide susceptibility research studies as causative factors. These factors were grouped into two sets, 10 factors and 8 factors. The aspect and rainfall intensity that are the least effective factors were separated from these 10 factors, the landslide susceptibility assessment of each watershed was performed using AHP with these 8 factors and 10 factors based data sets respectively.

In this section each watershed shall be discussed on its own and the results for the related watershed shall also be given separately.

5.2.1 Watershed No: 1 (Meriç-Ergene)

Pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Meriç-Ergene watershed were classified into 10 subclasses having a bin width of 0.10. The aim of this reclassification process was to simplify the produced maps and to aid the reader in understanding the distribution of the potential landslides areas in the watershed.

Landslide inventory maps published in hardcopy format by Mineral Research and Exploration Institute (MTA) were purchased and these maps were digitized in 1:500,000 scale. Digitized historical landslide boundaries were overlaid with produced landslides susceptibility maps for 8 factors and 10 factors after the classification process. For each map, total pixel counts in the landslide areas and out of the landslide areas are summarized in Table 5.2, considering a bin width having 0.10 values.

Table 5.2 Pixel counts in and out of historical landslide boundaries for Watershed-1.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	53	0	976	0
0.2	40093	0	54299	0
0.3	347632	0	314850	0
0.4	759892	2	395200	1
0.5	361051	4	590673	7
0.6	113679	11	239343	5
0.7	90904	21	105225	17
0.8	57053	21	67749	28
0.9	11944	4	14036	5
1	772	0	721	0

Histogram curves for each column (8 factors' pixel counts in landslide area, 8 factors' pixel counts out of landslide area, 10 factors' pixel counts in landslide area and 10 factors' pixel counts out of landslide area) were plotted in Figure 5.4 using pixel counts given in Table 5.2. Left axis values stands for pixel counts for out of landslide boundaries and right axis values stands for pixel counts for in landslide boundaries. Ranges of both axes differ with each other unless it is not possible to see inner and outer landslides boundary values (curves) on one figure. Peak locations tried to be plotted on the same horizontal line (E line on Figure 5.4) without considering peak values during this stage.

The major problem we faced after obtaining two different maps is which map to select, 8 factors based or 10 factors based landslide susceptibility map for the watershed.

For the ideal condition, the perfect histogram curve obtained from pixel values located in historical landslide boundaries should be right tailed, or peak value of this curve should be closest to (horizontal axis of histogram) value 1. On the other hand, the perfect histogram curve obtained from pixel values located out of historical landslide boundaries should be left tailed, or peak value of this curve should be closest to (horizontal axis of histogram) value 0. This criterion was selected as a rule of thumb for preliminary selection of 8 factors based or 10 factors based map.

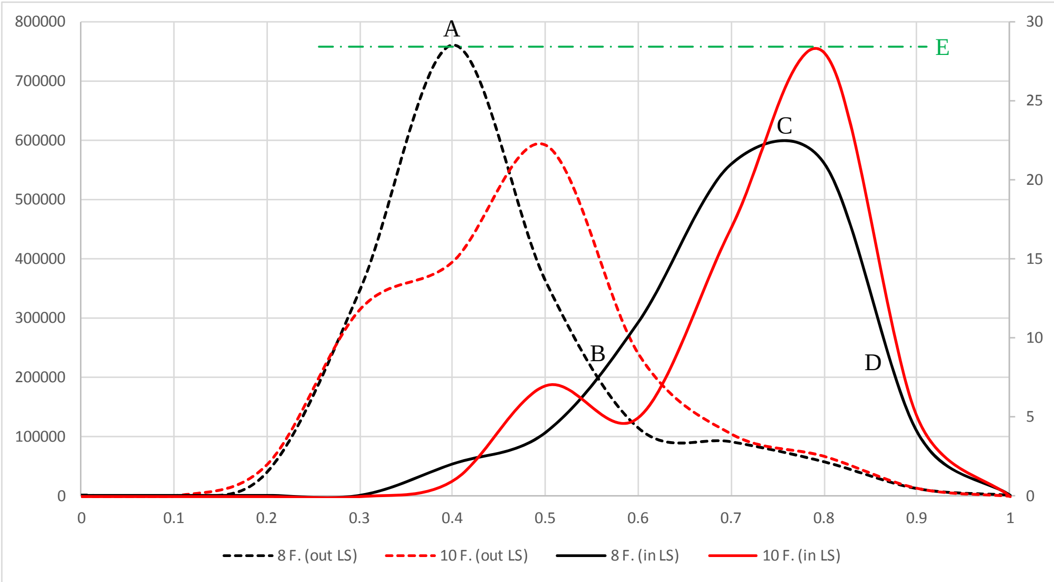

Figure 5.4 Histogram curves for the in and out of landslide boundaries for Watershed-1.

According to Figure 5.4, 10 factors based histogram for pixel values located in historical landslide boundaries are more close to value 1 than 8 factors based histogram. However, 8 factors based histogram for pixel values located out of historical landslide boundaries are more close to value 0 than 10 factors based histogram. Briefly, 10 factors based map gives better results for areas located in landslide boundaries but 8 factors based map gives better results for areas out of landslide boundaries abruptly for this watershed. One of the solutions for this dilemma is to review receiver operator characteristics (ROC) curve analysis for these susceptibility maps.

The performances of two different maps (8 factors based and 10 factors based) were compared and evaluated using ROC curves. The area under the ROC curve shows the global accuracy statistics for the each of these two maps. When the area under the ROC curves (Fig. 5.5) is to be considered, it is observed that 8 factors based map is superior to the other map in prediction skills. 8 factors based approach also more accurate than 10 factors based approach.

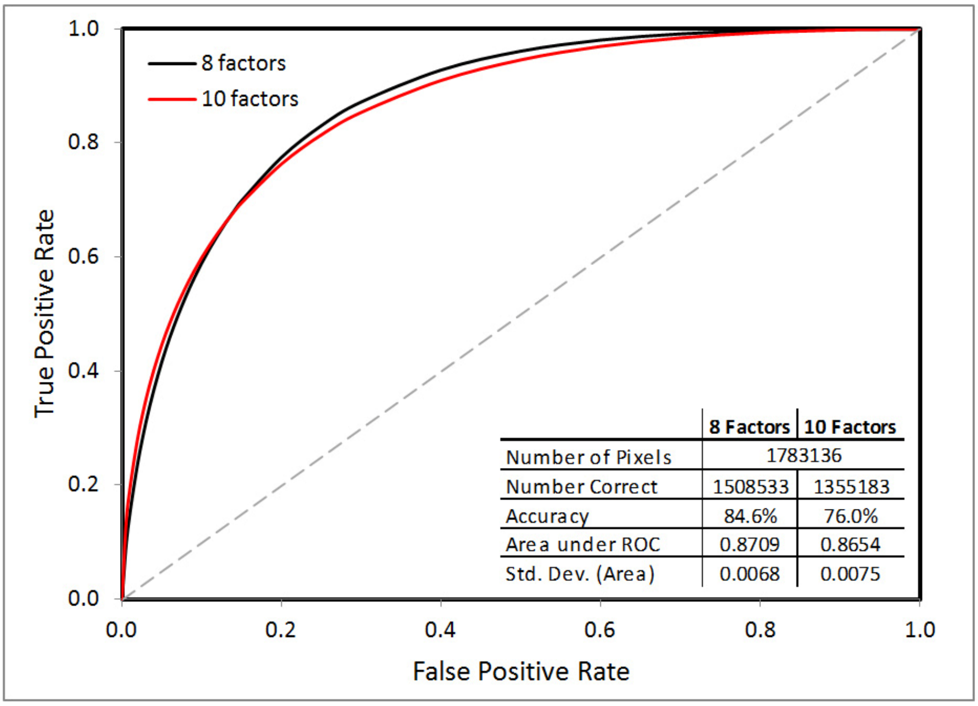

Figure 5.5 ROC curve analysis results for both 8 factors and 10 factors based landslide susceptibility maps for Watershed-1.

Another solution could be reviewing historical landslide occurrences in the watershed for selecting 8 or 10 factors based maps. The Meriç-Ergene watershed has very low landslide activity according to Table 5.6. It could be concluded that performances of both proposed 8 and 10 factors based maps are more important for non-landslide occurred areas than landslides occurred. 8 factors' histogram curve for areas out of historical landslides is more close to value 0 than curve of 10 factors in Figure 5.4 for the Meriç-Ergene watershed. 8 factors based landslide susceptibility map was selected in light of the foregoing for Watershed-1.

These kind of maps (susceptibility maps, risk maps, etc.) are generally reclassified into 3 or 5 synthetic classes (no, low, moderate, high, very high, etc.) for easy understanding. Another problem for this study was that since landslide susceptibility maps for produced each watershed of Turkey were completely different from each other and generic threshold values (e.g. 0, 0.2, 0.4, 0.6, 0.8, 1.0) could not be used for any of these landslide susceptibility maps. Hence, each of these maps must be analyzed separately, and the threshold values must be determined differently. Some other methods were performed for synthetic classification; unfortunately none of them give sufficient results. For example, natural breaks (jenks) which is so popular method for these type classification procedures results 0.64 threshold for "Very High" subclass. On the other hand, quantile method results 0.49 and geometrical interval method results 0.71 threshold value for "Very High" subclass. After applying any of the methods mentioned above, most of the area of Watershed-1 classified as very highly susceptible to landslide, which is illogical situation by considering very low landslide activity of this watershed. Briefly, standard procedures could not handle well enough synthetic classification of maps produced in this study.

A new procedure which is more subjective tried to be develop during synthetic classification of produced maps. Firstly, all peak values of both inner and out landslides boundaries were plotted on the same line (E) without considering their real values in Figure 5.4. Peak value (A) of outer landslide pixel count histogram curve was selected as first threshold value between No and Low classes. Intersection (B) of outer landslide histogram curve and inner landslide histogram curve was selected as second threshold value between Low and Moderate classes. Peak value (C) of inner landslide pixel count histogram curve was selected as third threshold value between Moderate and High classes. Finally, midpoint (D) between C and value of 1.0 was selected as fourth threshold value between High and Very High classes. These thresholds and bin widths for synthetic classes were summarized in Table 5.3. Finally landslide susceptibility map of the Meriç-Ergene watershed was classified according to Table 5.3 and given in Figure 5.6.

Table 5.3 Threshold values and bin widths selected for synthetic classification of Watershed-1 (for 8 factors).

Class	Bin
No	0 - 0.4
Low	0.4 - 0.55
Moderate	0.55 - 0.75
High	0.75 - 0.88
Very high	0.88 - 1

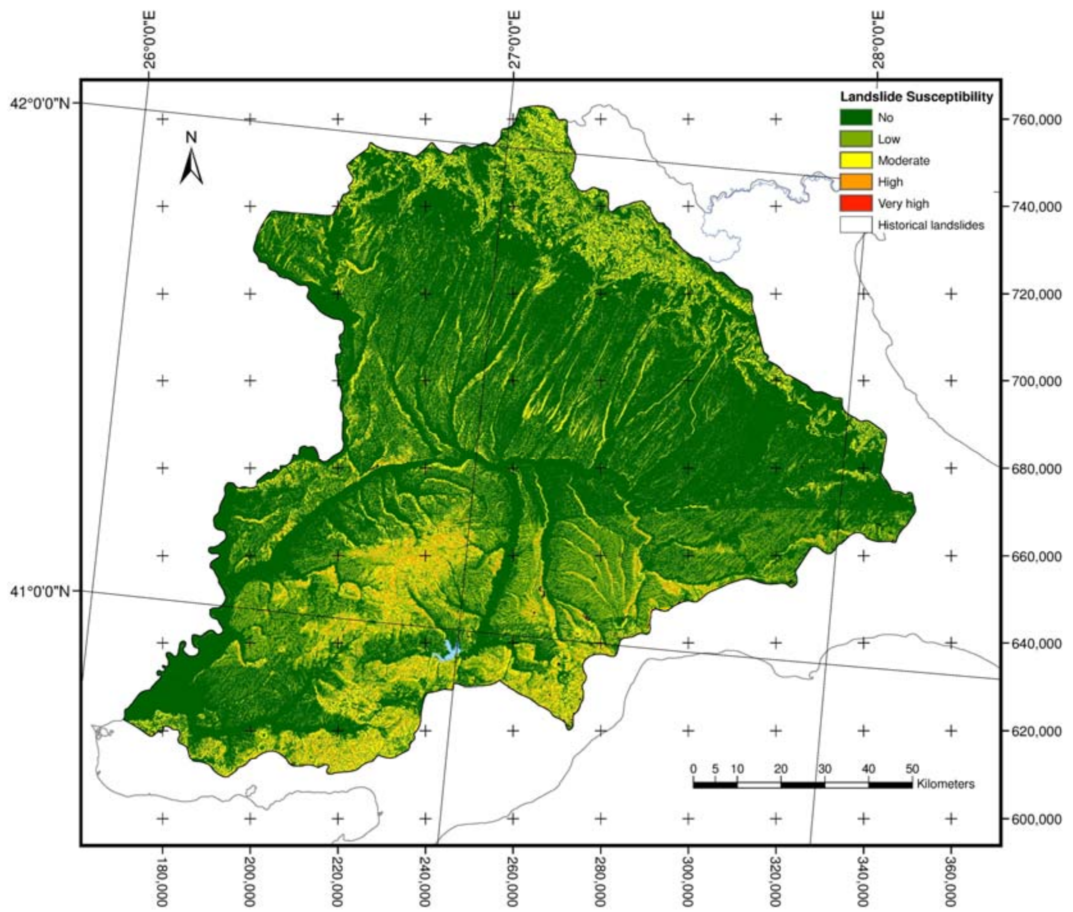

Figure 5.6 Synthetically classified landslide susceptibility map for Watershed-1.

5.2.2 Watershed No: 2 (Marmara)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Marmara watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.1 for the 8 factor based and 10 factor based maps, respectively.

The histogram curves for each column are plotted in Figure 5.7 using the pixel counts given in Table D.1. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.7. However, the 10 factor based histogram for the pixel values located out of the historical landslide boundaries are more close to a value of 0 than the 8 factor based histogram. According to these histogram curves, the 10 factor based map gives better results for both of the areas that are located in the inner and outer landslide boundaries.

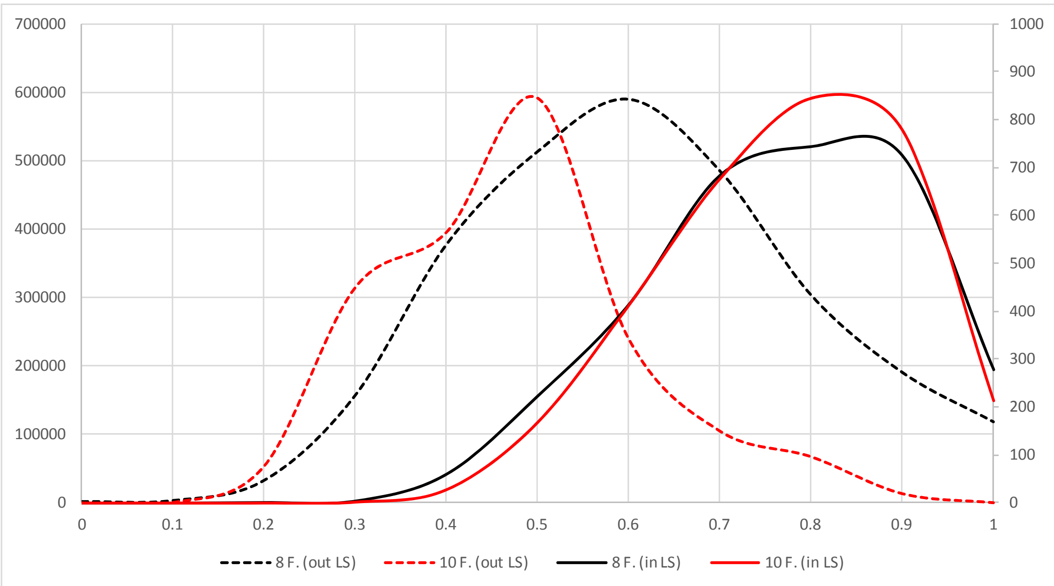

Figure 5.7 Histogram curves for the in and out of landslide boundaries for Watershed-2.

The area under the ROC curve (Fig. E.1) plotted for the 8 factor based map gives a slightly greater value than the 10 factor based map. Unfortunately, the 8 factor based approach is more accurate than the 10 factor based one. The ROC curve analysis does not provide enough information for selecting an 8 or 10 factor based map in this watershed.

Finally, the 10 factor based map was selected for this watershed by considering its proximity to a value of 0 for the peak value of the outer landslide areas histogram curve. The threshold values were selected as described in the previous section and summarized in Table 5.4 for this watershed. The landslide susceptibility map of the Marmara watershed was classified into five groups according to Table 5.4 and given in Figure 5.8.

Table 5.4 Threshold values and bin widths selected for synthetic classification of Watershed-2 (for 10 factors).

Class	Bin
No	0 - 0.5
Low	0.5 - 0.58
Moderate	0.58 - 0.83
High	0.83 - 0.92
Very high	0.92 - 1

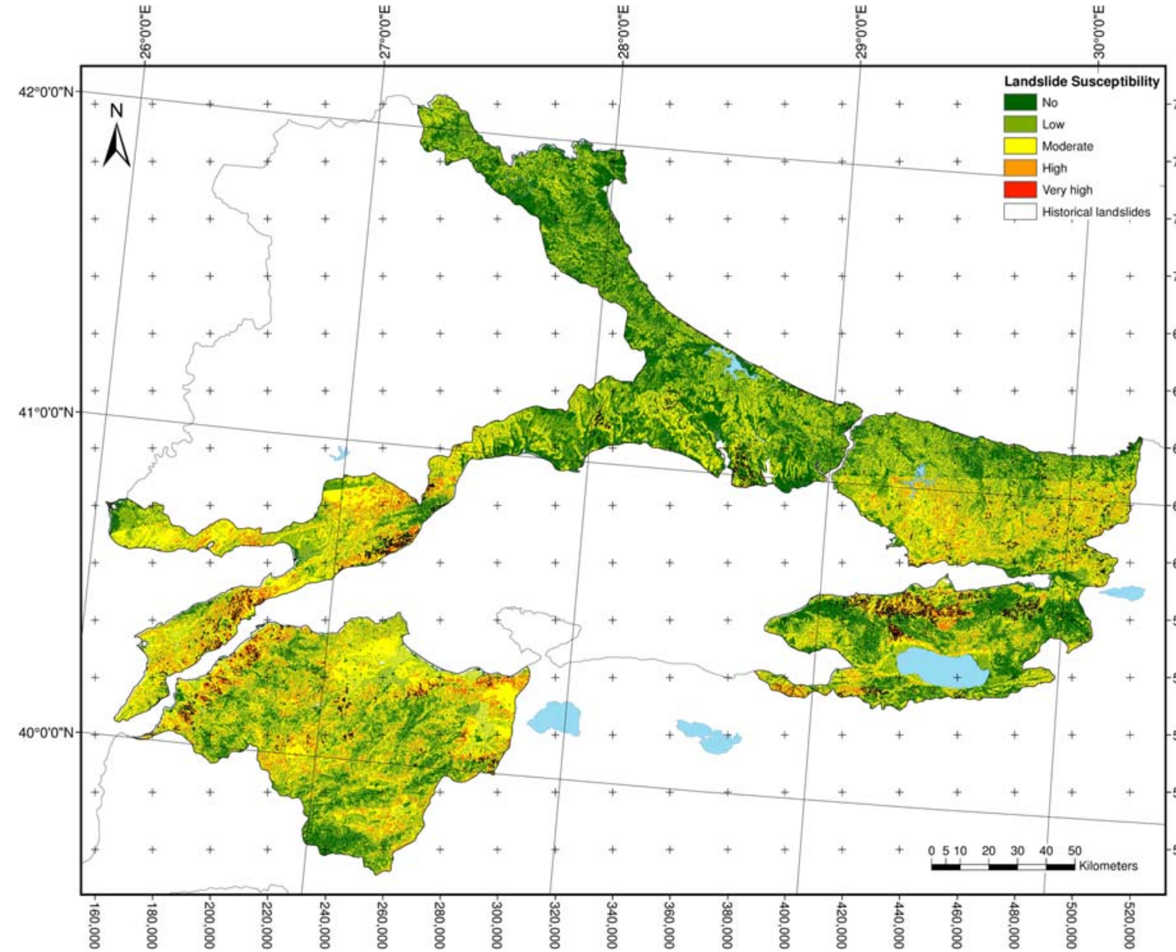

Figure 5.8 Synthetically classified landslide susceptibility map for Watershed-2.

5.2.3 Watershed No: 3 (Susurluk)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Susurluk watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.2 for the 8 factor based and 10 factor based maps, respectively. The histogram curves for each column are plotted in Figure 5.9 using the pixel counts given in Table D.2. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.9. However, the 8 factor based histogram for the pixel values located out of the historical landslide boundaries are more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for both of the areas that are located in the inner and outer landslide boundaries.

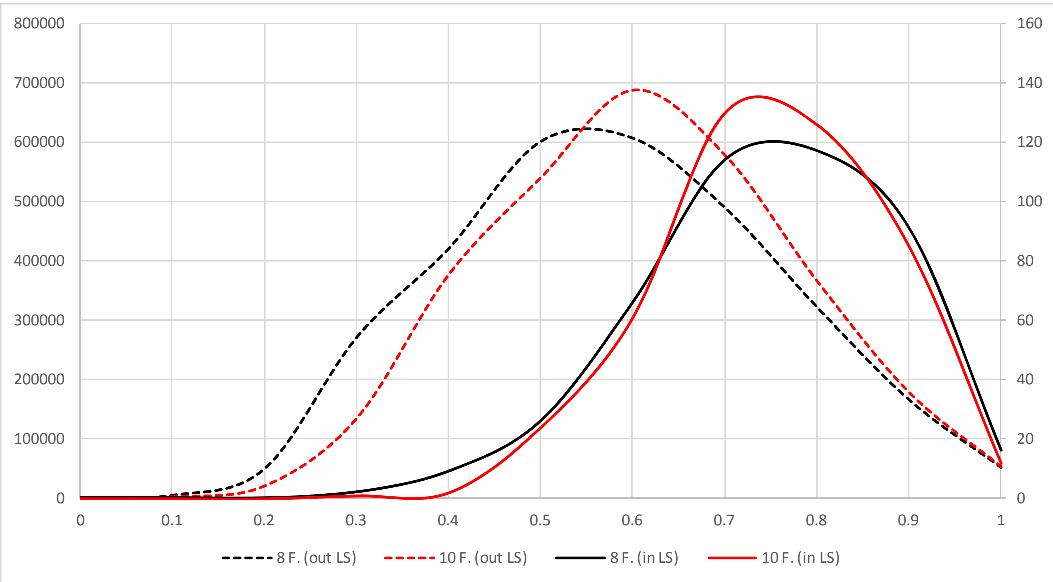

Figure 5.9 Histogram curves for the in and out of landslide boundaries for Watershed-3 (for 8 factors).

The area under the ROC curve (Fig. E.2) plotted for the 8 factor based map gives nearly the same value for the 10 factor based approach, but the 8 factor based map is more accurate than the 10 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its proximity to a value of 0 for the peak value of the outer landslide areas histogram curve. The threshold values were selected as described in the previous section and summarized in Table 5.5 for this watershed. The landslide susceptibility map of the Susurluk watershed was classified into five groups according to Table 5.5 and given in Figure 5.10.

Table 5.5 Threshold values and bin widths selected for synthetic classification of Watershed-3 (for 8 factors).

Class	Bin
No	0 - 0.55
Low	0.55 - 0.67
Moderate	0.67 - 0.75
High	0.75 - 0.88
Very high	0.88 - 1

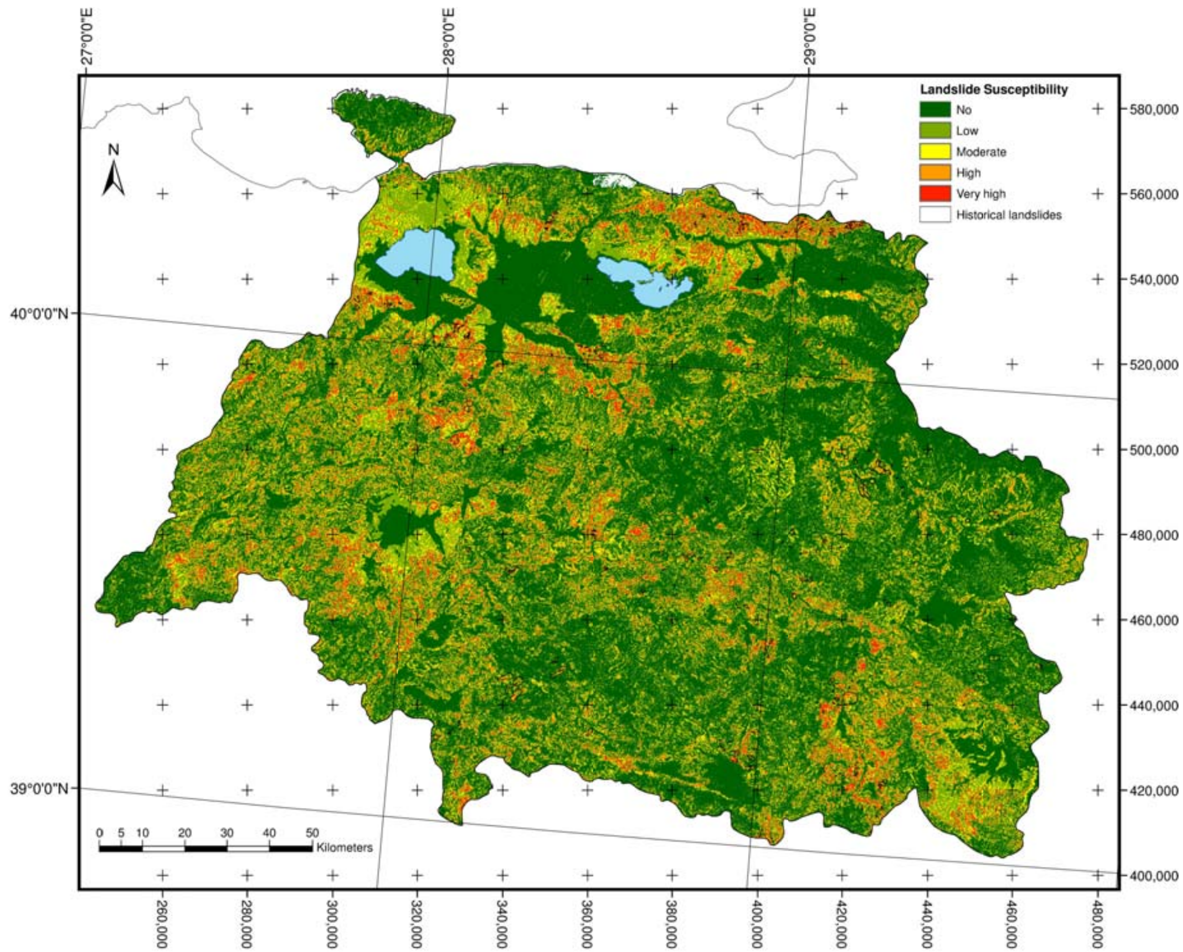

Figure 5.10 Synthetically classified landslide susceptibility map for Watershed-3.

5.2.4 Watershed No: 4 (Kuzey Ege)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Kuzey Ege watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.3 for the 8 factor based and 10 factor based maps, respectively.

The histogram curves for each column are plotted in Figure 5.11 using the pixel counts given in Table D.3. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.11. However, the 8 factor based histogram for the pixel values located out of the historical landslide boundaries are more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for both of the areas that are located in the inner and outer landslide boundaries.

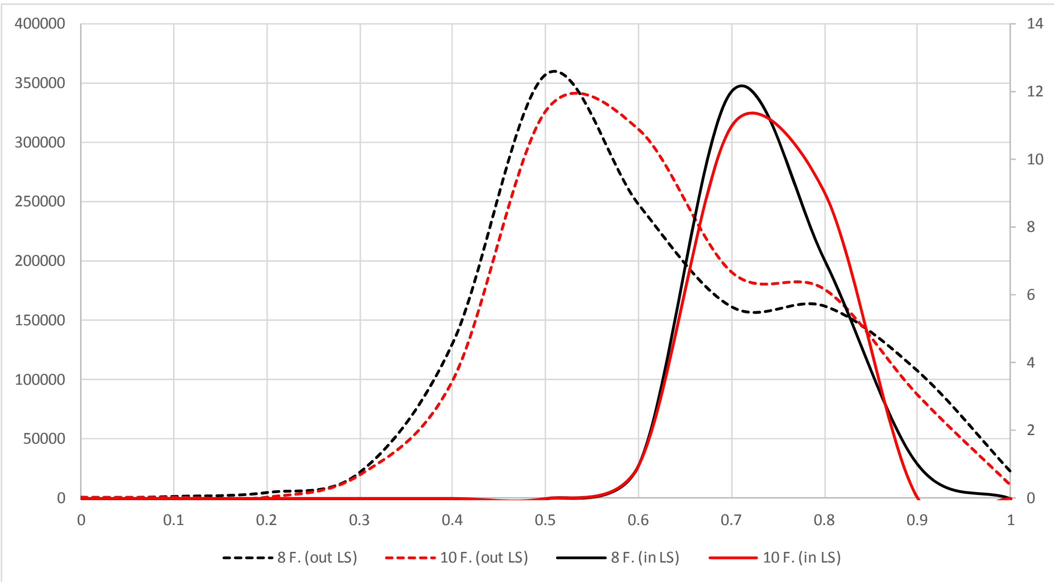

Figure 5.11 Histogram curves for the in and out of landslide boundaries for Watershed-4.

The area under the ROC curve (Fig. E.3) plotted for the 8 factor based map gives a greater value than the 10 factor based map. The 8 factor based approach is also more accurate than the 10 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its proximity to a value of 0 for the peak value of the outer landslide areas histogram curve and accurate ROC curve values. The threshold values were selected as described in the previous section and summarized in Table 5.6 for this watershed. The landslide susceptibility map of the Kuzey Ege watershed was classified into five groups according to Table 5.6 and given in Figure 5.12.

Table 5.6 Threshold values and bin widths selected for synthetic classification of Watershed-4 (for 8 factors).

Class	Bin
No	0 - 0.52
Low	0.52 - 0.65
Moderate	0.65 - 0.72
High	0.72 - 0.86
Very high	0.86 - 1

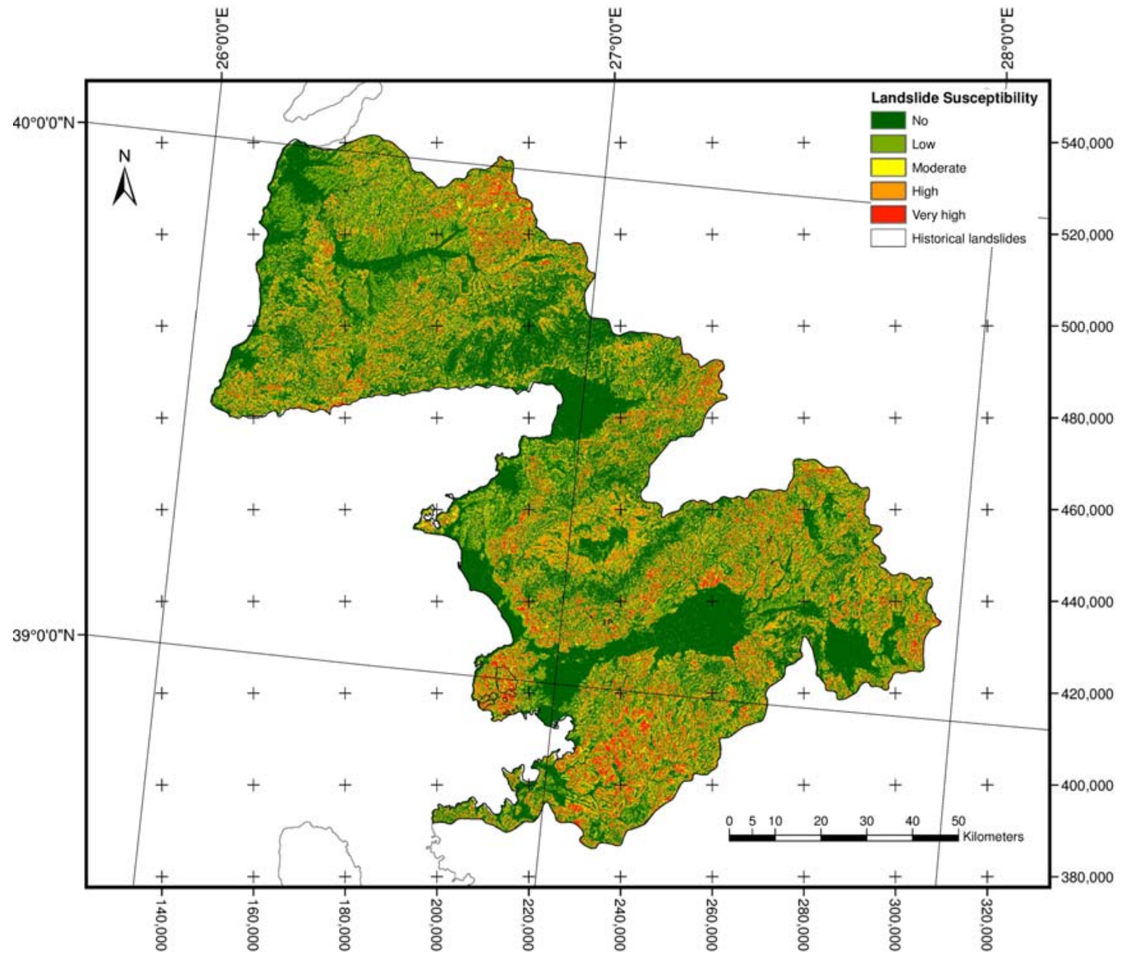

Figure 5.12 Synthetically classified landslide susceptibility map for Watershed-4.

5.2.5 Watershed No: 5 (Gediz)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Gediz watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.4 for the 8 factor based and 10 factor based maps, respectively.

The histogram curves for each column are plotted in Figure 5.13 using the pixel counts given in Table D.4. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries are more close to a value of 1 than the peak value of the 10 factor based histogram in Figure 5.13. The 8 factor based histogram for the pixel values located out of the historical landslide boundaries are also more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for both of the areas located in the inner and outer landslide boundaries.

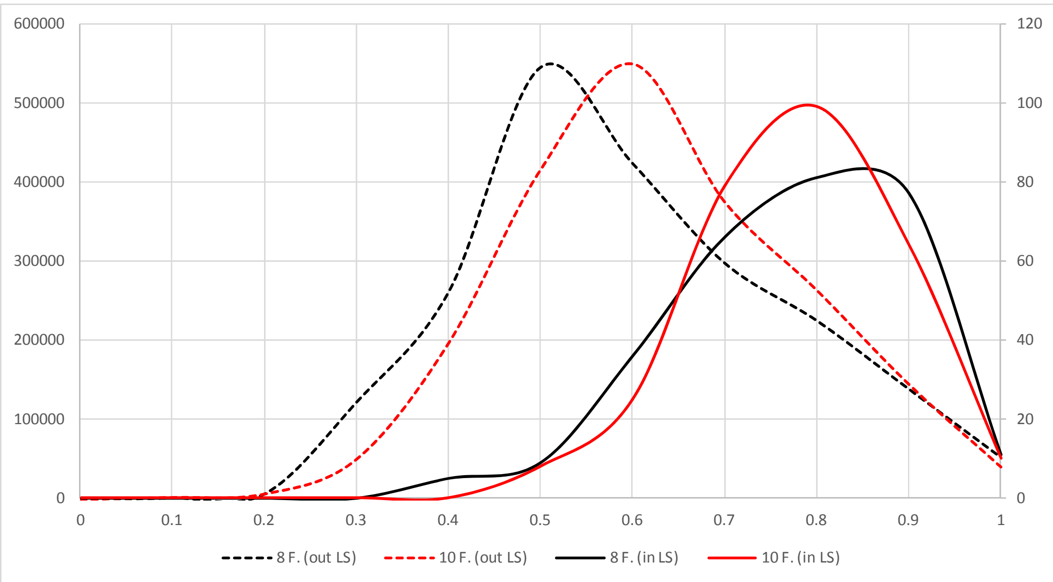

Figure 5.13 Histogram curves for the in and out of landslide boundaries for Watershed-5.

The area under the ROC curve (Fig. E.4) plotted for the 10 factor based map gives a slightly greater value than the 8 factor based map. Unfortunately, the 8 factor based approach is more accurate than the 10 factor based one. The ROC curve analysis does not provide enough information for selecting an 8 or 10 factor based map in this watershed.

Finally, the 8 factor based map was selected for this watershed by considering its proximity to a value of 0 for the peak value of the outer landslide areas histogram curve. The threshold values were selected as described in the previous section and summarized in Table 5.7 for this watershed. The landslide susceptibility map of the Gediz watershed was classified according to Table 5.7 and given in Figure 5.14.

Table 5.7 Threshold values and bin widths selected for synthetic classification of Watershed-5 (for 8 factors).

Class	Bin
No	0 - 0.52
Low	0.52 - 0.68
Moderate	0.68 - 0.85
High	0.85 - 0.93
Very high	0.93 - 1

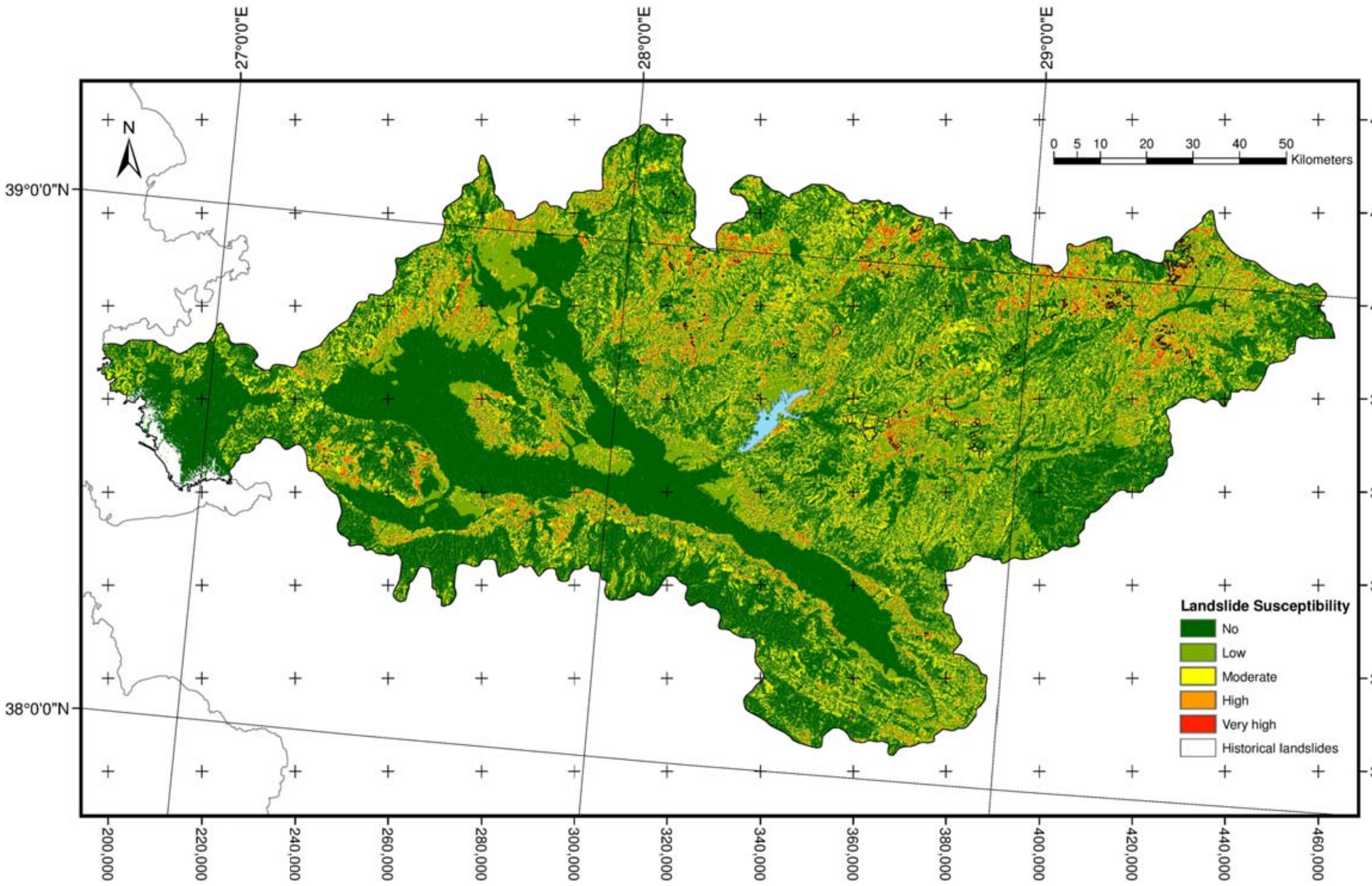

Figure 5.14 Synthetically classified landslide susceptibility map for Watershed-5.

5.2.6 Watershed No: 6 (Küçük Menderes)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Küçük Menderes watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.5 for the 8 factor based and 10 factor based maps, respectively.

The histogram curves for each column are plotted in Figure 5.15 using the pixel counts given in Table D.5. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.15. The same condition continues for both of the 8 factor and 10 factor based histogram curves for the pixel values of the outer historical landslide boundaries. According to these histogram curves, it is really hard to determine which map to select.

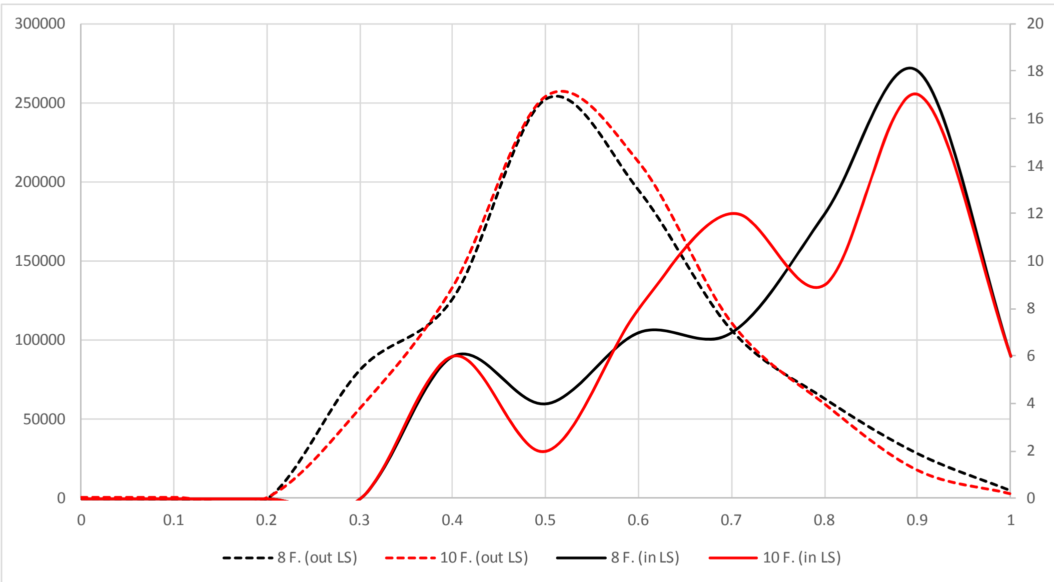

Figure 5.15 Histogram curves for the in and out of landslide boundaries for Watershed-6.

The area under the ROC curve (Fig. E.5) plotted for 10 factor based map gives a slightly greater value than the 8 factor based map. Unfortunately, the 8 factor based approach is more accurate than 10 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its ROC curve accuracy. The threshold values were selected as described in the previous section and summarized in Table 5.8 for this watershed. The landslide susceptibility map of the Küçük Menderes watershed was classified into five groups according to Table 5.8 and given in Figure 5.16.

Table 5.8 Threshold values and bin widths selected for synthetic classification of Watershed-6 (for 8 factors).

Class	Bin
No	0 - 0.51
Low	0.51 - 0.7
Moderate	0.7 - 0.88
High	0.88 - 0.94
Very high	0.94 - 1

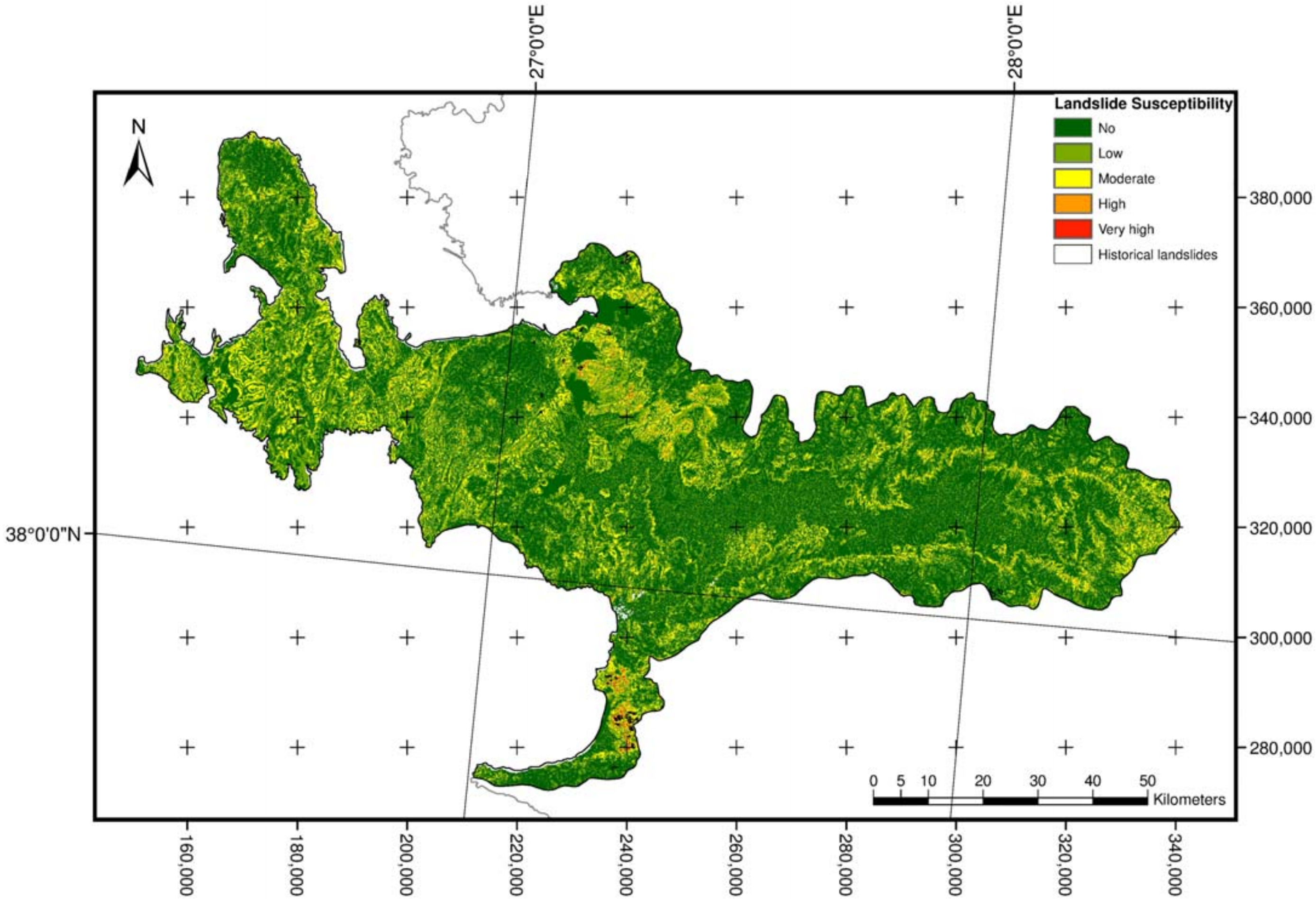

Figure 5.16 Synthetically classified landslide susceptibility map for Watershed-6.

5.2.7 Watershed No: 7 (Büyük Menderes)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Büyük Menderes watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.6 for the 8 factor based and 10 factor based maps, respectively.

The histogram curves for each column are plotted in Figure 5.17 using the pixel counts given in Table D.6. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.17. The 8 factor based histogram for the pixel values located out of the historical landslide boundaries are slightly close to a value of 0 than the 10 factor based histogram. The histogram curves do not provide appropriate information for selecting an 8 factor or 10 factor based map for this watershed.

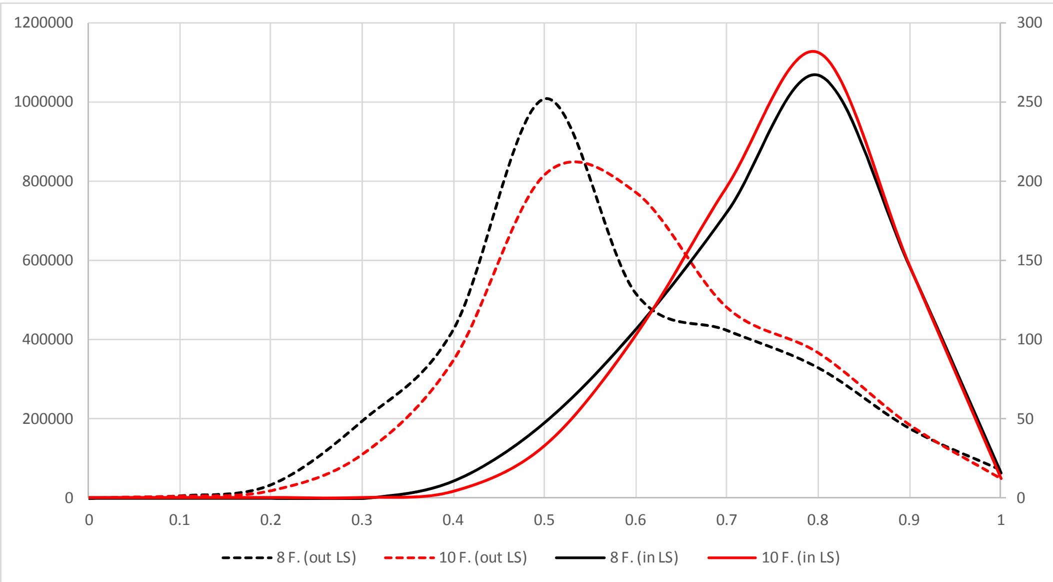

Figure 5.17 Histogram curves for the in and out of landslide boundaries for Watershed-7.

The area under the ROC curve (Fig. E.6) plotted for the 10 factor based map gives a greater value than the 8 factor based map. The 10 factor based approach is also more accurate than the 8 factor based one.

Finally, the 10 factor based map was selected for this watershed by considering its ROC curve values. The threshold values were selected as described in the previous section and summarized in Table 5.9 for this watershed. The landslide susceptibility map of the Büyük Menderes watershed was classified into five groups according to Table 5.9 and given in Figure 5.18.

Table 5.9 Threshold values and bin widths selected for synthetic classification of Watershed-7 (for 10 factors).

Class	Bin
No	0 - 0.53
Low	0.53 - 0.65
Moderate	0.65 - 0.79
High	0.79 - 0.9
Very high	0.9 - 1

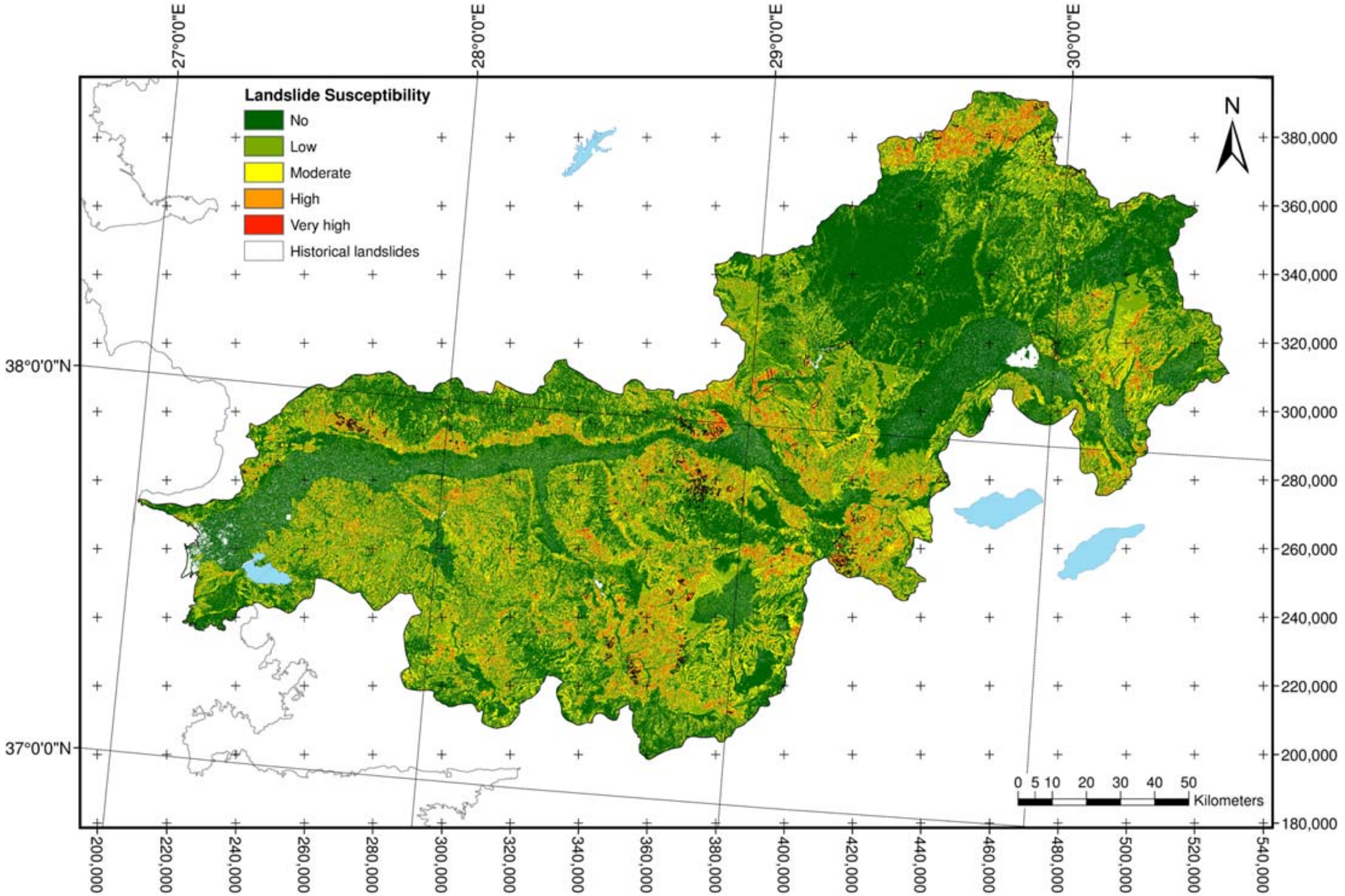

Figure 5.18 Synthetically classified landslide susceptibility map for Watershed-7.

5.2.8 Watershed No: 8 (Batı Akdeniz)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Batı Akdeniz watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.7 for the 8 factor based and 10 factor based maps, respectively.

The histogram curves for each column are plotted in Figure 5.19 using the pixel counts given in Table D.7. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.19. However, the 8 factor based histogram for the pixel values located out of the historical landslide boundaries are slightly close to a value of 0 than the 10 factor based histogram. Unfortunately, histogram curves do not provide appropriate information for selecting an 8 factor or 10 factor based map for this watershed.

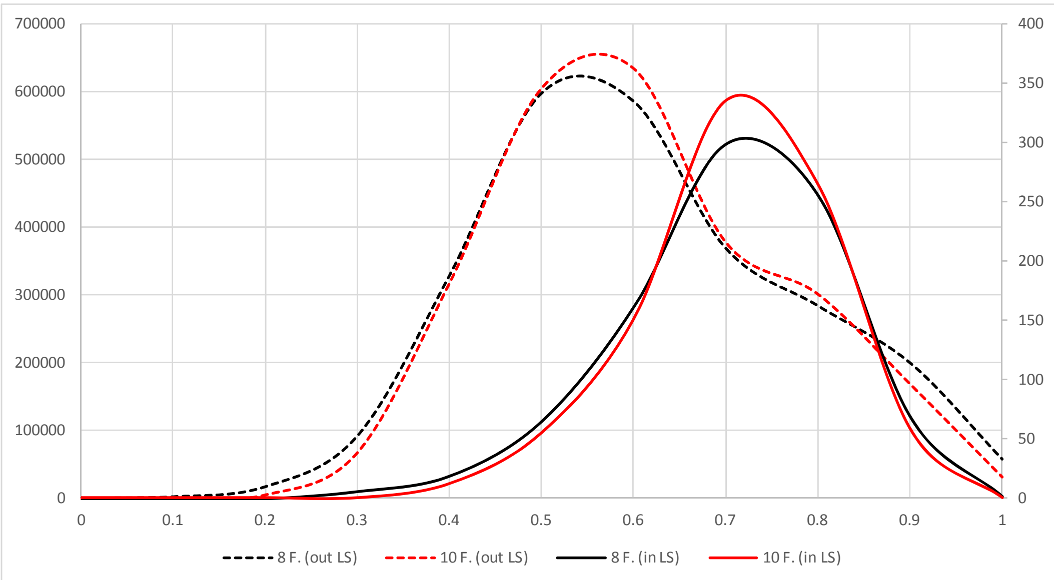

Figure 5.19 Histogram curves for the in and out of landslide boundaries for Watershed-8.

The area under the ROC curve (Fig. E.7) plotted for the 10 factor based map gives a greater value than the 8 factor based map. Unfortunately, the 8 factor based approach is slightly more accurate than the 10 factor based one.

Finally, the 10 factor based map was selected for this watershed by considering its area under the ROC curve. The threshold values were selected as described in the previous section and summarized in Table 5.10 for this watershed. The landslide susceptibility map of the Batı Akdeniz watershed was classified into five groups according to Table 5.10 and given in Figure 5.20.

Table 5.10 Threshold values and bin widths selected for synthetic classification of Watershed-8 (for 10 factors).

Class	Bin
No	0 - 0.56
Low	0.56 - 0.66
Moderate	0.66 - 0.72
High	0.72 - 0.86
Very high	0.86 - 1

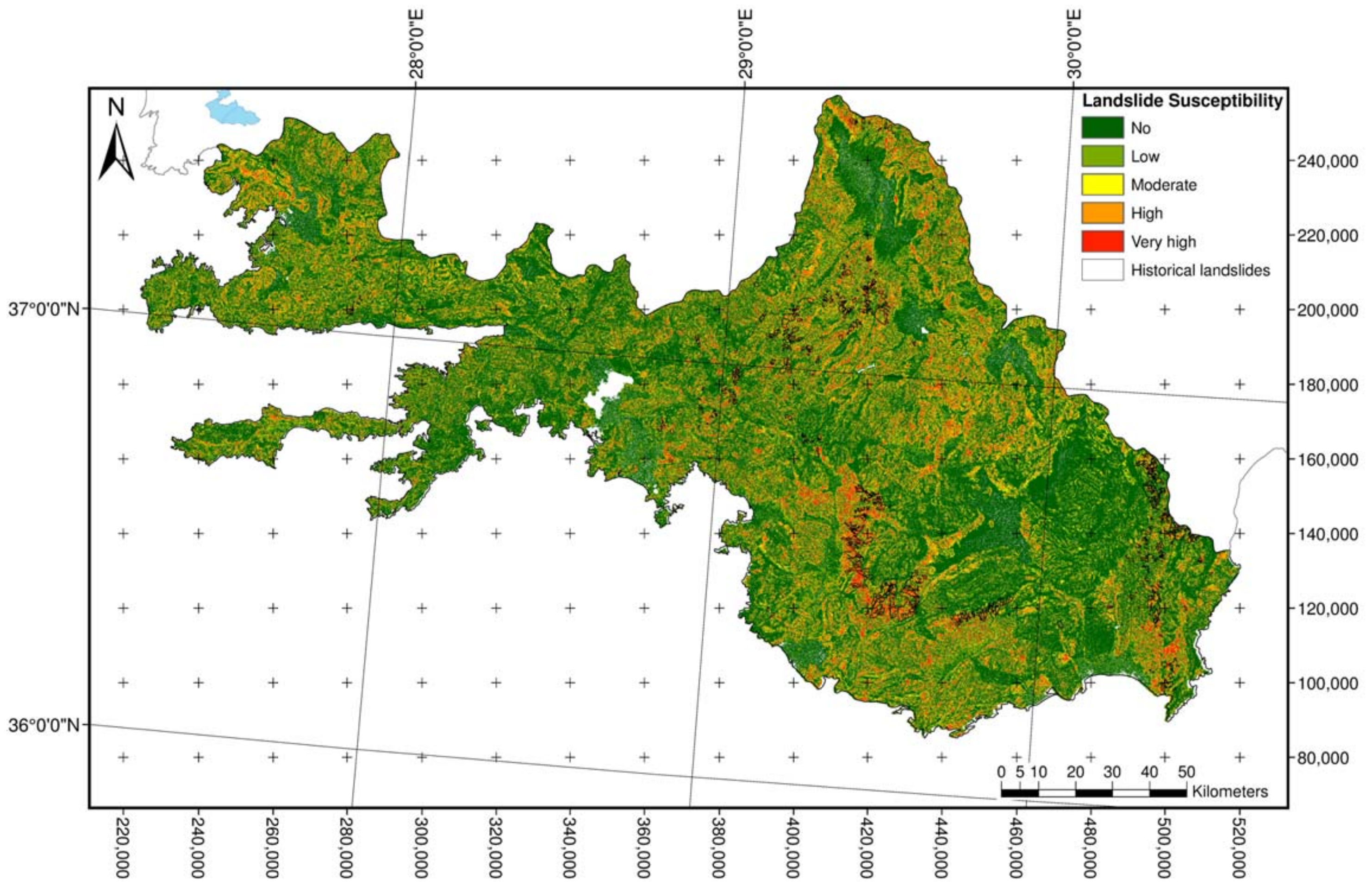

Figure 5.20 Synthetically classified landslide susceptibility map for Watershed-9.

5.2.9 Watershed No: 9 (Antalya)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Antalya watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.8 for the 8 factor based and 10 factor based maps, respectively.

The histogram curves for each column are plotted in Figure 5.21 using the pixel counts given in Table D.8. The peak value of the 10 factor based histogram for the pixel values located in the historical landslide boundaries are more close to a value of 1 than the peak value of the 8 factor based histogram in Figure 5.21. The peak points of both the 8 factor and 10 factor based histograms for the pixel values located out of the historical landslide boundaries are nearly on the same vertical axis. According to these histogram curves, the 10 factor based map seems to provide better results for both of the areas located in the inner and outer landslide boundaries.

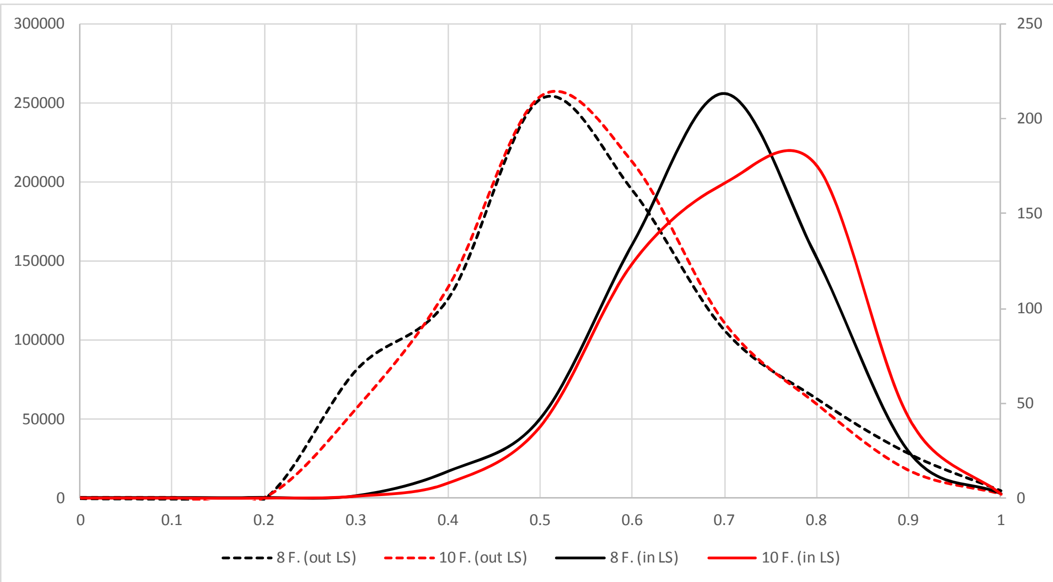

Figure 5.21 Histogram curves for the in and out of landslide boundaries for Watershed-9.

The area under the ROC curve (Fig. E.8) plotted for the 10 factor based map gives a slightly greater value than the 8 factor based map. Unfortunately, the 8 factor based approach is more accurate than the 10 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its ROC curve accuracy. The threshold values were selected as described in the previous section and summarized in Table 5.11 for this watershed. The landslide susceptibility map of the Antalya watershed was classified into five groups according to Table 5.11 and given in Figure 5.22.

Table 5.11 Threshold values and bin widths selected for synthetic classification of Watershed-9 (for 8 factors).

Class	Bin
No	0 - 0.51
Low	0.51 - 0.62
Moderate	0.62 - 0.7
High	0.7 - 0.85
Very high	0.85 - 1

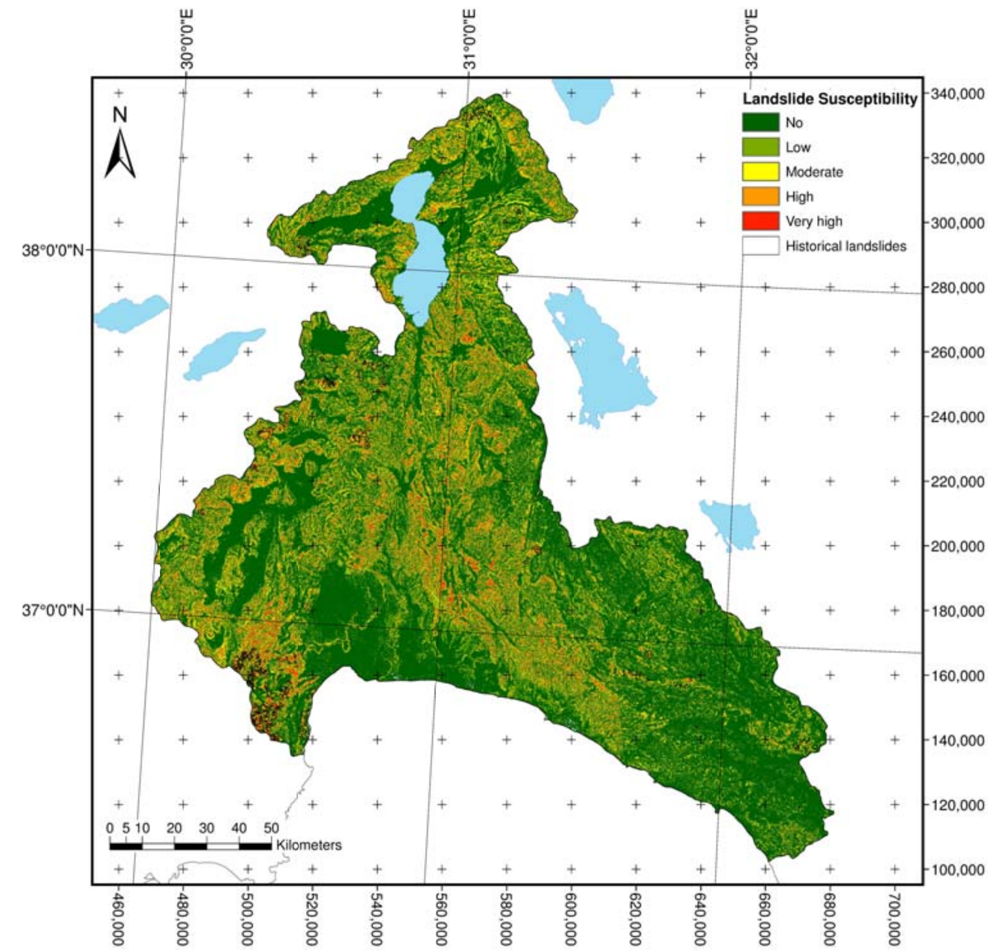

Figure 5.22 Synthetically classified landslide susceptibility map for Watershed-9.

5.2.10 Watershed No: 10 (Burdur)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Burdur watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.9 for the 8 factor based and 10 factor based maps, respectively. The histogram curves for each column are plotted in Figure 5.23 using the pixel counts given in Table D.9. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries are more close to a value of 1 than the peak value of the 10 factor based histogram in Figure 5.23. The 8 factor based histogram for pixel values located out of historical landslide boundaries are also more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for both of the areas located in the inner and outer landslide boundaries.

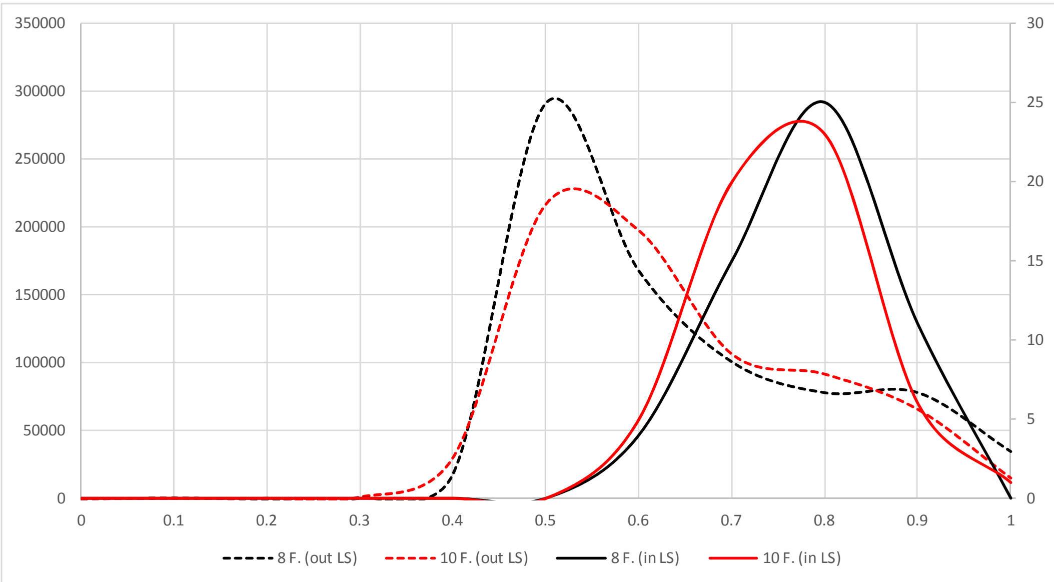

Figure 5.23 Histogram curves for the in and out of landslide boundaries for Watershed-10.

The area under the ROC curve (Fig. E.9) plotted for the 8 factor based map gives a greater value than the 10 factor based map. The 8 factor based approach is also more accurate than the 10 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its ROC curve values. The threshold values were selected as described in the previous section and summarized in Table 5.12 for this watershed. The landslide susceptibility map of the Burdur watershed was classified into five groups according to Table 5.12 and given in Figure 5.24.

Table 5.12 Threshold values and bin widths selected for synthetic classification of Watershed-10 (for 8 factors).

Class	Bin
No	0 - 0.51
Low	0.51 - 0.66
Moderate	0.66 - 0.8
High	0.8 - 0.9
Very high	0.9 - 1

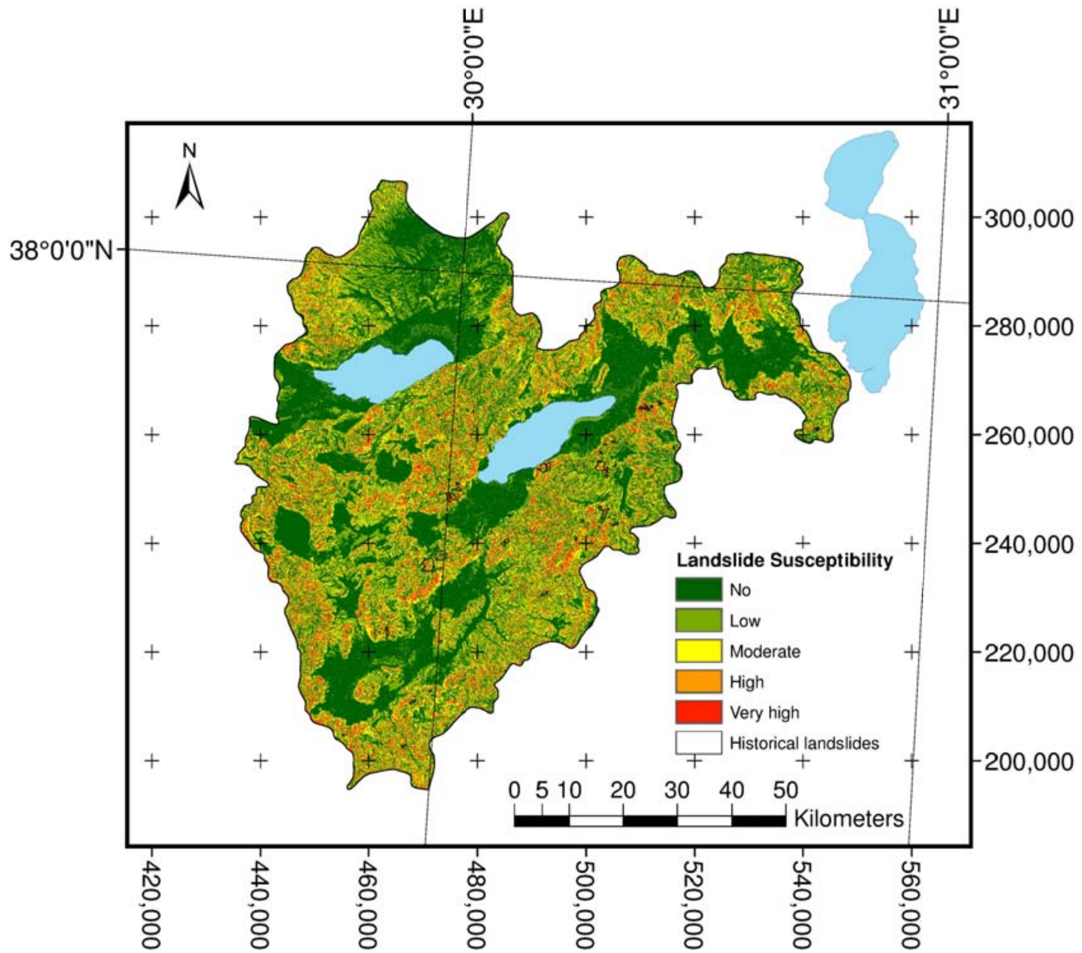

Figure 5.24 Synthetically classified landslide susceptibility map for Watershed-10.

5.2.11 Watershed No: 11 (Akarçay)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Akarçay watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.10 for the 8 factor based and 10 factor based maps, respectively.

The histogram curves for each column are plotted in Figure 5.25 using the pixel counts given in Table D.10. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.25. The 8 factor based histogram for the pixel values located out of the historical landslide boundaries are also more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for both of the areas located in the inner and outer landslide boundaries.

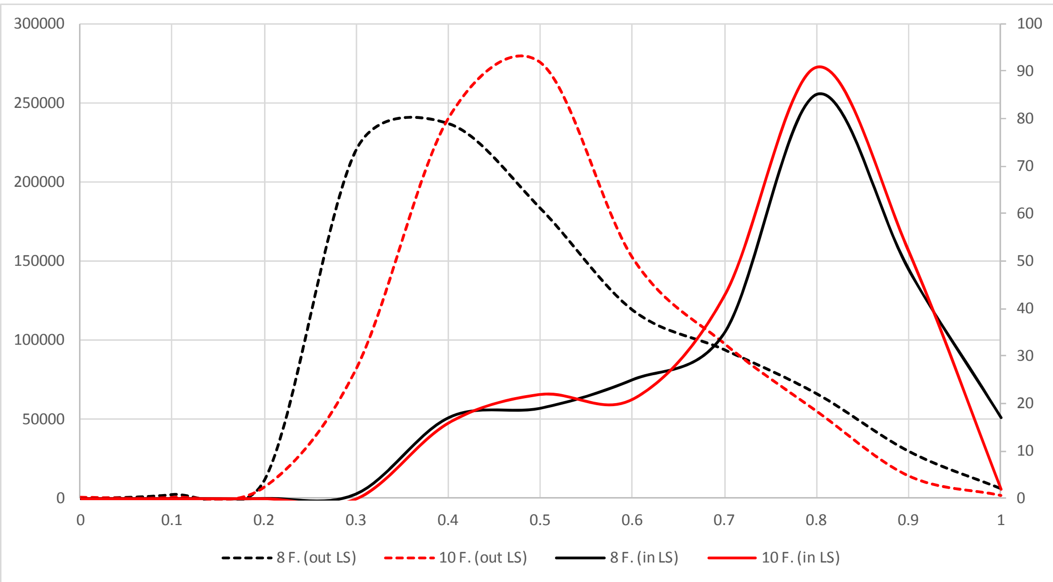

Figure 5.25 Histogram curves for the in and out of landslide boundaries for Watershed-11.

The area under the ROC curve (Fig. E.10) plotted for the 10 factor based map gives a slightly greater value than the 8 factor based map. Unfortunately, the 8 factor based approach is more accurate than the 10 factor based one. The ROC curve analysis does not provide enough information for selecting an 8 or 10 factor based map in this watershed.

Finally, the 8 factor based map was selected for this watershed by considering its proximity to a value of 0 for the peak value of the outer landslide areas histogram curve. The threshold values were selected as described in the previous section and summarized in Table 5.13 for this watershed. The landslide susceptibility map of the Akarçay watershed was classified into five groups according to Table 5.13 and given in Figure 5.26.

Table 5.13 Threshold values and bin widths selected for synthetic classification of Watershed-11 (for 10 factors).

Class	Bin
No	0 - 0.48
Low	0.48 - 0.67
Moderate	0.67 - 0.8
High	0.8 - 0.9
Very high	0.9 - 1

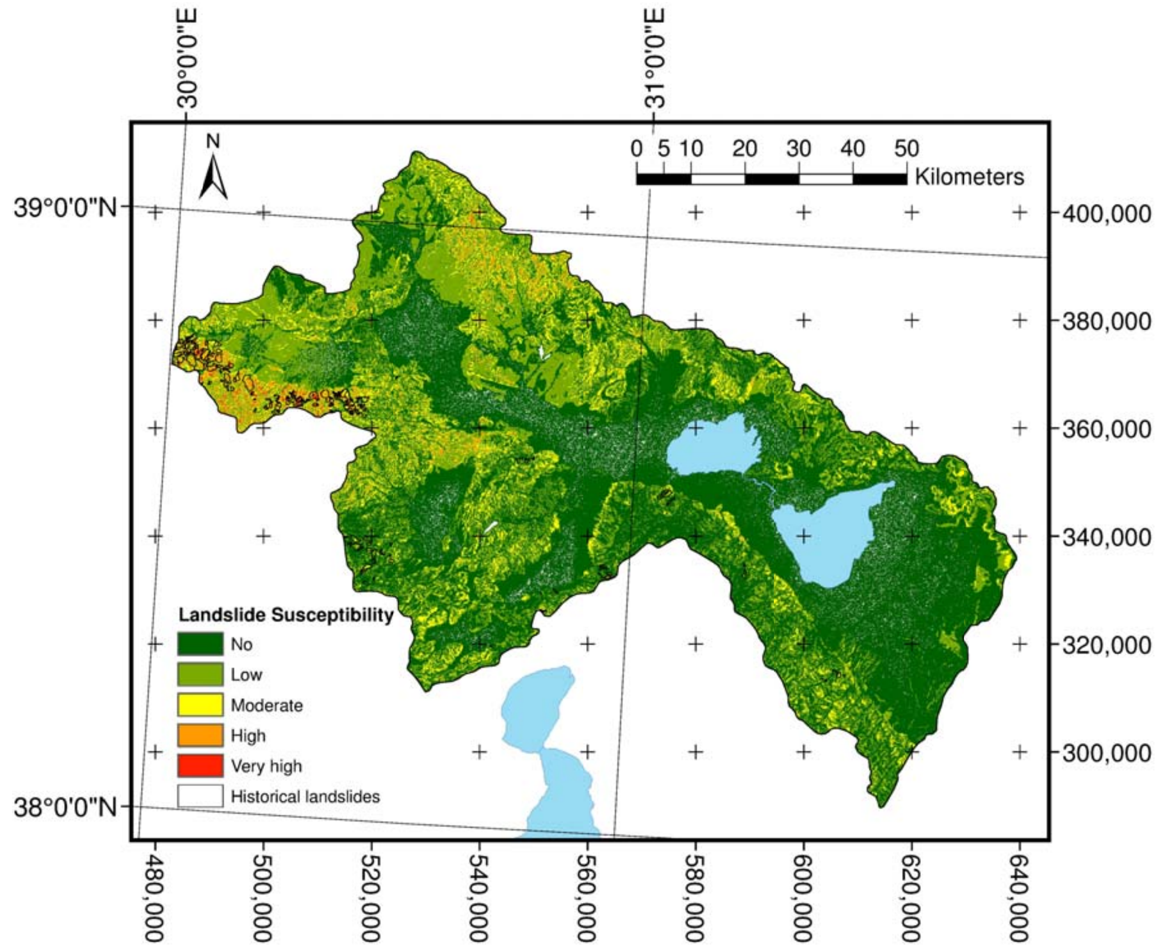

Figure 5.26 Synthetically classified landslide susceptibility map for Watershed-11.

5.2.12 Watershed No: 12 (Sakarya)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Sakarya watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.11 for the 8 factor based and 10 factor based maps, respectively.

The histogram curves for each column are plotted in Figure 5.27 using the pixel counts given in Table D.11. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.27. The 8 factor based histogram for pixel values located out of the historical landslide boundaries are also more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for both of the areas located in the inner and outer landslide boundaries.

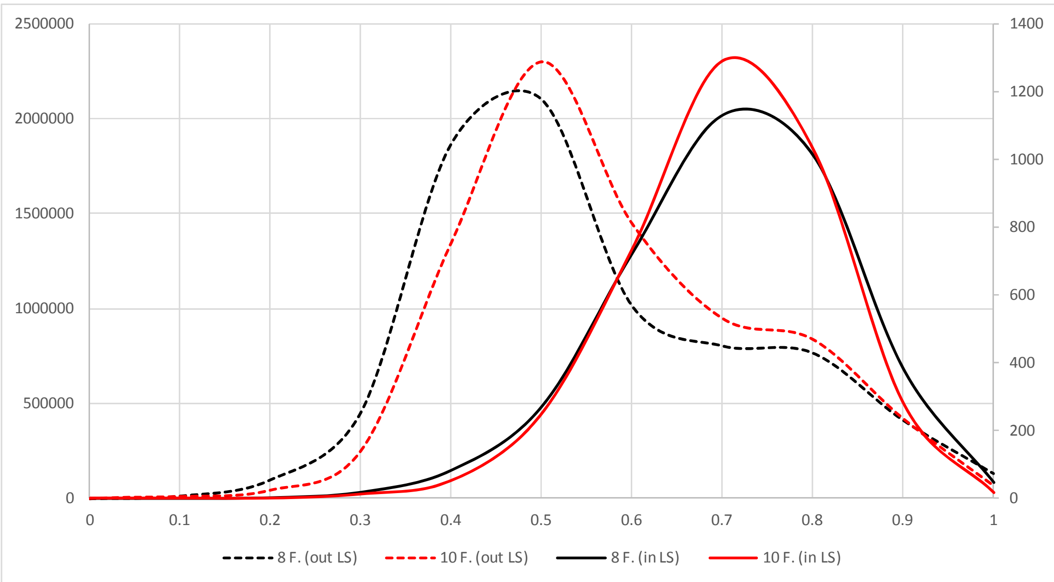

Figure 5.27 Histogram curves for the in and out of landslide boundaries for Watershed-12.

The area under the ROC curve (Fig. E.11) plotted for the 8 factor based map gives a greater value than the 8 factor based map. The 8 factor based approach is also more accurate than the 10 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its proximity to a value of 0 for the peak value of the outer landslide areas histogram curve. The threshold values were selected as described in the previous section and summarized in Table 5.14 for this watershed. The landslide susceptibility map of the Sakarya watershed was classified into five groups according to Table 5.14 and given in Figure 5.28.

Table 5.14 Threshold values and bin widths selected for synthetic classification of Watershed-12 (for 8 factors).

Class	Bin
No	0 - 0.46
Low	0.46 - 0.58
Moderate	0.58 - 0.73
High	0.73 - 0.87
Very high	0.87 - 1

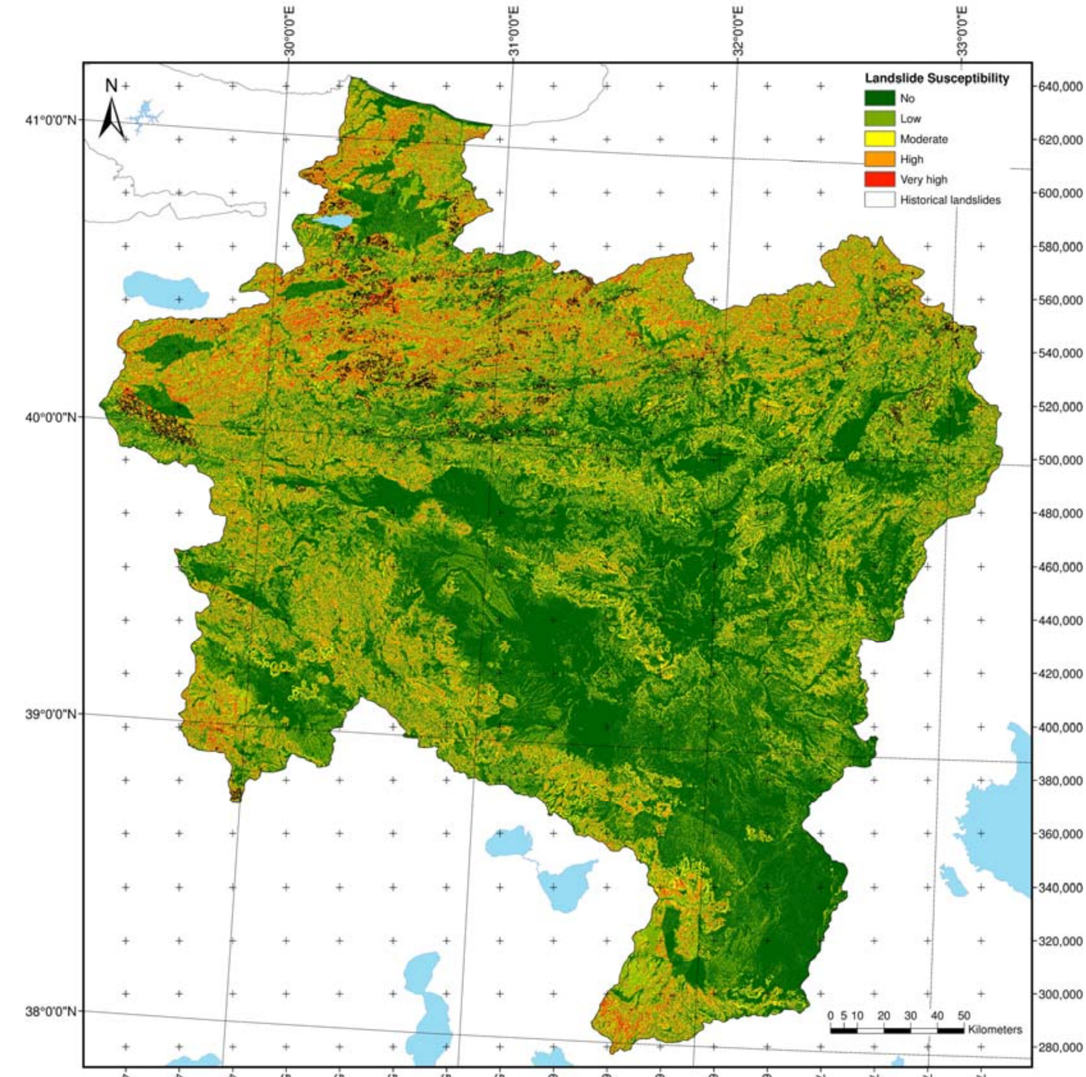

Figure 5.28 Synthetically classified landslide susceptibility map for Watershed-12.

5.2.13 Watershed No: 13 (Batı Karadeniz)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Batı Karadeniz watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.12 for the 8 factor based and 10 factor based maps, respectively.

The histogram curves for each column are plotted in Figure 5.29 using the pixel counts given in Table D.12. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.29. The 8 factor based histogram for the pixel values located out of the historical landslide boundaries are also more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for both of the areas located in the inner and outer landslide boundaries.

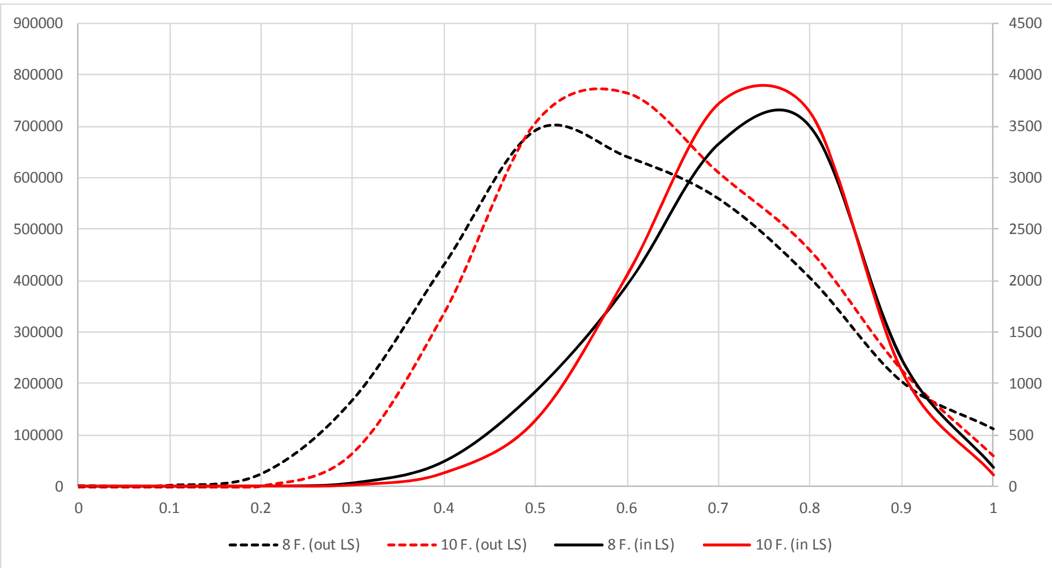

Figure 5.29 Histogram curves for the in and out of landslide boundaries for Watershed-13.

The area under the ROC curve (Fig. E.12) plotted for the 10 factor based map gives a greater value than the 8 factor based map. Unfortunately, the 8 factor based approach is more accurate than the 10 factor based one.

Finally, the 10 factor based map was selected for this watershed by considering its area under the ROC curve. The threshold values were selected as described in the previous section and summarized in Table 5.15 for this watershed. The landslide susceptibility map of the Batı Karadeniz watershed was classified into five groups according to Table 5.15 and given in Figure 5.30.

Table 5.15 Threshold values and bin widths selected for synthetic classification of Watershed-13 (for 10 factors).

Class	Bin
No	0 - 0.56
Low	0.56 - 0.67
Moderate	0.67 - 0.74
High	0.74 - 0.87
Very high	0.87 - 1

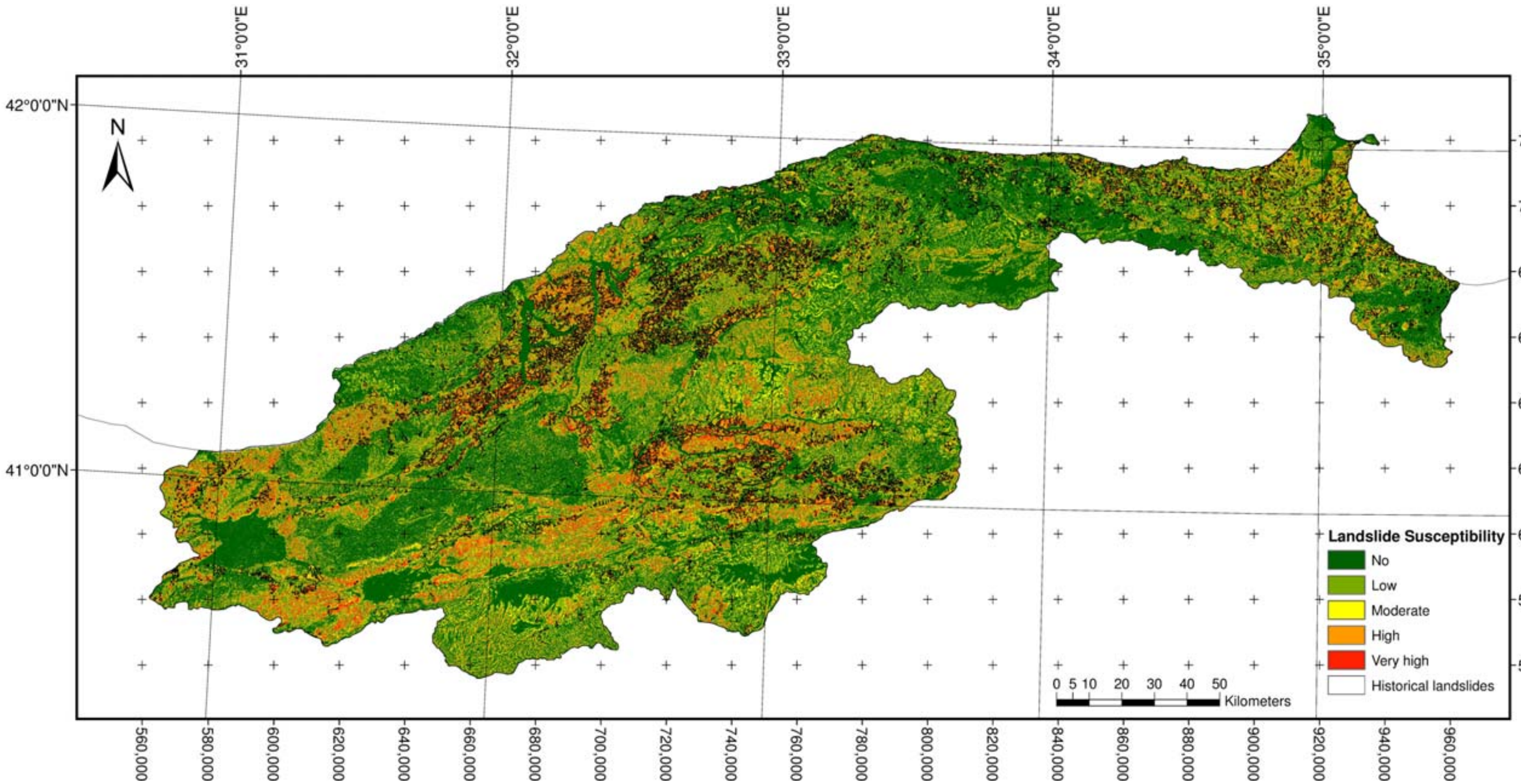

Figure 5.30 Synthetically classified landslide susceptibility map for Watershed-13.

5.2.14 Watershed No: 14 (Yeşilırmak)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Yeşilırmak watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.13 for the 8 factor based and 10 factor based maps, respectively.

The histogram curves for each column are plotted in Figure 5.31 using the pixel counts given in Table D.13. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.31. The 8 factor based histogram for the pixel values located out of the historical landslide boundaries are also more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for both of the areas located in the inner and outer landslide boundaries.

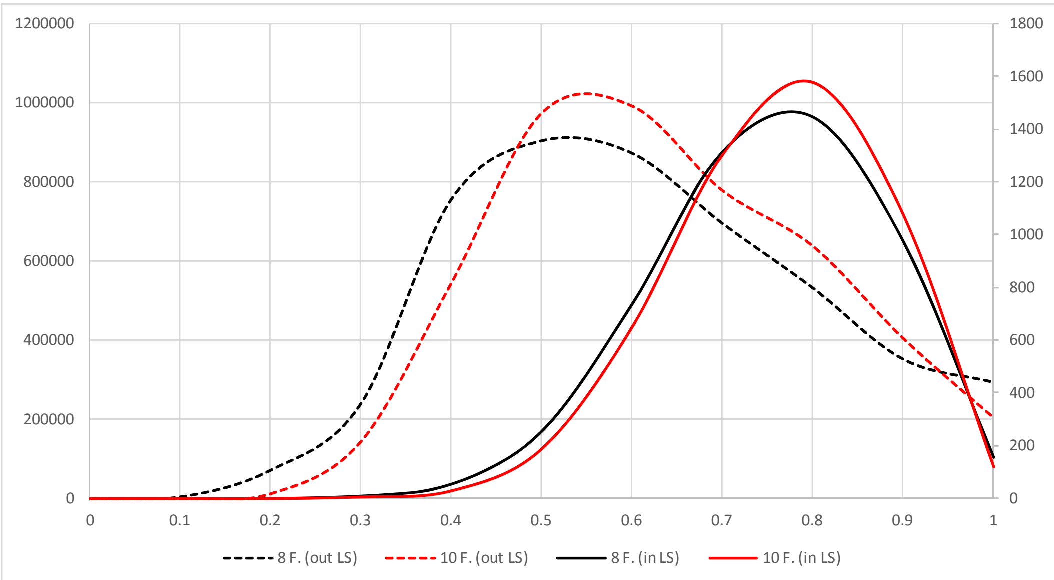

Figure 5.31 Histogram curves for in and out of landslide boundaries for Watershed-14.

The area under the ROC curve (Fig. E.12) plotted for the 10 factor based map gives a greater value than the 8 factor based map. Unfortunately, the 8 factor based approach is more accurate than the 10 factor based one.

Finally, the 10 factor based map was selected for this watershed by considering its area under the ROC curve. The threshold values were selected as described in the previous section and summarized in Table 5.16 for this watershed. The landslide susceptibility map of the Yeşilırmak watershed was classified into five groups according to Table 5.16 and given in Figure 5.32.

Table 5.16 Threshold values and bin widths selected for synthetic classification of Watershed-14 (for 10 factors).

Class	Bin
No	0 - 0.54
Low	0.54 - 0.68
Moderate	0.68 - 0.78
High	0.78 - 0.89
Very high	0.89 - 1

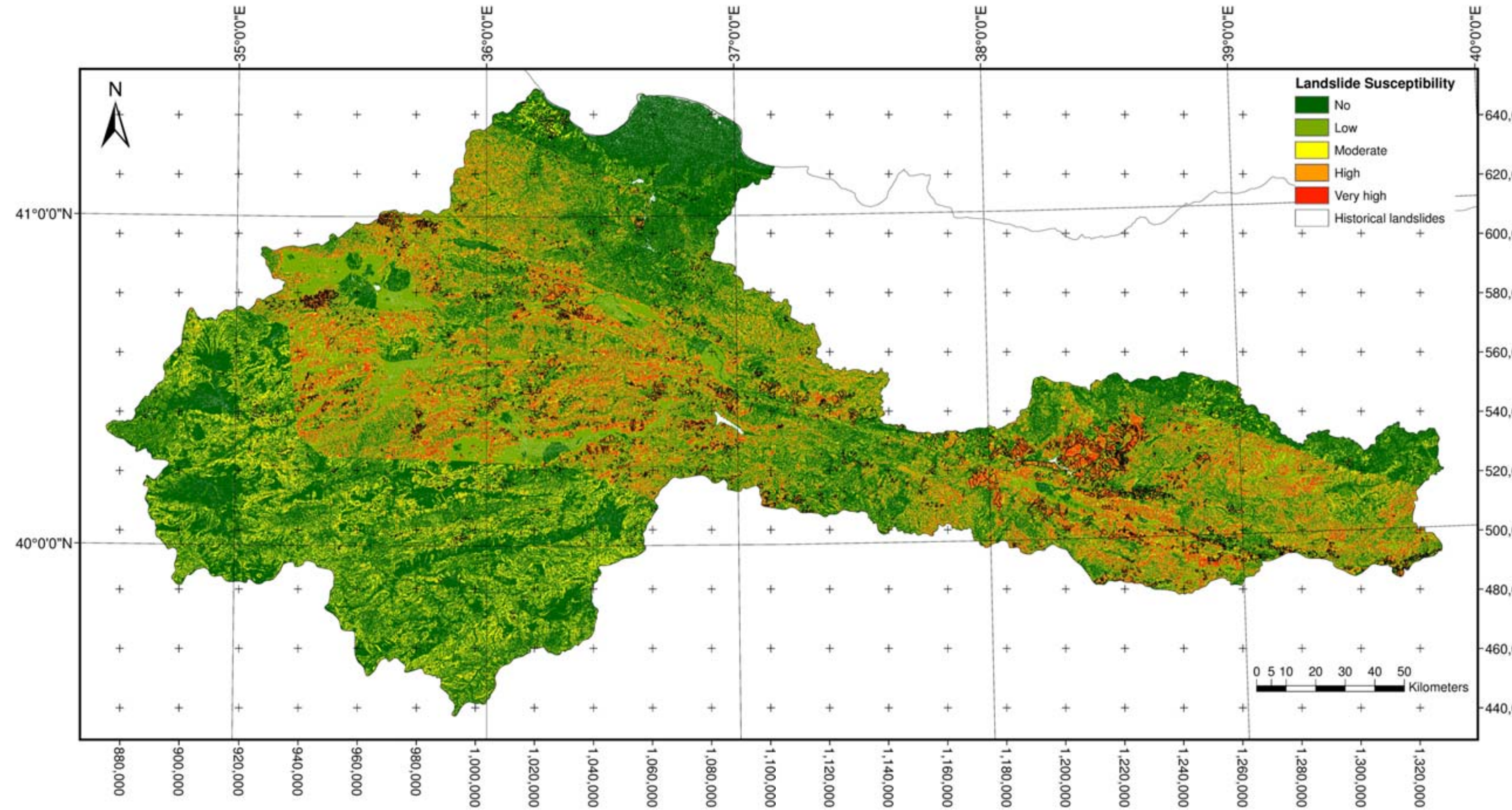

Figure 5.32 Synthetically classified landslide susceptibility map for Watershed-14.

5.2.15 Watershed No: 15 (Kızılırmak)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Kızılırmak watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.14 for the 8 factor based and 10 factors based maps, respectively.

The histogram curves for each column are plotted in Figure 5.33 using the pixel counts given in Table D.14. The peak value of the 10 factor based histogram for the pixel values located in the historical landslide boundaries are more close to a value of 1 than the peak value of the 8 factor based histogram in Figure 5.33. However, the 8 factor based histogram for pixel values located out of historical landslide boundaries are more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, it is really hard to determine which map to select.

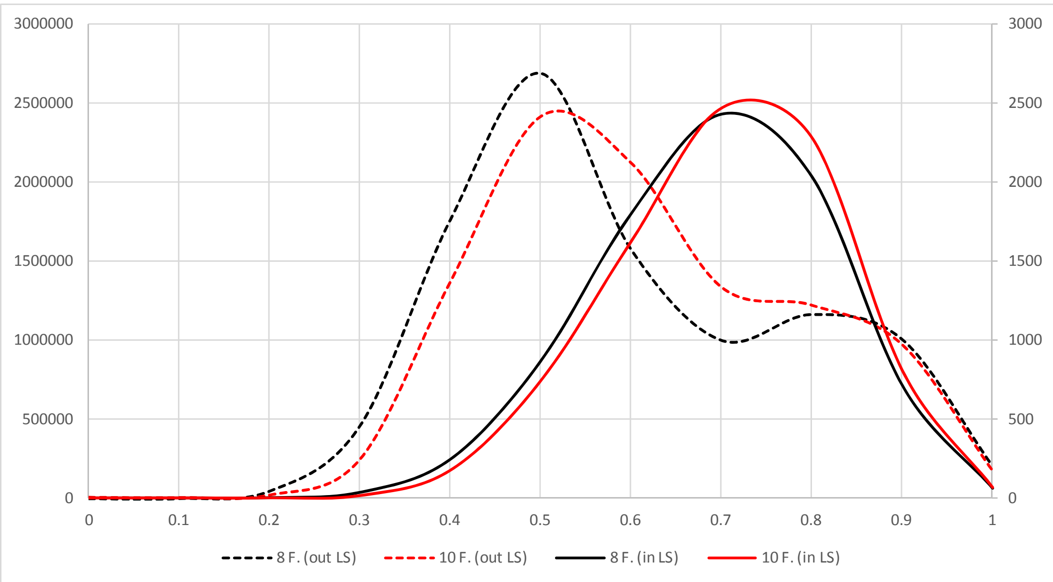

Figure 5.33 Histogram curves for the in and out of landslide boundaries for Watershed-15.

The area under the ROC curve (Fig. E.14) plotted for the 10 factor based map gives a greater value than the 8 factor based map. Unfortunately, the 8 factor based approach is more accurate than the 10 factor based one.

Finally, the 10 factor based map was selected for this watershed by considering its area under the ROC curve. The threshold values were selected as described in the previous section and summarized in Table 5.17 for this watershed. The landslide susceptibility map of the Kızılırmak watershed was classified into five groups according to Table 5.17 and given in Figure 5.34.

Table 5.17 Threshold values and bin widths selected for synthetic classification of Watershed-15 (for 10 factors).

Class	Bin
No	0 - 0.52
Low	0.52 - 0.64
Moderate	0.64 - 0.73
High	0.73 - 0.87
Very high	0.87 - 1

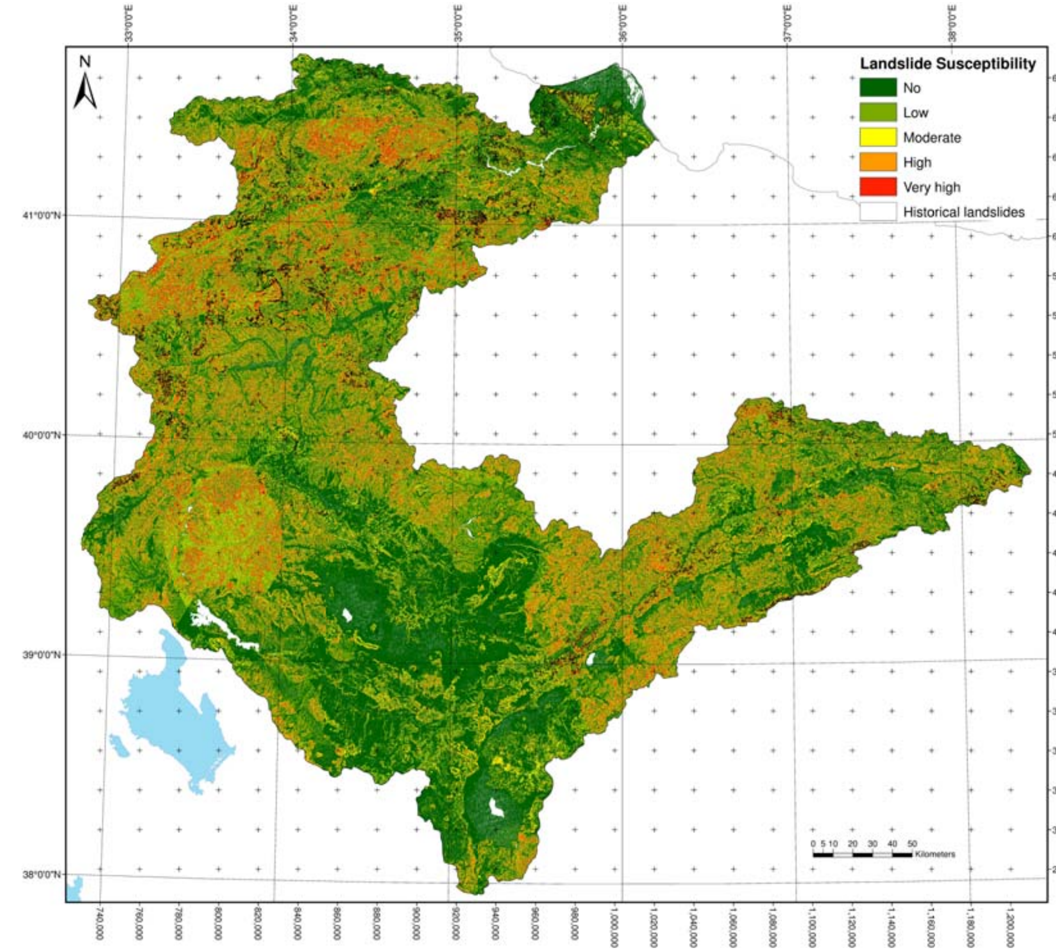

Figure 5.34 Synthetically classified landslide susceptibility map for Watershed-15.

5.2.16 Watershed No: 16 (Konya Kapalı)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Konya Kapalı watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.15 for the 8 factor based and 10 factors based maps, respectively.

The histogram curves for each column are plotted in Figure 5.35 using the pixel counts given in Table D.15. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries are more close to a value of 1 than the peak value of the 10 factor based histogram in Figure 5.35. The 8 factor based histogram for the pixel values located out of the historical landslide boundaries are more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for both of the areas located in the inner and outer landslide boundaries.

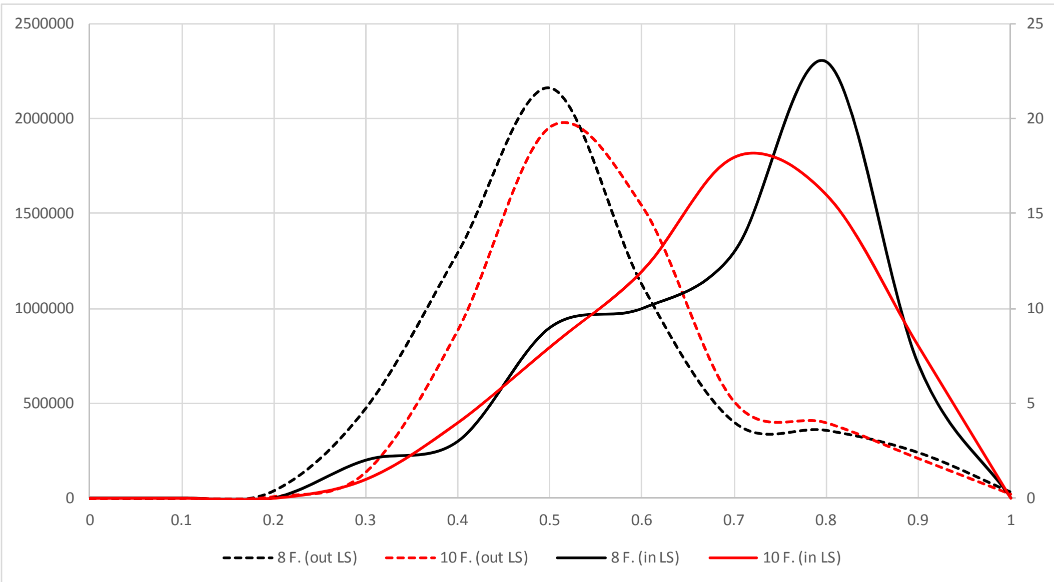

Figure 5.35 Histogram curves for the in and out of landslide boundaries for Watershed-16.

The area under the ROC curve (Fig. E.15) plotted for the 8 factor based map gives nearly the same value for the 10 factor based approach, but the 10 factor based map is more accurate than the 8 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its proximity to a value of 1 for the peak value of the outer landslide areas histogram curve. The threshold values were selected as described in the previous section and summarized in Table 5.18 for this watershed. The landslide susceptibility map of the Konya Kapalı watershed was classified into five groups according to Table 5.18 and given in Figure 5.36.

Table 5.18 Threshold values and bin widths selected for synthetic classification of Watershed-16 (for 8 factors).

Class	Bin
No	0 - 0.5
Low	0.5 - 0.62
Moderate	0.62 - 0.79
High	0.79 - 0.9
Very high	0.9 - 1

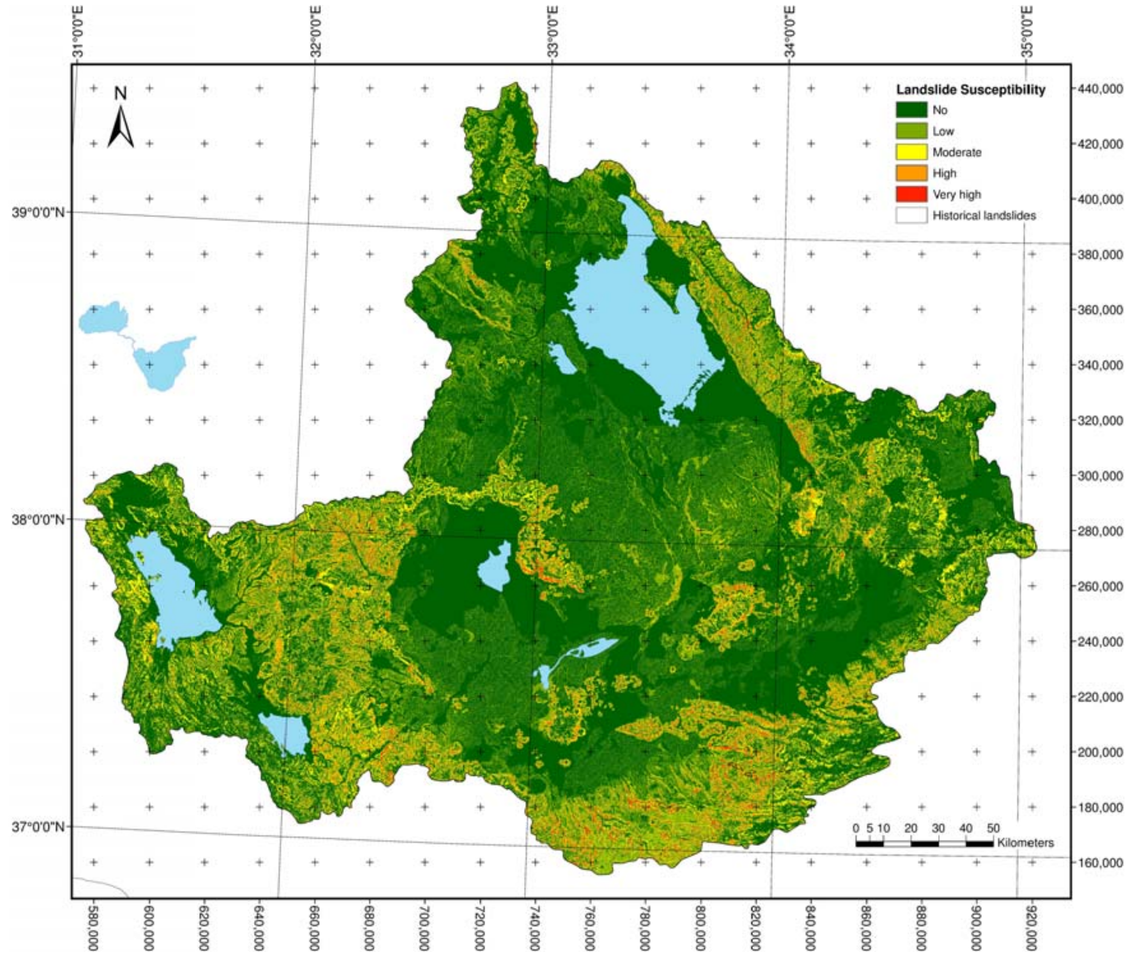

Figure 5.36 Synthetically classified landslide susceptibility map for Watershed-16.

5.2.17 Watershed No: 17 (Doğu Akdeniz)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Doğu Akdeniz watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.16 for the 8 factor based and 10 factors based maps, respectively.

The histogram curves for each column are plotted in Figure 5.37 using the pixel counts given in Table D.16. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.37. However, the 8 factor based histogram for the pixel values located out of the historical landslide boundaries are more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for the areas that are located in the outer landslide boundaries.

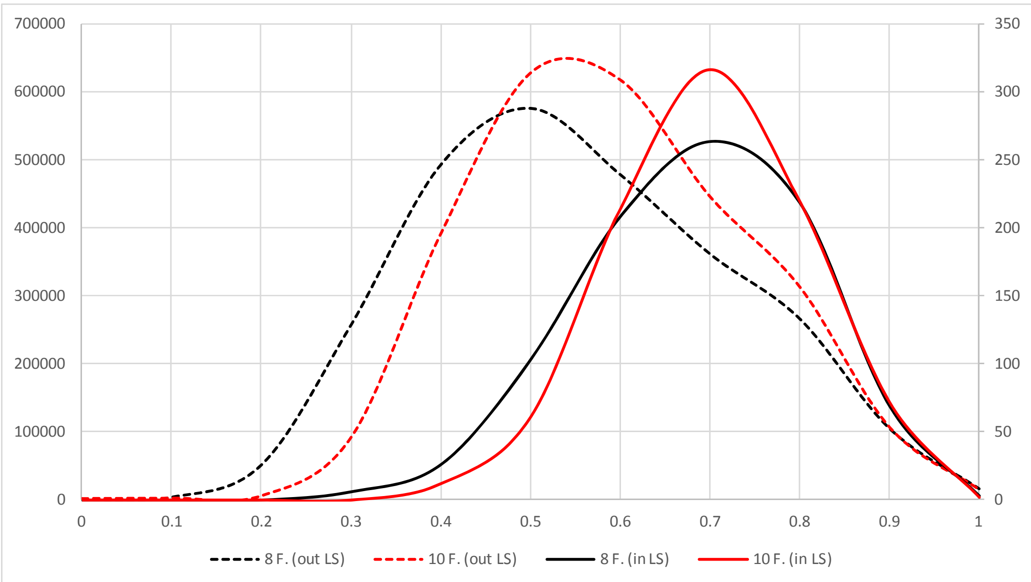

Figure 5.37 Histogram curves for the in and out of landslide boundaries for Watershed-17.

The area under the ROC curve (Fig. E.16) plotted for the 8 factor based map gives a greater value than the 10 factor based map. The 8 factor based approach is also more accurate than the 10 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its proximity to a value of 0 for the peak value of the outer landslide areas histogram curve and greater ROC curve values. The threshold values were selected as described in the previous section and summarized in Table 5.19 for this watershed. The landslide susceptibility map of the Doğu Akdeniz watershed was classified into five groups according to Table 5.19 and given in Figure 5.38.

Table 5.19 Threshold values and bin widths selected for synthetic classification of Watershed-17 (for 8 factors).

Class	Bin
No	0 - 0.5
Low	0.5 - 0.63
Moderate	0.63 - 0.71
High	0.71 - 0.86
Very high	0.86 - 1

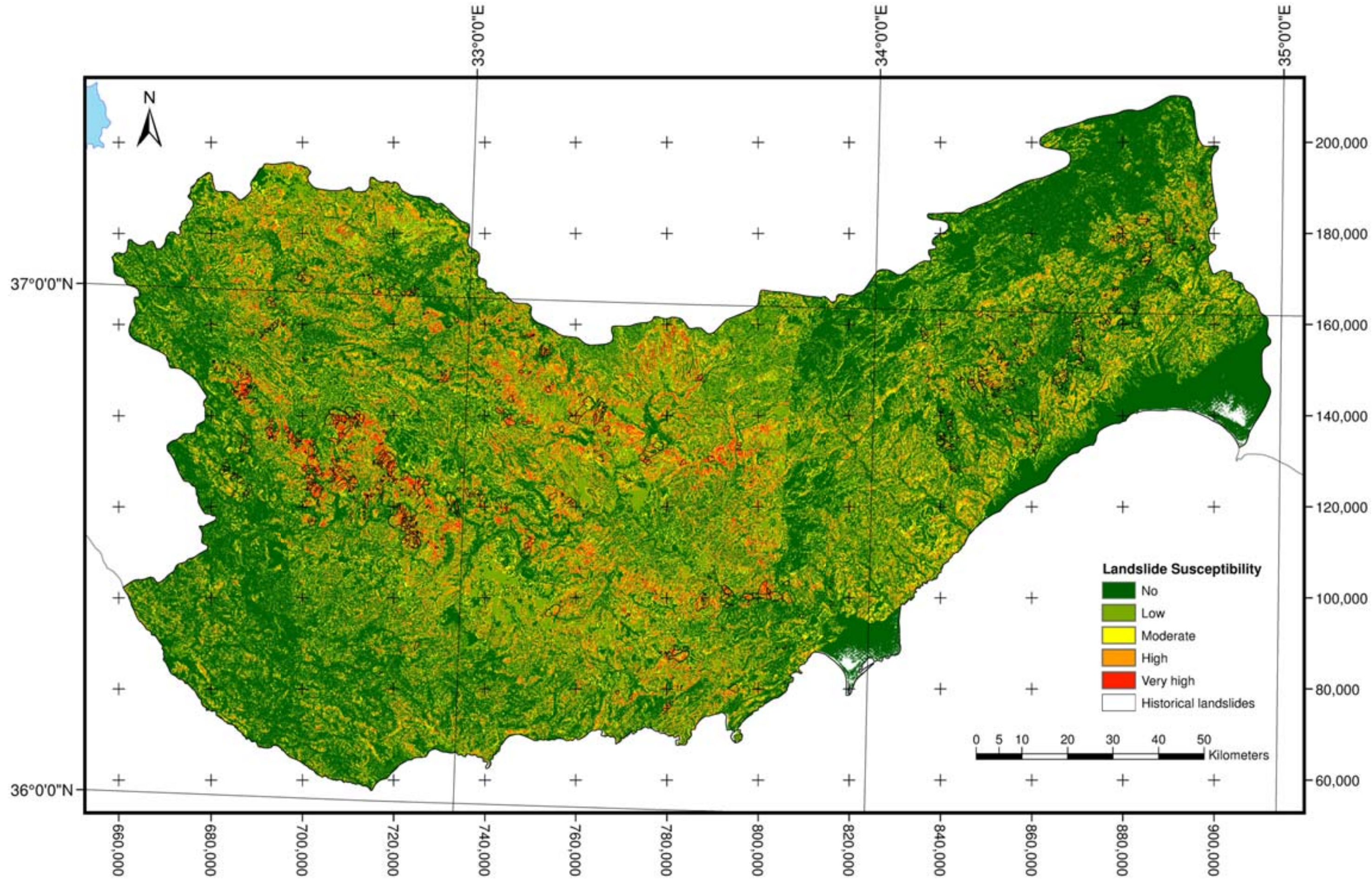

Figure 5.38 Synthetically classified landslide susceptibility map for Watershed-17.

5.2.18 Watershed No: 18 (Seyhan)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Seyhan watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.17 for the 8 factor based and 10 factors based maps, respectively.

The histogram curves for each column are plotted in Figure 5.39 using the pixel counts given in Table D.17. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.39. However, the 8 factor based histogram for the pixel values located out of the historical landslide boundaries are more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for the areas that are located in the outer landslide boundaries.

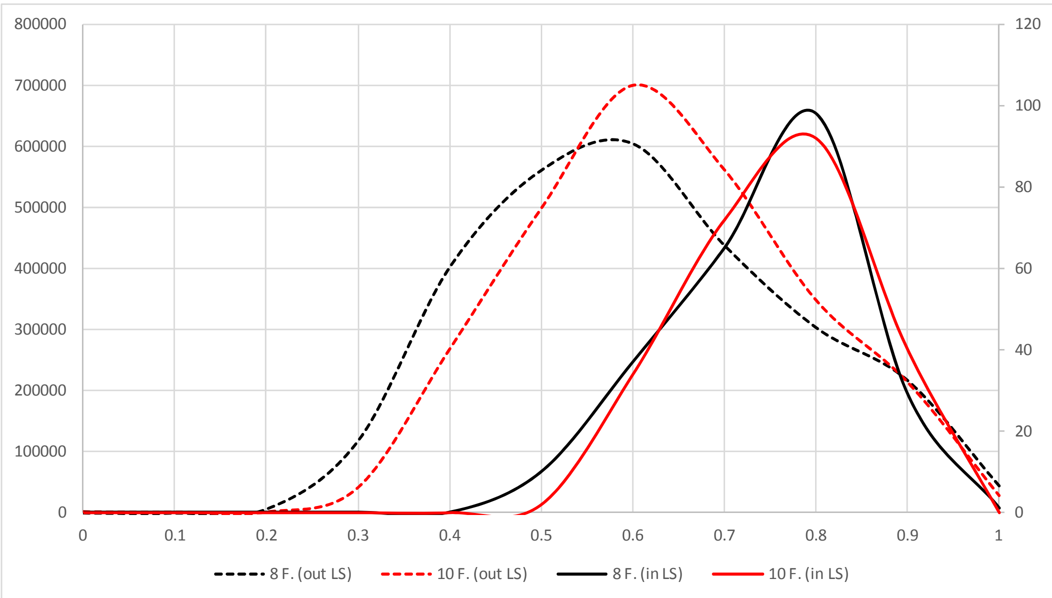

Figure 5.39 Histogram curves for the in and out of landslide boundaries for Watershed-18.

The area under the ROC curve (Fig. E.17) plotted for the 10 factor based map gives a slightly greater value than the 8 factor based map. Unfortunately, the 8 factor based approach is more accurate than the 10 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its proximity to a value of 0 for the outer landslide areas histogram curve. The threshold values were selected as described in the previous section and summarized in Table 5.20 for this watershed. The landslide susceptibility map of the Seyhan watershed was classified into five groups according to Table 5.20 and given in Figure 5.40.

Table 5.20 Threshold values and bin widths selected for synthetic classification of Watershed-18 (for 8 factors).

Class	Bin
No	0 - 0.57
Low	0.57 - 0.7
Moderate	0.7 - 0.79
High	0.79 - 0.9
Very high	0.9 - 1

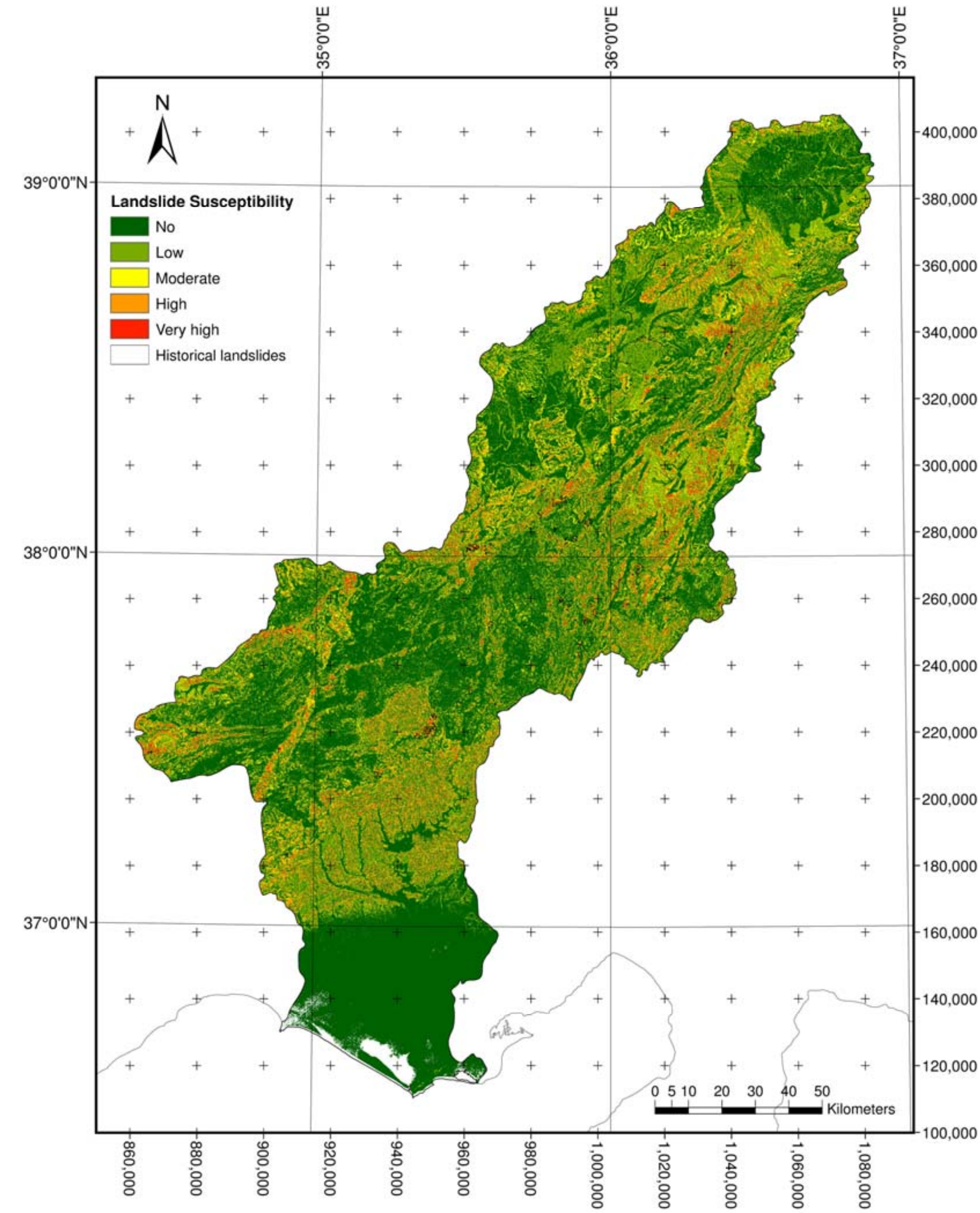

Figure 5.40 Synthetically classified landslide susceptibility map for Watershed-18.

5.2.19 Watershed No: 19 (Asi)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Asi watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.18 for the 8 factor based and 10 factors based maps, respectively.

The histogram curves for each column are plotted in Figure 5.41 using the pixel counts given in Table D.18. The peak value of the 10 factor based histogram for the pixel values located in the historical landslide boundaries is more close to a value of 1 than the peak value of the 8 factor based histogram in Figure 5.41. The peak points of both the 8 factor and 10 factor based histograms for the pixel values located out of the historical landslide boundaries are nearly on the same vertical axis. According to these histogram curves, the 10 factor based map seems to provide better results for both of the areas located in the inner and outer landslide boundaries.

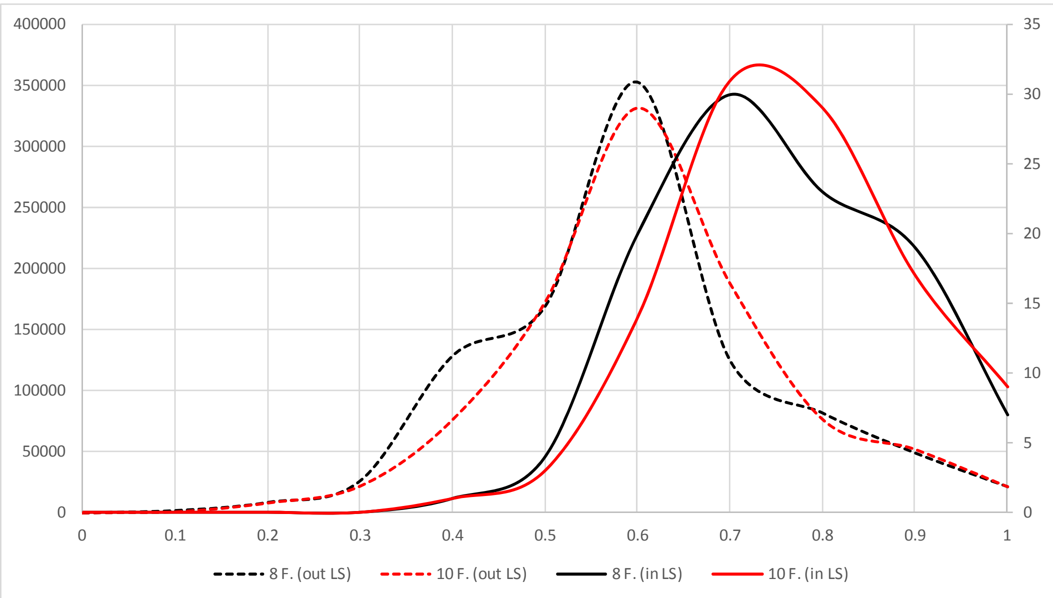

Figure 5.41 Histogram curves for the in and out of landslide boundaries for Watershed-19.

The area under the ROC curve (Fig. E.18) plotted for the 10 factor based map gives a slightly greater value than the 8 factor based map. Unfortunately, the 8 factor based approach is more accurate than the 10 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its ROC curve accuracy. The threshold values were selected as described in the previous section and summarized in Table 5.21 for this watershed. The landslide susceptibility map of the Asi watershed was classified into five groups according to Table 5.21 and given in Figure 5.42.

Table 5.21 Threshold values and bin widths selected for synthetic classification of Watershed-19 (for 8 factors).

Class	Bin
No	0 - 0.6
Low	0.6 - 0.64
Moderate	0.64 - 0.71
High	0.71 - 0.86
Very high	0.86 - 1

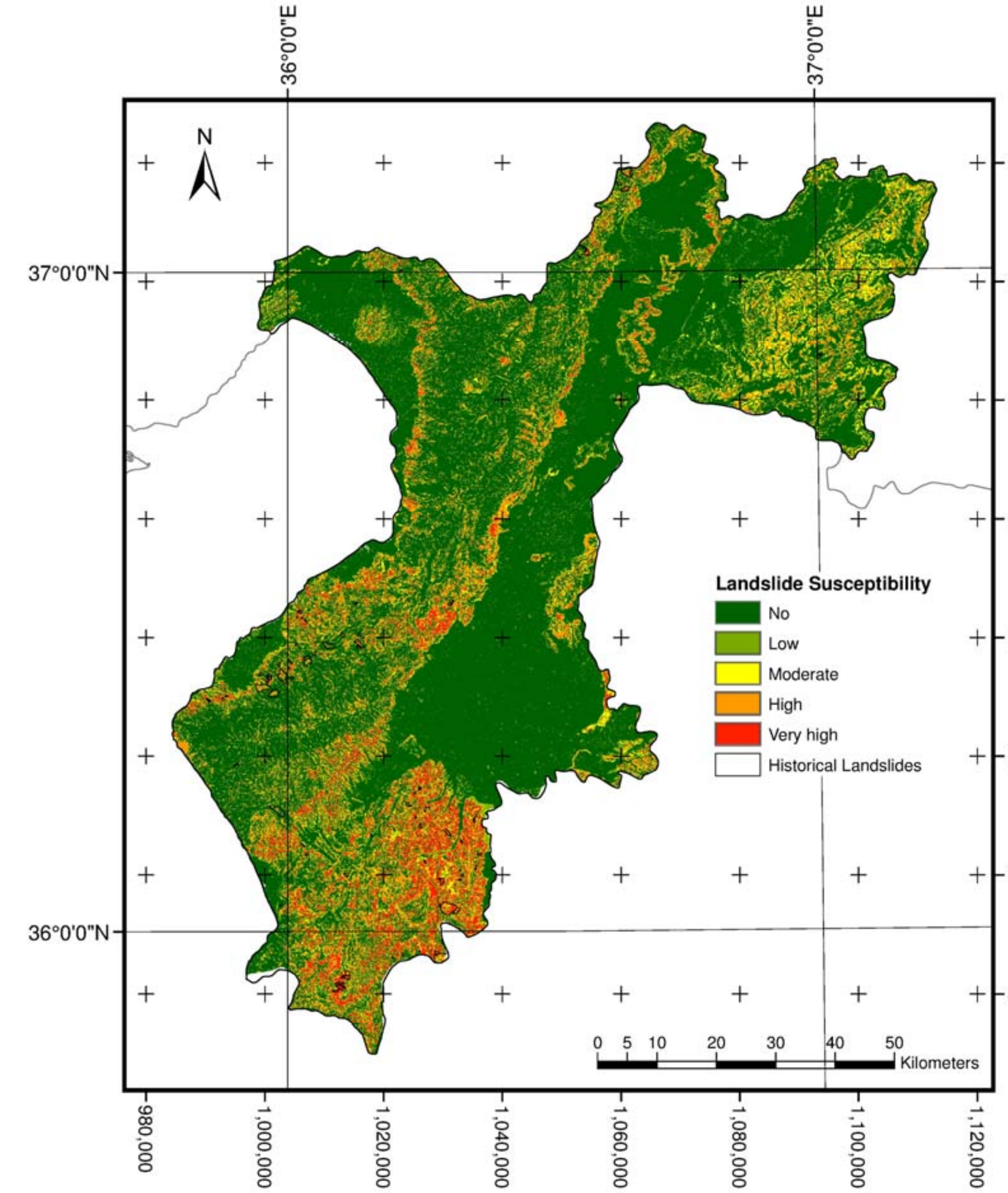

Figure 5.42 Synthetically classified landslide susceptibility map for Watershed-19.

5.2.20 Watershed No: 20 (Ceyhan)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Ceyhan watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.19 for the 8 factor based and 10 factors based maps, respectively.

The histogram curves for each column are plotted in Figure 5.43 using the pixel counts given in Table D.19. The peak value of the 10 factor based histogram for the pixel values located in the historical landslide boundaries is more close to a value of 1 than the peak value of the 8 factor based histogram in Figure 5.43. The peak points of both the 8 factor and 10 factor based histograms for the pixel values located out of the historical landslide boundaries are nearly on the same vertical axis. According to these histogram curves, the 10 factor based map seems to provide better results for both of the areas located in the inner and outer landslide boundaries.

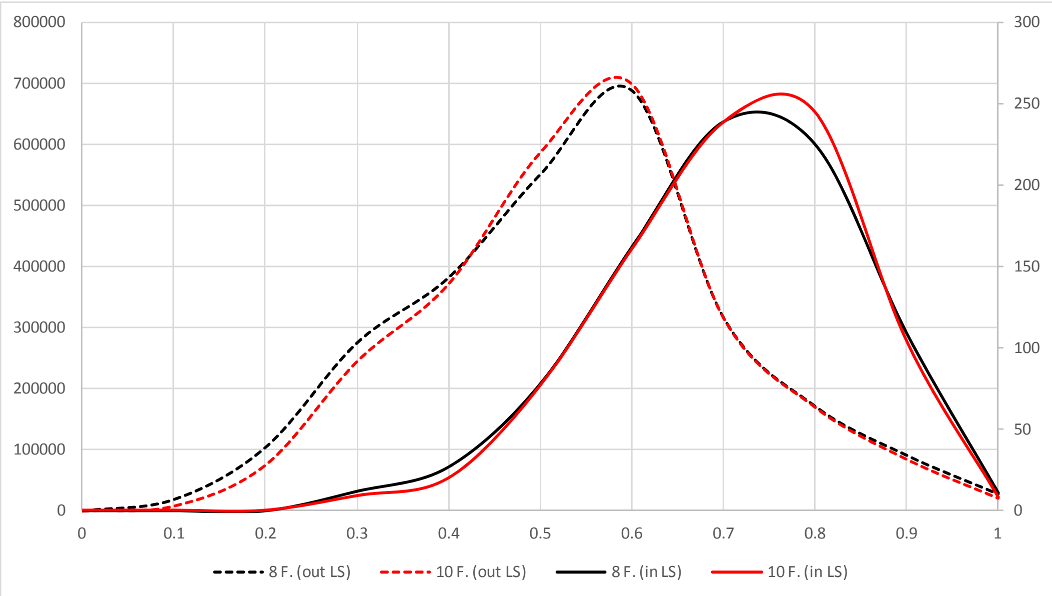

Figure 5.43 Histogram curves for the in and out of landslide boundaries for Watershed-20.

The area under the ROC curve (Fig. E.19) plotted for the 10 factor based map gives a slightly greater value than the 8 factor based map. Unfortunately, the 8 factor based approach is more accurate than the 10 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its ROC curve accuracy. The threshold values were selected as described in the previous section and summarized in Table 5.22 for this watershed. The landslide susceptibility map of the Ceyhan watershed was classified into five groups according to Table 5.22 and given in Figure 5.44.

Table 5.22 Threshold values and bin widths selected for synthetic classification of Watershed-20 (for 8 factors).

Class	Bin
No	0 - 0.58
Low	0.58 - 0.64
Moderate	0.64 - 0.74
High	0.74 - 0.87
Very high	0.87 - 1

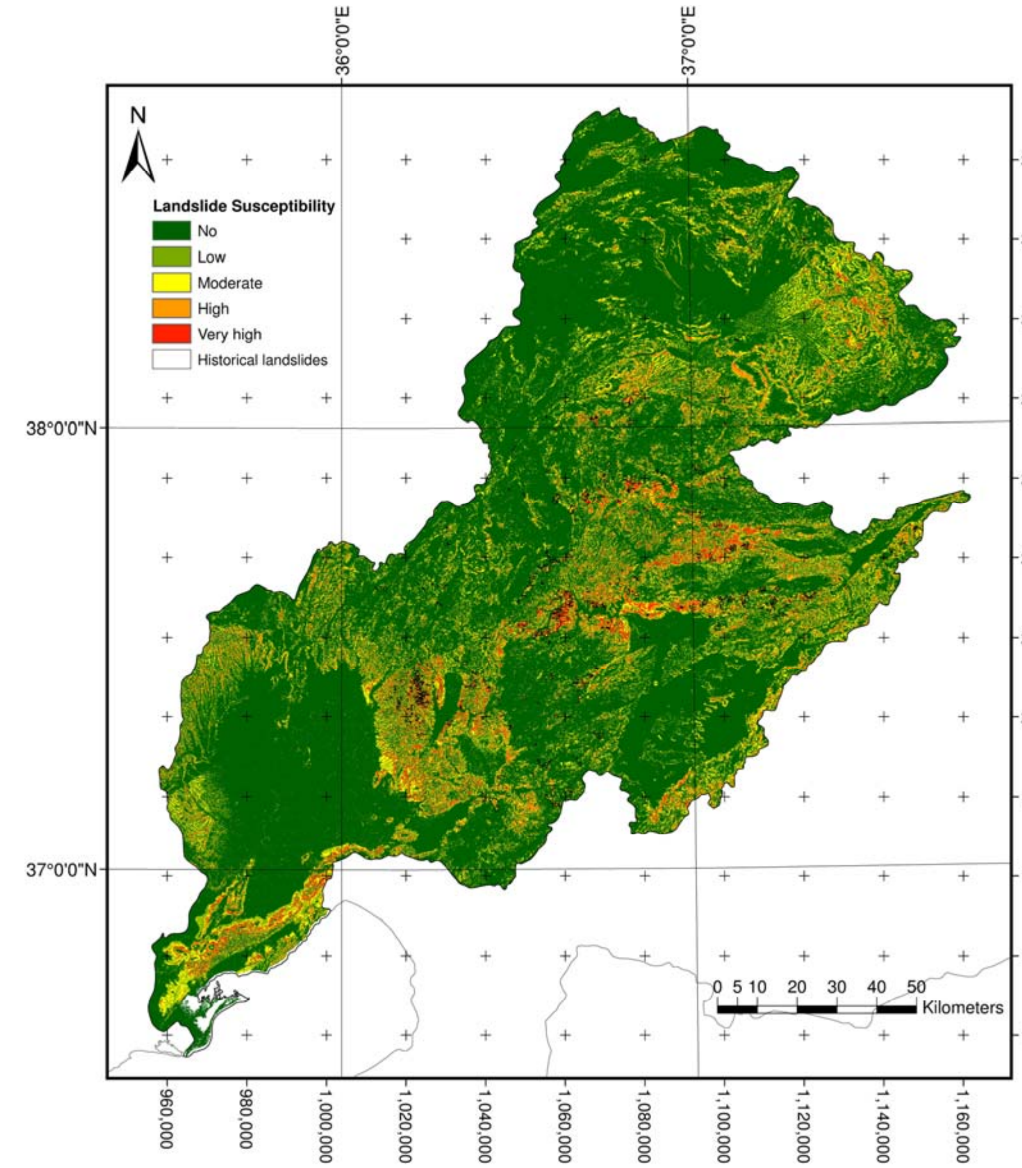

Figure 5.44 Synthetically classified landslide susceptibility map for Watershed-20.

5.2.21 Watershed No: 21 (Fırat)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Fırat watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.20 for the 8 factor based and 10 factors based maps, respectively.

The histogram curves for each column are plotted in Figure 5.45 using the pixel counts given in Table D.20. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.45. However, the 8 factor based histogram for the pixel values located out of the historical landslide boundaries is more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for both of the areas that are located in the inner and outer landslide boundaries.

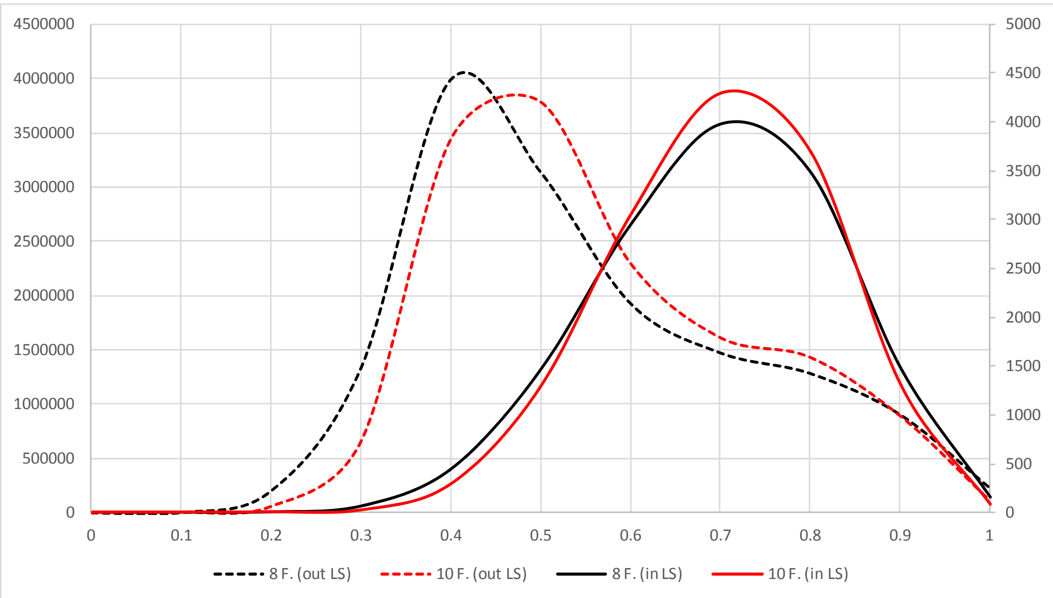

Figure 5.45 Histogram curves for the in and out of landslide boundaries for Watershed-21.

The area under the ROC curve (Fig. E.20) plotted for the 10 factor based map gives a greater value than the 8 factor based map. The 10 factor based approach is also more accurate than the 8 factor based one.

Finally, the 10 factor based map was selected for this watershed by considering its greater ROC curve values. The threshold values were selected as described in the previous section and summarized in Table 5.23 for this watershed. The landslide susceptibility map of the Fırat watershed was classified into five groups according to Table 5.23 and given in Figure 5.46.

Table 5.23 Threshold values and bin widths selected for synthetic classification of Watershed-21 (for 10 factors).

Class	Bin
No	0 - 0.47
Low	0.47 - 0.58
Moderate	0.58 - 0.72
High	0.72 - 0.86
Very high	0.86 - 1

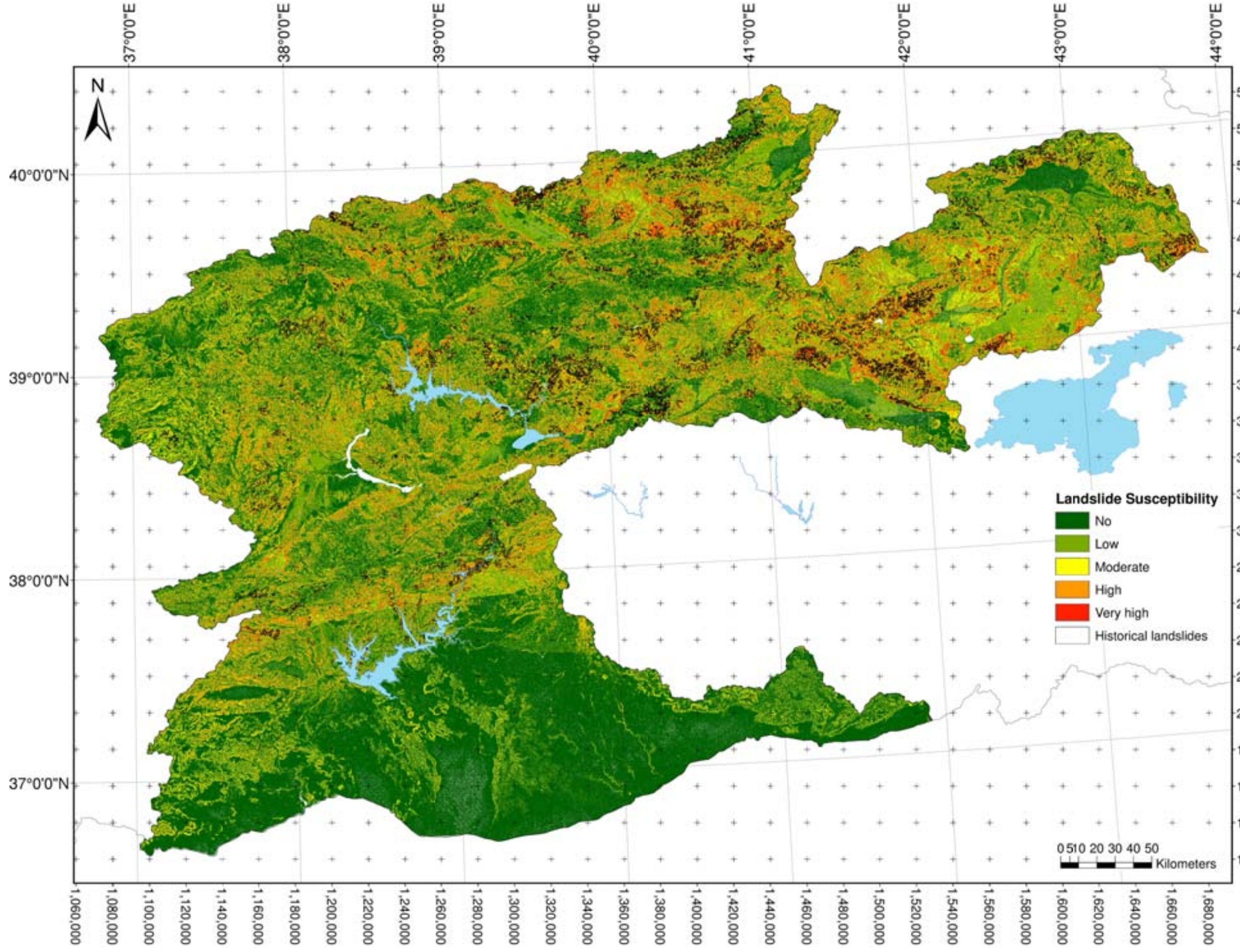

Figure 5.46 Synthetically classified landslide susceptibility map for Watershed-21.

5.2.22 Watershed No: 22 (Doğu Karadeniz)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Doğu Karadeniz watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.21 for the 8 factor based and 10 factors based maps, respectively.

The histogram curves for each column are plotted in Figure 5.47 using the pixel counts given in Table D.21. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.47. However, the 8 factor based histogram for the pixel values located out of the historical landslide boundaries is slightly close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for both of the areas that are located in the inner and outer landslide boundaries.

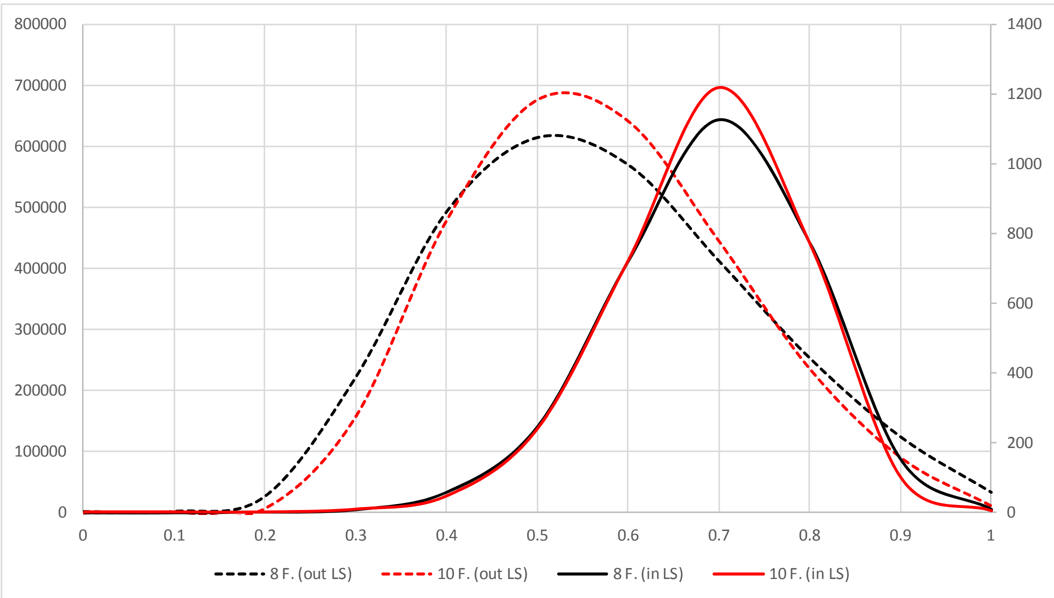

Figure 5.47 Histogram curves for the in and out of landslide boundaries for Watershed-22.

The area under the ROC curve (Fig. E.21) plotted for the 10 factor based map gives a greater value than the 8 factor based map. The 10 factor based approach is also more accurate than the 8 factor based one.

Finally, the 10 factor based map was selected for this watershed by considering its ROC curve values. The threshold values were selected as described in the previous section and summarized in Table 5.24 for this watershed. The landslide susceptibility map of the Doğu Karadeniz watershed was classified into five groups according to Table 5.24 and given in Figure 5.48.

Table 5.24 Threshold values and bin widths selected for synthetic classification of Watershed-22 (for 10 factors).

Class	Bin
No	0 - 0.53
Low	0.53 - 0.64
Moderate	0.64 - 0.7
High	0.7 - 0.85
Very high	0.85 - 1

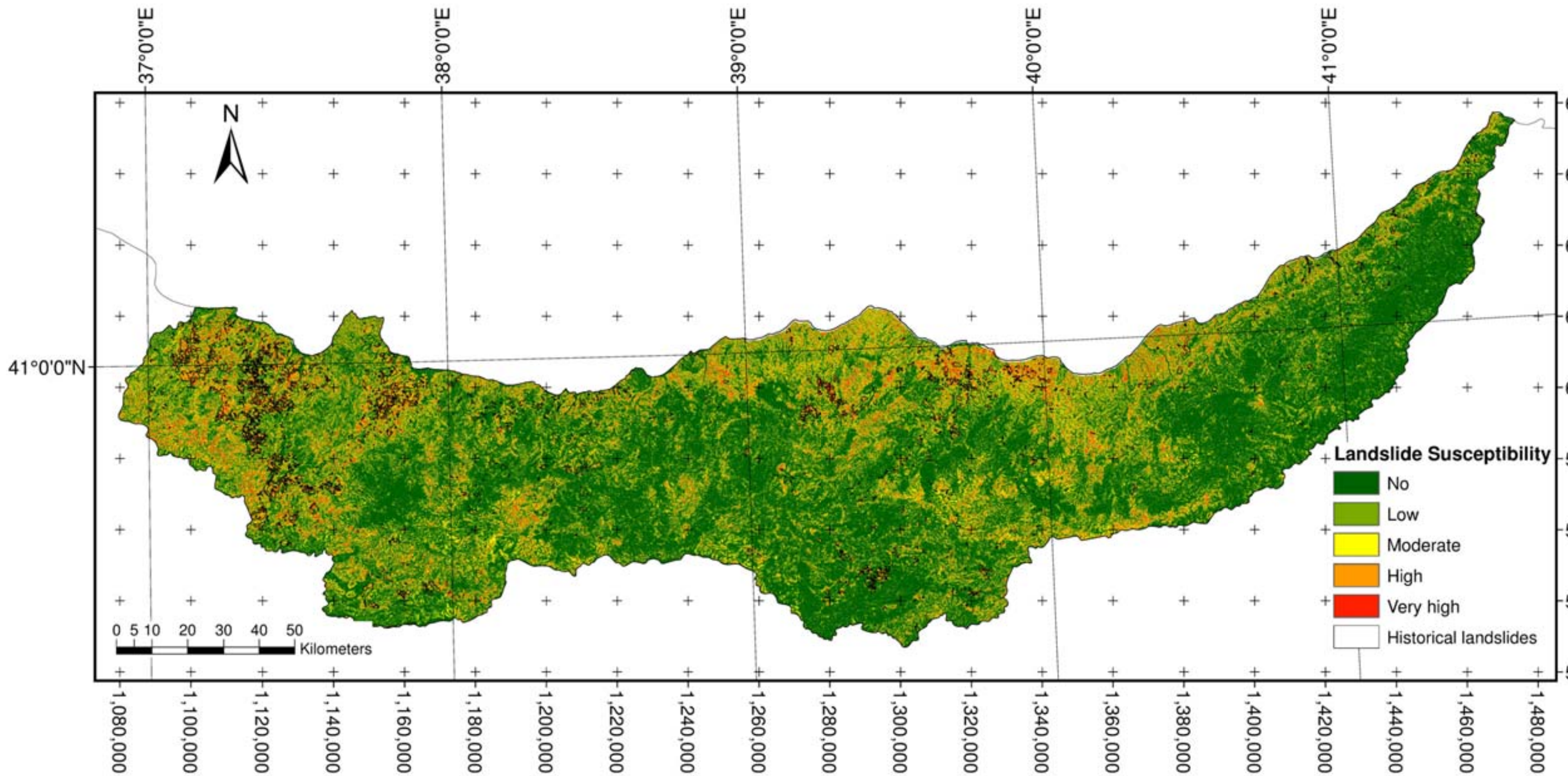

Figure 5.48 Synthetically classified landslide susceptibility map for Watershed-22.

5.2.23 Watershed No: 23 (Çoruh)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Çoruh watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.22 for the 8 factor based and 10 factors based maps, respectively.

The histogram curves for each column are plotted in Figure 5.49 using the pixel counts given in Table D.22. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.49. However, the 8 factor based histogram for the pixel values located out of the historical landslide boundaries is more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for both of the areas that are located in the inner and outer landslide boundaries.

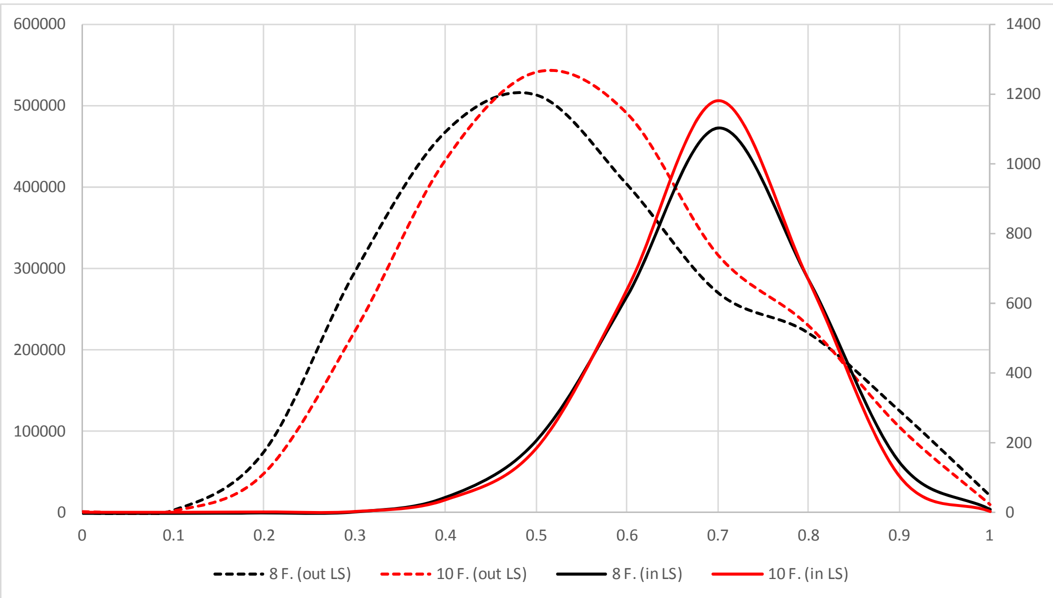

Figure 5.49 Histogram curves for the in and out of landslide boundaries for Watershed-23.

The area under the ROC curve (Fig. E.22) plotted for the 8 factor based map gives a slightly greater value than the 10 factor based map. The 8 factor based approach is also more accurate than the 10 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its greater ROC curve values. The threshold values were selected as described in the previous section and summarized in Table 5.25 for this watershed. The landslide susceptibility map of the Çoruh watershed was classified into five groups according to Table 5.25 and given in Figure 5.50.

Table 5.25 Threshold values and bin widths selected for synthetic classification of Watershed-23 (for 8 factors).

Class	Bin
No	0 - 0.48
Low	0.48 - 0.64
Moderate	0.64 - 0.7
High	0.7 - 0.85
Very high	0.85 - 1

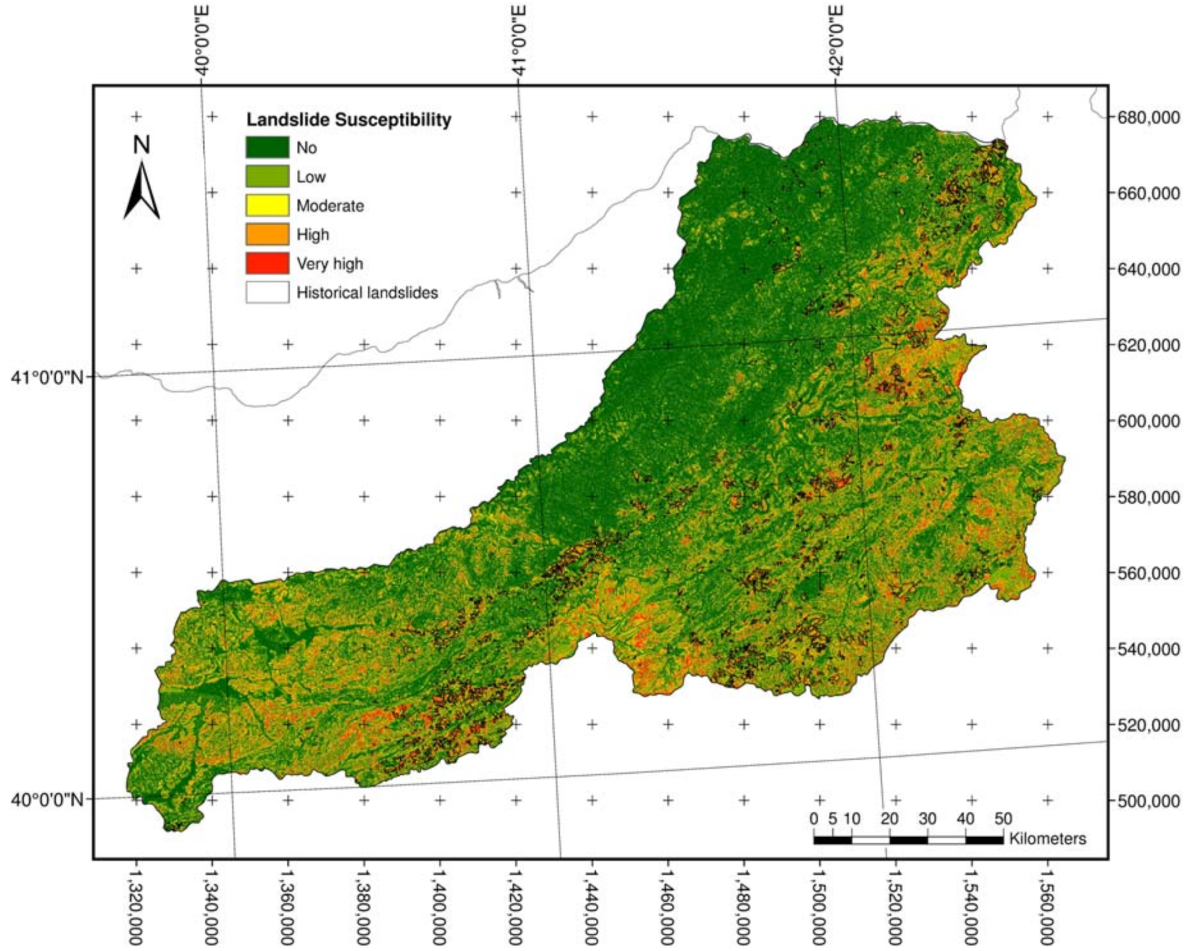

Figure 5.50 Synthetically classified landslide susceptibility map for Watershed-23.

5.2.24 Watershed No: 24 (Aras)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Aras watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.23 for the 8 factor based and 10 factors based maps, respectively.

The histogram curves for each column are plotted in Figure 5.51 using the pixel counts given in Table D.23. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.51. However, the 8 factor based histogram for the pixel values located out of the historical landslide boundaries are slightly close to a value of 0 than the 10 factor based histogram. Unfortunately, histogram curves do not provide appropriate information for selecting an 8 factor or 10 factor based map for this watershed.

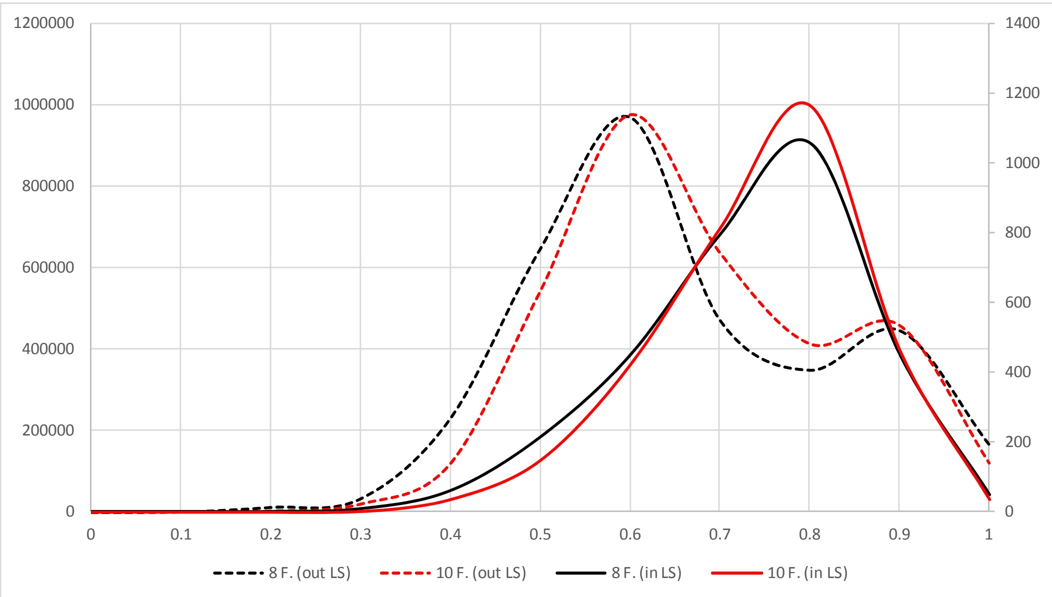

Figure 5.51 Histogram curves for the in and out of landslide boundaries for Watershed-24.

The area under the ROC curve (Fig. E.23) plotted for the 8 factor based map gives nearly the same value for the 10 factor based approach, but the 8 factor based map is more accurate than the 8 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its ROC curve accuracy. The threshold values were selected as described in the previous section and summarized in Table 5.26 for this watershed. The landslide susceptibility map of the Aras watershed was classified into five groups according to Table 5.26 and given in Figure 5.52.

Table 5.26 Threshold values and bin widths selected for synthetic classification of Watershed-24 (for 8 factors).

Class	Bin
No	0 - 0.59
Low	0.59 - 0.67
Moderate	0.67 - 0.79
High	0.79 - 0.9
Very high	0.9 - 1

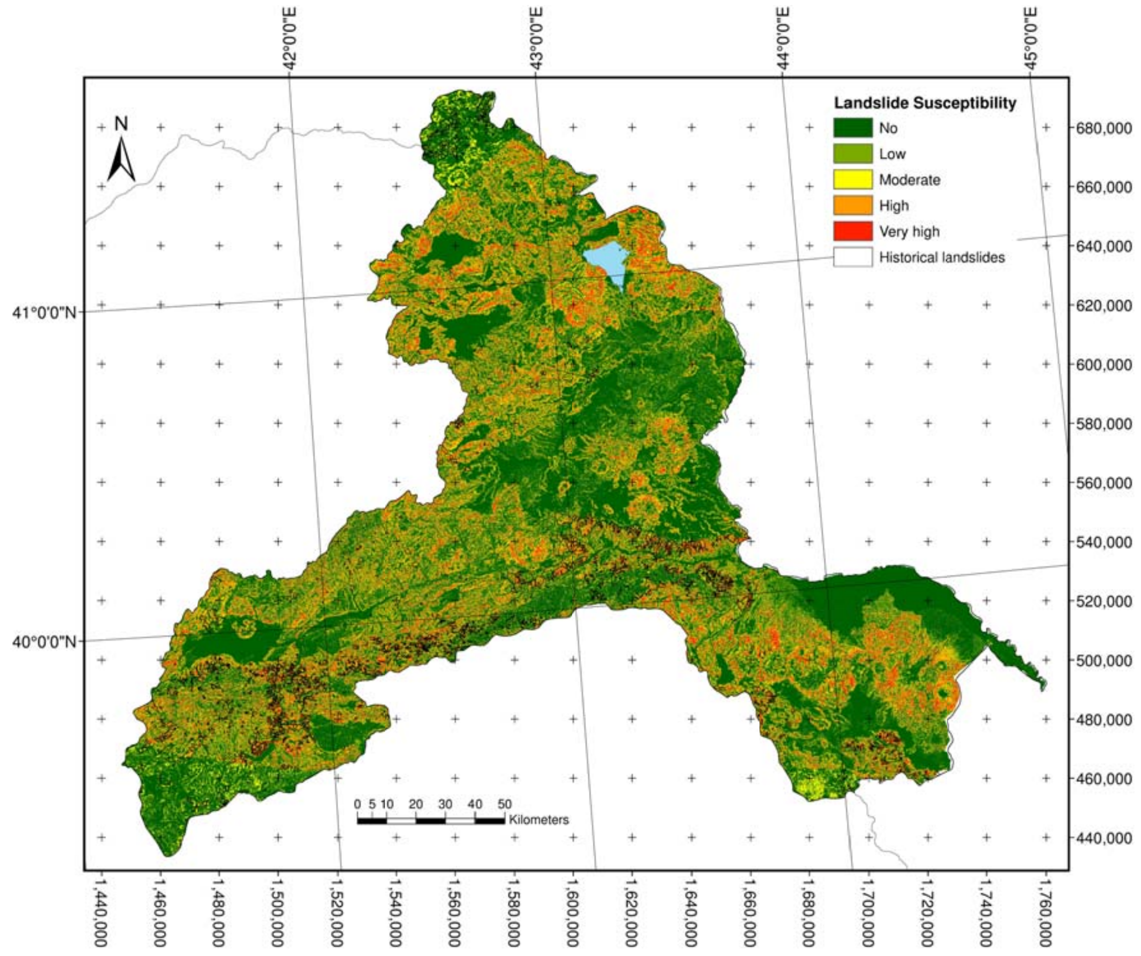

Figure 5.52 Synthetically classified landslide susceptibility map for Watershed-24.

5.2.25 Watershed No: 25 (Van Gölü)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Van Gölü watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.24 for the 8 factor based and 10 factors based maps, respectively.

The histogram curves for each column are plotted in Figure 5.53 using the pixel counts given in Table D.24. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.53. However, the 8 factor based histogram for the pixel values located out of the historical landslide boundaries is more close to a value of 0 than the 10 factor based histogram. According to these histogram curves, the 8 factor based map gives better results for both of the areas that are located in the inner and outer landslide boundaries.

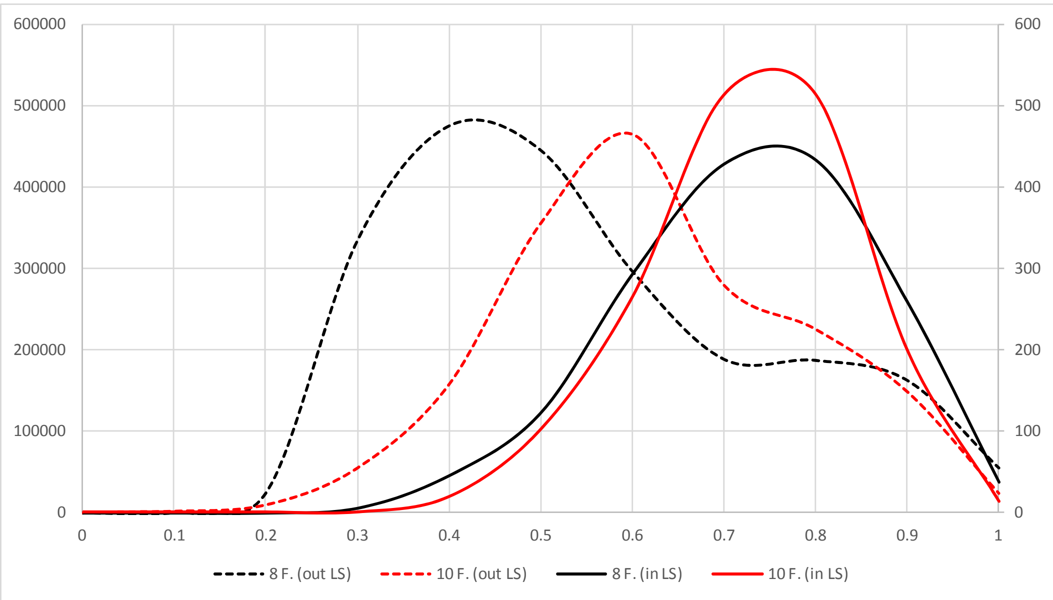

Figure 5.53 Histogram curves for the in and out of landslide boundaries for Watershed-25.

The area under the ROC curve (Fig. E.24) plotted for the 8 factor based map gives a greater value than 10 factor based map. The 8 factor based approach is also more accurate than 10 factor based one.

Finally, 8 factor based map is selected for this watershed by considering its greater ROC curve values. The threshold values were selected as described in the previous section and summarized in Table 5.27 for this watershed. The landslide susceptibility map of the Van Gölü watershed was classified into five groups according to Table 5.27 and given in Figure 5.54.

Table 5.27 Threshold values and bin widths selected for synthetic classification of Watershed-25 (for 8 factors).

Class	Bin
No	0 - 0.43
Low	0.43 - 0.6
Moderate	0.6 - 0.76
High	0.76 - 0.88
Very high	0.88 - 1

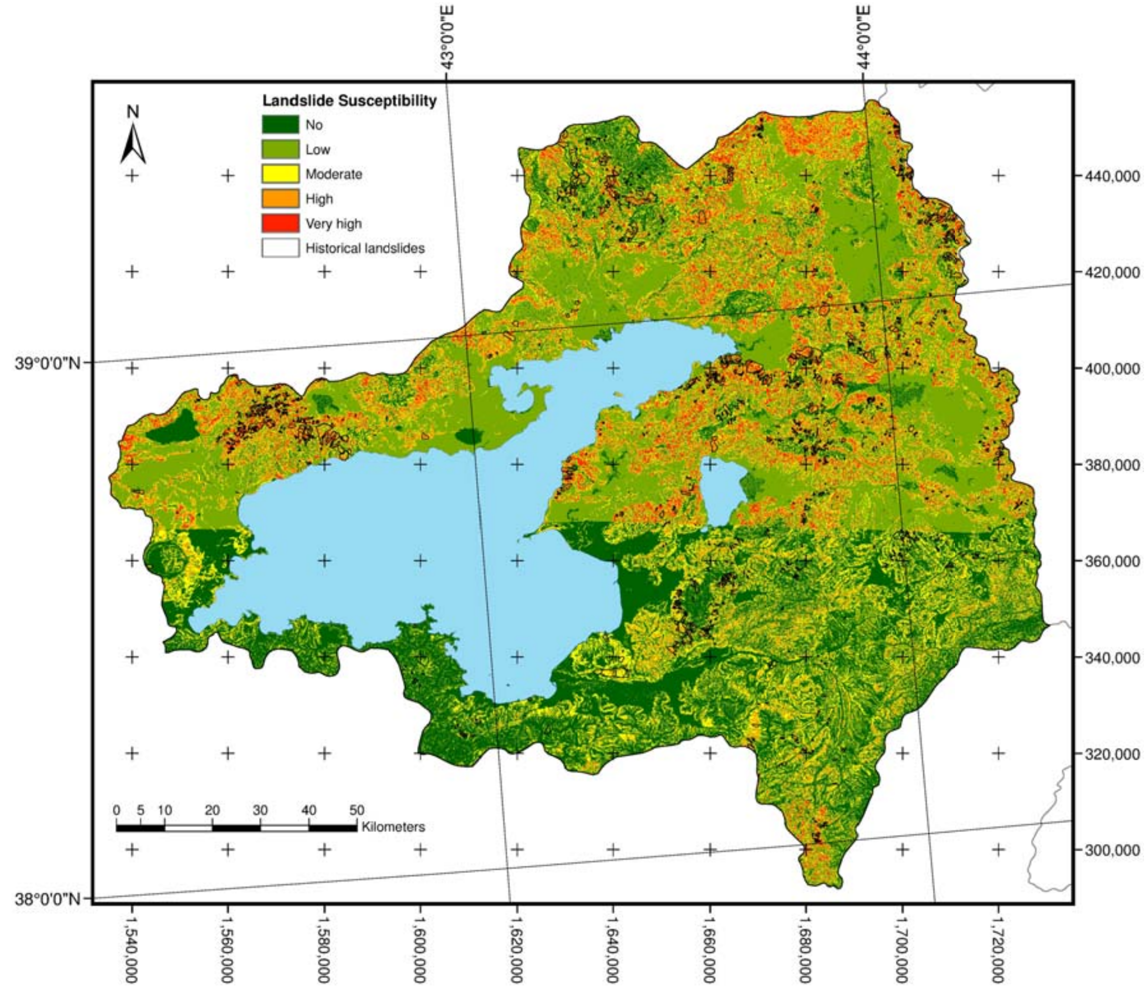

Figure 5.54 Synthetically classified landslide susceptibility map for Watershed-25.

5.2.26 Watershed No: 26 (Dicle)

The pixel values of both landslide susceptibility maps with 8 factors and 10 factors obtained for the Dicle watershed were classified into 10 subclasses having a bin width of 0.10. The total pixel counts in the landslide areas and out of the landslide areas are summarized in Table D.25 for the 8 factor based and 10 factors based maps, respectively.

The histogram curves for each column are plotted in Figure 5.55 using the pixel counts given in Table D.25. The peak value of the 8 factor based histogram for the pixel values located in the historical landslide boundaries and the peak value of the 10 factor based histogram are located nearly in the same location on the vertical axis in Figure 5.55. The same condition continues for both of the 8 factor and 10 factor based histogram curves for the pixel values of the outer historical landslide boundaries. According to these histogram curves, it is really hard to determine which map to select.

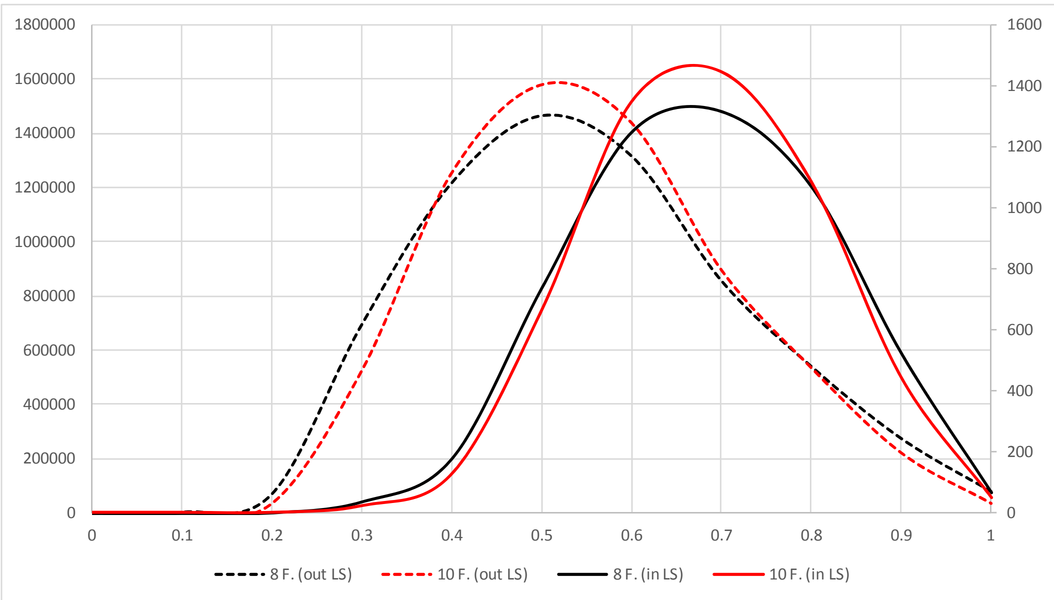

Figure 5.55 Histogram curves for the in and out of landslide boundaries for Watershed-26.

The area under the ROC curve (Fig. E.25) plotted for the 8 factor based map gives a slightly greater value than the 10 factor based map. The 8 factor based approach is also more accurate than the 10 factor based one.

Finally, the 8 factor based map was selected for this watershed by considering its greater ROC curve values. The threshold values were selected as described in the previous section and summarized in Table 5.28 for this watershed. The landslide susceptibility map of the Dicle watershed was classified into five groups according to Table 5.28 and given in Figure 5.56.

Table 5.28 Threshold values and bin widths selected for synthetic classification of Watershed-26 (for 8 factors).

Class	Bin
No	0 - 0.51
Low	0.51 - 0.58
Moderate	0.58 - 0.66
High	0.66 - 0.83
Very high	0.83 - 1

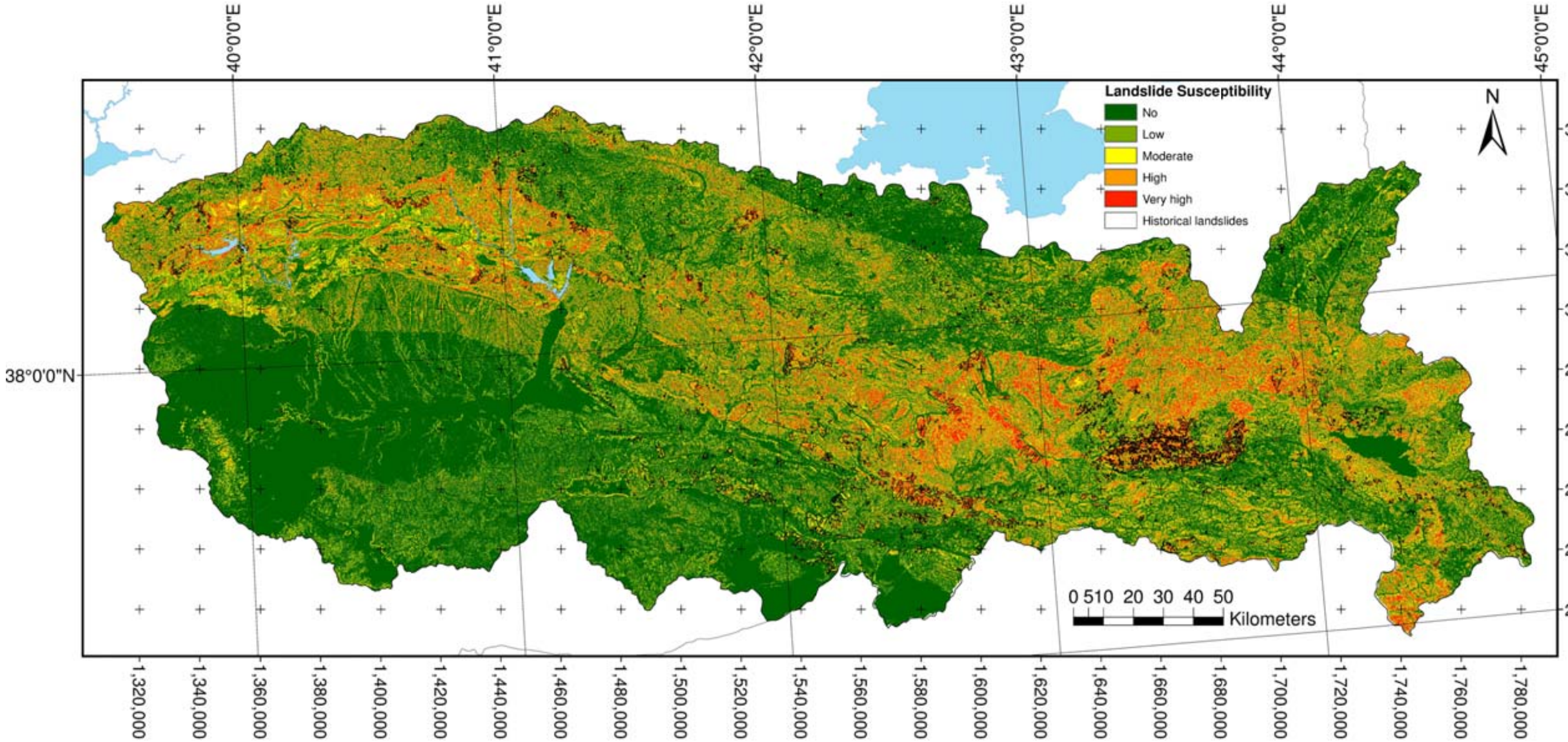

Figure 5.56 Synthetically classified landslide susceptibility map for Watershed-26.

5.3 Performances of the produced landslide susceptibility maps

Most of these factors (i.e., slope, internal relief, aspect, topographic wetness index, classified landforms and classified curvature factors) used in this study have been derived from DEM which is the most important data source for landslide susceptibility assessments. Only slope and relief could be comparable between two different levels of studies (1:2,000,000 and 1:500,000 scaled). The differences between the ranges of these factors for entire Turkey are summarized in Table 5.29. It is clear that the DEM resolution has great impact for its derivatives; the increment of DEM resolution causes increment of range width for its derivatives. These increments are expected to result in more reliable factor maps.

Table 5.29 Slope and relief factor ranges for different resolutions in Turkey.

Pixel Resolution	Slope Angle (°)		Relief (m/km^2)	
	Min	Max	Min	Max
500 m	0	57	0	869
90 m	0	81	0	1961

AHP is a convenient way for a quantitative analysis to unquantitative matters in multi criteria decision analysis; it is also an effective method for people to objectively subscribe the subjective judgments. Using AHP to solve the problem, first the problem is made hierarchic, separated into several different factors according to its quality and target, and then the factors are grouped into several levels according to their mutual influence and their subordinate relationship in order to form a multi-hierarchy analysis model, and, finally, the system analysis is summed up as the determination of the weight which represents the importance of the lowest level relative to the highest level or as the queuing process of system quality. There are no fixed or standard values of weight and rating for a landslide related to the factors, a determination of a weight and rating value that are proved to be very important in a landslide susceptibility analysis. The weight and rating should be determinate based on an objective analysis, not on subjective experts' opinions. During AHP stages performed to obtain rating values or to determine which factor is more effective on landslide occurrences, the footprint areas of the historical landslides have been used. These areas have been overlain with unnormalized values of each factor based, respectively.

It is found that there is no linear relation between slope and landslide. The historical landslides that have mainly occurred in Turkey generally concentrates between slope values of 5° and 15°, which imply that areas having 50° of slope are not more susceptible to landslide than areas having 10° of slope. The landslides have mainly occurred between relief values of 100 m/km^2 and 250 m/km^2 throughout entire Turkey.

Another leading observation is wetness index range for the landslides that have occurred in Turkey. The huge percentage of historical landslides occurred in TWI layer possessing values of 12 and 13 that were derived from 90 m resolution DEM. Based on the assumption that topography controls the movement of water in sloping terrains, TWI can quantify the control of local topography on hydrological processes and indicate the spatial distribution of soil moisture and surface saturation. It forms the key component of distributed hydrological model, TOPMODEL, and is used to characterize hydrological similarity. So TWI is an important index for modeling the topography-related geographical processes at a hillslope or watershed scale. After investigating TWI distribution for any of the watersheds, the values of 12-13 seems nearly half of the watershed area and this range is located nearly in the middle of the entire TWI range. It could be concluded that a TWI value of 12 seems to be a threshold value for the beginning process of a landslide in any watershed for this resolution.

Most of the historical landslides occurred in open slope type of landforms and planar slope (S/S) type of curvatures as expected. Unfortunately, there is no significant aggregation on any range of either rainfall and aspect range for entire Turkey, that is why AHP has been performed for each watershed with 8 factor and 10 factor based layers, respectively.

The agricultural areas and forests are the land cover types that are more susceptible to landslides according to the historical data in Turkey. Most of the historical landslides occurred in earthquake zone-1 of Turkey as expected. The continental clastic rock type is the most landslide prone lithologic unit of Turkey. Clastic and carbonate rocks are also the consequent lithologic unit that is landslide susceptible in Turkey according to the historical landslides.

After obtaining unclassified landslide susceptibly maps containing 8 factor and 10 factor based approach for the 26 watersheds, the selection procedure was carried out as described in section 5.2.1. Most of the watersheds provided better results for the 8 factor based approach than the 10 factor based one. In fact, there is no rule of thumb of using more factors for higher number of landslide occurred watersheds. For example, the watershed-23 (Aras) which is on the second order considering the historical landslide footprint area distribution gives better results with a 8 factor based approach. But, the watershed-7 (Büyük Menderes) which is on the 15th order considering the historical landslide footprint area distribution gives better results with a 10 factor based approach.

The selection of an 8 factor or 10 factor based approach has been completely performed on pixel counts located in the inner and outer historical landslide and ROC curves. The closest peak value of the outer landslide histogram to a value of 0 and also the closest peak value of the inner landslide histogram to a value of 1 was the main criteria utilized for selection. The secondary criterion is the values of the ROC curves. The area under the ROC curve and also the accuracy were checked in case of insufficient information obtained from the histogram curves.

The watersheds of Akarçay (11), Batı Karadeniz (13), Yeşilırmak (14) and Kızılırmak (15) which have higher historical landslide occurrences have good accuracy (between 0.80 and 0.90) that is measured by the areas under the ROC curves. The majority of the watersheds numbered as 1, 2, 3, 4, 5 ,6 ,7 ,8 ,9 ,10, 17, 18, 19, 20, 22, 23 and 25 have rather fair accuracy (between 0.70 and 0.80) according to the areas under the ROC curves. The watersheds of Konya Kapalı (16), Fırat (21), Aras (24) and Dicle (26) of which most have higher historical landslide occurrences have poor accuracy (between 0.60 and 0.70) that is measured by the area under the ROC curve. Unfortunately, the Watershed-12 (Sakarya) has failed (the area under the ROC curve between 0.50 and 0.60) for both an 8 factor and 10 factor based approach.

The major observation for the accuracy values of the area under the ROC curve mentioned above is that all of the watersheds having good accuracy were selected as a 10 factor based approach. But the rest of the watersheds have both 8 factor and 10 factor based approaches for fair and poor accuracies, where there is no significant discrimination for the number of factors utilized.

The failure of the Watershed-12 (Sakarya) could be explained by the distribution of the lithologic units in this watershed. The number of different lithologic units located in this watershed is 19; unfortunately 18 of these units are landslide prone according to the historical landslide datasets. This implies that rating 18 of these 19 units and also weighing lithology is not logical for this watershed. It seems that even though a 8 factor based approach has been selected for this watershed, this watershed most probably requires a different number of factors for its analysis. It is clear that the area under the ROC curve for the 8 factor based approach has a greater value (0.5672) than the 10 factor based one (0.5189). The decreasing number of factors would most probably give a better result for this watershed. With the help this finding, it could be concluded that other watersheds having poor and fair accuracies according to the area under the ROC curve have more factors for determining landslide susceptibility. But this option is out of the scope of this study that was aimed to obtain landslide susceptibility map of the entire Turkey using a 8 factor or 10 factor based AHP approach in watershed scale. The results presented in this section represent the optimum (best) values reached after time consuming trials.

The selected unclassified landslide susceptibility maps based on AHP approaches having 8 or 10 factors have synthetically classified the watersheds into five groups as explained in section 5.2.1. The distributions of these groups are summarized in Table 5.30.

Table 5.30 Synthetically classified landslide susceptibility zone distributions for watersheds.

No	Watershed Name	Selected Factors	Pixel Counts	Classified Landslide Susceptibility Zones				
				No	*Low*	*Moderate*	*High*	*Very High*
1	Meriç-Ergene	8	1783136	64.35%	23.22%	10.26%	2.10%	0.07%
2	Marmara	10	2764674	31.42%	18.53%	41.49%	6.38%	2.18%
3	Susurluk	8	2938688	55.49%	21.84%	10.68%	9.01%	2.98%
4	Kuzey Ege	8	1223660	45.55%	23.62%	9.75%	16.98%	4.10%
5	Gediz	8	2050888	51.17%	26.51%	16.51%	4.52%	1.28%
6	Küçük Menderes	8	847415	57.04%	31.62%	10.48%	0.73%	0.12%
7	Büyük Menderes	10	3155909	57.03%	18.65%	15.50%	6.56%	2.26%
8	Batı Akdeniz	10	2552371	55.82%	18.29%	7.95%	14.68%	3.26%
9	Antalya	8	2492362	62.63%	16.80%	9.36%	9.50%	1.71%
10	Burdur	8	724849	45.87%	24.79%	14.49%	10.18%	4.66%
11	Akarçay	10	932025	60.37%	28.87%	8.78%	1.76%	0.21%
12	Sakarya	8	7412864	49.23%	20.46%	15.87%	11.46%	2.98%
13	Batı Karadeniz	10	3568596	46.39%	22.41%	12.24%	14.37%	4.59%
14	Yeşilırmak	10	4863497	42.89%	26.02%	14.92%	10.23%	5.94%
15	Kızılırmak	10	9863497	45.84%	21.97%	11.46%	16.62%	4.11%
16	Konya Kapalı	8	5928017	64.77%	20.05%	9.97%	4.61%	0.59%
17	Doğu Akdeniz	8	2656410	52.36%	22.79%	10.87%	12.15%	1.82%
18	Seyhan	8	2655827	55.39%	23.53%	10.44%	8.93%	1.70%
19	Asi	8	947267	71.06%	5.98%	8.25%	10.95%	3.76%
20	Ceyhan	8	2595952	73.98%	8.68%	9.29%	6.21%	1.84%
21	Fırat	10	14484190	47.05%	20.87%	16.12%	13.13%	2.84%
22	Doğu Karadeniz	10	2813106	54.85%	23.17%	8.89%	11.31%	1.77%
23	Çoruh	8	2495302	51.02%	25.96%	6.46%	13.34%	3.22%
24	Aras	8	3420905	53.81%	12.91%	12.74%	15.24%	5.30%
25	Van Gölü	8	2210789	41.25%	30.64%	14.17%	9.81%	4.13%
26	Dicle	8	6426892	54.19%	14.68%	12.08%	14.87%	4.19%

The landslide susceptibility zones that have been grouped as high and very high were compared with the historical landslide distributions for watersheds that are given in the last column of Table 5.6 and in Table 5.31. It is expected that the area size of susceptibility zone grouped as very high should be greater than the size of the historical landslide footprint area for the related watershed.

It is observed that most of watersheds follow this criterion, but 6 of them have lower area size than the historical landslides areas for the susceptibility zones grouped as very high. These watersheds are highlighted in red color in Table 5.31. Akarçay, Batı Karadeniz and Fırat watersheds have great difference between area of very high susceptible group and the historical landslide areas, but the difference obtained for the other watersheds may be ignored. The reason of this situation is the selection of the threshold values for the synthetic classification of landslide susceptibility maps. It is clear that the procedure explained in section 5.2.1 leads to underestimations for these watersheds.

According to this observation, it could be concluded that these watersheds could be synthetically re-classified to handle this situation. Unfortunately, this option is out of the scope of this study because every watershed was synthetically classified according to the standard procedure explained in section 5.2.1. Another column is added to Table 5.31 that has the sum area percentages of landslide susceptibility zones grouped as high and very high. The area distributions obtained for these groups are greater than the historical landslide areas, expect for Watershed-11 (Akarçay). The value of the Akarçay watershed is so close to the historical landslide area that could be ignored for the landslide susceptibility assessment performed in a 1:500,000 scale.

Finally, synthetically classified landslide susceptibility maps of each watershed were merged into one map that is the final product of this study and given as a Figure F.1 in Appendix-F.

Table 5.31 Comparison of synthetically classified highly landslide susceptible zone areas and the historical landslide areas for each watershed.

No	Watershed Name	Selected Factors	Pixel Counts	Classified LS zones vs Historical LS					
				Very High			*High+Very High*		
1	Meriç-Ergene	8	1783136	0.07%	>	0.04%	2.17%	>	0.04%
2	Marmara	10	2764674	2.18%	>	1.89%	8.56%	>	1.89%
3	Susurluk	8	2938688	2.98%	>	0.59%	11.99%	>	0.59%
4	Kuzey Ege	8	1223660	4.10%	>	0.54%	21.08%	>	0.54%
5	Gediz	8	2050888	1.28%	>	0.50%	5.80%	>	0.50%
6	Küçük Menderes	8	847415	0.12%	>	0.08%	0.85%	>	0.08%
7	Büyük Menderes	10	3155909	2.26%	>	0.80%	8.82%	>	0.80%
8	Batı Akdeniz	10	2552371	3.26%	>	1.42%	17.94%	>	1.42%
9	Antalya	8	2492362	1.71%	>	0.70%	11.21%	>	0.70%
10	Burdur	8	724849	4.66%	>	0.15%	14.84%	>	0.15%
11	Akarçay	10	932025	0.21%	<	2.81%	1.97%	<	2.81%
12	Sakarya	8	7412864	2.98%	>	1.70%	14.44%	>	1.70%
13	Batı Karadeniz	10	3568596	4.59%	<	10.56%	18.96%	>	10.56%
14	Yeşilırmak	10	4863497	5.94%	>	4.38%	16.17%	>	4.38%
15	Kızılırmak	10	9863497	4.11%	>	2.01%	20.73%	>	2.01%
16	Konya Kapalı	8	5928017	0.59%	>	0.05%	5.21%	>	0.05%
17	Doğu Akdeniz	8	2656410	1.82%	<	2.24%	13.98%	>	2.24%
18	Seyhan	8	2655827	1.70%	>	0.26%	10.63%	>	0.26%
19	Asi	8	947267	3.76%	>	0.35%	14.71%	>	0.35%
20	Ceyhan	8	2595952	1.84%	>	0.77%	8.05%	>	0.77%
21	Fırat	10	14484190	2.84%	<	4.98%	15.97%	>	4.98%
22	Doğu Karadeniz	10	2813106	1.77%	<	2.91%	13.08%	>	2.91%
23	Çoruh	8	2495302	3.22%	<	5.01%	16.56%	>	5.01%
24	Aras	8	3420905	5.30%	>	4.54%	20.54%	>	4.54%
25	Van Gölü	8	2210789	4.13%	>	2.08%	13.94%	>	2.08%
26	Dicle	8	6426892	4.19%	>	2.40%	19.05%	>	2.40%

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

In this dissertation, the difficulties in obtaining the landslide susceptibility map of Turkey from publicly available datasets at a national level scale and a regional level scale by using heuristic and semi-quantitative techniques have been discussed. A comprehensive review of the state of the art methodology employed in landslide susceptibility mapping has been presented.

A landslide susceptibility index model has been developed for the entire country by applying a scoring system to a set of conditioning factors based on expert judgment (heuristic model). Five susceptibility classes have been differentiated in the final map. The high and very high susceptibility classes mainly occur in the western and middle Black sea regions, characterized by the presence of landslide-prone sedimentary rocks, high seismicity and frequent severe rainfall events (main triggering factor). A main stage in the development of models, procedures or methodologies consists of the validation/evaluation process, which allows the quantitative assessment of its quality. The predictive capability of the model presented in this study has been evaluated in landslide inventory maps of MTA (app. 30,000 km^2). The defined landslide boundaries on these maps only cover about 4% of Turkey's total footprint area. The landslide susceptibility map that is proposed for the nationwide study represents fair results considering the very large extent of the study area. The proposed study in Chapter 3 has not led to a reasonably well predictive capability, considering the size of the area, its complexity and the limited number of factors. The landslide susceptibility map of Turkey generated in Chapter 3 constitutes a preliminary step for a further more detailed susceptibility to be performed. It could be concluded that it is not possible to construct a nationwide landslide susceptibly map of Turkey with a heuristic method. For a thorough landslide susceptibility study, the scale of the study region should be larger and the number of parameters considered should also be increased.

In Chapter 4, Turkey has been divided into 26 main watersheds with increased spatial resolution (90 m) in a larger scale (1:500,000). Every watershed has been modeled on its own, through not only using a simple mathematical equation for entire Turkey. The Analytical Hierarchy Process (AHP) has been used as a semi-quantitative technique. AHP has been applied for every watershed twice by considering 8 factors and 10 factors, respectively. One of these factor based maps has been selected for each watershed after the validation and evaluation stage using histogram curves and ROC curve analysis. Finally, the landslide susceptibility map of Turkey has been obtained after merging susceptibility maps for each watershed that possessed a scale of 1:500,000. The landslide susceptibility map of Turkey has been produced by using a standard procedure that was applied to each watershed after tedious trials that encompassed several months of hard work. The performances of these selected maps have been discussed in Chapter 5. It is not fair to compare a heuristic model with a semi-quantitative model due to their completely different philosophies employed. In addition, the pixel resolution and scale are different for these different models. It could be concluded that an increase in the increment of pixel resolution would lead to an increase in the capability of the landslide susceptibility modeling.

The selected scale and also the selected pixel size are two of the most important key points for landslide susceptibility assessment. The selection of these parameters should be feasible, unless no hardware or software can handle datasets having 10 m pixel resolution for entire Turkey. It is also not logical to try to create a landslide susceptibility model for entire Turkey using statistical or deterministic approaches for rough scale sizes such as 1:500,000. There are more red lines and boundaries that limit the handling capability, for example the size of the datasets, hardware and software limitations, etc. After considering these limitations, it was observed that a 90 m pixel resolution and 1:500,000 scale are both feasible values in order to study landslide susceptibility of entire Turkey. It is clear that a 10 factor based approach is sufficient for landslide susceptibility assessment of any watershed. The 8 factor based approach was sufficient for some of the watersheds (like Watershed-12). The synthetic classification of landslide susceptibility maps produced by AHP is aimed to carry out using only one technique as explained in Chapter 5. This technique does not fit well for 6 of the watersheds; however, no modification has been performed on this technique for these watersheds for the sake of consistency in the application of the same technique for the entire watersheds.

Semi-quantitative modeling gives better results than heuristic modeling for the landslide susceptibility assessment of entire Turkey. According to the findings and also considering both hardware/software capabilities and analysis time, semi-quantitative modeling is the limit for the selected scale and pixel resolution in this study. Applying a more detailed and sophisticated modeling approach for landslide susceptibility assessment of Turkey would need a larger scale and a higher pixel resolution that is nearly impossible in this present day by considering hardware and software limitations.

It is observed that the huge percentage of historical landslides occurred in the topographic wetness index (TWI) layer possessing values of 12 and 13 that were derived from 90 m resolution DEM. It is known that TWI is an important index for modeling the topography-related geographical processes at hill slope or watershed scale. After investigating TWI distribution for any of the watersheds, the values of 12-13 seem to constitute nearly half of the watershed area and this range is located nearly in the middle of the entire TWI range. A TWI value of 12 seems to be a threshold value for the beginning process of a landslide in any watershed for 90 m pixel resolution.

The factors of aspect and rainfall were not considered in 15 of 26 watersheds in this small scale assessment. In fact, aspect and rainfall could be accepted as triggering factors of landsliding process. Aspect that has the lowest weight value throughout the all factors in this study could be considered in larger scaled landslide studies in order to determine rapid snow melt triggered landslide modeling. Rainfall could also be accepted as triggering factor with time dependent intensity values at larger scaled studies. Unfortunately, the only nation-wide available rainfall data is yearly total mean values, which could only be used as descriptive or informative data in hydrology.

The governing factors used in watershed based assessments are curvature, landform and earthquake; the sum of mean values of these factors reaches nearly 50% (Table 6.1). Curvature and landform layers used in this study which are the derivative of terrain are directly obtained from digital elevation model (DEM). In real world, curvature and landform type are controlled by lithology, climate and also seismicity during millions of years. In brief, curvature and landform type are also the derivative or final product of these actors in the real world. It could be concluded that governing factors used in digital world matches with the actors that are the main indicators of potential landsliding in the real world.

Finally, these selected 26 zones have been merged and a more detailed landslide susceptibility map of Turkey has been prepared. This map has been divided into province boundaries for easy understanding of the distributions of landslide prone areas and summarized in Table 6.2. According to Table 6.2, Amasya, Sakarya, Muş, Çankırı and Bartın are the most landslide prone provinces of Turkey. Also Kilis, Nevşehir, Mardin, Kırklareli and Şanlıurfa are the least landslide prone provinces of Turkey. City planners and decision makers should consider these findings during producing city development plans.

The final product of this dissertation, which is a small scaled landslide susceptibility map of Turkey can be used as supporting information in spatial planning process as well as particularly in corridor based project planning (e.g., routing of highway, pipeline, tunnel, etc.), compiling hydropower power plant system formulation (e.g., site selection of power house, penstock route, axis of dam, etc.) and restricting landslide prone area as free of any development zone.

Table 6.1 Weights of factors obtained for watersheds (governing factors highlighted with gray color).

$Watershed^{Param.}$	Slope	Int. Relief	Rainfall	Lithology	Land Cover	Earthquake	Aspect	TWI	Landforms	Curvature
1^{8}	12.24%	9.24%	-	9.97%	11.11%	9.31%	-	11.11%	18.47%	18.55%
2^{10}	10.67%	6.87%	7.66%	7.66%	12.92%	15.04%	2.83%	8.31%	14.02%	14.02%
3^{8}	12.03%	5.86%	-	12.01%	12.99%	16.39%	-	10.13%	14.92%	15.66%
4^{8}	9.04%	7.25%	-	11.67%	11.67%	18.08%	-	10.08%	15.40%	16.83%
5^{8}	10.45%	7.74%	-	11.42%	12.02%	18.27%	-	9.13%	15.48%	15.48%
6^{8}	12.17%	8.54%	-	9.28%	11.13%	18.56%	-	10.17%	14.45%	15.70%
7^{10}	7.44%	7.44%	6.75%	12.02%	8.66%	16.67%	4.06%	8.01%	14.47%	14.47%
8^{10}	10.88%	5.76%	6.48%	5.76%	9.77%	13.44%	4.50%	10.45%	15.89%	17.06%
9^{8}	12.01%	6.16%	-	12.01%	12.01%	12.92%	-	12.92%	14.75%	17.22%
10^{8}	10.00%	5.00%	-	6.01%	10.00%	22.21%	-	10.00%	17.52%	19.27%
11^{10}	7.02%	6.18%	11.97%	8.23%	12.74%	12.74%	3.94%	9.50%	13.64%	14.04%
12^{8}	9.94%	6.28%	-	7.57%	13.95%	15.14%	-	11.86%	19.14%	16.14%
13^{10}	8.41%	4.89%	5.94%	14.61%	12.88%	11.57%	3.97%	9.35%	13.77%	14.61%
14^{10}	8.93%	4.57%	8.47%	4.05%	9.33%	17.91%	3.62%	9.75%	16.68%	16.68%
15^{10}	8.71%	5.79%	12.68%	5.18%	9.87%	10.65%	3.20%	11.03%	17.15%	15.75%
17^{8}	12.06%	6.73%	-	8.48%	14.17%	14.17%	-	11.10%	15.49%	17.79%
18^{8}	10.94%	6.14%	-	10.94%	11.90%	15.70%	-	11.90%	13.07%	19.42%
19^{8}	7.77%	7.22%	-	9.06%	15.13%	19.98%	-	8.17%	16.34%	16.34%
20^{8}	8.76%	3.93%	-	12.13%	17.52%	14.81%	-	10.18%	14.93%	17.74%
21^{10}	9.17%	5.72%	5.47%	6.17%	9.77%	14.97%	3.21%	10.53%	17.49%	17.49%
22^{10}	8.73%	5.49%	6.41%	10.70%	17.00%	9.35%	5.26%	10.07%	13.24%	13.76%
23^{8}	11.84%	6.12%	-	9.23%	11.97%	15.49%	-	10.88%	15.42%	19.06%
24^{8}	10.19%	6.10%	-	5.29%	10.19%	20.73%	-	9.76%	19.59%	18.15%
25^{8}	10.81%	6.09%	-	5.08%	10.10%	19.48%	-	10.10%	20.85%	17.48%
26^{8}	9.10%	4.99%	-	11.72%	13.43%	19.79%	-	11.72%	14.63%	14.63%

Table 6.2 Synthetically classified landslide susceptibility zone distributions for provinces.

Province Name	Pixel Counts	Classified Landslide Susceptibility Zones				
		No	Low	Moderate	High	Very High
Adana	1745209	65.86%	16.17%	8.35%	7.92%	1.70%
Adıyaman	878648	40.07%	24.79%	16.91%	15.91%	2.32%
Afyon	1670453	56.58%	26.09%	11.66%	5.22%	0.45%
Ağrı	1380775	36.11%	24.96%	17.39%	17.19%	4.36%
Aksaray	982075	65.04%	23.17%	6.37%	5.08%	0.34%
Amasya	650694	26.32%	36.40%	12.99%	14.70%	9.59%
Ankara	3075200	51.84%	19.19%	16.10%	11.07%	1.80%
Antalya	2541245	63.77%	16.89%	8.10%	9.27%	1.96%
Ardahan	639732	50.12%	12.19%	13.77%	18.02%	5.88%
Artvin	875741	68.73%	19.34%	4.43%	6.23%	1.27%
Aydın	978120	57.94%	17.68%	15.87%	6.98%	1.53%
Balıkesir	1702234	47.84%	23.45%	14.57%	10.69%	3.46%
Bartın	278849	35.97%	26.03%	12.91%	17.05%	8.04%
Batman	524838	63.14%	14.29%	10.86%	10.47%	1.24%
Bayburt	392881	40.63%	28.94%	7.99%	18.66%	3.78%
Bilecik	512211	27.77%	22.20%	21.35%	21.21%	7.46%
Bingöl	993342	34.07%	23.62%	18.81%	18.91%	4.59%
Bitlis	995768	55.81%	20.67%	10.85%	10.35%	2.31%
Bolu	1146586	35.46%	23.35%	17.44%	16.19%	7.56%
Burdur	868815	47.66%	21.69%	12.79%	13.56%	4.30%
Bursa	1285381	51.70%	19.97%	14.86%	9.65%	3.83%
Çanakkale	1176513	27.50%	20.65%	36.88%	11.64%	3.33%
Çankırı	1079874	31.15%	26.41%	13.88%	19.79%	8.77%
Çorum	1526552	43.23%	24.00%	14.17%	13.72%	4.87%
Denizli	1455149	52.83%	19.65%	14.02%	9.91%	3.60%
Diyarbakır	1827941	59.35%	15.78%	9.62%	12.43%	2.81%
Düzce	211091	45.60%	23.25%	10.59%	13.79%	6.77%
Edirne	724462	61.57%	22.28%	13.39%	2.46%	0.31%
Elazığ	1078310	35.80%	23.55%	17.64%	19.74%	3.26%
Erzincan	1420071	33.02%	25.45%	18.39%	15.53%	7.61%
Erzurum	2991910	39.23%	23.78%	13.55%	17.93%	5.51%
Eskişehir	1674642	62.13%	17.41%	12.93%	7.45%	0.09%
Gaziantep	847607	70.86%	9.05%	13.52%	6.26%	0.31%
Giresun	868499	51.63%	23.39%	10.03%	10.39%	4.56%
Gümüşhane	827589	53.10%	23.54%	9.85%	10.15%	3.36%
Hakkari	870564	41.28%	17.23%	15.42%	19.21%	6.85%
Hatay	692800	70.59%	6.04%	7.01%	11.42%	4.94%
İçel	1881812	53.09%	22.97%	10.59%	11.94%	1.41%
Iğdır	432344	56.40%	12.45%	11.61%	13.28%	6.26%
Isparta	1067015	58.43%	17.68%	12.91%	9.34%	1.65%
İstanbul	651700	44.30%	20.24%	33.21%	2.01%	0.24%
İzmir	1434175	56.21%	26.74%	10.11%	5.34%	1.60%

Table 6.2 Synthetically classified landslide susceptibility zone distributions for provinces (continued).

Province Name	Pixel Counts	Classified Landslide Susceptibility Zones				
		No	Low	Moderate	High	Very High
Kahramanmaraş	1687188	70.04%	10.27%	10.73%	7.20%	1.76%
Karabük	311396	36.29%	24.96%	13.62%	18.18%	6.96%
Karaman	863105	46.49%	26.65%	12.70%	10.85%	3.31%
Kars	1206138	56.46%	13.42%	11.53%	14.67%	3.91%
Kastamonu	1592278	47.00%	21.64%	12.43%	14.35%	4.58%
Kayseri	2028077	54.50%	22.83%	11.33%	9.70%	1.64%
Kilis	161805	74.08%	5.04%	13.49%	7.38%	0.00%
Kırıkkale	551549	30.37%	28.94%	14.11%	19.87%	6.70%
Kırklareli	786285	69.53%	15.33%	14.97%	0.16%	0.01%
Kırşehir	792006	54.67%	20.60%	10.09%	12.44%	2.19%
Kocaeli	415287	26.16%	17.59%	40.48%	12.64%	3.13%
Konya	5158944	64.24%	20.19%	9.24%	5.57%	0.77%
Kütahya	1408973	49.59%	23.05%	13.84%	11.19%	2.33%
Malatya	1446146	39.87%	23.88%	18.18%	16.84%	1.22%
Manisa	1606606	50.09%	26.15%	15.68%	6.40%	1.68%
Mardin	1020415	80.42%	9.31%	9.14%	1.13%	0.00%
Muğla	1486516	54.13%	19.33%	10.28%	13.26%	3.01%
Muş	1016832	20.87%	32.41%	19.32%	18.20%	9.21%
Nevşehir	682068	76.62%	9.26%	10.09%	4.03%	0.00%
Niğde	826859	62.34%	18.54%	12.21%	6.06%	0.84%
Ordu	702097	42.20%	25.96%	11.43%	17.40%	3.00%
Osmaniye	306125	68.41%	9.10%	10.50%	8.73%	3.27%
Rize	473956	69.58%	18.89%	5.53%	5.20%	0.81%
Sakarya	562627	30.98%	27.23%	17.16%	15.26%	9.36%
Samsun	1135020	58.50%	18.03%	9.76%	11.83%	1.88%
Şanlıurfa	2280027	83.12%	9.50%	6.02%	1.31%	0.05%
Siirt	704771	40.07%	15.82%	14.39%	23.70%	6.02%
Sinop	693986	40.89%	23.13%	12.39%	18.46%	5.12%
Şırnak	894034	56.62%	13.13%	12.68%	12.82%	4.75%
Sivas	3402058	45.32%	20.87%	15.36%	15.82%	2.63%
Tekirdağ	758427	42.93%	29.61%	20.91%	5.29%	1.25%
Tokat	1173049	36.82%	28.86%	15.25%	12.00%	7.07%
Trabzon	557130	43.95%	26.51%	11.44%	15.15%	2.94%
Tunceli	925219	46.60%	19.71%	16.88%	15.08%	1.73%
Uşak	694853	59.44%	20.67%	14.37%	3.90%	1.61%
Van	2534796	41.05%	25.84%	15.13%	13.03%	4.96%
Yalova	83874	39.37%	14.54%	34.40%	7.86%	3.82%
Yozgat	1614829	52.85%	21.42%	13.33%	10.68%	1.72%
Zonguldak	404324	48.26%	21.59%	10.69%	13.55%	5.91%

Consequently, two different landslide susceptibility maps of Turkey having different pixel resolutions that are based on different models (heuristic and semi-quantitative) have been developed and tested. Histogram curves and ROC curve values obtained from semi-quantitative model were compared with the heuristic model. Based on the experience gained during this study, the following recommendations can be given for future studies:

- Open source or publicly available datasets have been used in this study. Obtaining reliable data in Turkey is not an easy task. Geological maps, landslide inventory maps and rainfall intensity values have been purchased from the related governmental institutions in hard copy format. These datasets have been digitized into vector format after months of tedious work. Fortunately, the rest of the datasets have been obtained freely from NASA and European Union. There tends to be a big dilemma here: this study is aimed for nationwide scale, but most of the datasets used here are not national; a nationwide landslide susceptibility assessment was performed by using non-national datasets. There have also been some unexpected discoveries for the purchased hardcopy maps where coastal line and Turkish boundaries drawn in geological maps have not matched with coastal lines and boundaries drawn in the landslide inventory maps. Turkey still does not have any digital elevation model that is produced and approved by any governmental institute; since more than a decade researchers are using DEM produced by NASA for any scientific research carried out in Turkey.

- The 8 factor and 10 factor based approaches have been applied in semi-quantitative model in this study. The number of factors used for modeling seems more than enough for some watersheds (like Watershed-12). These watersheds could be reanalyzed by decreasing the number of factors and performing a sensitivity analysis in future works.

- A standard procedure has been applied on landslide susceptibility maps produced by a semi-quantitative model for synthetic classification. This standard classification does not fit well for some watersheds; these watersheds could be reclassified by modifying this procedure for the related watersheds.

- The TWI variable should be studied with different pixel resolutions and scales in future works in order to decide whether TWI=12 is a magic number/threshold or not for landslide susceptibility assessments.

- The product of this dissertation can be accepted as a milestone for the further works that would be performed to obtain a perfect landslide susceptibility map of Turkey, despite its shortcomings.

- Watersheds studied in this dissertation could be divided into sub-watersheds having a higher pixel resolution and larger scale in order to apply a more detailed and sophisticated landslide susceptibility assessment for the further studies. But it needs to be stressed that these kinds of studies needs serious coordination between different institutions, trained personnel, time, funding and of course reliable datasets.

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APPENDIX A

DISTRIBUTION OF HISTORICAL LANDSLIDE AREAS FOR WATERSHEDS

Table A.1 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-2 (Marmara).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	12.01%	0.2045	0.0269	0.0218
	5° - 10°	58.70%	1.0000	0.1317	0.1067
	10° - 15°	24.40%	0.4156	0.0547	0.0444
	15° - 20°	4.03%	0.0687	0.0091	0.0073
	20° - 25°	0.79%	0.0135	0.0018	0.0014
	25° - 30°	0.03%	0.0005	0.0001	0.0001
	30° - 35°	0.03%	0.0005	0.0001	0.0001
	> 35°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	1.97%	0.0546	0.0040	0.0038
	50 - 100	36.05%	1.0000	0.0735	0.0687
	100 - 150	34.31%	0.9515	0.0699	0.0653
	150 - 200	18.87%	0.5233	0.0384	0.0359
	200 - 250	5.59%	0.1551	0.0114	0.0106
	250 - 300	2.00%	0.0555	0.0041	0.0038
	300 - 350	0.73%	0.0203	0.0015	0.0014
	350 - 400	0.41%	0.0115	0.0008	0.0008
	400 - 450	0.06%	0.0018	0.0001	0.0001
	> 450	0.00%	0.0000	0.0000	0.0000
Rainfall	< 500	0.00%	0.0000	-	0.0000
	500 - 600	3.84%	0.0856	-	0.0066
	600 - 700	44.89%	1.0000	-	0.0766
	700 - 800	36.40%	0.8110	-	0.0622
	800 - 900	6.77%	0.1507	-	0.0116
	900 - 1000	3.05%	0.0679	-	0.0052
	1000 - 1100	4.54%	0.1012	-	0.0078
	1100 - 1200	0.44%	0.0099	-	0.0008
	1200 - 1300	0.06%	0.0014	-	0.0001
	> 1300	0.00%	0.0000	-	0.0000
Lithology	Young deposits	5.68%	0.1388	0.0118	0.0106
	Andesite	0.16%	0.0039	0.0003	0.0003
	Undifferentiated volcanic rocks	15.28%	0.3736	0.0318	0.0286
	Basalt	0.99%	0.0242	0.0021	0.0019
	Gneiss	0.41%	0.0101	0.0009	0.0008
	Continental clastic rocks	40.89%	1.0000	0.0851	0.0766
	Clastic and carbonate rocks	29.25%	0.7153	0.0609	0.0548
	Limestone	2.65%	0.0647	0.0055	0.0050
	Marble	0.06%	0.0016	0.0001	0.0001
	Metamorpic rocks	2.39%	0.0585	0.0050	0.0045
	Flisch	0.38%	0.0094	0.0008	0.0007
	Ophiolitic rocks	0.10%	0.0023	0.0002	0.0002
	Granitoid	0.22%	0.0055	0.0005	0.0004

Table A.1 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-2 (Marmara, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Lithology	Volcanic and sedimentary rocks	1.50%	0.0367	0.0031	0.0028
	Plutonic rocks	0.03%	0.0008	0.0001	0.0001
Land Cover	Artificial surfaces	5.15%	0.0801	0.0105	0.0103
	Agricultural areas	64.26%	1.0000	0.1317	0.1292
	Forest	29.80%	0.4637	0.0611	0.0599
	Semi natural areas	0.57%	0.0089	0.0012	0.0011
	Wetlands and water bodies	0.22%	0.0035	0.0005	0.0004
Earthquake	Zone 1	81.16%	1.0000	0.1691	0.1504
	Zone 2	11.59%	0.1429	0.0242	0.0215
	Zone 3	5.59%	0.0689	0.0117	0.0104
	Zone 4	1.65%	0.0204	0.0034	0.0031
	Zone 5	0.00%	0.0000	0.0000	0.0000
Aspect	N	3.81%	0.2348	-	0.0067
	NE	11.15%	0.6869	-	0.0195
	E	16.23%	1.0000	-	0.0283
	SE	15.37%	0.9472	-	0.0268
	S	13.28%	0.8180	-	0.0232
	SW	13.09%	0.8063	-	0.0228
	W	16.20%	0.9980	-	0.0283
	NW	10.86%	0.6693	-	0.0190
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	1.65%	0.0384	0.0036	0.0032
	11 - 12	21.57%	0.5015	0.0466	0.0417
	12 - 13	43.01%	1.0000	0.0929	0.0831
	13 - 14	25.32%	0.5886	0.0547	0.0489
	14 - 15	6.58%	0.1529	0.0142	0.0127
	15 - 16	1.49%	0.0347	0.0032	0.0029
	16 - 17	0.25%	0.0059	0.0005	0.0005
	17 - 18	0.13%	0.0030	0.0003	0.0002
	> 18	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	2.84%	0.0382	0.0059	0.0054
	Midslope drainages, shallow valleys	7.43%	0.1000	0.0153	0.0140
	Upland drainages, headwaters	0.00%	0.0000	0.0000	0.0000
	U-shaped valleys	4.69%	0.0631	0.0097	0.0088
	Plains	8.90%	0.1197	0.0184	0.0168
	Open slopes	74.38%	1.0000	0.1535	0.1402
	Upper slopes, mesas	0.73%	0.0099	0.0015	0.0014
	Local ridges/hills in valleys	0.03%	0.0004	0.0001	0.0001
	Midslope ridges, small hills in plains	0.86%	0.0116	0.0018	0.0016
	Mountain tops, high ridges	0.13%	0.0017	0.0003	0.0002

Table A.1 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-2 (Marmara, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Curvature	V / V	2.52%	0.0334	0.0054	0.0047
	V / S	9.57%	0.1267	0.0206	0.0178
	V / X	0.41%	0.0055	0.0009	0.0008
	S / V	8.90%	0.1178	0.0191	0.0165
	S / S	75.56%	1.0000	0.1624	0.1402
	S / X	1.56%	0.0207	0.0034	0.0029
	X / V	0.03%	0.0004	0.0001	0.0001
	X / S	1.12%	0.0148	0.0024	0.0021
	X / X	0.32%	0.0042	0.0007	0.0006

Table A.2 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-3 (Susurluk).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	5.22%	0.0836	0.0101	0.0091
	5° - 10°	62.36%	1.0000	0.1203	0.1092
	10° - 15°	29.71%	0.4764	0.0573	0.0520
	15° - 20°	2.72%	0.0436	0.0053	0.0048
	> 20°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.00%	0.0000	0.0000	0.0000
	50 - 100	18.14%	0.5442	0.0319	0.0267
	100 - 150	33.33%	1.0000	0.0586	0.0491
	150 - 200	27.66%	0.8299	0.0487	0.0408
	200 - 250	10.20%	0.3061	0.0179	0.0150
	250 - 300	8.16%	0.2449	0.0144	0.0120
	300 - 350	2.27%	0.0680	0.0040	0.0033
	350 - 400	0.00%	0.0000	0.0000	0.0000
	400 - 450	0.23%	0.0068	0.0004	0.0003
	> 450	0.00%	0.0000	0.0000	0.0000
Rainfall	< 400	0.00%	0.0000	-	0.0000
	400 - 500	2.72%	0.0561	-	0.0046
	500 - 600	25.40%	0.5234	-	0.0431
	600 - 700	48.53%	1.0000	-	0.0823
	700 - 800	23.36%	0.4813	-	0.0396
	> 800	0.00%	0.0000	-	0.0000
Lithology	Young deposits	1.59%	0.0263	0.0032	0.0025
	Andesite	0.23%	0.0038	0.0005	0.0004
	Undifferentiated volcanic rocks	3.41%	0.0564	0.0068	0.0054
	Basalt	2.73%	0.0451	0.0054	0.0043
	Dacite	0.91%	0.0150	0.0018	0.0014
	Gneiss	0.23%	0.0038	0.0005	0.0004
	Continental clastic rocks	60.45%	1.0000	0.1201	0.0950
	Carbonate rocks	0.91%	0.0150	0.0018	0.0014
	Clastic and carbonate rocks	3.18%	0.0526	0.0063	0.0050
	Limestone	0.68%	0.0113	0.0014	0.0011
	Marble	1.14%	0.0188	0.0023	0.0018
	Metamorpic rocks	5.91%	0.0977	0.0117	0.0093
	Ophiolitic rocks	12.27%	0.2030	0.0244	0.0193
	Pyroclastic rocks	5.91%	0.0977	0.0117	0.0093
	Granitoid	0.45%	0.0075		
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	2.72%	0.0375	0.0049	0.0045
	Agricultural areas	72.56%	1.0000	0.1299	0.1199
	Forest	23.81%	0.3281	0.0426	0.0394
	Semi natural areas	0.91%	0.0125	0.0016	0.0015
	Wetlands and water bodies	0.00%	0.0000	0.0000	0.0000
Earthquake	Zone 1	35900.00%	0.8141	1.0000	0.1184
	Zone 2	8200.00%	0.1859	0.2284	0.0270
	Others	0.00%	0.0000	0.0000	0.0000

Table A.2 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-3 (Susurluk, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Aspect	N	1.36%	0.0759	-	0.0022
	NE	11.56%	0.6456	-	0.0187
	E	17.23%	0.9620	-	0.0279
	SE	12.70%	0.7089	-	0.0206
	S	14.06%	0.7848	-	0.0228
	SW	14.97%	0.8354	-	0.0242
	W	17.91%	1.0000	-	0.0290
	NW	10.20%	0.5696	-	0.0165
TWI	< 11	0.00%	0.0000	0.0000	0.0000
	11 - 12	9.98%	0.1947	0.0197	0.0172
	12 - 13	51.25%	1.0000	0.1013	0.0884
	13 - 14	32.65%	0.6372	0.0646	0.0563
	14 - 15	4.99%	0.0973	0.0099	0.0086
	15 - 16	0.68%	0.0133	0.0013	0.0012
	16 - 17	0.23%	0.0044	0.0004	0.0004
	17 - 18	0.23%	0.0044	0.0004	0.0004
	> 18	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	1.13%	0.0142	0.0021	0.0019
	Midslope drainages, shallow valleys	3.40%	0.0425	0.0063	0.0058
	U-shaped valleys	9.98%	0.1246	0.0186	0.0170
	Plains	4.54%	0.0567	0.0085	0.0077
	Open slopes	80.05%	1.0000	0.1492	0.1362
	Upper slopes, mesas	0.91%	0.0113	0.0017	0.0015
	Others	0.00%	0.0000	0.0000	0.0000
Curvature	V / V	0.68%	0.0083	0.0013	0.0012
	V / S	8.84%	0.1074	0.0168	0.0156
	V / X	0.23%	0.0028	0.0004	0.0004
	S / V	7.26%	0.0882	0.0138	0.0128
	S / S	82.31%	1.0000	0.1566	0.1454
	S / X	0.68%	0.0083	0.0013	0.0012
	Others	0.00%	0.0000	0.0000	0.0000

Table A.3 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-4 (Kuzey Ege).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	4.76%	0.0909	0.0082	0.0069
	5° - 10°	52.38%	1.0000	0.0904	0.0763
	10° - 15°	33.33%	0.6364	0.0575	0.0485
	15° - 20°	9.52%	0.1818	0.0164	0.0139
	> 20°	0.00%	0.0000	0.0000	0.0000
Internal Relief	< 100	0.00%	0.0000	0.0000	0.0000
	100 - 150	23.81%	0.5556	0.0403	0.0350
	150 - 200	42.86%	1.0000	0.0725	0.0630
	200 - 250	23.81%	0.5556	0.0403	0.0350
	250 - 300	4.76%	0.1111	0.0081	0.0070
	300 - 350	4.76%	0.1111	0.0081	0.0070
	> 350	0.00%	0.0000	0.0000	0.0000
Rainfall	< 500	0.00%	0.0000	-	0.0000
	500 - 600	23.81%	0.4167	-	0.0367
	600 - 700	57.14%	1.0000	-	0.0881
	700 - 800	19.05%	0.3333	-	0.0294
	> 800	0.00%	0.0000	-	0.0000
Lithology	Undifferentiated volcanic rocks	66.67%	1.0000	0.1167	0.0947
	Basalt	4.76%	0.0714	0.0083	0.0068
	Continental clastic rocks	14.29%	0.2143	0.0250	0.0203
	Pyroclastic rocks	14.29%	0.2143	0.0250	0.0203
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Agricultural areas	33.33%	0.5000	0.0583	0.0474
	Forest	66.67%	1.0000	0.1167	0.0947
	Others	0.00%	0.0000	0.0000	0.0000
Earthquake	Zone 1	100.00%	1.0000	0.1808	0.1581
	Others	0.00%	0.0000	0.0000	0.0000
Aspect	NE	4.76%	0.1250	-	0.0070
	E	14.29%	0.3750	-	0.0211
	SE	28.57%	0.7500	-	0.0423
	S	14.29%	0.3750	-	0.0211
	SW	38.10%	1.0000	-	0.0564
	W	0.00%	0.0000	-	0.0000
	Others	0.00%	0.0000	-	0.0000
TWI	< 11	0.00%	0.0000	0.0000	0.0000
	11 - 12	4.76%	0.0909	0.0092	0.0074
	12 - 13	52.38%	1.0000	0.1008	0.0818
	13 - 14	38.10%	0.7273	0.0733	0.0595
	14 - 15	4.76%	0.0909	0.0092	0.0074
	> 15	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	4.76%	0.0588	0.0091	0.0079
	U-shaped valleys	9.52%	0.1176	0.0181	0.0158
	Plains	4.76%	0.0588	0.0091	0.0079
	Open slopes	80.95%	1.0000	0.1540	0.1344
	Others	0.00%	0.0000	0.0000	0.0000

Table A.3 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-4 (Kuzey Ege, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Curvature	V / S	4.76%	0.0526	0.0089	0.0080
	V / X	4.76%	0.0526	0.0089	0.0080
	S / S	90.48%	1.0000	0.1683	0.1525
	Others	0.00%	0.0000	0.0000	0.0000

Table A.4 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-5 (Gediz).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	1.40%	0.0233	0.0024	0.0019
	5° - 10°	60.35%	1.0000	0.1045	0.0838
	10° - 15°	32.63%	0.5407	0.0565	0.0453
	15° - 20°	5.61%	0.0930	0.0097	0.0078
	> 20°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.35%	0.0078	0.0006	0.0005
	50 - 100	3.16%	0.0703	0.0054	0.0046
	100 - 150	30.88%	0.6875	0.0532	0.0449
	150 - 200	44.91%	1.0000	0.0774	0.0653
	200 - 250	14.74%	0.3281	0.0254	0.0214
	250 - 300	4.91%	0.1094	0.0085	0.0071
	300 - 350	1.05%	0.0234	0.0018	0.0015
	> 350	0.00%	0.0000	0.0000	0.0000
Rainfall	< 400	0.00%	0.0000	-	0.0000
	400 - 500	66.32%	1.0000	-	0.1032
	500 - 600	30.53%	0.4603	-	0.0475
	600 - 700	3.16%	0.0476	-	0.0049
	> 700	0.00%	0.0000	-	0.0000
Lithology	Young deposits	0.35%	0.0053	0.0006	0.0005
	Basalt	2.81%	0.0421	0.0048	0.0043
	Dacite	0.35%	0.0053	0.0006	0.0005
	Gneiss	4.91%	0.0737	0.0084	0.0076
	Continental clastic rocks	66.67%	1.0000	0.1142	0.1032
	Carbonate rocks	12.98%	0.1947	0.0222	0.0201
	Clastic and carbonate rocks	0.35%	0.0053	0.0006	0.0005
	Metamorpic rocks	1.05%	0.0158	0.0018	0.0016
	Ophiolitic rocks	4.56%	0.0684	0.0078	0.0071
	Pyroclastic rocks	5.61%	0.0842	0.0096	0.0087
	Plutonic rocks	0.35%	0.0053	0.0006	0.0005
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	0.35%	0.0051	0.0006	0.0005
	Agricultural areas	68.77%	1.0000	0.1202	0.1032
	Forest	24.91%	0.3622	0.0435	0.0374
	Semi natural areas	5.96%	0.0867	0.0104	0.0089
	Wetlands and water bodies	0.00%	0.0000	0.0000	0.0000
Earthquake	Zone 1	100.00%	1.0000	0.1827	0.1644
	Others	0.00%	0.0000	0.0000	0.0000
Aspect	N	2.81%	0.1311	-	0.0042
	NE	10.53%	0.4918	-	0.0156
	E	18.95%	0.8852	-	0.0281
	SE	15.09%	0.7049	-	0.0223
	S	21.40%	1.0000	-	0.0317
	SW	14.74%	0.6885	-	0.0218
	W	10.53%	0.4918	-	0.0156
	NW	5.96%	0.2787	-	0.0088

Table A.4 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-5 (Gediz, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	0.70%	0.0127	0.0012	0.0011
	11 - 12	10.53%	0.1911	0.0175	0.0160
	12 - 13	55.09%	1.0000	0.0913	0.0838
	13 - 14	28.42%	0.5159	0.0471	0.0432
	14 - 15	4.91%	0.0892	0.0081	0.0075
	15 - 16	0.35%	0.0064	0.0006	0.0005
	> 16	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	0.70%	0.0083	0.0013	0.0011
	Midslope drainages, shallow valleys	4.56%	0.0542	0.0084	0.0071
	U-shaped valleys	5.96%	0.0708	0.0110	0.0093
	Plains	2.81%	0.0333	0.0052	0.0044
	Open slopes	84.21%	1.0000	0.1548	0.1307
	Upper slopes, mesas	1.40%	0.0167	0.0026	0.0022
	Midslope ridges, small hills in plains	0.35%	0.0042	0.0006	0.0005
	Others	0.00%	0.0000	0.0000	0.0000
Curvature	V / V	1.05%	0.0126	0.0019	0.0016
	V / S	9.12%	0.1088	0.0168	0.0142
	V / X	0.00%	0.0000	0.0000	0.0000
	S / V	4.56%	0.0544	0.0084	0.0071
	S / S	83.86%	1.0000	0.1548	0.1307
	S / X	0.35%	0.0042	0.0006	0.0005
	X / V	0.35%	0.0042	0.0006	0.0005
	X / S	0.70%	0.0084	0.0013	0.0011
	X / X	0.00%	0.0000	0.0000	0.0000

Table A.5 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-6 (Küçük Menderes).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	3.33%	0.0488	0.0059	0.0047
	5° - 10°	68.33%	1.0000	0.1217	0.0972
	10° - 15°	16.67%	0.2439	0.0297	0.0237
	15° - 20°	1.67%	0.0244	0.0030	0.0024
	20° - 25°	6.67%	0.0976	0.0119	0.0095
	25° - 30°	1.67%	0.0244	0.0030	0.0024
	30° - 35°	1.67%	0.0244	0.0030	0.0024
	> 35°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.00%	0.0000	0.0000	0.0000
	50 - 100	20.00%	0.4138	0.0354	0.0335
	100 - 150	48.33%	1.0000	0.0854	0.0809
	150 - 200	11.67%	0.2414	0.0206	0.0195
	200 - 250	6.67%	0.1379	0.0118	0.0112
	250 - 300	3.33%	0.0690	0.0059	0.0056
	300 - 350	3.33%	0.0690	0.0059	0.0056
	350 - 400	1.67%	0.0345	0.0029	0.0028
	400 - 450	1.67%	0.0345	0.0029	0.0028
	450 - 500	1.67%	0.0345	0.0029	0.0028
	500 - 550	1.67%	0.0345	0.0029	0.0028
	> 550	0.00%	0.0000	0.0000	0.0000
Rainfall	< 500	0.00%	0.0000	-	0.0000
	500 - 600	10.00%	0.1579	-	0.0154
	600 - 700	15.00%	0.2368	-	0.0230
	700 - 800	63.33%	1.0000	-	0.0972
	800 - 900	11.67%	0.1842	-	0.0179
	> 900	0.00%	0.0000	-	0.0000
Lithology	Young deposits	1.67%	0.0323	0.0030	0.0026
	Gneiss	5.00%	0.0968	0.0090	0.0078
	Continental clastic rocks	15.00%	0.2903	0.0269	0.0235
	Carbonate rocks	51.67%	1.0000	0.0928	0.0809
	Clastic and carbonate rocks	8.33%	0.1613	0.0150	0.0130
	Limestone	3.33%	0.0645	0.0060	0.0052
	Limestone, marl, shale	1.67%	0.0323	0.0030	0.0026
	Metamorpic rocks	3.33%	0.0645	0.0060	0.0052
	Pyroclastic rocks	10.00%	0.1935	0.0180	0.0157
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	16.67%	0.2857	0.0318	0.0278
	Agricultural areas	58.33%	1.0000	0.1113	0.0972
	Forest	23.33%	0.4000	0.0445	0.0389
	Semi natural areas	1.67%	0.0286	0.0032	0.0028
	Wetlands and water bodies	0.00%	0.0000	0.0000	0.0000
Earthquake	Zone 1	100.00%	1.0000	0.1856	0.1652
	Others	0.00%	0.0000	0.0000	0.0000

Table A.5 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-6 (Küçük Menderes, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Aspect	N	3.33%	0.1538	-	0.0054
	NE	10.00%	0.4615	-	0.0161
	E	8.33%	0.3846	-	0.0134
	SE	6.67%	0.3077	-	0.0107
	S	11.67%	0.5385	-	0.0187
	SW	18.33%	0.8462	-	0.0294
	W	21.67%	1.0000	-	0.0348
	NW	20.00%	0.9231	-	0.0321
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	3.33%	0.0645	0.0066	0.0052
	11 - 12	15.00%	0.2903	0.0295	0.0235
	12 - 13	51.67%	1.0000	0.1017	0.0809
	13 - 14	28.33%	0.5484	0.0558	0.0444
	14 - 15	1.67%	0.0323	0.0033	0.0026
	> 15	0.00%	0.0000	0.0000	0.0000
Landforms	Midslope drainages, shallow valleys	3.33%	0.0435	0.0063	0.0058
	U-shaped valleys	15.00%	0.1957	0.0283	0.0260
	Plains	1.67%	0.0217	0.0031	0.0029
Landforms	Open slopes	76.67%	1.0000	0.1445	0.1328
	Upper slopes, mesas	3.33%	0.0435	0.0063	0.0058
	Others	0.00%	0.0000	0.0000	0.0000
Curvature	V / V	1.67%	0.0217	0.0034	0.0029
	V / S	13.33%	0.1739	0.0273	0.0231
	S / V	6.67%	0.0870	0.0136	0.0115
	S / S	76.67%	1.0000	0.1570	0.1328
	S / X	1.67%	0.0217	0.0034	0.0029
	X / X	0.00%	0.0000	0.0000	0.0000

Table A.6 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-7 (Büyük Menderes).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	0.77%	0.0182	0.0017	0.0014
	5° - 10°	36.08%	0.8485	0.0772	0.0632
	10° - 15°	42.53%	1.0000	0.0910	0.0744
	15° - 20°	15.46%	0.3636	0.0331	0.0271
	20° - 25°	3.74%	0.0879	0.0080	0.0065
	25° - 30°	1.29%	0.0303	0.0028	0.0023
	30° - 35°	0.13%	0.0030	0.0003	0.0002
	> 35°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.00%	0.0000	0.0000	0.0000
	50 - 100	1.55%	0.0392	0.0032	0.0029
	100 - 150	17.27%	0.4379	0.0359	0.0326
	150 - 200	39.43%	1.0000	0.0820	0.0744
	200 - 250	21.78%	0.5523	0.0453	0.0411
	250 - 300	9.54%	0.2418	0.0198	0.0180
	300 - 350	4.64%	0.1176	0.0097	0.0088
	350 - 400	3.48%	0.0882	0.0072	0.0066
	400 - 450	1.68%	0.0425	0.0035	0.0032
	450 - 500	0.39%	0.0098	0.0008	0.0007
	500 - 550	0.13%	0.0033	0.0003	0.0002
	550 - 600	0.13%	0.0033	0.0003	0.0002
	> 600	0.00%	0.0000	0.0000	0.0000
Rainfall	< 400	0.00%	0.0000	-	0.0000
	400 - 500	2.96%	0.0875	-	0.0059
	500 - 600	33.89%	1.0000	-	0.0675
	600 - 700	30.67%	0.9049	-	0.0611
	700 - 800	17.27%	0.5095	-	0.0344
	800 - 900	14.05%	0.4144	-	0.0280
	900 - 1000	1.16%	0.0342	-	0.0023
	> 1000	0.00%	0.0000	-	0.0000
Lithology	Young deposits	1.94%	0.0291	0.0043	0.0035
	Andesite	0.52%	0.0078	0.0011	0.0009
	Undifferentiated volcanic rocks	0.39%	0.0058	0.0009	0.0007
	Basalt	0.13%	0.0019	0.0003	0.0002
	Gneiss	5.43%	0.0814	0.0121	0.0098
	Continental clastic rocks	66.67%	1.0000	0.1481	0.1202
	Carbonate rocks	6.98%	0.1047	0.0155	0.0126
	Clastic and carbonate rocks	3.88%	0.0581	0.0086	0.0070
	Limestone	1.03%	0.0155	0.0023	0.0019
	Limestone, marl, shale	0.39%	0.0058	0.0009	0.0007
	Marble	1.03%	0.0155	0.0023	0.0019
	Metamorpic rocks	6.85%	0.1027	0.0152	0.0123
	Ophiolitic rocks	2.71%	0.0407	0.0060	0.0049
	Phyllite	0.26%	0.0039	0.0006	0.0005
	Pyroclastic rocks	1.81%	0.0271	0.0040	0.0033
	Others	0.00%	0.0000	0.0000	0.0000

Table A.6 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-7 (Büyük Menderes, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Land Cover	Artificial surfaces	0.13%	0.0027	0.0002	0.0002
	Agricultural areas	48.07%	1.0000	0.0910	0.0866
	Forest	47.42%	0.9866	0.0898	0.0854
	Semi natural areas	4.38%	0.0912	0.0083	0.0079
	Wetlands and water bodies	0.00%	0.0000	0.0000	0.0000
Earthquake	Zone 1	92.14%	1.0000	0.1730	0.1667
	Zone 2	7.86%	0.0853	0.0148	0.0142
	Others	0.00%	0.0000	0.0000	0.0000
Aspect	N	1.29%	0.0602	-	0.0024
	NE	10.57%	0.4940	-	0.0201
	E	21.39%	1.0000	-	0.0406
	SE	19.20%	0.8976	-	0.0364
	S	12.37%	0.5783	-	0.0235
	SW	11.47%	0.5361	-	0.0218
	W	13.02%	0.6084	-	0.0247
	NW	10.70%	0.5000	-	0.0203
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	1.42%	0.0302	0.0030	0.0024
	11 - 12	20.23%	0.4313	0.0431	0.0346
	12 - 13	46.91%	1.0000	0.0999	0.0801
	13 - 14	25.52%	0.5440	0.0543	0.0436
	14 - 15	4.51%	0.0962	0.0096	0.0077
	15 - 16	1.03%	0.0220	0.0022	0.0018
	16 - 17	0.39%	0.0082	0.0008	0.0007
	> 17	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	3.35%	0.0464	0.0074	0.0067
	Midslope drainages, shallow valleys	6.31%	0.0875	0.0140	0.0127
	Upland drainages, headwaters	0.39%	0.0054	0.0009	0.0008
	U-shaped valleys	13.92%	0.1929	0.0308	0.0279
	Plains	1.03%	0.0143	0.0023	0.0021
	Open slopes	72.16%	1.0000	0.1598	0.1447
	Upper slopes, mesas	2.32%	0.0321	0.0051	0.0047
	Midslope ridges, small hills in plains	0.52%	0.0071	0.0011	0.0010
	Others	0.00%	0.0000	0.0000	0.0000
Curvature	V / V	1.93%	0.0269	0.0042	0.0039
	V / S	13.14%	0.1831	0.0284	0.0265
	V / X	0.77%	0.0108	0.0017	0.0016
	S / V	10.31%	0.1436	0.0223	0.0208
	S / S	71.78%	1.0000	0.1552	0.1447
	S / X	1.29%	0.0180	0.0028	0.0026
	X / V	0.13%	0.0018	0.0003	0.0003
	X / S	0.64%	0.0090	0.0014	0.0013
	X / X	0.00%	0.0000	0.0000	0.0000

Table A.7 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-8 (Batı Akdeniz).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	0.00%	0.0000	0.0000	0.0000
	5° - 10°	18.40%	0.3643	0.0421	0.0396
	10° - 15°	50.51%	1.0000	0.1156	0.1088
	15° - 20°	25.37%	0.5023	0.0581	0.0547
	20° - 25°	4.23%	0.0837	0.0097	0.0091
	25° - 30°	0.69%	0.0136	0.0016	0.0015
	30° - 35°	0.69%	0.0136	0.0016	0.0015
	35° - 40°	0.11%	0.0023	0.0003	0.0002
	> 40°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.00%	0.0000	0.0000	0.0000
	50 - 100	0.34%	0.0118	0.0008	0.0007
	100 - 150	3.89%	0.1333	0.0086	0.0077
	150 - 200	18.29%	0.6275	0.0403	0.0362
	200 - 250	29.14%	1.0000	0.0643	0.0576
	250 - 300	23.77%	0.8157	0.0524	0.0470
	300 - 350	14.40%	0.4941	0.0318	0.0285
	350 - 400	5.26%	0.1804	0.0116	0.0104
	400 - 450	2.97%	0.1020	0.0066	0.0059
	450 - 500	0.46%	0.0157	0.0010	0.0009
	500 - 550	0.69%	0.0235	0.0015	0.0014
	550 - 600	0.46%	0.0157	0.0010	0.0009
	600 - 650	0.11%	0.0039	0.0003	0.0002
	650 - 700	0.23%	0.0078	0.0005	0.0005
	> 700	0.00%	0.0000	0.0000	0.0000
Rainfall	< 500	0.00%	0.0000	-	0.0000
	500 - 600	32.11%	1.0000	-	0.0648
	600 - 700	29.83%	0.9288	-	0.0602
	700 - 800	20.34%	0.6335	-	0.0411
	800 - 900	17.37%	0.5409	-	0.0351
	900 - 1000	0.23%	0.0071	-	0.0005
	1000 - 1100	0.11%	0.0036	-	0.0002
	> 1100	0.00%	0.0000	-	0.0000
Lithology	Young deposits	8.00%	0.2713	0.0174	0.0156
	Basalt	4.23%	0.1434	0.0092	0.0083
	Gabbro	0.11%	0.0039	0.0002	0.0002
	Continental clastic rocks	20.23%	0.6860	0.0441	0.0395
	Carbonate rocks	1.94%	0.0659	0.0042	0.0038
	Clastic and carbonate rocks	29.49%	1.0000	0.0643	0.0576
	Limestone	7.20%	0.2442	0.0157	0.0141
	Marble	0.23%	0.0078	0.0005	0.0004
	Metamorpic rocks	1.03%	0.0349	0.0022	0.0020
	Ophiolitic rocks	27.54%	0.9341	0.0601	0.0538
	Others	0.00%	0.0000	0.0000	0.0000

Table A.7 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-8 (Batı Akdeniz, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Land Cover	Agricultural areas	42.74%	0.9639	0.1111	0.0941
	Forest	44.34%	1.0000	0.1153	0.0977
	Semi natural areas	12.91%	0.2912	0.0336	0.0284
	Others	0.00%	0.0000	0.0000	0.0000
Earthquake	Zone 1	67.31%	1.0000	0.1695	0.1344
	Zone 2	32.69%	0.4856	0.0823	0.0652
	Others	0.00%	0.0000	0.0000	0.0000
Aspect	N	1.03%	0.0517	-	0.0023
	NE	6.63%	0.3333	-	0.0150
	E	15.09%	0.7586	-	0.0342
	SE	18.06%	0.9080	-	0.0409
	S	13.03%	0.6552	-	0.0295
	SW	14.74%	0.7414	-	0.0334
	W	19.89%	1.0000	-	0.0450
	NW	11.54%	0.5805	-	0.0261
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	1.37%	0.0305	0.0035	0.0032
	11 - 12	17.26%	0.3832	0.0443	0.0400
	12 - 13	45.03%	1.0000	0.1156	0.1045
	13 - 14	29.94%	0.6650	0.0769	0.0695
	14 - 15	5.37%	0.1193	0.0138	0.0125
	15 - 16	1.03%	0.0228	0.0026	0.0024
	> 16	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	3.20%	0.0469	0.0078	0.0075
	Midslope drainages, shallow valleys	4.11%	0.0603	0.0101	0.0096
	Upland drainages, headwaters	0.57%	0.0084	0.0014	0.0013
	U-shaped valleys	20.91%	0.3065	0.0511	0.0487
	Plains	0.34%	0.0050	0.0008	0.0008
	Open slopes	68.23%	1.0000	0.1669	0.1589
	Upper slopes, mesas	2.29%	0.0335	0.0056	0.0053
	Local ridges/hills in valleys	0.23%	0.0034	0.0006	0.0005
	Midslope ridges, small hills in plains	0.11%	0.0017	0.0003	0.0003
	Mountain tops, high ridges	0.00%	0.0000	0.0000	0.0000
Curvature	V / V	1.37%	0.0186	0.0035	0.0032
	V / S	11.77%	0.1597	0.0301	0.0273
	V / X	0.69%	0.0093	0.0018	0.0016
	S / V	10.17%	0.1380	0.0260	0.0235
	S / S	73.71%	1.0000	0.1886	0.1706
	S / X	1.14%	0.0155	0.0029	0.0026
	X / V	0.11%	0.0016	0.0003	0.0003
	X / S	0.91%	0.0124	0.0023	0.0021
	X / X	0.11%	0.0016	0.0003	0.0003

Table A.8 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-9 (Antalya).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	0.36%	0.0072	0.0009	0.0007
	5° - 10°	13.31%	0.2681	0.0322	0.0251
	10° - 15°	49.64%	1.0000	0.1201	0.0937
	15° - 20°	28.42%	0.5725	0.0687	0.0536
	20° - 25°	6.47%	0.1304	0.0157	0.0122
	25° - 30°	1.44%	0.0290	0.0035	0.0027
	30° - 35°	0.36%	0.0072	0.0009	0.0007
	> 35°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.00%	0.0000	0.0000	0.0000
	50 - 100	1.44%	0.0548	0.0034	0.0027
	100 - 150	3.60%	0.1370	0.0084	0.0067
	150 - 200	12.41%	0.4726	0.0291	0.0233
	200 - 250	23.20%	0.8836	0.0544	0.0435
	250 - 300	26.26%	1.0000	0.0616	0.0493
	300 - 350	14.39%	0.5479	0.0337	0.0270
	350 - 400	8.45%	0.3219	0.0198	0.0159
	400 - 450	6.12%	0.2329	0.0143	0.0115
	450 - 500	1.26%	0.0479	0.0030	0.0024
	500 - 550	1.80%	0.0685	0.0042	0.0034
	550 - 600	0.54%	0.0205	0.0013	0.0010
	600 - 650	0.54%	0.0205	0.0013	0.0010
	> 650	0.00%	0.0000	0.0000	0.0000
Rainfall	< 300	0.00%	0.0000	-	0.0000
	300 - 400	0.00%	0.0000	-	0.0000
	400 - 500	0.00%	0.0000	-	0.0000
	500 - 600	4.68%	0.0602	-	0.0087
	600 - 700	11.15%	0.1435	-	0.0208
	700 - 800	77.70%	1.0000	-	0.1452
	> 800	5.94%	0.0764		0.0111
Lithology	Young deposits	0.18%	0.0039	0.0005	0.0004
	Basalt	3.06%	0.0656	0.0079	0.0062
	Gabbro	0.36%	0.0077	0.0009	0.0007
	Continental clastic rocks	5.40%	0.1158	0.0139	0.0109
	Clastic and carbonate rocks	26.98%	0.5792	0.0695	0.0543
	Limestone	11.15%	0.2394	0.0287	0.0224
	Limestone, marl, shale	4.50%	0.0965	0.0116	0.0090
	Marble	0.36%	0.0077	0.0009	0.0007
	Metamorpic rocks	0.54%	0.0116	0.0014	0.0011
	Ophiolitic rocks	46.58%	1.0000	0.1201	0.0937
	Pyroclastic rocks	0.18%	0.0039	0.0005	0.0004
	Travertine	0.72%	0.0154	0.0019	0.0014
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Agricultural areas	35.07%	0.7677	0.0922	0.0719
	Forest	45.68%	1.0000	0.1201	0.0937
	Semi natural areas	19.24%	0.4213	0.0506	0.0395
	Others	0.00%	0.0000	0.0000	0.0000

Table A.8 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-9 (Antalya, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Earthquake	Zone 1	37.59%	0.6967	0.0900	0.0754
	Zone 2	53.96%	1.0000	0.1292	0.1082
	Zone 3	4.86%	0.0900	0.0116	0.0097
	Zone 4	3.60%	0.0667	0.0086	0.0072
	Zone 5	0.00%	0.0000	0.0000	0.0000
Aspect	N	1.44%	0.0630	-	0.0030
	NE	17.09%	0.7480	-	0.0354
	E	22.84%	1.0000	-	0.0474
	SE	16.73%	0.7323	-	0.0347
	S	12.05%	0.5276	-	0.0250
	SW	9.53%	0.4173	-	0.0198
	W	12.59%	0.5512	-	0.0261
	NW	7.73%	0.3386	-	0.0160
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	1.62%	0.0333	0.0043	0.0034
	11 - 12	16.19%	0.3333	0.0431	0.0336
	12 - 13	48.56%	1.0000	0.1292	0.1007
	13 - 14	28.42%	0.5852	0.0756	0.0589
	14 - 15	4.68%	0.0963	0.0124	0.0097
	15 - 16	0.36%	0.0074	0.0010	0.0007
	16 - 17	0.18%	0.0037	0.0005	0.0004
	> 17	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	5.22%	0.0915	0.0135	0.0103
	Midslope drainages, shallow valleys	4.14%	0.0726	0.0107	0.0082
	Upland drainages, headwaters	0.54%	0.0095	0.0014	0.0011
	U-shaped valleys	30.58%	0.5363	0.0791	0.0606
	Plains	0.18%	0.0032	0.0005	0.0004
	Open slopes	57.01%	1.0000	0.1475	0.1129
	Upper slopes, mesas	1.80%	0.0315	0.0047	0.0036
	Local ridges/hills in valleys	0.18%	0.0032	0.0005	0.0004
	Midslope ridges, small hills in plains	0.36%	0.0063	0.0009	0.0007
	Mountain tops, high ridges	0.00%	0.0000	0.0000	0.0000
Curvature	V / V	1.80%	0.0260	0.0045	0.0040
	V / S	13.67%	0.1979	0.0341	0.0307
	V / X	0.72%	0.0104	0.0018	0.0016
	S / V	13.13%	0.1901	0.0327	0.0295
	S / S	69.06%	1.0000	0.1722	0.1552
	S / X	0.54%	0.0078	0.0013	0.0012
	X / V	0.00%	0.0000	0.0000	0.0000
	X / S	0.90%	0.0130	0.0022	0.0020
	X / X	0.18%	0.0026	0.0004	0.0004

Table A.9 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-10 (Burdur).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	0.00%	0.0000	0.0000	0.0000
	5° - 10°	17.86%	0.3226	0.0323	0.0293
	10° - 15°	55.36%	1.0000	0.1000	0.0907
	15° - 20°	21.43%	0.3871	0.0387	0.0351
	20° - 25°	5.36%	0.0968	0.0097	0.0088
	> 25°	0.00%	0.0000	0.0000	0.0000
Internal Relief	< 100	0.00%	0.0000	0.0000	0.0000
	100 - 150	14.29%	0.5333	0.0266	0.0247
	150 - 200	19.64%	0.7333	0.0366	0.0339
	200 - 250	26.79%	1.0000	0.0500	0.0462
	250 - 300	25.00%	0.9333	0.0466	0.0431
	300 - 350	14.29%	0.5333	0.0266	0.0247
	> 350	0.00%	0.0000	0.0000	0.0000
Rainfall	< 400	0.00%	0.0000	-	0.0000
	400 - 500	3.57%	0.0606	-	0.0057
	500 - 600	58.93%	1.0000	-	0.0939
	600 - 700	23.21%	0.3939	-	0.0370
	700 - 800	5.36%	0.0909	-	0.0085
	800 - 900	8.93%	0.1515	-	0.0142
	> 900	0.00%	0.0000	-	0.0000
Lithology	Continental clastic rocks	28.57%	1.0000	0.0601	0.0462
	Clastic and carbonate rocks	17.86%	0.6250	0.0376	0.0289
	Limestone	23.21%	0.8125	0.0488	0.0376
	Ophiolitic rocks	28.57%	1.0000	0.0601	0.0462
	Pyroclastic rocks	1.79%	0.0625	0.0038	0.0029
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Agricultural areas	12.50%	0.2692	0.0269	0.0234
	Forest	46.43%	1.0000	0.1000	0.0870
	Semi natural areas	41.07%	0.8846	0.0885	0.0770
	Others	0.00%	0.0000	0.0000	0.0000
Earthquake	Zone 1	100.00%	1.0000	0.2221	0.1778
	Others	0.00%	0.0000	0.0000	0.0000
Aspect	N	1.79%	0.0909	-	0.0035
	NE	16.07%	0.8182	-	0.0312
	E	14.29%	0.7273	-	0.0278
	SE	7.14%	0.3636	-	0.0139
	S	8.93%	0.4545	-	0.0173
	SW	12.50%	0.6364	-	0.0243
	W	19.64%	1.0000	-	0.0382
	NW	19.64%	1.0000	-	0.0382
TWI	< 11	0.00%	0.0000	0.0000	0.0000
	11 - 12	19.64%	0.3667	0.0367	0.0365
	12 - 13	53.57%	1.0000	0.1000	0.0996
	13 - 14	25.00%	0.4667	0.0467	0.0465
	14 - 15	1.79%	0.0333	0.0033	0.0033
	> 15	0.00%	0.0000	0.0000	0.0000

Table A.9 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-10 (Burdur, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Landforms	Canyons, deeply incised streams	1.79%	0.0238	0.0042	0.0037
	Midslope drainages, shallow valleys	5.36%	0.0714	0.0125	0.0111
	U-shaped valleys	16.07%	0.2143	0.0376	0.0334
	Open slopes	75.00%	1.0000	0.1752	0.1557
	Upper slopes, mesas	1.79%	0.0238	0.0042	0.0037
	Others	0.00%	0.0000	0.0000	0.0000
Curvature	V / S	8.93%	0.1136	0.0219	0.0187
	V / X	1.79%	0.0227	0.0044	0.0037
	S / V	8.93%	0.1136	0.0219	0.0187
	S / S	78.57%	1.0000	0.1927	0.1646
	X / S	1.79%	0.0227	0.0044	0.0037
	Others	0.00%	0.0000	0.0000	0.0000

Table A.10 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-11 (Akarçay).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	1.21%	0.0275	0.0022	0.0019
	5° - 10°	43.32%	0.9817	0.0780	0.0689
	10° - 15°	44.13%	1.0000	0.0795	0.0702
	15° - 20°	10.93%	0.2477	0.0197	0.0174
	20° - 25°	0.40%	0.0092	0.0007	0.0006
	> 25°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.00%	0.0000	0.0000	0.0000
	50 - 100	2.02%	0.0562	0.0038	0.0035
	100 - 150	25.91%	0.7191	0.0483	0.0445
	150 - 200	36.03%	1.0000	0.0672	0.0618
	200 - 250	21.86%	0.6067	0.0408	0.0375
	250 - 300	7.29%	0.2022	0.0136	0.0125
	300 - 350	4.05%	0.1124	0.0076	0.0069
	350 - 400	2.43%	0.0674	0.0045	0.0042
	400 - 450	0.40%	0.0112	0.0008	0.0007
	> 450	0.00%	0.0000	0.0000	0.0000
Rainfall	< 400	0.00%	0.0000	-	0.0000
	400 - 500	37.65%	0.6039	-	0.0723
	500 - 600	62.35%	1.0000	-	0.1197
	> 600	0.00%	0.0000	-	0.0000
Lithology	Young deposits	3.24%	0.0635	0.0068	0.0052
	Andesite	19.43%	0.3810	0.0405	0.0313
	Continental clastic rocks	51.01%	1.0000	0.1064	0.0823
	Clastic and carbonate rocks	6.07%	0.1190	0.0127	0.0098
	Limestone	3.24%	0.0635	0.0068	0.0052
	Limestone, marl, shale	0.40%	0.0079	0.0008	0.0007
	Marble	1.62%	0.0317	0.0034	0.0026
	Metamorpic rocks	1.21%	0.0238	0.0025	0.0020
	Pyroclastic rocks	13.77%	0.2698	0.0287	0.0222
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	0.40%	0.0057	0.0008	0.0007
	Agricultural areas	24.29%	0.3429	0.0500	0.0437
	Forest	70.85%	1.0000	0.1458	0.1274
	Semi natural areas	4.45%	0.0629	0.0092	0.0080
	Wetlands and water bodies	0.00%	0.0000	0.0000	0.0000
Earthquake	Zone 1	24.29%	0.3209	0.0486	0.0409
	Zone 2	75.71%	1.0000	0.1515	0.1274
	Others	0.00%	0.0000	0.0000	0.0000
Aspect	N	2.83%	0.1186	-	0.0047
	NE	23.08%	0.9661	-	0.0380
	E	23.89%	1.0000	-	0.0394
	SE	10.93%	0.4576	-	0.0180
	S	6.07%	0.2542	-	0.0100
	SW	6.88%	0.2881	-	0.0113
	W	11.74%	0.4915	-	0.0194
	NW	14.57%	0.6102	-	0.0240

Table A.10 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-11 (Akarçay, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
TWI	< 11	0.00%	0.0000	0.0000	0.0000
	11 - 12	11.74%	0.2248	0.0263	0.0214
	12 - 13	52.23%	1.0000	0.1171	0.0950
	13 - 14	29.15%	0.5581	0.0654	0.0530
	14 - 15	4.45%	0.0853	0.0100	0.0081
	15 - 16	2.02%	0.0388	0.0045	0.0037
	16 - 17	0.40%	0.0078	0.0009	0.0007
	> 17	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	2.02%	0.0256	0.0041	0.0035
	Midslope drainages, shallow valleys	3.24%	0.0410	0.0066	0.0056
	Upland drainages, headwaters	0.00%	0.0000	0.0000	0.0000
	U-shaped valleys	12.55%	0.1590	0.0257	0.0217
	Plains	2.02%	0.0256	0.0041	0.0035
	Open slopes	78.95%	1.0000	0.1618	0.1364
	Upper slopes, mesas	1.21%	0.0154	0.0025	0.0021
	Local ridges/hills in valleys	0.00%	0.0000	0.0000	0.0000
Curvature	V / S	9.72%	0.1182	0.0202	0.0166
	S / V	7.69%	0.0936	0.0160	0.0131
	S / S	82.19%	1.0000	0.1707	0.1404
	S / X	0.40%	0.0049	0.0008	0.0007
	Others	0.00%	0.0000	0.0000	0.0000

Table A.11 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-12 (Sakarya).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating $Value_8$	Rating $Value_{10}$
Slope	0° - 5°	2.12%	0.0488	0.0049	0.0044
	5° - 10°	34.57%	0.7946	0.0790	0.0710
	10° - 15°	43.50%	1.0000	0.0994	0.0894
	15° - 20°	15.94%	0.3663	0.0364	0.0327
	20° - 25°	3.11%	0.0714	0.0071	0.0064
	25° - 30°	0.74%	0.0169	0.0017	0.0015
	30° - 35°	0.03%	0.0006	0.0001	0.0001
	> 35°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.16%	0.0059	0.0004	0.0003
	50 - 100	6.02%	0.2160	0.0136	0.0121
	100 - 150	19.69%	0.7067	0.0444	0.0395
	150 - 200	27.87%	1.0000	0.0628	0.0559
	200 - 250	22.01%	0.7898	0.0496	0.0442
	250 - 300	13.76%	0.4936	0.0310	0.0276
	300 - 350	5.99%	0.2151	0.0135	0.0120
	350 - 400	2.78%	0.0997	0.0063	0.0056
	400 - 450	1.31%	0.0469	0.0029	0.0026
	450 - 500	0.27%	0.0098	0.0006	0.0005
	500 - 550	0.08%	0.0029	0.0002	0.0002
	550 - 600	0.00%	0.0000	0.0000	0.0000
	600 - 650	0.05%	0.0020	0.0001	0.0001
	> 650	0.00%	0.0000	0.0000	0.0000
Rainfall	< 200	0.00%	0.0000	-	0.0000
	200 - 300	2.40%	0.0609	-	0.0045
	300 - 400	39.36%	1.0000	-	0.0742
	400 - 500	21.71%	0.5516	-	0.0409
	500 - 600	13.65%	0.3467	-	0.0257
	600 - 700	8.34%	0.2118	-	0.0157
	700 - 800	9.62%	0.2443	-	0.0181
	800 - 900	2.64%	0.0671	-	0.0050
	900 - 1000	0.84%	0.0215	-	0.0016
	1000 - 1100	1.01%	0.0256	-	0.0019
	1100 - 1200	0.35%	0.0090	-	0.0007
	1200 - 1300	0.08%	0.0021	-	0.0002
	> 1300	0.00%	0.0000	-	0.0000
Lithology	Young deposits	2.49%	0.0773	0.0059	0.0053
	Andesite	0.66%	0.0204	0.0015	0.0014
	Undifferentiated volcanic rocks	8.29%	0.2574	0.0195	0.0177
	Basalt	1.59%	0.0493	0.0037	0.0034
	Gneiss	0.05%	0.0017	0.0001	0.0001
	Continental clastic rocks	24.95%	0.7749	0.0586	0.0533
	Carbonate rocks	0.19%	0.0059	0.0005	0.0004
	Clastic and carbonate rocks	32.19%	1.0000	0.0757	0.0688
	Limestone	7.28%	0.2260	0.0171	0.0155
	Limestone, marl, shale	5.96%	0.1852	0.0140	0.0127

Table A.11 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-12 (Sakarya, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Lithology	Marble	0.41%	0.0127	0.0010	0.0009
	Metamorpic rocks	5.09%	0.1580	0.0120	0.0109
	Flisch	0.03%	0.0008	0.0001	0.0001
	Ophiolitic rocks	2.43%	0.0756	0.0057	0.0052
	Pyroclastic rocks	1.59%	0.0493	0.0037	0.0034
	Granitoid	0.82%	0.0255	0.0019	0.0018
	Volcanic and sedimentary rocks	1.31%	0.0408	0.0031	0.0028
	Gypsum	4.68%	0.1453	0.0110	0.0100
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	0.30%	0.0056	0.0008	0.0007
	Agricultural areas	42.41%	0.7888	0.1100	0.0989
	Forest	53.77%	1.0000	0.1395	0.1254
	Semi natural areas	3.38%	0.0628	0.0088	0.0079
	Wetlands and water bodies	0.14%	0.0025	0.0004	0.0003
Earthquake	Zone 1	58.87%	1.0000	0.1514	0.1339
	Zone 2	30.16%	0.5123	0.0775	0.0686
	Zone 3	9.04%	0.1536	0.0233	0.0206
	Zone 4	1.93%	0.0329	0.0050	0.0044
	Zone 5	0.00%	0.0000	0.0000	0.0000
Aspect	N	3.05%	0.1764	-	0.0064
	NE	9.04%	0.5228	-	0.0188
	E	14.66%	0.8472	-	0.0305
	SE	14.71%	0.8504	-	0.0306
	S	15.31%	0.8850	-	0.0319
	SW	14.14%	0.8173	-	0.0294
	W	17.30%	1.0000	-	0.0360
	NW	11.80%	0.6819	-	0.0246
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	1.39%	0.0288	0.0034	0.0032
	11 - 12	22.15%	0.4591	0.0544	0.0506
	12 - 13	48.24%	1.0000	0.1186	0.1102
	13 - 14	23.15%	0.4800	0.0569	0.0529
	14 - 15	4.33%	0.0898	0.0106	0.0099
	15 - 16	0.49%	0.0102	0.0012	0.0011
	16 - 17	0.22%	0.0045	0.0005	0.0005
	17 - 18	0.03%	0.0006	0.0001	0.0001
	> 18	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	3.54%	0.0505	0.0097	0.0077
	Midslope drainages, shallow valleys	6.65%	0.0947	0.0181	0.0145
	Upland drainages, headwaters	0.30%	0.0043	0.0008	0.0007
	U-shaped valleys	13.92%	0.1984	0.0380	0.0304
	Plains	2.10%	0.0299	0.0057	0.0046
	Open slopes	70.17%	1.0000	0.1914	0.1531

Table A.11 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-12 (Sakarya, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Landforms	Upper slopes, mesas	2.64%	0.0377	0.0072	0.0058
	Local ridges/hills in valleys	0.08%	0.0012	0.0002	0.0002
	Midslope ridges, small hills in plains	0.46%	0.0066	0.0013	0.0010
	Mountain tops, high ridges	0.14%	0.0019	0.0004	0.0003
Curvature	V / V	2.15%	0.0318	0.0051	0.0049
	V / S	13.57%	0.2006	0.0324	0.0307
	V / X	0.60%	0.0089	0.0014	0.0014
	S / V	12.78%	0.1889	0.0305	0.0289
	S / S	67.64%	1.0000	0.1614	0.1531
	S / X	1.55%	0.0230	0.0037	0.0035
	X / V	0.22%	0.0032	0.0005	0.0005
	X / S	1.44%	0.0213	0.0034	0.0033
	X / X	0.05%	0.0008	0.0001	0.0001

Table A.12 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-13 (Batı Karadeniz).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	1.15%	0.0289	0.0026	0.0024
	5° - 10°	18.88%	0.4762	0.0434	0.0401
	10° - 15°	39.64%	1.0000	0.0912	0.0841
	15° - 20°	29.96%	0.7558	0.0689	0.0636
	20° - 25°	8.71%	0.2197	0.0200	0.0185
	25° - 30°	1.47%	0.0371	0.0034	0.0031
	30° - 35°	0.17%	0.0044	0.0004	0.0004
	> 35°	0.02%	0.0004	0.0000	0.0000
Internal Relief	0 - 50	0.04%	0.0019	0.0001	0.0001
	50 - 100	3.53%	0.1517	0.0083	0.0074
	100 - 150	11.12%	0.4775	0.0261	0.0233
	150 - 200	17.59%	0.7553	0.0412	0.0369
	200 - 250	23.29%	1.0000	0.0546	0.0489
	250 - 300	22.53%	0.9673	0.0528	0.0473
	300 - 350	13.24%	0.5683	0.0310	0.0278
	350 - 400	5.49%	0.2357	0.0129	0.0115
	400 - 450	2.19%	0.0942	0.0051	0.0046
	450 - 500	0.73%	0.0312	0.0017	0.0015
	500 - 550	0.17%	0.0071	0.0004	0.0003
	550 - 600	0.06%	0.0026	0.0001	0.0001
	> 600	0.00%	0.0000	0.0000	0.0000
Rainfall	< 300	0.00%	0.0000	-	0.0000
	300 - 400	0.05%	0.0024	-	0.0001
	400 - 500	8.25%	0.3838	-	0.0228
	500 - 600	12.53%	0.5832	-	0.0346
	600 - 700	9.35%	0.4351	-	0.0258
	700 - 800	12.79%	0.5954	-	0.0353
	800 - 900	21.48%	1.0000	-	0.0594
	900 - 1000	21.19%	0.9866	-	0.0586
	1000 - 1100	11.24%	0.5230	-	0.0310
	1100 - 1200	2.67%	0.1241	-	0.0074
	1200 - 1300	0.45%	0.0212	-	0.0013
	> 1300	0.00%	0.0000	-	0.0000
Lithology	Young deposits	1.44%	0.0195	0.0037	0.0028
	Undifferentiated volcanic rocks	3.55%	0.0481	0.0092	0.0070
	Basalt	0.61%	0.0083	0.0016	0.0012
	Dacite	0.01%	0.0001	0.0000	0.0000
	Continental clastic rocks	5.65%	0.0767	0.0146	0.0112
	Clastic and carbonate rocks	73.70%	1.0000	0.1910	0.1461
	Limestone	3.71%	0.0503	0.0096	0.0073
	Limestone, marl, shale	0.22%	0.0030	0.0006	0.0004
	Marble	0.06%	0.0008	0.0002	0.0001
	Metamorpic rocks	7.38%	0.1001	0.0191	0.0146
	Ophiolitic rocks	0.14%	0.0019	0.0004	0.0003
	Pyroclastic rocks	0.15%	0.0020	0.0004	0.0003
	Volcanic and sedimentary rocks	3.39%	0.0460	0.0088	0.0067
	Others	0.00%	0.0000	0.0000	0.0000

Table A.12 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-13 (Batı Karadeniz, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Land Cover	Artificial surfaces	0.86%	0.0161	0.0021	0.0021
	Agricultural areas	53.30%	1.0000	0.1289	0.1288
	Forest	44.21%	0.8294	0.1069	0.1068
	Semi natural areas	1.60%	0.0300	0.0039	0.0039
	Wetlands and water bodies	0.03%	0.0007	0.0001	0.0001
Earthquake	Zone 1	50.27%	1.0000	0.1180	0.1157
	Zone 2	21.37%	0.4251	0.0502	0.0492
	Zone 3	13.98%	0.2781	0.0328	0.0322
	Zone 4	14.38%	0.2861	0.0338	0.0331
	Zone 5	0.00%	0.0000	0.0000	0.0000
Aspect	N	4.03%	0.2419	-	0.0096
	NE	9.50%	0.5703	-	0.0227
	E	15.04%	0.9024	-	0.0359
	SE	14.00%	0.8400	-	0.0334
	S	12.75%	0.7650	-	0.0304
	SW	11.73%	0.7041	-	0.0280
	W	16.67%	1.0000	-	0.0397
	NW	16.28%	0.9769	-	0.0388
TWI	< 9	0.00%	0.0000	0.0000	0.0000
	9 - 10	0.01%	0.0002	0.00002	0.00002
	10 - 11	3.66%	0.0823	0.0089	0.0077
	11 - 12	28.71%	0.6447	0.0697	0.0603
	12 - 13	44.54%	1.0000	0.1081	0.0935
	13 - 14	19.01%	0.4268	0.0461	0.0399
	14 - 15	3.23%	0.0724	0.0078	0.0068
	15 - 16	0.60%	0.0135	0.0015	0.0013
	16 - 17	0.17%	0.0039	0.0004	0.0004
	17 - 18	0.06%	0.0014	0.0001	0.0001
	> 18	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	5.71%	0.0988	0.0146	0.0136
	Midslope drainages, shallow valleys	7.83%	0.1356	0.0200	0.0187
	Upland drainages, headwaters	0.87%	0.0151	0.0022	0.0021
	U-shaped valleys	22.02%	0.3812	0.0562	0.0525
	Plains	0.87%	0.0150	0.0022	0.0021
	Open slopes	57.76%	1.0000	0.1475	0.1377
	Upper slopes, mesas	3.59%	0.0622	0.0092	0.0086
	Local ridges/hills in valleys	0.19%	0.0033	0.0005	0.0005
	Midslope ridges, small hills in plains	0.89%	0.0154	0.0023	0.0021
	Mountain tops, high ridges	0.26%	0.0045	0.0007	0.0006

Table A.12 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-13 (Batı Karadeniz, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Curvature	V / V	3.39%	0.0555	0.0089	0.0081
	V / S	16.95%	0.2772	0.0445	0.0405
	V / X	0.98%	0.0160	0.0026	0.0023
	S / V	12.88%	0.2107	0.0339	0.0308
	S / S	61.13%	1.0000	0.1607	0.1461
	S / X	1.68%	0.0275	0.0044	0.0040
	X / V	0.30%	0.0049	0.0008	0.0007
	X / S	2.33%	0.0382	0.0061	0.0056
	X / X	0.37%	0.0060	0.0010	0.0009

Table A.13 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-14 (Yeşilırmak).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	1.23%	0.0291	0.0029	0.0026
	5° - 10°	31.86%	0.7507	0.0747	0.0671
	10° - 15°	42.44%	1.0000	0.0995	0.0893
	15° - 20°	19.28%	0.4542	0.0452	0.0406
	20° - 25°	4.09%	0.0963	0.0096	0.0086
	25° - 30°	0.95%	0.0224	0.0022	0.0020
	30° - 35°	0.14%	0.0033	0.0003	0.0003
	> 35°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.02%	0.0008	0.0000	0.0000
	50 - 100	4.03%	0.1691	0.0091	0.0077
	100 - 150	17.56%	0.7375	0.0396	0.0337
	150 - 200	23.81%	1.0000	0.0537	0.0457
	200 - 250	23.27%	0.9771	0.0525	0.0447
	250 - 300	15.68%	0.6585	0.0354	0.0301
	300 - 350	8.80%	0.3696	0.0199	0.0169
	350 - 400	4.55%	0.1912	0.0103	0.0087
	400 - 450	1.58%	0.0663	0.0036	0.0030
	450 - 500	0.49%	0.0204	0.0011	0.0009
	500 - 550	0.18%	0.0076	0.0004	0.0003
	550 - 600	0.04%	0.0017	0.0001	0.0001
	> 600	0.00%	0.0000	0.0000	0.0000
Rainfall	< 300	0.00%	0.0000	-	0.0000
	300 - 400	1.62%	0.0374	-	0.0032
	400 - 500	43.25%	1.0000	-	0.0847
	500 - 600	39.15%	0.9051	-	0.0767
	600 - 700	9.10%	0.2105	-	0.0178
	700 - 800	4.71%	0.1090	-	0.0092
	800 - 900	1.23%	0.0285	-	0.0024
	900 - 1000	0.93%	0.0215	-	0.0018
	> 1000	0.00%	0.0000	-	0.0000
Lithology	Young deposits	1.32%	0.0678	0.0031	0.0027
	Andesite	0.65%	0.0334	0.0015	0.0014
	Undifferentiated volcanic rocks	3.74%	0.1919	0.0089	0.0078
	Basalt	7.69%	0.3942	0.0183	0.0160
	Dacite	0.06%	0.0031	0.0001	0.0001
	Continental clastic rocks	19.50%	1.0000	0.0464	0.0405
	Clastic and carbonate rocks	16.00%	0.8206	0.0381	0.0332
	Limestone	5.94%	0.3045	0.0141	0.0123
	Limestone, marl, shale	0.12%	0.0063	0.0003	0.0003
	Marble	0.41%	0.0209	0.0010	0.0008
	Metamorpic rocks	15.29%	0.7842	0.0364	0.0318
	Ophiolitic rocks	5.80%	0.2972	0.0138	0.0120
	Travertine	0.16%	0.0083	0.0004	0.0003
	Granitoid	0.31%	0.0156	0.0007	0.0006
	Volcanic and sedimentary rocks	16.14%	0.8279	0.0384	0.0335
	Gypsum	6.87%	0.3525	0.0163	0.0143
	Others	0.00%	0.0000	0.0000	0.0000

Table A.13 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-14 (Yeşilırmak, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Land Cover	Artificial surfaces	0.61%	0.0121	0.0013	0.0011
	Agricultural areas	50.03%	1.0000	0.1052	0.0933
	Forest	40.34%	0.8063	0.0848	0.0753
	Semi natural areas	9.00%	0.1799	0.0189	0.0168
	Wetlands and water bodies	0.02%	0.0004	0.0000	0.0000
Earthquake	Zone 1	88.41%	1.0000	0.2047	0.1791
	Zone 2	8.60%	0.0973	0.0199	0.0174
	Zone 3	2.99%	0.0339	0.0069	0.0061
	Others	0.00%	0.0000	0.0000	0.0000
Aspect	N	3.66%	0.2248	-	0.0081
	NE	12.50%	0.7677	-	0.0278
	E	15.64%	0.9602	-	0.0347
	SE	16.29%	1.0000	-	0.0362
	S	14.77%	0.9068	-	0.0328
	SW	12.04%	0.7391	-	0.0267
	W	14.22%	0.8733	-	0.0316
	NW	10.88%	0.6683	-	0.0242
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	1.19%	0.0270	0.0027	0.0026
	11 - 12	20.15%	0.4556	0.0453	0.0444
	12 - 13	44.22%	1.0000	0.0995	0.0975
	13 - 14	27.33%	0.6180	0.0615	0.0602
	14 - 15	6.01%	0.1359	0.0135	0.0132
	15 - 16	0.85%	0.0192	0.0019	0.0019
	16 - 17	0.16%	0.0037	0.0004	0.0004
	17 - 18	0.06%	0.0014	0.0001	0.0001
	18 - 19	0.02%	0.0005	0.00005	0.00004
	> 19	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	3.38%	0.0482	0.0086	0.0080
	Midslope drainages, shallow valleys	5.30%	0.0757	0.0135	0.0126
	Upland drainages, headwaters	0.24%	0.0035	0.0006	0.0006
	U-shaped valleys	16.91%	0.2415	0.0431	0.0403
	Plains	1.15%	0.0165	0.0029	0.0027
	Open slopes	70.04%	1.0000	0.1784	0.1668
	Upper slopes, mesas	2.25%	0.0321	0.0057	0.0053
	Local ridges/hills in valleys	0.06%	0.0009	0.0002	0.0001
	Midslope ridges, small hills in plains	0.55%	0.0078	0.0014	0.0013
	Mountain tops, high ridges	0.12%	0.0017	0.0003	0.0003

Table A.13 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-14 (Yeşilırmak, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Curvature	V / V	2.43%	0.0337	0.0072	0.0056
	V / S	12.54%	0.1739	0.0370	0.0290
	V / X	0.40%	0.0056	0.0012	0.0009
	S / V	9.71%	0.1346	0.0286	0.0225
	S / S	72.12%	1.0000	0.2126	0.1668
	S / X	1.05%	0.0146	0.0031	0.0024
	X / V	0.14%	0.0020	0.0004	0.0003
	X / S	1.44%	0.0199	0.0042	0.0033
	X / X	0.16%	0.0022	0.0005	0.0004

Table A.14 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-15 (Kızılırmak).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	1.31%	0.0320	0.0034	0.0028
	5° - 10°	32.71%	0.7984	0.0859	0.0696
	10° - 15°	40.97%	1.0000	0.1076	0.0871
	15° - 20°	19.30%	0.4710	0.0507	0.0410
	20° - 25°	5.14%	0.1254	0.0135	0.0109
	25° - 30°	0.53%	0.0128	0.0014	0.0011
	30° - 35°	0.05%	0.0012	0.0001	0.0001
	> 35°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.09%	0.0031	0.0002	0.0002
	50 - 100	4.54%	0.1651	0.0113	0.0096
	100 - 150	22.92%	0.8336	0.0570	0.0483
	150 - 200	27.50%	1.0000	0.0684	0.0579
	200 - 250	20.55%	0.7472	0.0511	0.0433
	250 - 300	13.06%	0.4749	0.0325	0.0275
	300 - 350	6.72%	0.2443	0.0167	0.0142
	350 - 400	2.97%	0.1081	0.0074	0.0063
	400 - 450	1.17%	0.0427	0.0029	0.0025
	450 - 500	0.39%	0.0142	0.0010	0.0008
	500 - 550	0.05%	0.0018	0.0001	0.0001
	550 - 600	0.02%	0.0009	0.00006	0.00005
	600 - 650	0.02%	0.0009	0.00006	0.00005
	> 650	0.00%	0.0000	0.0000	0.0000
Rainfall	< 200	0.00%	0.0000	-	0.0000
	200 - 300	0.01%	0.0002	-	0.0000
	300 - 400	6.91%	0.1143	-	0.0145
	400 - 500	60.46%	1.0000	-	0.1268
	500 - 600	22.28%	0.3685	-	0.0467
	600 - 700	3.60%	0.0595	-	0.0075
	700 - 800	6.45%	0.1067	-	0.0135
	800 - 900	0.28%	0.0047	-	0.0006
	> 900	0.00%	0.0000	-	0.0000
Lithology	Young deposits	1.98%	0.0831	0.0051	0.0043
	Undifferentiated volcanic rocks	5.56%	0.2329	0.0144	0.0121
	Basalt	10.30%	0.4315	0.0267	0.0223
	Dacite	0.23%	0.0097	0.0006	0.0005
	Gabbro	0.22%	0.0092	0.0006	0.0005
	Continental clastic rocks	13.42%	0.5618	0.0347	0.0291
	Carbonate rocks	0.22%	0.0092	0.0006	0.0005
	Clastic and carbonate rocks	23.88%	1.0000	0.0618	0.0518
	Limestone	3.52%	0.1473	0.0091	0.0076
	Limestone, marl, shale	4.14%	0.1734	0.0107	0.0090
	Marble	0.96%	0.0400	0.0025	0.0021
	Metamorpic rocks	10.11%	0.4233	0.0262	0.0219
	Ophiolitic rocks	5.97%	0.2499	0.0154	0.0129
	Pyroclastic rocks	1.25%	0.0523	0.0032	0.0027
	Travertine	0.04%	0.0015	0.0001	0.0001
	Granitoid	0.34%	0.0144	0.0009	0.0007

Table A.14 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-15 (Kızılırmak, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Lithology	Volcanic and sedimentary rocks	3.57%	0.1493	0.0092	0.0077
	Gypsum	14.20%	0.5947	0.0368	0.0308
	Plutonic rocks	0.10%	0.0041	0.0003	0.0002
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	0.34%	0.0077	0.0009	0.0008
	Agricultural areas	44.49%	1.0000	0.1159	0.0987
	Forest	39.38%	0.8850	0.1026	0.0873
	Semi natural areas	15.72%	0.3534	0.0410	0.0349
	Wetlands and water bodies	0.06%	0.0014	0.0002	0.0001
Earthquake	Zone 1	52.36%	1.0000	0.1270	0.1065
	Zone 2	17.77%	0.3393	0.0431	0.0361
	Zone 3	25.89%	0.4945	0.0628	0.0526
	Zone 4	3.98%	0.0760	0.0096	0.0081
	Zone 5	0.00%	0.0000	0.0000	0.0000
Aspect	N	3.71%	0.2393	-	0.0077
	NE	11.93%	0.7701	-	0.0246
	E	15.49%	1.0000	-	0.0320
	SE	14.46%	0.9336	-	0.0299
	S	13.17%	0.8499	-	0.0272
	SW	11.33%	0.7314	-	0.0234
	W	15.19%	0.9803	-	0.0313
	NW	14.72%	0.9502	-	0.0304
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	1.76%	0.0378	0.0053	0.0042
	11 - 12	24.35%	0.5224	0.0727	0.0576
	12 - 13	46.61%	1.0000	0.1391	0.1103
	13 - 14	22.38%	0.4802	0.0668	0.0530
	14 - 15	3.88%	0.0832	0.0116	0.0092
	15 - 16	0.80%	0.0171	0.0024	0.0019
	16 - 17	0.13%	0.0029	0.0004	0.0003
	17 - 18	0.06%	0.0013	0.0002	0.0001
	18 - 19	0.02%	0.0005	0.00007	0.00006
	> 19	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	2.94%	0.0405	0.0080	0.0069
	Midslope drainages, shallow valleys	6.84%	0.0942	0.0186	0.0162
	Upland drainages, headwaters	0.39%	0.0054	0.0011	0.0009
	U-shaped valleys	12.03%	0.1657	0.0328	0.0284
	Plains	1.37%	0.0189	0.0037	0.0032
	Open slopes	72.60%	1.0000	0.1979	0.1715

Table A.14 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-15 (Kızılırmak, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Landforms	Upper slopes, mesas	3.02%	0.0416	0.0082	0.0071
	Local ridges/hills in valleys	0.06%	0.0008	0.0002	0.0001
	Midslope ridges, small hills in plains	0.62%	0.0086	0.0017	0.0015
	Mountain tops, high ridges	0.12%	0.0017	0.0003	0.0003
Curvature	V / V	2.08%	0.0303	0.0055	0.0048
	V / S	15.17%	0.2209	0.0403	0.0348
	V / X	0.73%	0.0107	0.0019	0.0017
	S / V	10.10%	0.1470	0.0268	0.0231
	S / S	68.70%	1.0000	0.1823	0.1575
	S / X	1.28%	0.0187	0.0034	0.0029
	X / V	0.26%	0.0037	0.0007	0.0006
	X / S	1.51%	0.0219	0.0040	0.0034
	X / X	0.17%	0.0025	0.0005	0.0004

Table A.15 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-16 (Konya Kapalı).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	0.00%	0.0000	0.0000	0.0000
	5° - 10°	41.79%	1.0000	0.1040	0.0877
	10° - 15°	38.81%	0.9286	0.0965	0.0814
	15° - 20°	13.43%	0.3214	0.0334	0.0282
	20° - 25°	1.49%	0.0357	0.0037	0.0031
	25° - 30°	4.48%	0.1071	0.0111	0.0094
	> 30°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.00%	0.0000	0.0000	0.0000
	50 - 100	5.97%	0.1538	0.0143	0.0135
	100 - 150	38.81%	1.0000	0.0932	0.0877
	150 - 200	22.39%	0.5769	0.0538	0.0506
	200 - 250	14.93%	0.3846	0.0359	0.0337
	250 - 300	5.97%	0.1538	0.0143	0.0135
	300 - 350	1.49%	0.0385	0.0036	0.0034
	350 - 400	7.46%	0.1923	0.0179	0.0169
	400 - 450	2.99%	0.0769	0.0072	0.0067
	> 450	0.00%	0.0000	0.0000	0.0000
Rainfall	< 300	0.00%	0.0000	-	0.0000
	300 - 400	23.88%	0.5714	-	0.0501
	400 - 500	41.79%	1.0000	-	0.0877
	500 - 600	19.40%	0.4643	-	0.0407
	600 - 700	14.93%	0.3571	-	0.0313
	> 700	0.00%	0.0000	-	0.0000
Lithology	Continental clastic rocks	43.28%	1.0000	0.0992	0.0877
	Carbonate rocks	1.49%	0.0345	0.0034	0.0030
	Clastic and carbonate rocks	22.39%	0.5172	0.0513	0.0454
	Limestone	16.42%	0.3793	0.0376	0.0333
	Marble	1.49%	0.0345	0.0034	0.0030
	Ophiolitic rocks	1.49%	0.0345	0.0034	0.0030
	Pyroclastic rocks	7.46%	0.1724	0.0171	0.0151
	Gypsum	5.97%	0.1379	0.0137	0.0121
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Agricultural areas	32.84%	0.7333	0.0815	0.0643
	Forest	22.39%	0.5000	0.0555	0.0438
	Semi natural areas	44.78%	1.0000	0.1111	0.0877
	Others	0.00%	0.0000	0.0000	0.0000
Earthquake	Zone 1	0.00%	0.0000	0.0000	0.0000
	Zone 2	8.96%	0.1765	0.0195	0.0169
	Zone 3	22.39%	0.4412	0.0488	0.0422
	Zone 4	17.91%	0.3529	0.0390	0.0337
	Zone 5	50.75%	1.0000	0.1105	0.0956
Aspect	N	0.00%	0.0000	-	0.0000
	NE	13.43%	0.6429	-	0.0299
	E	19.40%	0.9286	-	0.0433
	SE	4.48%	0.2143	-	0.0100
	S	16.42%	0.7857	-	0.0366
	SW	20.90%	1.0000	-	0.0466

Table A.15 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-16 (Konya Kapalı, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Aspect	W	14.93%	0.7143	-	0.0333
	NW	10.45%	0.5000	-	0.0233
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	2.99%	0.0769	0.0076	0.0067
	11 - 12	25.37%	0.6538	0.0648	0.0573
	12 - 13	38.81%	1.0000	0.0992	0.0877
	13 - 14	31.34%	0.8077	0.0801	0.0708
	14 - 15	1.49%	0.0385	0.0038	0.0034
	> 15	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	5.97%	0.0889	0.0164	0.0143
	Midslope drainages, shallow valleys	7.46%	0.1111	0.0205	0.0179
	U-shaped valleys	14.93%	0.2222	0.0410	0.0358
	Plains	1.49%	0.0222	0.0041	0.0036
	Open slopes	67.16%	1.0000	0.1845	0.1611
	Upper slopes, mesas	1.49%	0.0222	0.0041	0.0036
	Mountain tops, high ridges	1.49%	0.0222	0.0041	0.0036
	Others	0.00%	0.0000	0.0000	0.0000
Curvature	V / V	5.97%	0.0870	0.0172	0.0148
	V / S	11.94%	0.1739	0.0345	0.0297
	S / V	11.94%	0.1739	0.0345	0.0297
	S / S	68.66%	1.0000	0.1984	0.1706
	S / X	0.00%	0.0000	0.0000	0.0000
	X / V	0.00%	0.0000	0.0000	0.0000
	X / S	1.49%	0.0217	0.0043	0.0037
	Others	0.00%	0.0000	0.0000	0.0000

Table A.16 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-17 (Doğu Akdeniz).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	0.56%	0.0113	0.0014	0.0012
	5° - 10°	17.52%	0.3536	0.0426	0.0368
	10° - 15°	49.55%	1.0000	0.1206	0.1040
	15° - 20°	24.89%	0.5023	0.0606	0.0522
	20° - 25°	6.14%	0.1239	0.0149	0.0129
	25° - 30°	0.67%	0.0135	0.0016	0.0014
	30° - 35°	0.45%	0.0090	0.0011	0.0009
	35° - 40°	0.22%	0.0045	0.0005	0.0005
	> 40°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.00%	0.0000	0.0000	0.0000
	50 - 100	0.33%	0.0124	0.0008	0.0007
	100 - 150	4.91%	0.1818	0.0122	0.0100
	150 - 200	15.63%	0.5785	0.0389	0.0317
	200 - 250	27.01%	1.0000	0.0673	0.0548
	250 - 300	19.75%	0.7314	0.0492	0.0401
	300 - 350	16.29%	0.6033	0.0406	0.0331
	350 - 400	9.38%	0.3471	0.0234	0.0190
	400 - 450	4.46%	0.1653	0.0111	0.0091
	450 - 500	1.34%	0.0496	0.0033	0.0027
	500 - 550	0.67%	0.0248	0.0017	0.0014
	550 - 600	0.11%	0.0041	0.0003	0.0002
	600 - 650	0.00%	0.0000	0.0000	0.0000
	650 - 700	0.11%	0.0041	0.0003	0.0002
	> 700	0.00%	0.0000	0.0000	0.0000
Rainfall	< 300	0.00%	0.0000	-	0.0000
	300 - 400	0.11%	0.0018	-	0.0002
	400 - 500	6.14%	0.0967	-	0.0115
	500 - 600	63.50%	1.0000	-	0.1185
	600 - 700	30.25%	0.4763	-	0.0564
	> 700	0.00%	0.0000	-	0.0000
Lithology	Young deposits	0.45%	0.0125	0.0011	0.0009
	Basalt	7.60%	0.2118	0.0180	0.0150
	Continental clastic rocks	35.87%	1.0000	0.0848	0.0709
	Clastic and carbonate rocks	21.45%	0.5981	0.0507	0.0424
	Limestone	16.42%	0.4579	0.0388	0.0325
	Marble	0.11%	0.0031	0.0003	0.0002
	Metamorpic rocks	0.11%	0.0031	0.0003	0.0002
	Ophiolitic rocks	12.63%	0.3520	0.0299	0.0250
	Pyroclastic rocks	4.36%	0.1215	0.0103	0.0086
	Travertine	1.01%	0.0280	0.0024	0.0020
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	0.22%	0.0041	0.0006	0.0004
	Agricultural areas	55.02%	1.0000	0.1417	0.1109
	Forest	36.27%	0.6592	0.0934	0.0731
	Semi natural areas	8.48%	0.1542	0.0218	0.0171
	Wetlands and water bodies	0.00%	0.0000	0.0000	0.0000

Table A.16 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-17 (Doğu Akdeniz, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Earthquake	Zone 3	14.51%	0.2394	0.0339	0.0284
	Zone 4	24.89%	0.4107	0.0582	0.0487
	Zone 5	60.60%	1.0000	0.1417	0.1185
	Others	0.00%	0.0000	0.0000	0.0000
Aspect	N	2.12%	0.1145	-	0.0045
	NE	17.19%	0.9277	-	0.0361
	E	18.53%	1.0000	-	0.0389
	SE	13.62%	0.7349	-	0.0286
	S	14.96%	0.8072	-	0.0314
	SW	16.85%	0.9096	-	0.0354
	W	11.94%	0.6446	-	0.0251
	NW	4.80%	0.2590	-	0.0101
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	2.01%	0.0446	0.0049	0.0044
	11 - 12	16.29%	0.3614	0.0401	0.0353
	12 - 13	45.09%	1.0000	0.1110	0.0976
	13 - 14	29.02%	0.6436	0.0714	0.0628
	14 - 15	6.03%	0.1337	0.0148	0.0131
	15 - 16	1.45%	0.0322	0.0036	0.0031
	16 - 17	0.11%	0.0025	0.0003	0.0002
	> 17	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	4.24%	0.0686	0.0106	0.0088
	Midslope drainages, shallow valleys	3.79%	0.0614	0.0095	0.0078
	Upland drainages, headwaters	0.22%	0.0036	0.0006	0.0005
	U-shaped valleys	25.56%	0.4134	0.0640	0.0528
	Plains	1.23%	0.0199	0.0031	0.0025
	Open slopes	61.83%	1.0000	0.1549	0.1277
	Upper slopes, mesas	2.57%	0.0415	0.0064	0.0053
	Local ridges/hills in valleys	0.22%	0.0036	0.0006	0.0005
	Midslope ridges, small hills in plains	0.33%	0.0054	0.0008	0.0007
	Mountain tops, high ridges	0.00%	0.0000	0.0000	0.0000
Curvature	V / V	1.45%	0.0198	0.0035	0.0031
	V / S	9.26%	0.1261	0.0224	0.0199
	V / X	0.45%	0.0061	0.0011	0.0010
	S / V	12.28%	0.1672	0.0297	0.0264
	S / S	73.44%	1.0000	0.1779	0.1580
	S / X	1.56%	0.0213	0.0038	0.0034
	X / V	0.45%	0.0061	0.0011	0.0010
	X / S	1.12%	0.0152	0.0027	0.0024
	X / X	0.00%	0.0000	0.0000	0.0000

Table A.17 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-18 (Seyhan).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	0.83%	0.0217	0.0024	0.0020
	5° - 10°	22.92%	0.5978	0.0654	0.0555
	10° - 15°	38.33%	1.0000	0.1094	0.0928
	15° - 20°	22.92%	0.5978	0.0654	0.0555
	20° - 25°	9.58%	0.2500	0.0273	0.0232
	25° - 30°	3.75%	0.0978	0.0107	0.0091
	30° - 35°	1.67%	0.0435	0.0048	0.0040
	> 35°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.00%	0.0000	0.0000	0.0000
	50 - 100	2.08%	0.0926	0.0057	0.0047
	100 - 150	9.58%	0.4259	0.0262	0.0218
	150 - 200	14.17%	0.6296	0.0387	0.0322
	200 - 250	22.50%	1.0000	0.0614	0.0512
	250 - 300	12.50%	0.5556	0.0341	0.0284
	300 - 350	12.50%	0.5556	0.0341	0.0284
	350 - 400	11.25%	0.5000	0.0307	0.0256
	400 - 450	6.67%	0.2963	0.0182	0.0152
	450 - 500	5.83%	0.2593	0.0159	0.0133
	500 - 550	1.67%	0.0741	0.0046	0.0038
	550 - 600	0.83%	0.0370	0.0023	0.0019
	600 - 650	0.42%	0.0185	0.0011	0.0009
	> 650	0.00%	0.0000	0.0000	0.0000
Rainfall	< 300	0.00%	0.0000	-	0.0000
	300 - 400	30.83%	1.0000	-	0.0815
	400 - 500	20.83%	0.6757	-	0.0551
	500 - 600	30.83%	1.0000	-	0.0815
	600 - 700	12.08%	0.3919	-	0.0319
	700 - 800	4.58%	0.1486	-	0.0121
	800 - 900	0.83%	0.0270	-	0.0022
	> 900	0.00%	0.0000	-	0.0000
Lithology	Young deposits	3.75%	0.0957	0.0105	0.0089
	Continental clastic rocks	37.92%	0.9681	0.1059	0.0899
	Carbonate rocks	2.92%	0.0745	0.0081	0.0069
	Clastic and carbonate rocks	39.17%	1.0000	0.1094	0.0928
	Limestone	12.92%	0.3298	0.0361	0.0306
	Metamorpic rocks	1.25%	0.0319	0.0035	0.0030
	Ophiolitic rocks	2.08%	0.0532	0.0058	0.0049
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	0.83%	0.0177	0.0021	0.0020
	Agricultural areas	47.08%	1.0000	0.1190	0.1117
	Forest	43.33%	0.9204	0.1095	0.1028
	Semi natural areas	8.75%	0.1858	0.0221	0.0208
	Wetlands and water bodies	0.00%	0.0000	0.0000	0.0000

Table A.17 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-18 (Seyhan, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Earthquake	Zone 2	0.42%	0.0078	0.0012	0.0011
	Zone 3	45.83%	0.8527	0.1339	0.1178
	Zone 4	53.75%	1.0000	0.1570	0.1381
	Others	0.00%	0.0000	0.0000	0.0000
Aspect	N	2.50%	0.1463	-	0.0064
	NE	10.83%	0.6341	-	0.0278
	E	10.83%	0.6341	-	0.0278
	SE	12.08%	0.7073	-	0.0310
	S	16.25%	0.9512	-	0.0416
	SW	15.42%	0.9024	-	0.0395
	W	15.00%	0.8780	-	0.0384
	NW	17.08%	1.0000	-	0.0438
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	2.08%	0.0510	0.0061	0.0051
	11 - 12	25.00%	0.6122	0.0728	0.0610
	12 - 13	40.83%	1.0000	0.1190	0.0997
	13 - 14	25.83%	0.6327	0.0753	0.0631
	14 - 15	6.25%	0.1531	0.0182	0.0153
	> 15	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	5.42%	0.1102	0.0144	0.0132
	Midslope drainages, shallow valleys	10.42%	0.2119	0.0277	0.0254
	Upland drainages, headwaters	1.25%	0.0254	0.0033	0.0030
	U-shaped valleys	30.42%	0.6186	0.0808	0.0742
	Plains	1.25%	0.0254	0.0033	0.0030
	Open slopes	49.17%	1.0000	0.1307	0.1199
	Upper slopes, mesas	2.08%	0.0424	0.0055	0.0051
	Others	0.00%	0.0000	0.0000	0.0000
Curvature	V / V	4.17%	0.0649	0.0126	0.0109
	V / S	14.17%	0.2208	0.0429	0.0372
	V / X	0.83%	0.0130	0.0025	0.0022
	S / V	15.83%	0.2468	0.0479	0.0416
	S / S	64.17%	1.0000	0.1942	0.1684
	S / X	0.83%	0.0130	0.0025	0.0022
	Others	0.00%	0.0000	0.0000	0.0000

Table A.18 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-19 (Asi).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	1.92%	0.0476	0.0037	0.0033
	5° - 10°	29.81%	0.7381	0.0573	0.0513
	10° - 15°	40.38%	1.0000	0.0777	0.0695
	15° - 20°	19.23%	0.4762	0.0370	0.0331
	20° - 25°	6.73%	0.1667	0.0129	0.0116
	25° - 30°	0.96%	0.0238	0.0018	0.0017
	30° - 35°	0.96%	0.0238	0.0018	0.0017
	> 35°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.00%	0.0000	0.0000	0.0000
	50 - 100	3.85%	0.1111	0.0080	0.0073
	100 - 150	34.62%	1.0000	0.0722	0.0656
	150 - 200	21.15%	0.6111	0.0441	0.0401
	200 - 250	15.38%	0.4444	0.0321	0.0291
	250 - 300	9.62%	0.2778	0.0201	0.0182
	300 - 350	6.73%	0.1944	0.0140	0.0128
	350 - 400	2.88%	0.0833	0.0060	0.0055
	400 - 450	0.96%	0.0278	0.0020	0.0018
	450 - 500	3.85%	0.1111	0.0080	0.0073
	500 - 550	0.96%	0.0278	0.0020	0.0018
	> 550	0.00%	0.0000	0.0000	0.0000
Rainfall	< 600	0.00%	0.0000	-	0.0000
	600 - 700	1.92%	0.0435	-	0.0033
	700 - 800	44.23%	1.0000	-	0.0756
	800 - 900	42.31%	0.9565	-	0.0723
	900 - 1000	11.54%	0.2609	-	0.0197
	> 1000	0.00%	0.0000	-	0.0000
Lithology	Young deposits	0.96%	0.0196	0.0018	0.0016
	Basalt	6.73%	0.1373	0.0124	0.0113
	Gabbro	0.96%	0.0196	0.0018	0.0016
	Continental clastic rocks	5.77%	0.1176	0.0107	0.0096
	Clastic and carbonate rocks	49.04%	1.0000	0.0906	0.0820
	Limestone	17.31%	0.3529	0.0320	0.0289
	Ophiolitic rocks	19.23%	0.3922	0.0355	0.0322
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	0.00%	0.0000	0.0000	0.0000
	Agricultural areas	65.38%	1.0000	0.1513	0.1361
	Forest	30.77%	0.4706	0.0712	0.0640
	Semi natural areas	2.88%	0.0441	0.0067	0.0060
	Wetlands and water bodies	0.96%	0.0147	0.0022	0.0020
Earthquake	Zone 1	98.08%	1.0000	0.1998	0.1774
	Zone 3	1.92%	0.0196	0.0039	0.0035
	Others	0.00%	0.0000	0.0000	0.0000

Table A.18 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-19 (Asi, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Aspect	N	3.85%	0.2222	-	0.0072
	NE	11.54%	0.6667	-	0.0215
	E	15.38%	0.8889	-	0.0286
	SE	16.35%	0.9444	-	0.0304
	S	12.50%	0.7222	-	0.0232
	SW	6.73%	0.3889	-	0.0125
	W	17.31%	1.0000	-	0.0322
	NW	16.35%	0.9444	-	0.0304
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	2.88%	0.0714	0.0058	0.0052
	11 - 12	31.73%	0.7857	0.0642	0.0568
	12 - 13	40.38%	1.0000	0.0817	0.0723
	13 - 14	21.15%	0.5238	0.0428	0.0379
	14 - 15	3.85%	0.0952	0.0078	0.0069
	> 15	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	1.92%	0.0294	0.0048	0.0043
	Midslope drainages, shallow valleys	11.54%	0.1765	0.0288	0.0255
	U-shaped valleys	12.50%	0.1912	0.0312	0.0277
	Plains	2.88%	0.0441	0.0072	0.0064
	Open slopes	65.38%	1.0000	0.1634	0.1447
	Upper slopes, mesas	5.77%	0.0882	0.0144	0.0128
	Others	0.00%	0.0000	0.0000	0.0000
Curvature	V / V	1.92%	0.0278	0.0045	0.0040
	V / S	9.62%	0.1389	0.0227	0.0201
	V / X	0.96%	0.0139	0.0023	0.0020
	S / V	13.46%	0.1944	0.0318	0.0281
	S / S	69.23%	1.0000	0.1634	0.1447
	S / X	1.92%	0.0278	0.0045	0.0040
	X / S	2.88%	0.0417	0.0068	0.0060
	Others	0.00%	0.0000	0.0000	0.0000

Table A.19 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-20 (Ceyhan).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	1.04%	0.0249	0.0022	0.0020
	5° - 10°	25.26%	0.6022	0.0527	0.0483
	10° - 15°	41.95%	1.0000	0.0876	0.0802
	15° - 20°	23.29%	0.5552	0.0486	0.0445
	20° - 25°	7.07%	0.1685	0.0148	0.0135
	25° - 30°	1.04%	0.0249	0.0022	0.0020
	30° - 35°	0.35%	0.0083	0.0007	0.0007
	> 35°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.35%	0.0188	0.0007	0.0007
	50 - 100	4.87%	0.2625	0.0103	0.0097
	100 - 150	18.54%	1.0000	0.0393	0.0368
	150 - 200	15.41%	0.8313	0.0326	0.0306
	200 - 250	15.76%	0.8500	0.0334	0.0313
	250 - 300	16.69%	0.9000	0.0353	0.0331
	300 - 350	13.44%	0.7250	0.0285	0.0267
	350 - 400	7.18%	0.3875	0.0152	0.0143
	400 - 450	4.87%	0.2625	0.0103	0.0097
	450 - 500	2.09%	0.1125	0.0044	0.0041
	500 - 550	0.46%	0.0250	0.0010	0.0009
	550 - 600	0.23%	0.0125	0.0005	0.0005
	600 - 650	0.12%	0.0063	0.0002	0.0002
	> 650	0.00%	0.0000	0.0000	0.0000
Rainfall	< 300	0.00%	0.0000	-	0.0000
	300 - 400	1.85%	0.1019	-	0.0043
	400 - 500	1.27%	0.0701	-	0.0030
	500 - 600	3.82%	0.2102	-	0.0089
	600 - 700	14.83%	0.8153	-	0.0347
	700 - 800	18.19%	1.0000	-	0.0425
	800 - 900	12.17%	0.6688	-	0.0284
	900 - 1000	11.82%	0.6497	-	0.0276
	1000 - 1100	15.53%	0.8535	-	0.0363
	1100 - 1200	12.40%	0.6815	-	0.0290
	1200 - 1300	4.98%	0.2739	-	0.0117
	1300 - 1400	1.85%	0.1019	-	0.0043
	1400 - 1500	0.93%	0.0510	-	0.0022
	1500 - 1600	0.35%	0.0191	-	0.0008
	> 1600	0.00%	0.0000	-	0.0000
Lithology	Young deposits	3.40%	0.0667	0.0081	0.0076
	Undifferentiated volcanic rocks	0.12%	0.0023	0.0003	0.0003
	Basalt	2.58%	0.0506	0.0061	0.0057
	Gabbro	0.94%	0.0184	0.0022	0.0021
	Continental clastic rocks	24.06%	0.4713	0.0572	0.0534
	Carbonate rocks	0.94%	0.0184	0.0022	0.0021
	Clastic and carbonate rocks	51.06%	1.0000	0.1213	0.1133
	Limestone	7.86%	0.1540	0.0187	0.0175
	Marble	2.11%	0.0414	0.0050	0.0047
	Metamorpic rocks	0.82%	0.0161	0.0020	0.0018

Table A.19 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-20 (Ceyhan, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Lithology	Ophiolitic rocks	4.93%	0.0966	0.0117	0.0109
	Travertine	0.35%	0.0069	0.0008	0.0008
	Volcanic and sedimentary rocks	0.82%	0.0161	0.0020	0.0018
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	0.00%	0.0000	0.0000	0.0000
	Agricultural areas	76.36%	1.0000	0.1752	0.1604
	Forest	21.09%	0.2762	0.0484	0.0443
	Semi natural areas	2.32%	0.0303	0.0053	0.0049
	Wetlands and water bodies	0.23%	0.0030	0.0005	0.0005
Earthquake	Zone 1	24.57%	0.3841	0.0569	0.0541
	Zone 2	63.96%	1.0000	0.1481	0.1407
	Zone 3	11.36%	0.1775	0.0263	0.0250
	Zone 4	0.12%	0.0018	0.0003	0.0003
	Zone 5	0.00%	0.0000	0.0000	0.0000
Aspect	N	2.32%	0.1299	-	0.0048
	NE	9.73%	0.5455	-	0.0201
	E	13.79%	0.7727	-	0.0285
	SE	17.84%	1.0000	-	0.0368
	S	13.90%	0.7792	-	0.0287
	SW	14.37%	0.8052	-	0.0297
	W	16.45%	0.9221	-	0.0340
	NW	11.59%	0.6494	-	0.0239
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	1.85%	0.0410	0.0042	0.0037
	11 - 12	25.49%	0.5641	0.0575	0.0511
	12 - 13	45.19%	1.0000	0.1018	0.0905
	13 - 14	21.55%	0.4769	0.0486	0.0432
	14 - 15	4.87%	0.1077	0.0110	0.0097
	15 - 16	1.04%	0.0231	0.0024	0.0021
	> 16	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	4.17%	0.0651	0.0097	0.0097
	Midslope drainages, shallow valleys	5.91%	0.0922	0.0138	0.0138
	Upland drainages, headwaters	0.46%	0.0072	0.0011	0.0011
	U-shaped valleys	20.97%	0.3273	0.0489	0.0489
	Plains	0.81%	0.0127	0.0019	0.0019
	Open slopes	64.08%	1.0000	0.1493	0.1493
	Upper slopes, mesas	2.55%	0.0398	0.0059	0.0059
	Local ridges/hills in valleys	0.12%	0.0018	0.0003	0.0003
	Midslope ridges, small hills in plains	0.70%	0.0108	0.0016	0.0016
	Mountain tops, high ridges	0.23%	0.0036	0.0005	0.0005

Table A.19 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-20 (Ceyhan, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Curvature	V / V	1.85%	0.0283	0.0050	0.0042
	V / S	14.60%	0.2226	0.0395	0.0332
	V / X	0.70%	0.0106	0.0019	0.0016
	S / V	13.56%	0.2067	0.0367	0.0309
	S / S	65.59%	1.0000	0.1774	0.1493
	S / X	1.39%	0.0212	0.0038	0.0032
	X / V	0.23%	0.0035	0.0006	0.0005
	X / S	1.97%	0.0300	0.0053	0.0045
	X / X	0.12%	0.0018	0.0003	0.0003

Table A.20 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-21 (Fırat).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	0.90%	0.0206	0.0020	0.0019
	5° - 10°	32.19%	0.7321	0.0709	0.0671
	10° - 15°	43.97%	1.0000	0.0969	0.0917
	15° - 20°	16.90%	0.3843	0.0372	0.0352
	20° - 25°	4.73%	0.1076	0.0104	0.0099
	25° - 30°	1.08%	0.0245	0.0024	0.0022
	30° - 35°	0.21%	0.0049	0.0005	0.0004
	> 35°	0.01%	0.0003	0.0000	0.0000
Internal Relief	0 - 50	0.17%	0.0060	0.0004	0.0003
	50 - 100	3.79%	0.1340	0.0083	0.0077
	100 - 150	17.56%	0.6209	0.0384	0.0355
	150 - 200	28.28%	1.0000	0.0618	0.0572
	200 - 250	22.44%	0.7935	0.0491	0.0454
	250 - 300	14.20%	0.5020	0.0310	0.0287
	300 - 350	7.17%	0.2534	0.0157	0.0145
	350 - 400	3.57%	0.1262	0.0078	0.0072
	400 - 450	1.54%	0.0544	0.0034	0.0031
	450 - 500	0.74%	0.0262	0.0016	0.0015
	500 - 550	0.32%	0.0113	0.0007	0.0006
	550 - 600	0.16%	0.0055	0.0003	0.0003
	600 - 650	0.04%	0.0015	0.0001	0.0001
	650 - 700	0.03%	0.0010	0.0001	0.0001
	> 700	0.00%	0.0000	0.0000	0.0000
Rainfall	< 300	0.00%	0.0000	-	0.0000
	300 - 400	2.16%	0.0801	-	0.0044
	400 - 500	24.08%	0.8937	-	0.0489
	500 - 600	26.95%	1.0000	-	0.0547
	600 - 700	21.11%	0.7835	-	0.0429
	700 - 800	10.56%	0.3918	-	0.0214
	800 - 900	9.67%	0.3587	-	0.0196
	900 - 1000	4.96%	0.1840	-	0.0101
	1000 - 1100	0.24%	0.0090	-	0.0005
	1100 - 1200	0.21%	0.0077	-	0.0004
	1200 - 1300	0.06%	0.0024	-	0.0001
	> 1300	0.00%	0.0000	-	0.0000
Lithology	Young deposits	1.95%	0.0646	0.0044	0.0040
	Andesite	3.76%	0.1245	0.0084	0.0077
	Undifferentiated volcanic rocks	8.62%	0.2853	0.0193	0.0176
	Basalt	9.45%	0.3127	0.0212	0.0193
	Dacite	0.19%	0.0062	0.0004	0.0004
	Gabbro	0.93%	0.0306	0.0021	0.0019
	Gneiss	1.71%	0.0565	0.0038	0.0035
	Continental clastic rocks	30.21%	1.0000	0.0678	0.0617
	Carbonate rocks	0.53%	0.0176	0.0012	0.0011
	Clastic and carbonate rocks	12.57%	0.4163	0.0282	0.0257
	Limestone	6.95%	0.2302	0.0156	0.0142

Table A.20 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-21 (Fırat, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Lithology	Limestone, marl, shale	1.38%	0.0456	0.0031	0.0028
	Marble	1.03%	0.0342	0.0023	0.0021
	Metamorpic rocks	2.02%	0.0670	0.0045	0.0041
	Ophiolitic rocks	7.94%	0.2628	0.0178	0.0162
	Pyroclastic rocks	3.34%	0.1107	0.0075	0.0068
	Travertine	0.02%	0.0007	0.0000	0.0000
	Granitoid	0.15%	0.0050	0.0003	0.0003
	Volcanic and sedimentary rocks	2.31%	0.0765	0.0052	0.0047
	Gypsum	4.93%	0.1632	0.0111	0.0101
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	0.46%	0.0112	0.0012	0.0011
	Agricultural areas	33.81%	0.8286	0.0872	0.0810
	Forest	40.80%	1.0000	0.1052	0.0977
	Semi natural areas	24.65%	0.6041	0.0635	0.0590
	Wetlands and water bodies	0.28%	0.0070	0.0007	0.0007
Earthquake	Zone 1	66.78%	1.0000	0.1642	0.1497
	Zone 2	30.75%	0.4605	0.0756	0.0689
	Zone 3	1.72%	0.0257	0.0042	0.0038
	Zone 4	0.76%	0.0113	0.0019	0.0017
	Zone 5	0.00%	0.0000	0.0000	0.0000
Aspect	N	3.86%	0.2492	-	0.0080
	NE	10.71%	0.6915	-	0.0222
	E	13.67%	0.8823	-	0.0284
	SE	13.51%	0.8717	-	0.0280
	S	14.00%	0.9034	-	0.0290
	SW	13.83%	0.8924	-	0.0287
	W	15.49%	1.0000	-	0.0321
	NW	14.93%	0.9637	-	0.0310
TWI	< 9	0.00%	0.0000	0.0000	0.0000
	9 - 10	0.02%	0.0004	0.00005	0.00005
	10 - 11	1.61%	0.0336	0.0039	0.0035
	11 - 12	20.09%	0.4198	0.0485	0.0442
	12 - 13	47.85%	1.0000	0.1156	0.1053
	13 - 14	25.48%	0.5325	0.0616	0.0561
	14 - 15	4.06%	0.0849	0.0098	0.0089
	15 - 16	0.59%	0.0124	0.0014	0.0013
	16 - 17	0.14%	0.0030	0.0003	0.0003
	17 - 18	0.09%	0.0019	0.0002	0.0002
	18 - 19	0.06%	0.0012	0.0001	0.0001
	19 - 20	0.01%	0.0001	0.00002	0.00002
	> 20	0.00%	0.0000	0.0000	0.0000

Table A.20 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-21 (Fırat, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Landforms	Canyons, deeply incised streams	2.69%	0.0369	0.0072	0.0065
	Midslope drainages, shallow valleys	5.31%	0.0730	0.0142	0.0128
	Upland drainages, headwaters	0.47%	0.0065	0.0013	0.0011
	U-shaped valleys	13.79%	0.1895	0.0368	0.0331
	Plains	1.11%	0.0153	0.0030	0.0027
	Open slopes	72.79%	1.0000	0.1942	0.1749
	Upper slopes, mesas	3.15%	0.0433	0.0084	0.0076
	Local ridges/hills in valleys	0.06%	0.0009	0.0002	0.0002
	Midslope ridges, small hills in plains	0.46%	0.0064	0.0012	0.0011
	Mountain tops, high ridges	0.16%	0.0023	0.0004	0.0004
Curvature	V / V	1.97%	0.0271	0.0053	0.0047
	V / S	12.40%	0.1701	0.0330	0.0298
	V / X	0.78%	0.0107	0.0021	0.0019
	S / V	9.57%	0.1312	0.0255	0.0230
	S / S	72.90%	1.0000	0.1942	0.1749
	S / X	1.00%	0.0138	0.0027	0.0024
	X / V	0.12%	0.0017	0.0003	0.0003
	X / S	1.03%	0.0142	0.0028	0.0025
	X / X	0.21%	0.0029	0.0006	0.0005

Table A.21 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-22 (Doğu Karadeniz).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	0.90%	0.0261	0.0026	0.0023
	5° - 10°	17.43%	0.5051	0.0502	0.0441
	10° - 15°	34.51%	1.0000	0.0993	0.0873
	15° - 20°	28.46%	0.8245	0.0819	0.0719
	20° - 25°	12.86%	0.3725	0.0370	0.0325
	25° - 30°	4.87%	0.1410	0.0140	0.0123
	30° - 35°	0.81%	0.0233	0.0023	0.0020
	35° - 40°	0.16%	0.0047	0.0005	0.0004
	> 40°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.03%	0.0015	0.0001	0.0001
	50 - 100	0.55%	0.0249	0.0015	0.0014
	100 - 150	7.19%	0.3265	0.0199	0.0179
	150 - 200	17.08%	0.7760	0.0473	0.0426
	200 - 250	22.01%	1.0000	0.0610	0.0549
	250 - 300	19.88%	0.9034	0.0551	0.0496
	300 - 350	13.79%	0.6266	0.0382	0.0344
	350 - 400	10.25%	0.4656	0.0284	0.0256
	400 - 450	4.61%	0.2094	0.0128	0.0115
	450 - 500	2.61%	0.1186	0.0072	0.0065
	500 - 550	1.10%	0.0498	0.0030	0.0027
	550 - 600	0.61%	0.0278	0.0017	0.0015
	600 - 650	0.10%	0.0044	0.0003	0.0002
	650 - 700	0.16%	0.0073	0.0004	0.0004
	700 - 750	0.03%	0.0015	0.0001	0.0001
	> 750	0.00%	0.0000	0.0000	0.0000
Rainfall	< 400	0.00%	0.0000	-	0.0000
	400 - 500	6.61%	0.2615	-	0.0167
	500 - 600	2.67%	0.1059	-	0.0068
	600 - 700	4.87%	0.1926	-	0.0123
	700 - 800	6.28%	0.2487	-	0.0159
	800 - 900	10.28%	0.4069	-	0.0261
	900 - 1000	24.33%	0.9630	-	0.0617
	1000 - 1100	25.27%	1.0000	-	0.0641
	1100 - 1200	7.48%	0.2959	-	0.0190
	1200 - 1300	3.22%	0.1276	-	0.0082
	1300 - 1400	1.10%	0.0434	-	0.0028
	1400 - 1500	1.16%	0.0459	-	0.0029
	1500 - 1600	0.61%	0.0242	-	0.0016
	1600 - 1700	0.93%	0.0370	-	0.0024
	1700 - 1800	0.68%	0.0268	-	0.0017
	1800 - 1900	0.97%	0.0383	-	0.0025
	1900 - 2000	1.03%	0.0408	-	0.0026
	2000 - 2100	1.13%	0.0446	-	0.0029
	2100 - 2200	0.84%	0.0332	-	0.0021
	2200 - 2300	0.42%	0.0166	-	0.0011
	2300 - 2400	0.13%	0.0051	-	0.0003
	> 2400	0.00%	0.0000	-	0.0000

Table A.21 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-22 (Doğu Karadeniz, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Lithology	Young deposits	0.61%	0.0157	0.0019	0.0017
	Andesite	0.39%	0.0099	0.0012	0.0011
	Undifferentiated volcanic rocks	27.10%	0.6956	0.0821	0.0744
	Basalt	0.23%	0.0058	0.0007	0.0006
	Dacite	5.87%	0.1505	0.0178	0.0161
	Continental clastic rocks	0.77%	0.0199	0.0023	0.0021
	Clastic and carbonate rocks	18.59%	0.4773	0.0563	0.0511
	Limestone	2.87%	0.0736	0.0087	0.0079
	Metamorpic rocks	0.03%	0.0008	0.0001	0.0001
	Granitoid	4.13%	0.1059	0.0125	0.0113
	Volcanic and sedimentary rocks	38.96%	1.0000	0.1181	0.1070
	Plutonic rocks	0.45%	0.0116	0.0014	0.0012
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	0.52%	0.0074	0.0014	0.0013
	Agricultural areas	69.55%	1.0000	0.1908	0.1700
	Forest	27.65%	0.3976	0.0759	0.0676
	Semi natural areas	2.16%	0.0310	0.0059	0.0053
	Wetlands and water bodies	0.13%	0.0019	0.0004	0.0003
Earthquake	Zone 1	17.63%	0.4932	0.0490	0.0461
	Zone 2	20.46%	0.5726	0.0569	0.0535
	Zone 3	26.17%	0.7322	0.0727	0.0685
	Zone 4	35.74%	1.0000	0.0993	0.0935
	Zone 5	0.00%	0.0000	0.0000	0.0000
Aspect	N	2.45%	0.1195	-	0.0063
	NE	12.89%	0.6289	-	0.0331
	E	20.50%	1.0000	-	0.0526
	SE	15.69%	0.7657	-	0.0403
	S	10.99%	0.5362	-	0.0282
	SW	11.21%	0.5472	-	0.0288
	W	16.15%	0.7877	-	0.0414
	NW	10.12%	0.4937	-	0.0260
TWI	< 9	0.00%	0.0000	0.0000	0.0000
	9 - 10	0.10%	0.0025	0.0003	0.0002
	10 - 11	6.45%	0.1641	0.0194	0.0165
	11 - 12	30.07%	0.7654	0.0904	0.0771
	12 - 13	39.28%	1.0000	0.1181	0.1007
	13 - 14	19.82%	0.5045	0.0596	0.0508
	14 - 15	3.09%	0.0788	0.0093	0.0079
	15 - 16	0.84%	0.0213	0.0025	0.0021
	16 - 17	0.19%	0.0049	0.0006	0.0005
	17 - 18	0.13%	0.0033	0.0004	0.0003
	18 - 19	0.03%	0.0008	0.0001	0.0001
	> 19	0.00%	0.0000	0.0000	0.0000

Table A.21 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-22 (Doğu Karadeniz, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Landforms	Canyons, deeply incised streams	10.05%	0.2068	0.0296	0.0274
	Midslope drainages, shallow valleys	8.44%	0.1736	0.0249	0.0230
	Upland drainages, headwaters	1.13%	0.0232	0.0033	0.0031
	U-shaped valleys	21.46%	0.4414	0.0632	0.0584
	Plains	0.71%	0.0146	0.0021	0.0019
	Open slopes	48.63%	1.0000	0.1432	0.1324
	Upper slopes, mesas	6.38%	0.1312	0.0188	0.0174
	Local ridges/hills in valleys	0.45%	0.0093	0.0013	0.0012
	Midslope ridges, small hills in plains	1.90%	0.0391	0.0056	0.0052
	Mountain tops, high ridges	0.84%	0.0172	0.0025	0.0023
Curvature	V / V	5.19%	0.1008	0.0172	0.0139
	V / S	16.31%	0.3166	0.0539	0.0436
	V / X	1.74%	0.0338	0.0058	0.0047
	S / V	17.37%	0.3373	0.0574	0.0464
	S / S	51.50%	1.0000	0.1703	0.1376
	S / X	3.03%	0.0588	0.0100	0.0081
	X / V	0.48%	0.0094	0.0016	0.0013
	X / S	3.61%	0.0701	0.0119	0.0096
	X / X	0.77%	0.0150	0.0026	0.0021

Table A.22 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-23 (Çoruh).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	0.64%	0.0145	0.0017	0.0015
	5° - 10°	24.08%	0.5438	0.0644	0.0548
	10° - 15°	44.27%	1.0000	0.1184	0.1007
	15° - 20°	23.51%	0.5309	0.0629	0.0535
	20° - 25°	6.15%	0.1390	0.0165	0.0140
	25° - 30°	1.03%	0.0233	0.0028	0.0023
	30° - 35°	0.28%	0.0064	0.0008	0.0006
	> 35°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.00%	0.0000	0.0000	0.0000
	50 - 100	0.68%	0.0275	0.0017	0.0014
	100 - 150	6.33%	0.2580	0.0158	0.0133
	150 - 200	17.89%	0.7290	0.0446	0.0376
	200 - 250	24.54%	1.0000	0.0612	0.0516
	250 - 300	20.66%	0.8420	0.0515	0.0435
	300 - 350	14.40%	0.5870	0.0359	0.0303
	350 - 400	8.82%	0.3594	0.0220	0.0186
	400 - 450	3.70%	0.1507	0.0092	0.0078
	450 - 500	2.03%	0.0826	0.0051	0.0043
	500 - 550	0.78%	0.0319	0.0020	0.0016
	550 - 600	0.14%	0.0058	0.0004	0.0003
	600 - 700	0.00%	0.0000	0.0000	0.0000
	700 - 750	0.04%	0.0014	0.0001	0.0001
	> 750	0.00%	0.0000	0.0000	0.0000
Rainfall	< 300	0.00%	0.0000	-	0.0000
	300 - 400	9.17%	0.1882	-	0.0204
	400 - 500	48.76%	1.0000	-	0.1082
	500 - 600	25.53%	0.5237	-	0.0567
	600 - 700	7.75%	0.1590	-	0.0172
	700 - 800	7.01%	0.1437	-	0.0156
	800 - 900	0.28%	0.0058	-	0.0006
	900 - 1000	0.04%	0.0007	-	0.0001
	1000 - 1100	0.25%	0.0051	-	0.0006
	1100 - 1200	0.07%	0.0015	-	0.0002
	1200 - 1300	0.28%	0.0058	-	0.0006
	1300 - 1400	0.25%	0.0051	-	0.0006
	1400 - 1500	0.32%	0.0066	-	0.0007
	1500 -1600	0.28%	0.0058	-	0.0006
	> 1600	0.00%	0.0000	-	0.0000
Lithology	Young deposits	3.09%	0.0929	0.0086	0.0077
	Andesite	0.04%	0.0011	0.0001	0.0001
	Undifferentiated volcanic rocks	5.76%	0.1731	0.0160	0.0144
	Basalt	1.35%	0.0406	0.0037	0.0034
	Dacite	0.53%	0.0160	0.0015	0.0013
	Gabbro	0.21%	0.0064	0.0006	0.0005
	Continental clastic rocks	5.41%	0.1624	0.0150	0.0135
	Clastic and carbonate rocks	33.29%	1.0000	0.0923	0.0831

Table A.22 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-23 (Çoruh, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Lithology	Limestone	9.74%	0.2927	0.0270	0.0243
	Metamorpic rocks	0.50%	0.0150	0.0014	0.0012
	Ophiolitic rocks	1.21%	0.0363	0.0034	0.0030
	Pyroclastic rocks	5.90%	0.1774	0.0164	0.0147
	Granitoid	0.18%	0.0053	0.0005	0.0004
	Volcanic and sedimentary rocks	19.91%	0.5983	0.0552	0.0497
	Gypsum	12.84%	0.3857	0.0356	0.0320
	Plutonic rocks	0.04%	0.0011	0.0001	0.0001
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	0.32%	0.0068	0.0008	0.0007
	Agricultural areas	35.42%	0.7580	0.0907	0.0822
	Forest	46.73%	1.0000	0.1197	0.1084
	Semi natural areas	17.53%	0.3752	0.0449	0.0407
	Wetlands and water bodies	0.00%	0.0000	0.0000	0.0000
Earthquake	Zone 1	1.35%	0.0235	0.0036	0.0028
	Zone 2	57.50%	1.0000	0.1549	0.1207
	Zone 3	39.19%	0.6815	0.1056	0.0823
	Zone 4	1.96%	0.0340	0.0053	0.0041
	Zone 5	0.00%	0.0000	0.0000	0.0000
Aspect	N	2.20%	0.1044	-	0.0050
	NE	8.21%	0.3889	-	0.0185
	E	15.26%	0.7222	-	0.0343
	SE	13.02%	0.6162	-	0.0293
	S	12.66%	0.5993	-	0.0285
	SW	12.80%	0.6061	-	0.0288
	W	21.12%	1.0000	-	0.0475
	NW	14.72%	0.6970	-	0.0331
TWI	< 9	0.00%	0.0000	0.0000	0.0000
	9 - 10	0.07%	0.0017	0.0002	0.0002
	10 - 11	1.96%	0.0469	0.0051	0.0044
	11 - 12	20.06%	0.4812	0.0524	0.0454
	12 - 13	41.68%	1.0000	0.1088	0.0944
	13 - 14	27.84%	0.6681	0.0727	0.0630
	14 - 15	6.69%	0.1604	0.0175	0.0151
	15 - 16	1.21%	0.0290	0.0032	0.0027
	16 - 17	0.32%	0.0077	0.0008	0.0007
	17 - 18	0.11%	0.0026	0.0003	0.0002
	18 - 19	0.04%	0.0009	0.0001	0.00008
	19 - 20	0.04%	0.0009	0.0001	0.00008
	> 20	0.00%	0.0000	0.0000	0.0000

Table A.22 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-23 (Çoruh, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Landforms	Canyons, deeply incised streams	5.12%	0.0893	0.0138	0.0116
	Midslope drainages, shallow valleys	6.12%	0.1067	0.0165	0.0138
	Upland drainages, headwaters	1.10%	0.0192	0.0030	0.0025
	U-shaped valleys	24.18%	0.4218	0.0650	0.0547
	Plains	1.24%	0.0217	0.0033	0.0028
	Open slopes	57.33%	1.0000	0.1542	0.1298
	Upper slopes, mesas	4.23%	0.0738	0.0114	0.0096
	Local ridges/hills in valleys	0.11%	0.0019	0.0003	0.0002
	Midslope ridges, small hills in plains	0.43%	0.0074	0.0011	0.0010
	Mountain tops, high ridges	0.14%	0.0025	0.0004	0.0003
Curvature	V / V	2.70%	0.0425	0.0081	0.0066
	V / S	17.11%	0.2687	0.0512	0.0418
	V / X	1.00%	0.0156	0.0030	0.0024
	S / V	12.73%	0.2000	0.0381	0.0311
	S / S	63.66%	1.0000	0.1906	0.1556
	S / X	1.07%	0.0168	0.0032	0.0026
	X / V	0.14%	0.0022	0.0004	0.0003
	X / S	1.42%	0.0223	0.0043	0.0035
	X / X	0.18%	0.0028	0.0005	0.0004

Table A.23 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-24 (Aras).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	0.75%	0.0147	0.0015	0.0013
	5° - 10°	30.30%	0.5972	0.0608	0.0541
	10° - 15°	50.73%	1.0000	0.1019	0.0906
	15° - 20°	14.43%	0.2845	0.0290	0.0258
	20° - 25°	3.11%	0.0614	0.0063	0.0056
	25° - 30°	0.52%	0.0102	0.0010	0.0009
	30° - 35°	0.13%	0.0026	0.0003	0.0002
	35° - 40°	0.03%	0.0006	0.0001	0.0001
	> 40°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.03%	0.0011	0.0001	0.0001
	50 - 100	2.82%	0.0958	0.0058	0.0052
	100 - 150	14.73%	0.5000	0.0305	0.0270
	150 - 200	29.45%	1.0000	0.0610	0.0540
	200 - 250	25.62%	0.8700	0.0530	0.0470
	250 - 300	15.54%	0.5275	0.0322	0.0285
	300 - 350	7.01%	0.2379	0.0145	0.0129
	350 - 400	3.11%	0.1057	0.0064	0.0057
	400 - 450	1.20%	0.0407	0.0025	0.0022
	450 - 500	0.29%	0.0099	0.0006	0.0005
	500 - 550	0.16%	0.0055	0.0003	0.0003
	550 - 600	0.03%	0.0011	0.0001	0.0001
	> 600	0.00%	0.0000	0.0000	0.0000
Rainfall	< 300	0.00%	0.0000	-	0.0000
	300 - 400	8.24%	0.1688	-	0.0145
	400 - 500	48.82%	1.0000	-	0.0860
	500 - 600	40.64%	0.8326	-	0.0716
	800 - 900	2.30%	0.0472	-	0.0041
	> 900	0.00%	0.0000	-	0.0000
Lithology	Young deposits	1.17%	0.0557	0.0029	0.0025
	Andesite	4.48%	0.2136	0.0113	0.0096
	Undifferentiated volcanic rocks	5.90%	0.2817	0.0149	0.0127
	Basalt	15.02%	0.7167	0.0379	0.0322
	Dacite	0.06%	0.0031	0.0002	0.0001
	Gabbro	1.30%	0.0619	0.0033	0.0028
	Continental clastic rocks	20.95%	1.0000	0.0529	0.0450
	Carbonate rocks	2.17%	0.1037	0.0055	0.0047
	Clastic and carbonate rocks	8.76%	0.4180	0.0221	0.0188
	Limestone	4.96%	0.2368	0.0125	0.0106
	Marble	0.23%	0.0108	0.0006	0.0005
	Metamorpic rocks	0.81%	0.0387	0.0020	0.0017
	Ophiolitic rocks	12.78%	0.6099	0.0323	0.0274
	Pyroclastic rocks	4.77%	0.2276	0.0120	0.0102
	Granitoid	0.36%	0.0170	0.0009	0.0008
	Volcanic and sedimentary rocks	5.19%	0.2477	0.0131	0.0111
	Gypsum	11.06%	0.5279	0.0279	0.0237
	Plutonic rocks	0.03%	0.0015	0.0001	0.0001
	Others	0.00%	0.0000	0.0000	0.0000

Table A.23 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-24 (Aras, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Land Cover	Artificial surfaces	0.06%	0.0016	0.0002	0.0001
	Agricultural areas	24.04%	0.6015	0.0613	0.0524
	Forest	35.87%	0.8977	0.0915	0.0783
	Semi natural areas	39.96%	1.0000	0.1019	0.0872
	Wetlands and water bodies	0.06%	0.0016	0.0002	0.0001
Earthquake	Zone 1	3.99%	0.0445	0.0092	0.0077
	Zone 2	89.62%	1.0000	0.2073	0.1724
	Zone 3	6.39%	0.0713	0.0148	0.0123
	Others	0.00%	0.0000	0.0000	0.0000
Aspect	N	2.50%	0.1519	-	0.0053
	NE	10.93%	0.6647	-	0.0231
	E	15.73%	0.9566	-	0.0333
	SE	16.15%	0.9822	-	0.0342
	S	12.62%	0.7673	-	0.0267
	SW	11.64%	0.7081	-	0.0246
	W	16.45%	1.0000	-	0.0348
	NW	13.98%	0.8501	-	0.0296
TWI	< 10	0.00%	0.0000	0.0000	0.0000
	10 - 11	1.20%	0.0270	0.0026	0.0027
	11 - 12	18.49%	0.4167	0.0407	0.0411
	12 - 13	44.37%	1.0000	0.0976	0.0987
	13 - 14	28.97%	0.6528	0.0637	0.0644
	14 - 15	6.00%	0.1352	0.0132	0.0134
	15 - 16	0.88%	0.0197	0.0019	0.0019
	16 - 17	0.10%	0.0022	0.0002	0.0002
	> 17	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	3.24%	0.0443	0.0087	0.0076
	Midslope drainages, shallow valleys	6.45%	0.0882	0.0173	0.0152
	Upland drainages, headwaters	0.58%	0.0080	0.0016	0.0014
	U-shaped valleys	12.00%	0.1639	0.0321	0.0283
	Plains	1.14%	0.0155	0.0030	0.0027
	Open slopes	73.21%	1.0000	0.1959	0.1724
	Upper slopes, mesas	2.85%	0.0390	0.0076	0.0067
	Local ridges/hills in valleys	0.03%	0.0004	0.0001	0.0001
	Midslope ridges, small hills in plains	0.36%	0.0049	0.0010	0.0008
	Mountain tops, high ridges	0.13%	0.0018	0.0003	0.0003
Curvature	V / V	2.37%	0.0336	0.0061	0.0053
	V / S	13.85%	0.1966	0.0357	0.0313
	V / X	0.88%	0.0124	0.0023	0.0020
	S / V	9.41%	0.1335	0.0242	0.0212
	S / S	70.45%	1.0000	0.1815	0.1590
	S / X	1.20%	0.0170	0.0031	0.0027
	X / V	0.23%	0.0032	0.0006	0.0005
	X / S	1.49%	0.0212	0.0038	0.0034
	X / X	0.13%	0.0018	0.0003	0.0003

Table A.24 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-25 (Van Gölü).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	1.35%	0.0283	0.0031	0.0025
	5° - 10°	32.27%	0.6757	0.0731	0.0600
	10° - 15°	47.76%	1.0000	0.1081	0.0888
	15° - 20°	14.94%	0.3127	0.0338	0.0278
	20° - 25°	3.01%	0.0631	0.0068	0.0056
	25° - 30°	0.55%	0.0116	0.0013	0.0010
	30° - 35°	0.06%	0.0013	0.0001	0.0001
	35° - 40°	0.06%	0.0013	0.0001	0.0001
	> 40°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.12%	0.0041	0.0003	0.0002
	50 - 100	2.95%	0.0990	0.0060	0.0048
	100 - 150	22.00%	0.7381	0.0450	0.0357
	150 - 200	29.81%	1.0000	0.0609	0.0484
	200 - 250	24.34%	0.8165	0.0497	0.0395
	250 - 300	12.97%	0.4351	0.0265	0.0210
	300 - 350	5.47%	0.1835	0.0112	0.0089
	350 - 400	1.66%	0.0557	0.0034	0.0027
	400 - 450	0.49%	0.0165	0.0010	0.0008
	450 - 500	0.18%	0.0062	0.0004	0.0003
	> 500	0.00%	0.0000	0.0000	0.0000
Rainfall	< 300	0.00%	0.0000	-	0.0000
	300 - 400	0.18%	0.0032	-	0.0004
	400 - 500	57.10%	1.0000	-	0.1089
	500 - 600	25.02%	0.4381	-	0.0477
	600 - 700	17.58%	0.3079	-	0.0335
	700 - 800	0.12%	0.0022	-	0.0002
	> 800	0.00%	0.0000	-	0.0000
Lithology	Young deposits	4.83%	0.2173	0.0110	0.0098
	Andesite	7.80%	0.3510	0.0178	0.0159
	Basalt	12.75%	0.5738	0.0292	0.0260
	Dacite	0.25%	0.0111	0.0006	0.0005
	Continental clastic rocks	18.56%	0.8357	0.0425	0.0379
	Carbonate rocks	0.68%	0.0306	0.0016	0.0014
	Clastic and carbonate rocks	22.22%	1.0000	0.0508	0.0453
	Limestone	5.07%	0.2284	0.0116	0.0103
	Marble	2.78%	0.1253	0.0064	0.0057
	Metamorpic rocks	1.67%	0.0752	0.0038	0.0034
	Flisch	1.92%	0.0864	0.0044	0.0039
	Ophiolitic rocks	7.12%	0.3203	0.0163	0.0145
	Pyroclastic rocks	6.19%	0.2786	0.0142	0.0126
	Travertine	0.62%	0.0279	0.0014	0.0013
	Granitoid	0.37%	0.0167	0.0008	0.0008
	Volcanic and sedimentary rocks	7.18%	0.3231	0.0164	0.0146
	Others	0.00%	0.0000	0.0000	0.0000

Table A.24 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-25 (Van Gölü, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Land Cover	Artificial surfaces	0.12%	0.0027	0.0003	0.0002
	Agricultural areas	20.96%	0.4678	0.0472	0.0415
	Forest	44.81%	1.0000	0.1010	0.0888
	Semi natural areas	33.93%	0.7572	0.0765	0.0672
	Wetlands and water bodies	0.18%	0.0041	0.0004	0.0004
Earthquake	Zone 1	76.46%	1.0000	0.1948	0.1678
	Zone 2	23.54%	0.3079	0.0600	0.0517
	Others	0.00%	0.0000	0.0000	0.0000
Aspect	N	5.59%	0.2542	-	0.0119
	NE	11.25%	0.5112	-	0.0239
	E	10.94%	0.4972	-	0.0232
	SE	8.85%	0.4022	-	0.0188
	S	9.96%	0.4525	-	0.0211
	SW	11.37%	0.5168	-	0.0241
	W	20.04%	0.9106	-	0.0425
	NW	22.00%	1.0000	-	0.0467
TWI	< 9	0.00%	0.0000	0.0000	0.0000
	9 - 10	0.06%	0.0013	0.0001	0.0001
	10 - 11	1.78%	0.0369	0.0037	0.0036
	11 - 12	20.84%	0.4318	0.0436	0.0426
	12 - 13	48.25%	1.0000	0.1010	0.0986
	13 - 14	23.72%	0.4917	0.0497	0.0485
	14 - 15	4.12%	0.0854	0.0086	0.0084
	15 - 16	0.92%	0.0191	0.0019	0.0019
	16 - 17	0.12%	0.0025	0.0003	0.0003
	17 - 18	0.18%	0.0038	0.0004	0.0004
	> 18	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	2.70%	0.0359	0.0075	0.0055
	Midslope drainages, shallow valleys	6.88%	0.0915	0.0191	0.0140
	Upland drainages, headwaters	0.12%	0.0016	0.0003	0.0003
	U-shaped valleys	10.76%	0.1430	0.0298	0.0219
	Plains	1.23%	0.0163	0.0034	0.0025
	Open slopes	75.23%	1.0000	0.2085	0.1534
	Upper slopes, mesas	2.58%	0.0343	0.0072	0.0053
	Local ridges/hills in valleys	0.06%	0.0008	0.0002	0.0001
	Midslope ridges, small hills in plains	0.31%	0.0041	0.0009	0.0006
	Mountain tops, high ridges	0.12%	0.0016	0.0003	0.0003

Table A.24 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-25 (Van Gölü, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Curvature	V / V	2.15%	0.0299	0.0052	0.0046
	V / S	12.66%	0.1761	0.0308	0.0270
	V / X	0.49%	0.0068	0.0012	0.0010
	S / V	10.39%	0.1444	0.0253	0.0222
	S / S	71.91%	1.0000	0.1748	0.1534
	S / X	1.23%	0.0171	0.0030	0.0026
	X / V	0.12%	0.0017	0.0003	0.0003
	X / S	0.86%	0.0120	0.0021	0.0018
	X / X	0.18%	0.0026	0.0004	0.0004

Table A.25 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-26 (Dicle).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Slope	0° - 5°	1.06%	0.0268	0.0024	0.0022
	5° - 10°	19.33%	0.4864	0.0442	0.0400
	10° - 15°	39.74%	1.0000	0.0910	0.0823
	15° - 20°	22.88%	0.5759	0.0524	0.0474
	20° - 25°	10.78%	0.2714	0.0247	0.0223
	25° - 30°	4.25%	0.1070	0.0097	0.0088
	30° - 35°	1.33%	0.0336	0.0031	0.0028
	35° - 40°	0.44%	0.0112	0.0010	0.0009
	40° - 45°	0.14%	0.0034	0.0003	0.0003
	45° - 50°	0.02%	0.0005	0.0000	0.0000
	50° - 55°	0.02%	0.0005	0.0000	0.0000
	> 55°	0.00%	0.0000	0.0000	0.0000
Internal Relief	0 - 50	0.14%	0.0065	0.0003	0.0003
	50 - 100	3.19%	0.1522	0.0076	0.0065
	100 - 150	7.13%	0.3404	0.0170	0.0145
	150 - 200	18.21%	0.8690	0.0433	0.0370
	200 - 250	20.95%	1.0000	0.0499	0.0426
	250 - 300	17.28%	0.8247	0.0411	0.0351
	300 - 350	11.23%	0.5360	0.0267	0.0228
	350 - 400	8.50%	0.4059	0.0202	0.0173
	400 - 450	6.07%	0.2897	0.0144	0.0123
	450 - 500	3.46%	0.1651	0.0082	0.0070
	500 - 550	1.66%	0.0793	0.0040	0.0034
	550 - 600	0.99%	0.0470	0.0023	0.0020
	600 - 650	0.66%	0.0314	0.0016	0.0013
	650 - 700	0.31%	0.0148	0.0007	0.0006
	700 - 750	0.12%	0.0055	0.0003	0.0002
	750 - 800	0.02%	0.0009	0.00005	0.00004
	800 - 850	0.04%	0.0018	0.0001	0.0001
	850 - 900	0.04%	0.0018	0.0001	0.0001
	900 - 1000	0.00%	0.0000	0.0000	0.0000
	1000 - 1050	0.02%	0.0009	0.00005	0.00004
	> 1050	0.00%	0.0000	0.0000	0.0000
Rainfall	< 300	0.00%	0.0000	-	0.0000
	300 - 400	0.10%	0.0024	-	0.0002
	400 - 500	0.68%	0.0165	-	0.0014
	500 - 600	1.64%	0.0401	-	0.0035
	600 - 700	3.05%	0.0746	-	0.0065
	700 - 800	12.43%	0.3034	-	0.0266
	800 - 900	19.19%	0.4686	-	0.0411
	900 - 1000	40.95%	1.0000	-	0.0878
	1000 - 1100	15.50%	0.3785	-	0.0332
	1100 - 1200	3.85%	0.0939	-	0.0082
	1200 - 1300	1.60%	0.0392	-	0.0034
	1300 - 1400	0.31%	0.0076	-	0.0007
	1400 - 1500	0.27%	0.0066	-	0.0006
	1500 - 1600	0.10%	0.0024	-	0.0002

Table A.25 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-26 (Dicle, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
Rainfall	1600 - 1700	0.12%	0.0028	-	0.0002
	1700 - 1800	0.14%	0.0033	-	0.0003
	1800 -1900	0.08%	0.0019	-	0.0002
	> 1900	0.00%	0.0000	-	0.0000
Lithology	Young deposits	1.01%	0.0222	0.0026	0.0022
	Undifferentiated volcanic rocks	0.15%	0.0034	0.0004	0.0003
	Basalt	5.05%	0.1114	0.0131	0.0113
	Gneiss	3.36%	0.0743	0.0087	0.0075
	Continental clastic rocks	12.82%	0.2831	0.0332	0.0286
	Carbonate rocks	0.02%	0.0004	0.0001	0.0000
	Clastic and carbonate rocks	45.27%	1.0000	0.1172	0.1010
	Limestone	12.20%	0.2694	0.0316	0.0272
	Marble	2.05%	0.0453	0.0053	0.0046
	Metamorpic rocks	6.88%	0.1520	0.0178	0.0153
	Ophiolitic rocks	1.49%	0.0329	0.0039	0.0033
	Pyroclastic rocks	0.04%	0.0009	0.0001	0.0001
	Travertine	0.02%	0.0004	0.00005	0.00004
	Granitoid	0.06%	0.0013	0.0002	0.0001
	Volcanic and sedimentary rocks	8.95%	0.1977	0.0232	0.0200
	Gypsum	0.64%	0.0141	0.0017	0.0014
	Others	0.00%	0.0000	0.0000	0.0000
Land Cover	Artificial surfaces	0.41%	0.0075	0.0010	0.0009
	Agricultural areas	15.58%	0.2896	0.0389	0.0328
	Forest	53.79%	1.0000	0.1343	0.1131
	Semi natural areas	28.33%	0.5268	0.0708	0.0596
	Wetlands and water bodies	1.89%	0.0352	0.0047	0.0040
Earthquake	Zone 1	80.60%	1.0000	0.1979	0.1722
	Zone 2	19.40%	0.2408	0.0476	0.0415
	Others	0.00%	0.0000	0.0000	0.0000
Aspect	N	3.87%	0.2448	-	0.0082
	NE	13.16%	0.8335	-	0.0279
	E	15.79%	1.0000	-	0.0335
	SE	13.66%	0.8654	-	0.0290
	S	13.30%	0.8421	-	0.0282
	SW	13.07%	0.8274	-	0.0277
	W	14.92%	0.9449	-	0.0316
	NW	12.23%	0.7748	-	0.0259
TWI	< 9	0.00%	0.0000	0.0000	0.0000
	9 - 10	0.06%	0.0013	0.0002	0.0001
	10 - 11	2.82%	0.0632	0.0074	0.0064
	11 - 12	25.26%	0.5656	0.0663	0.0571
	12 - 13	44.67%	1.0000	0.1172	0.1010
	13 - 14	21.86%	0.4894	0.0574	0.0494
	14 - 15	4.37%	0.0978	0.0115	0.0099
	15 - 16	0.87%	0.0195	0.0023	0.0020

Table A.25 Distribution of historical landslide areas for various data layer classes and rating values for Watershed-26 (Dicle, continued).

Data Layers	Classes	Landslide Area (%)	Normalized Value	Rating Value[8]	Rating Value[10]
TWI	16 - 17	0.06%	0.0013	0.0002	0.0001
	17 - 18	0.02%	0.0004	0.00005	0.00004
	18 - 19	0.02%	0.0004	0.00005	0.00004
	> 19	0.00%	0.0000	0.0000	0.0000
Landforms	Canyons, deeply incised streams	5.76%	0.1012	0.0148	0.0135
	Midslope drainages, shallow valleys	8.41%	0.1478	0.0216	0.0197
	Upland drainages, headwaters	1.47%	0.0258	0.0038	0.0034
	U-shaped valleys	21.45%	0.3770	0.0551	0.0503
	Plains	1.14%	0.0200	0.0029	0.0027
	Open slopes	56.90%	1.0000	0.1463	0.1333
	Upper slopes, mesas	3.87%	0.0679	0.0099	0.0091
	Local ridges/hills in valleys	0.19%	0.0034	0.0005	0.0005
	Midslope ridges, small hills in plains	0.52%	0.0092	0.0013	0.0012
	Mountain tops, high ridges	0.29%	0.0051	0.0007	0.0007
Curvature	V / V	3.25%	0.0548	0.0080	0.0073
	V / S	19.13%	0.3232	0.0473	0.0431
	V / X	1.57%	0.0264	0.0039	0.0035
	S / V	13.70%	0.2315	0.0339	0.0309
	S / S	59.20%	1.0000	0.1463	0.1333
	S / X	1.16%	0.0196	0.0029	0.0026
	X / V	0.33%	0.0056	0.0008	0.0007
	X / S	1.43%	0.0242	0.0035	0.0032
	X / X	0.23%	0.0039	0.0006	0.0005

APPENDIX B

UNCLASSIFIED SUSCEPTIBILITY MAPS OF WATERSHEDS

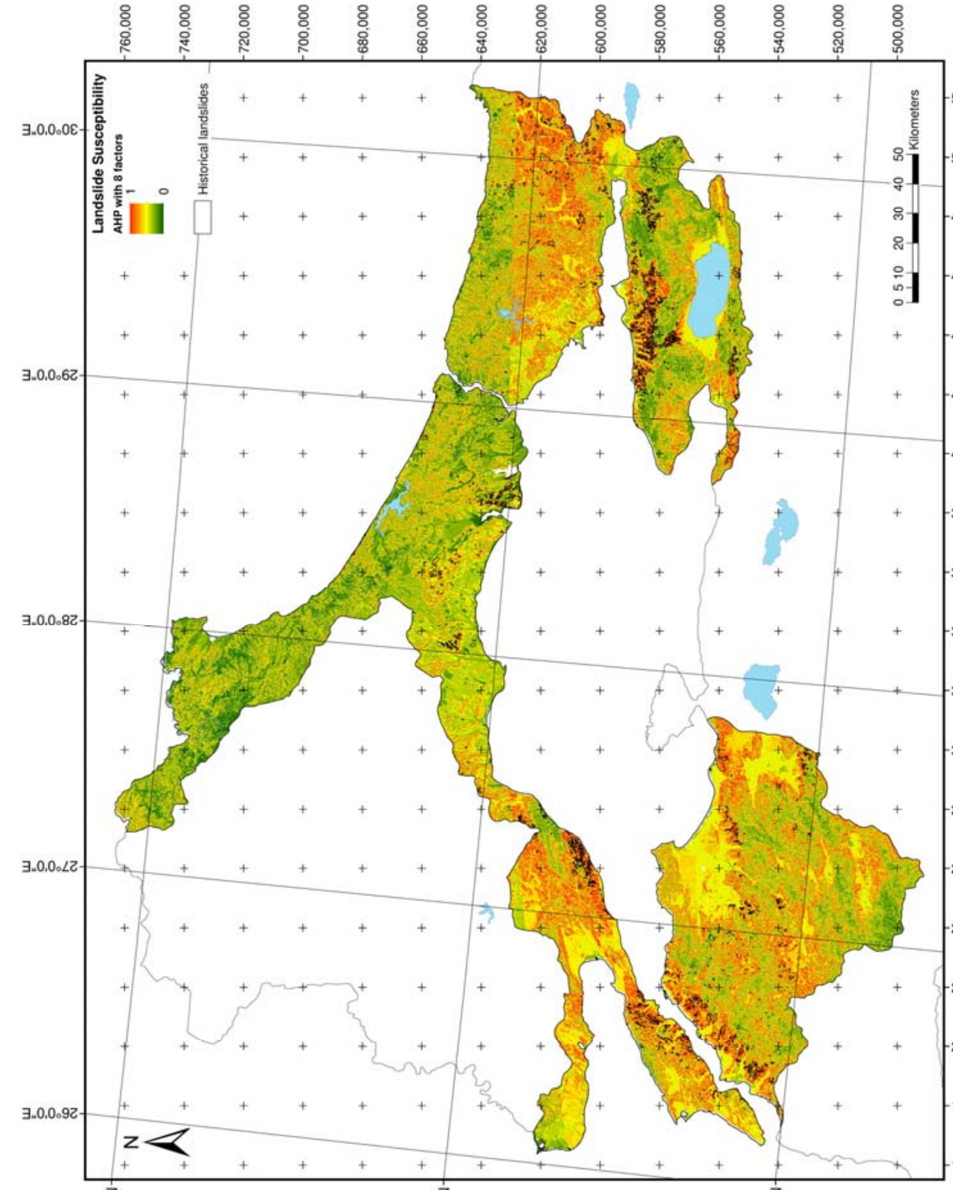


Figure B.1 Unclassified landslide susceptibility map for Watershed-2 (with 8 factors).

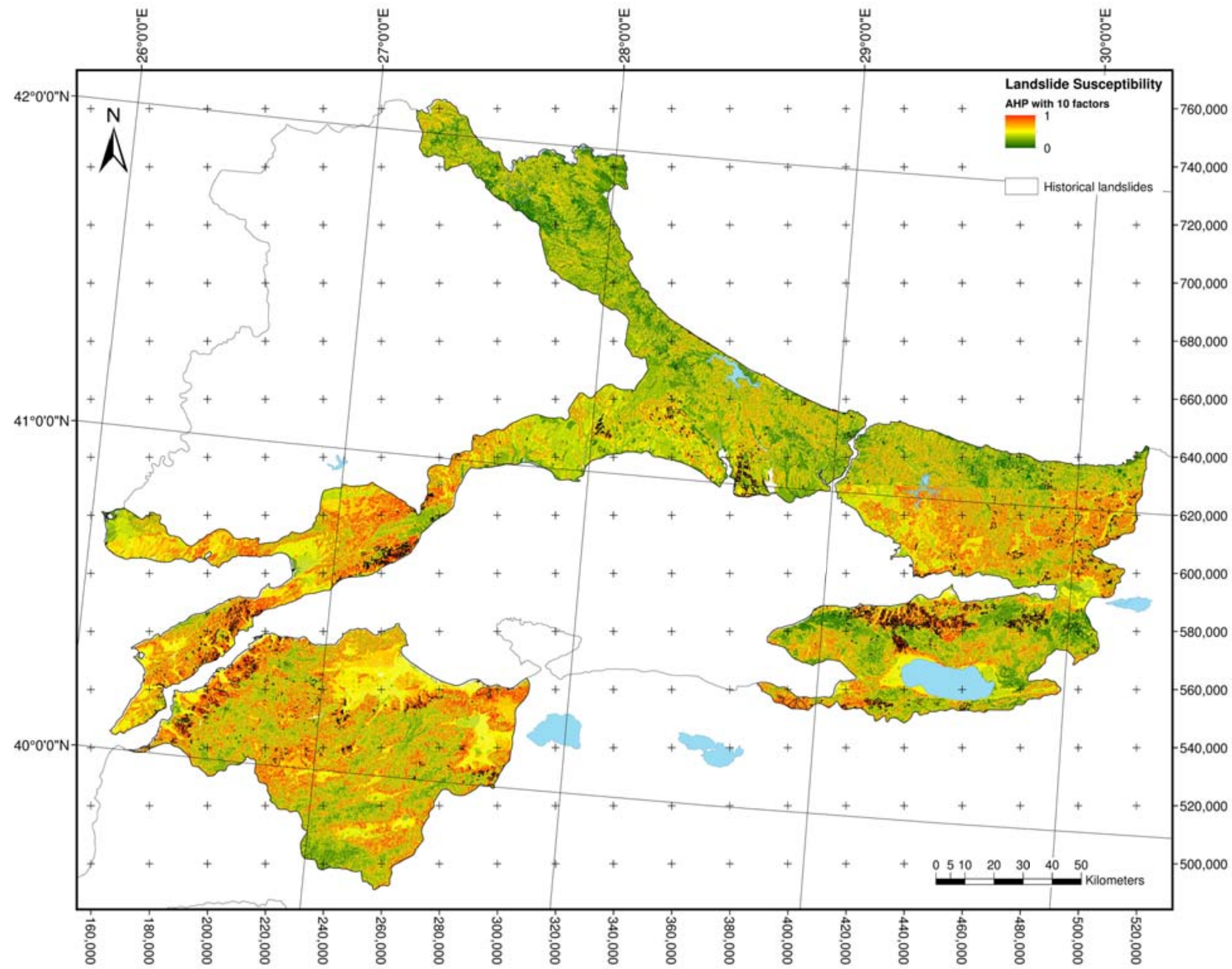


Figure B.2 Unclassified landslide susceptibility map for Watershed-2 (with 10 factors).

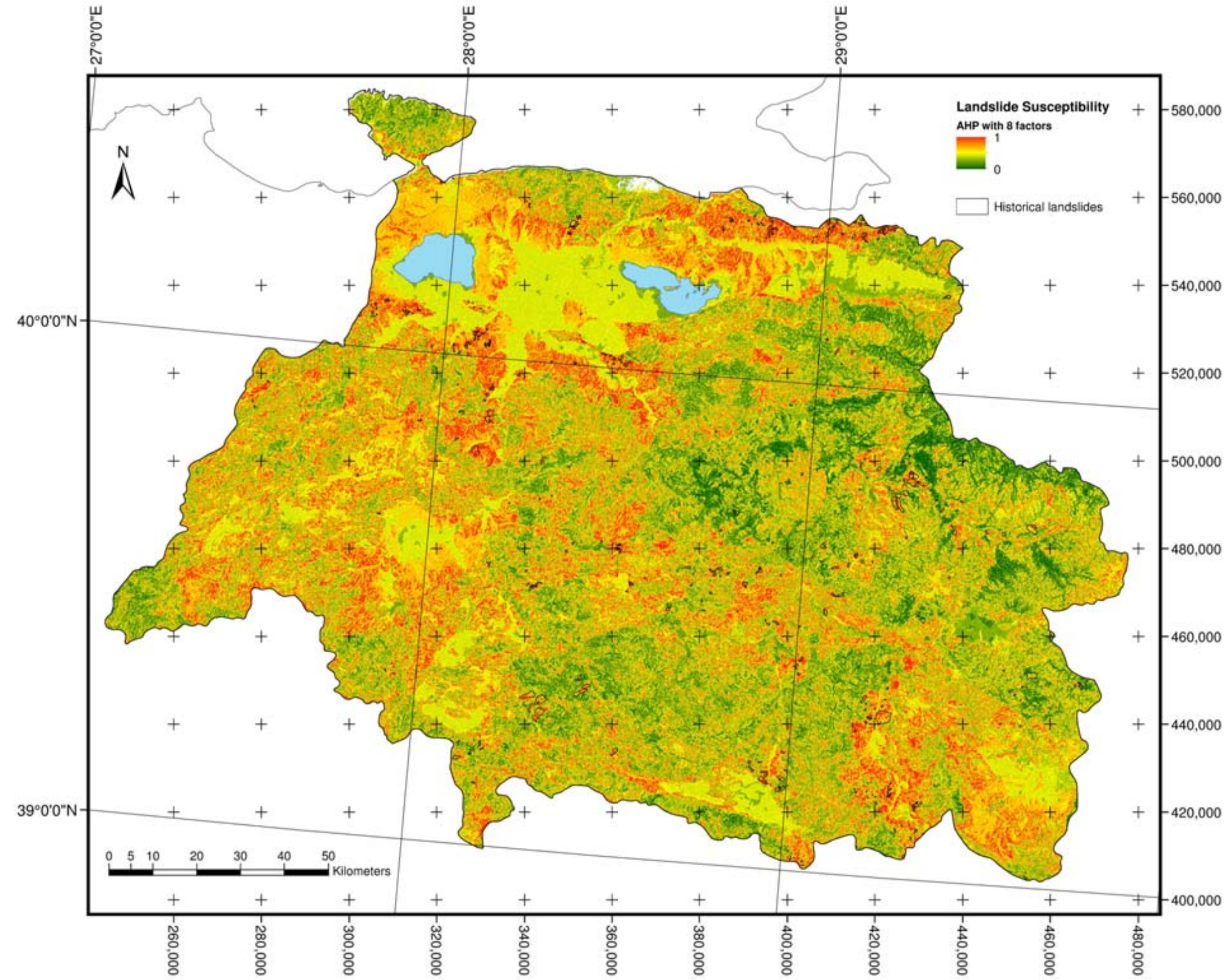


Figure B.3 Unclassified landslide susceptibility map for Watershed-3 (with 8 factors).

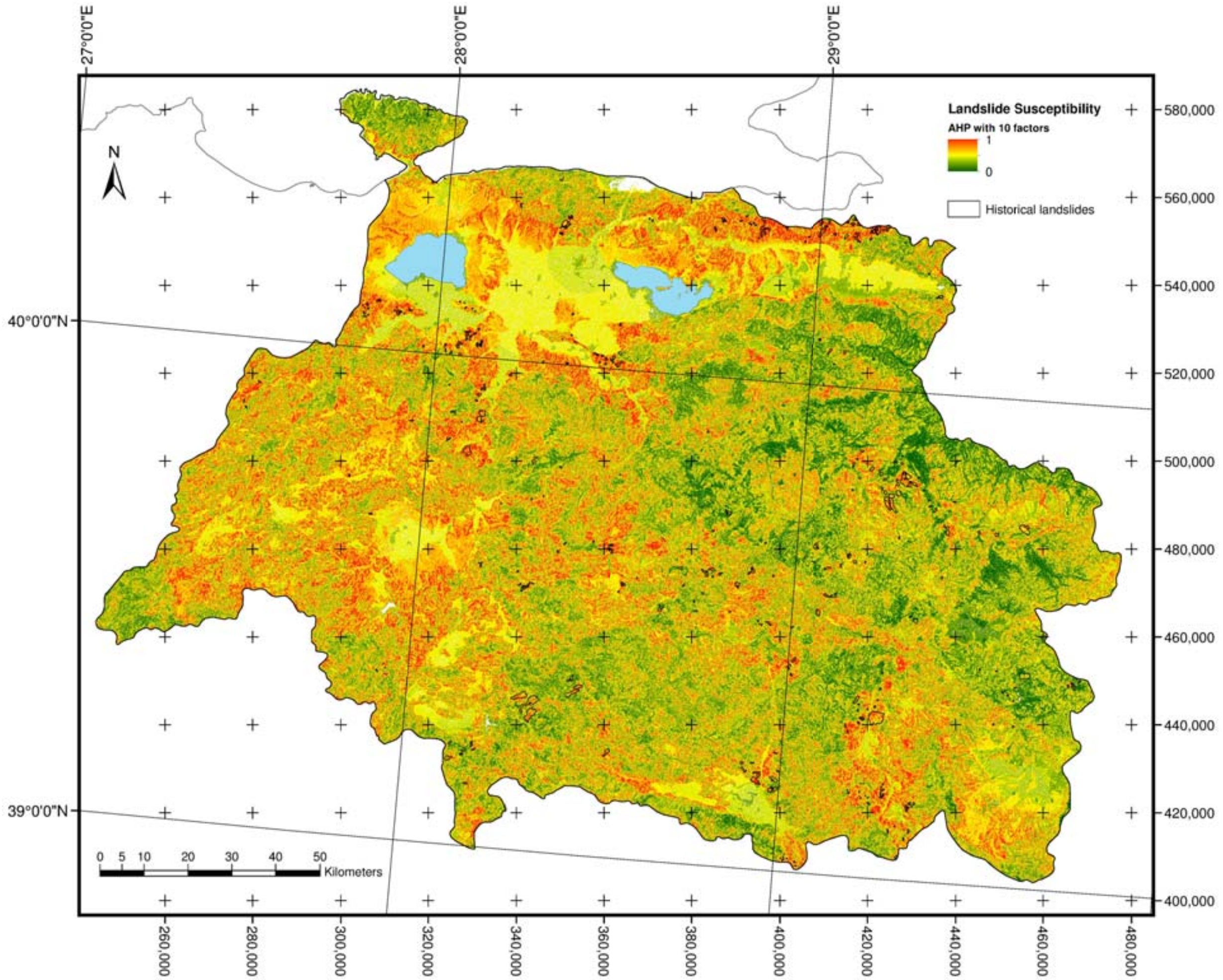


Figure B.4 Unclassified landslide susceptibility map for Watershed-3 (with 10 factors).

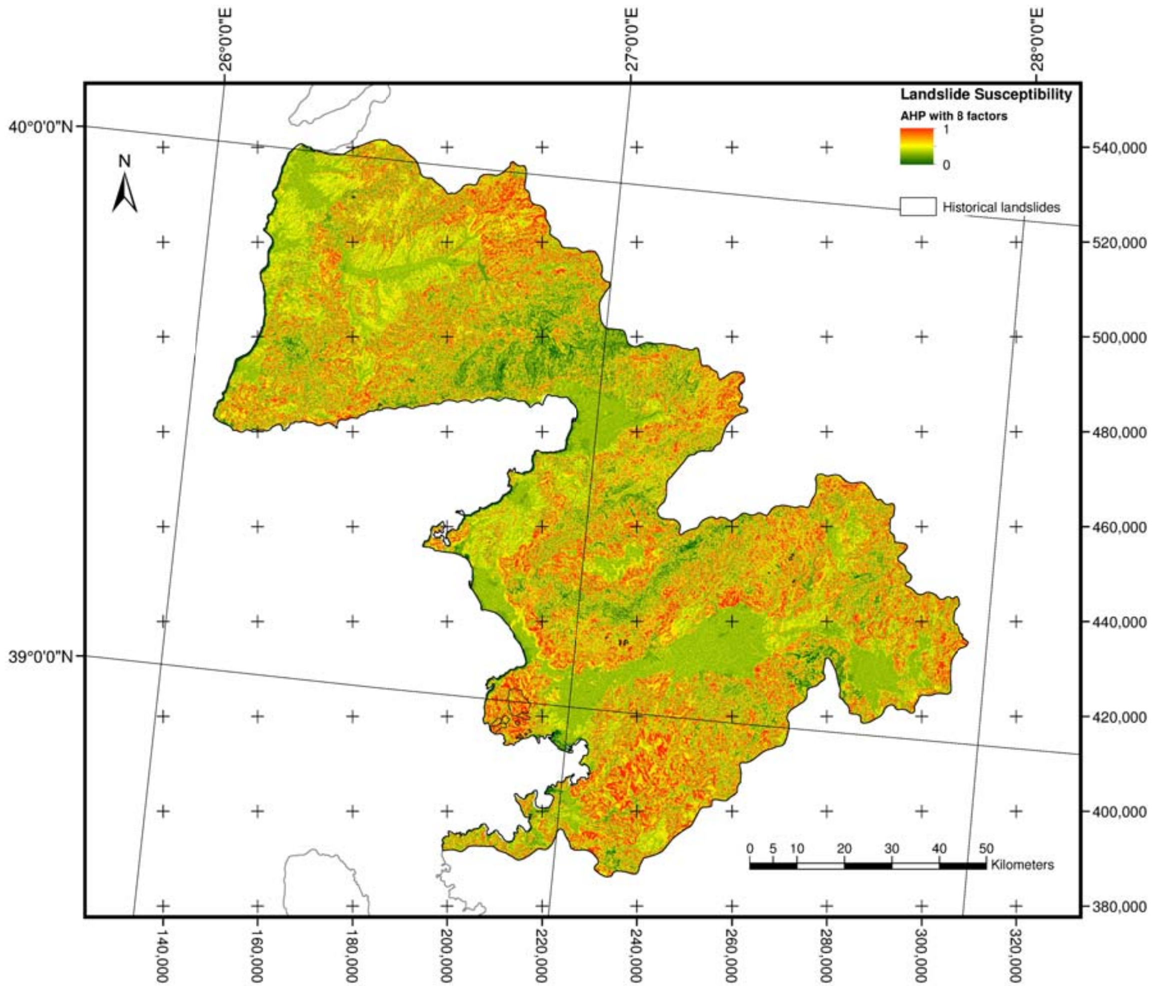


Figure B.5 Unclassified landslide susceptibility map for Watershed-4 (with 8 factors).

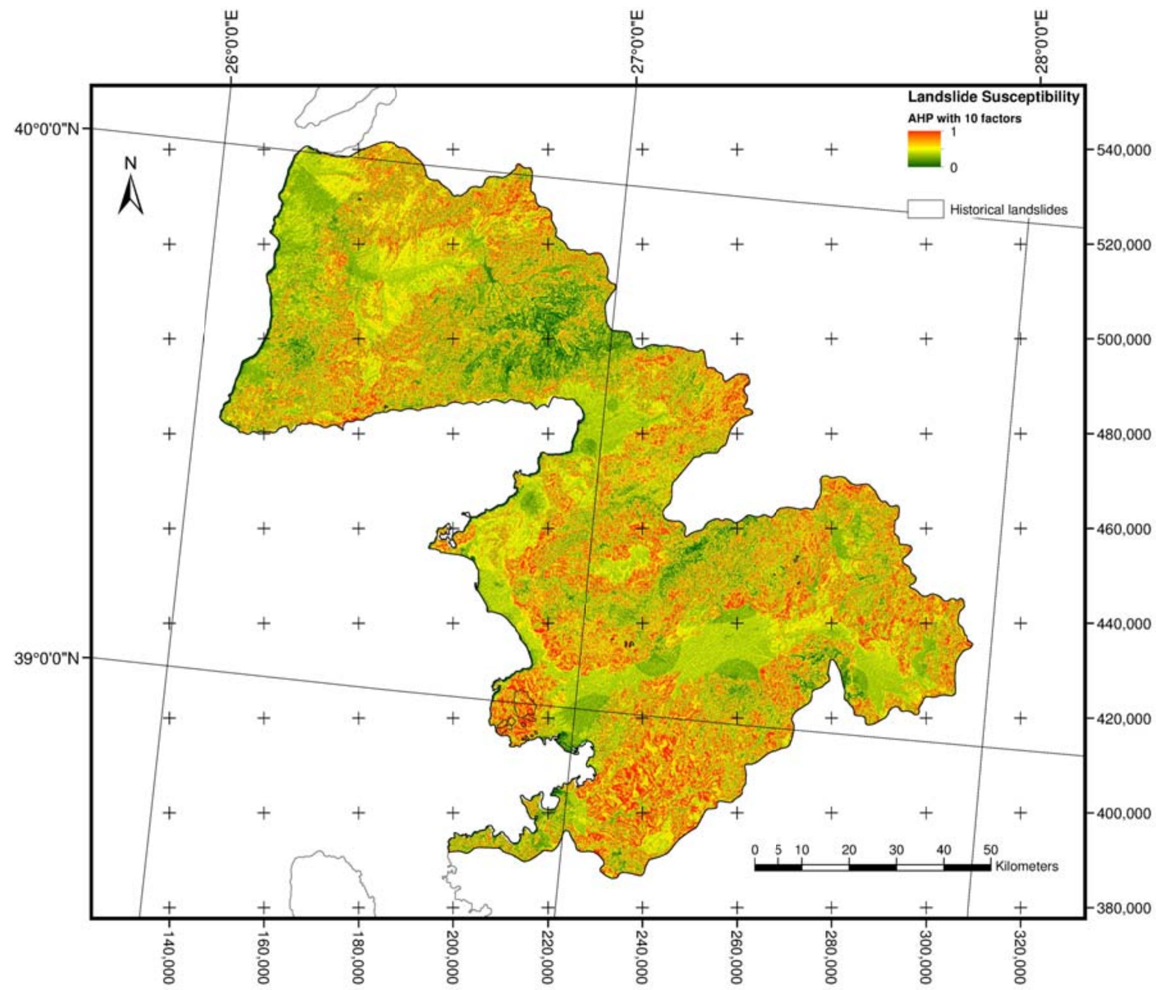


Figure B.6 Unclassified landslide susceptibility map for Watershed-4 (with 10 factors).

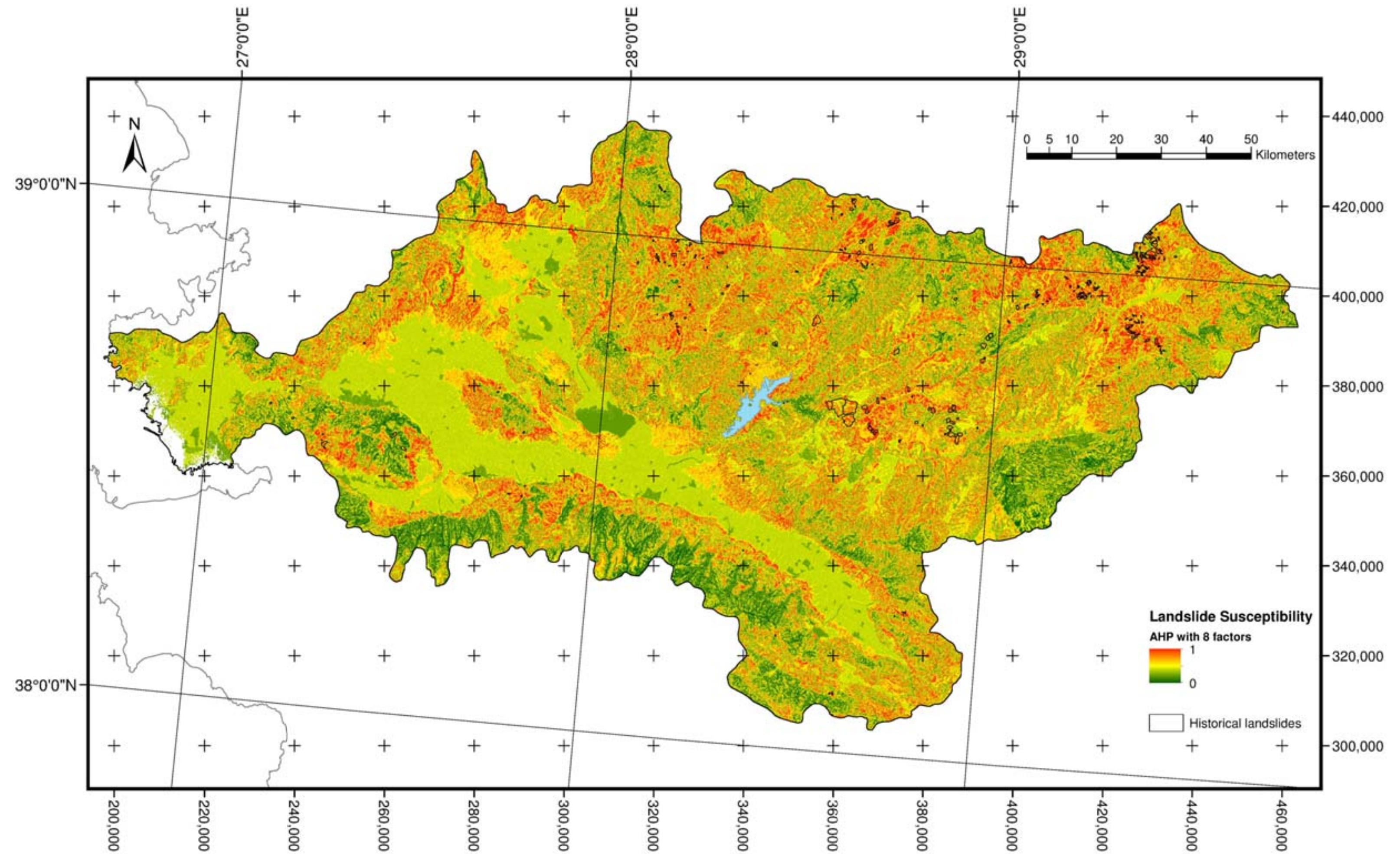


Figure B.7 Unclassified landslide susceptibility map for Watershed-5 (with 8 factors).

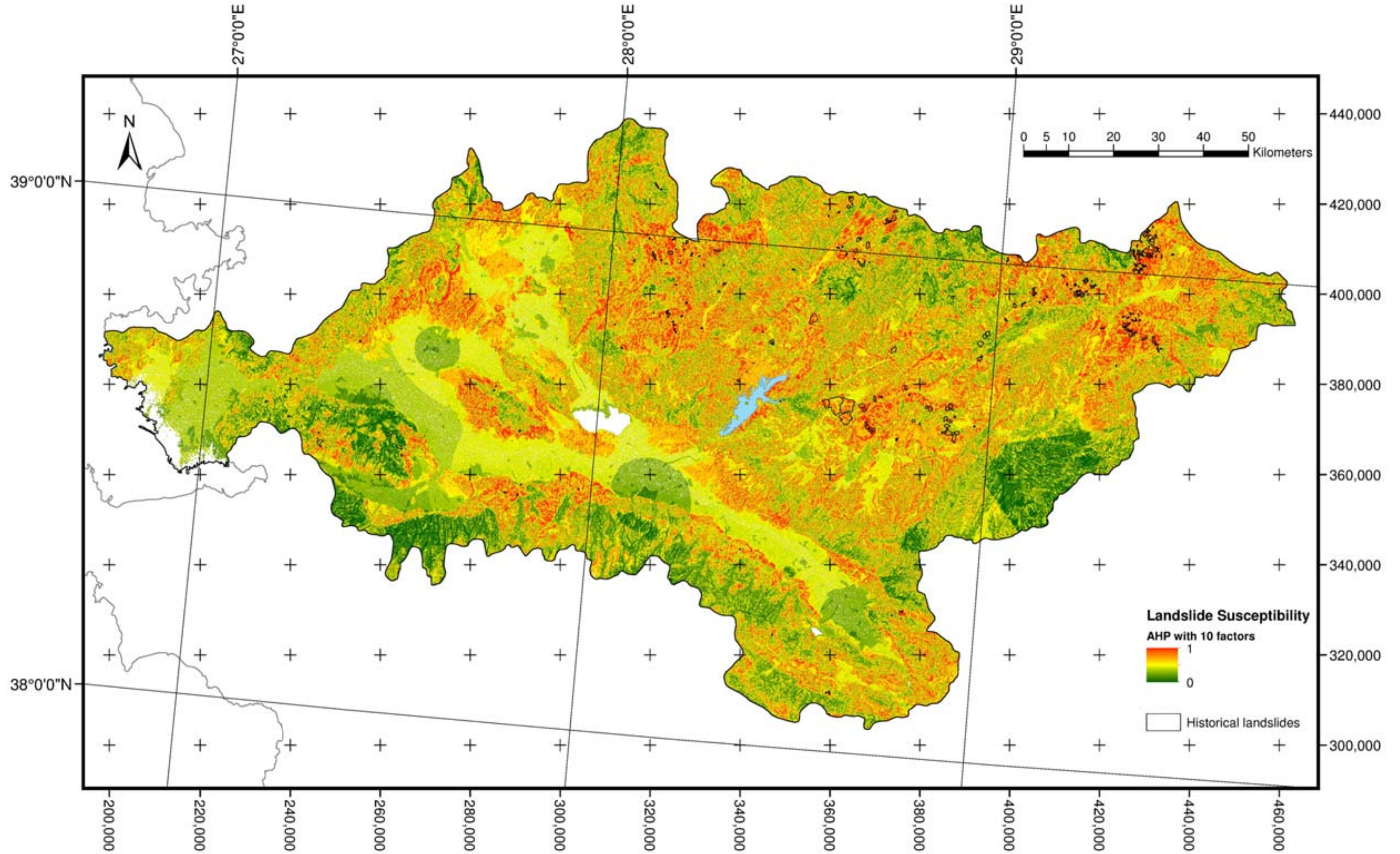


Figure B.8 Unclassified landslide susceptibility map for Watershed-5 (with 10 factors).

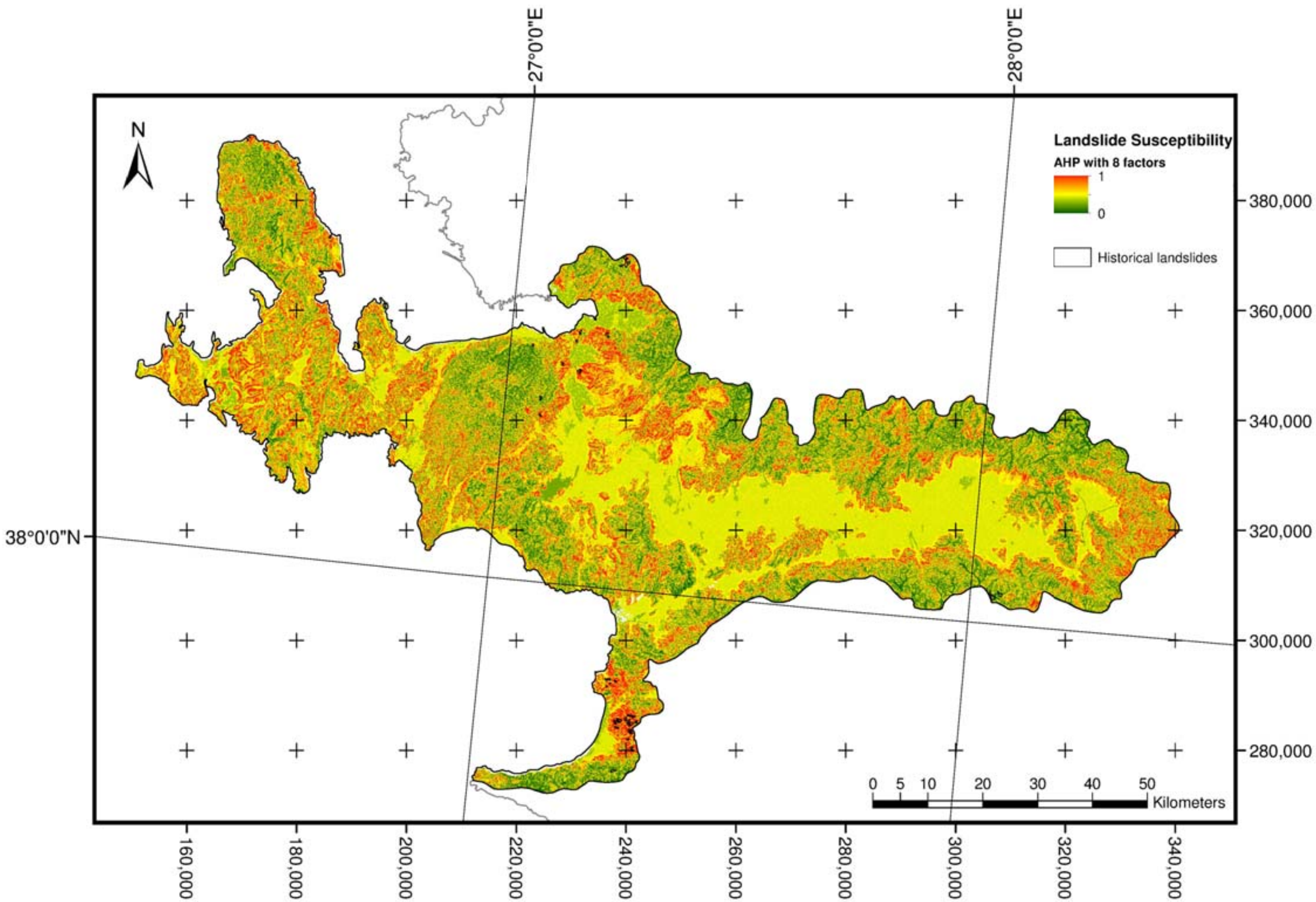


Figure B.9 Unclassified landslide susceptibility map for Watershed-6 (with 8 factors).

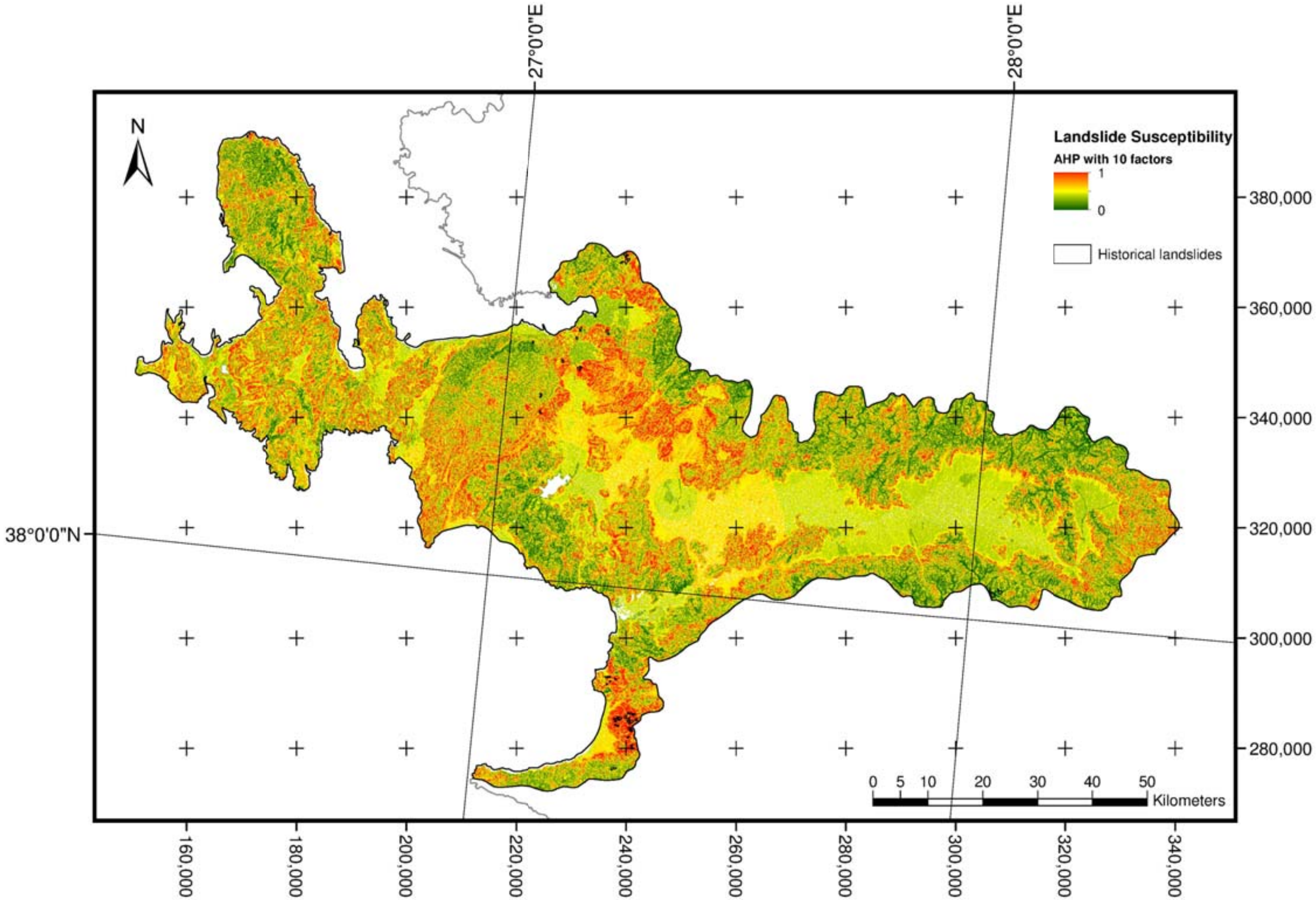


Figure B.10 Unclassified landslide susceptibility map for Watershed-6 (with 10 factors).

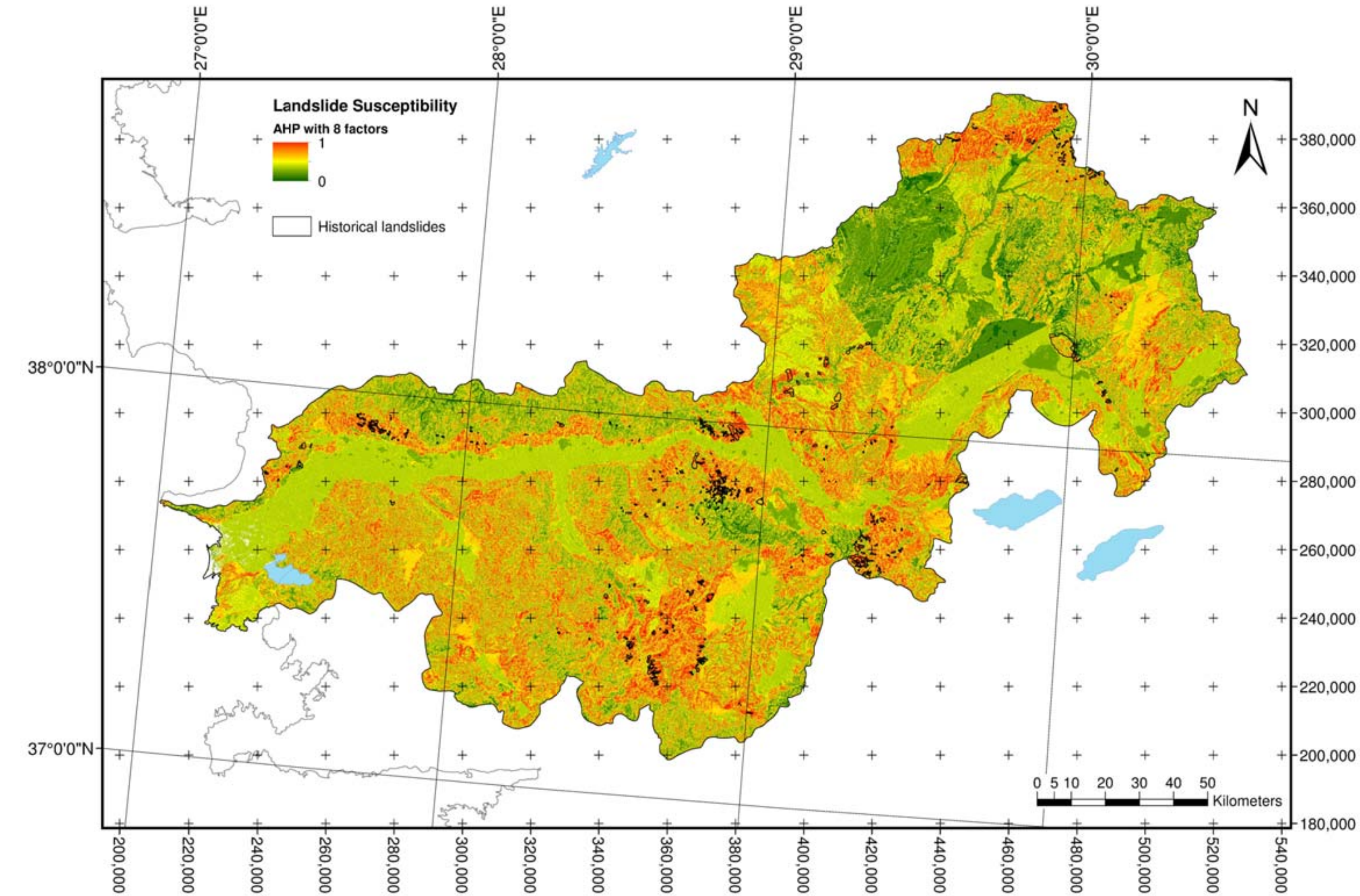


Figure B.11 Unclassified landslide susceptibility map for Watershed-7 (with 8 factors).

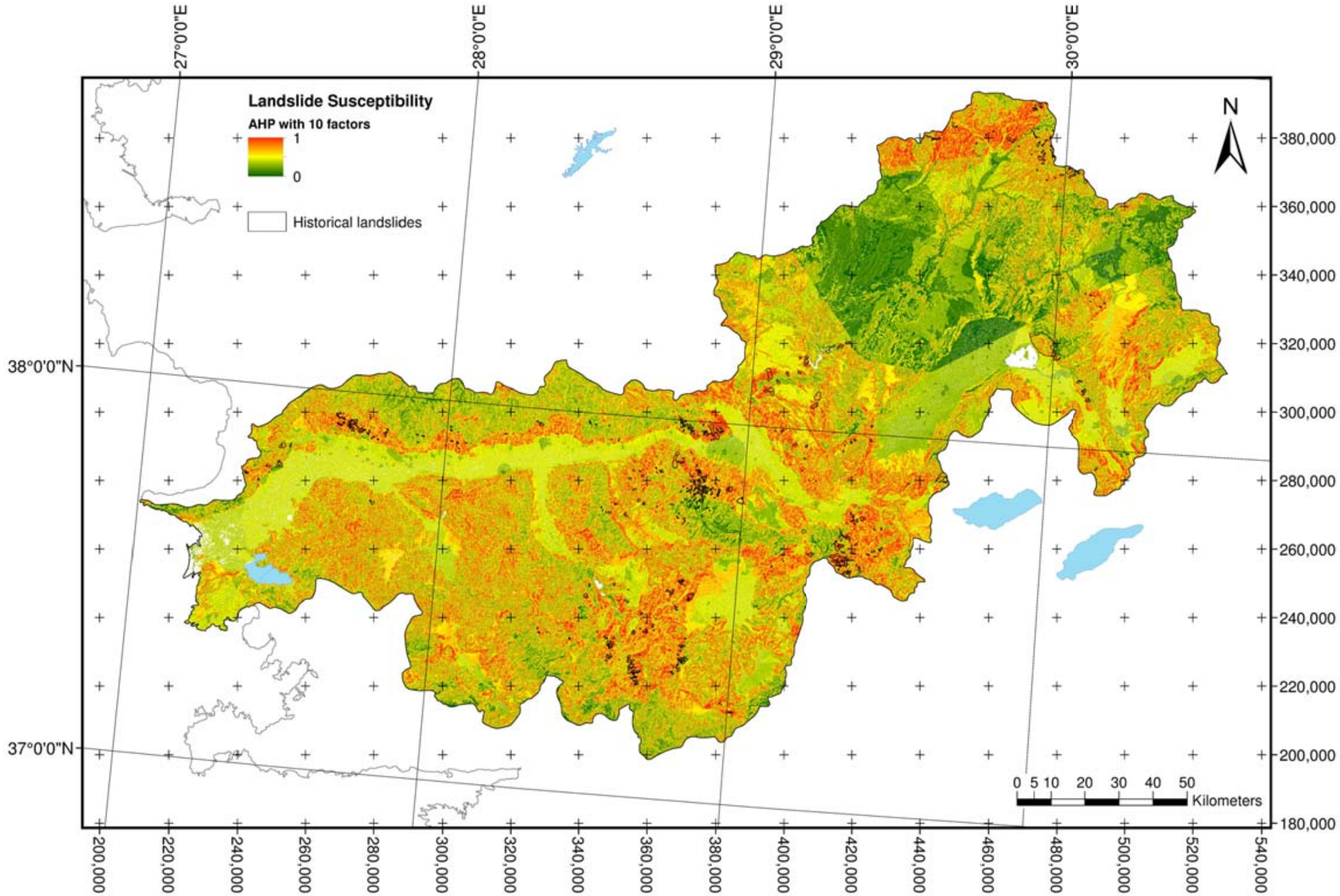


Figure B.12 Unclassified landslide susceptibility map for Watershed-7 (with 10 factors).

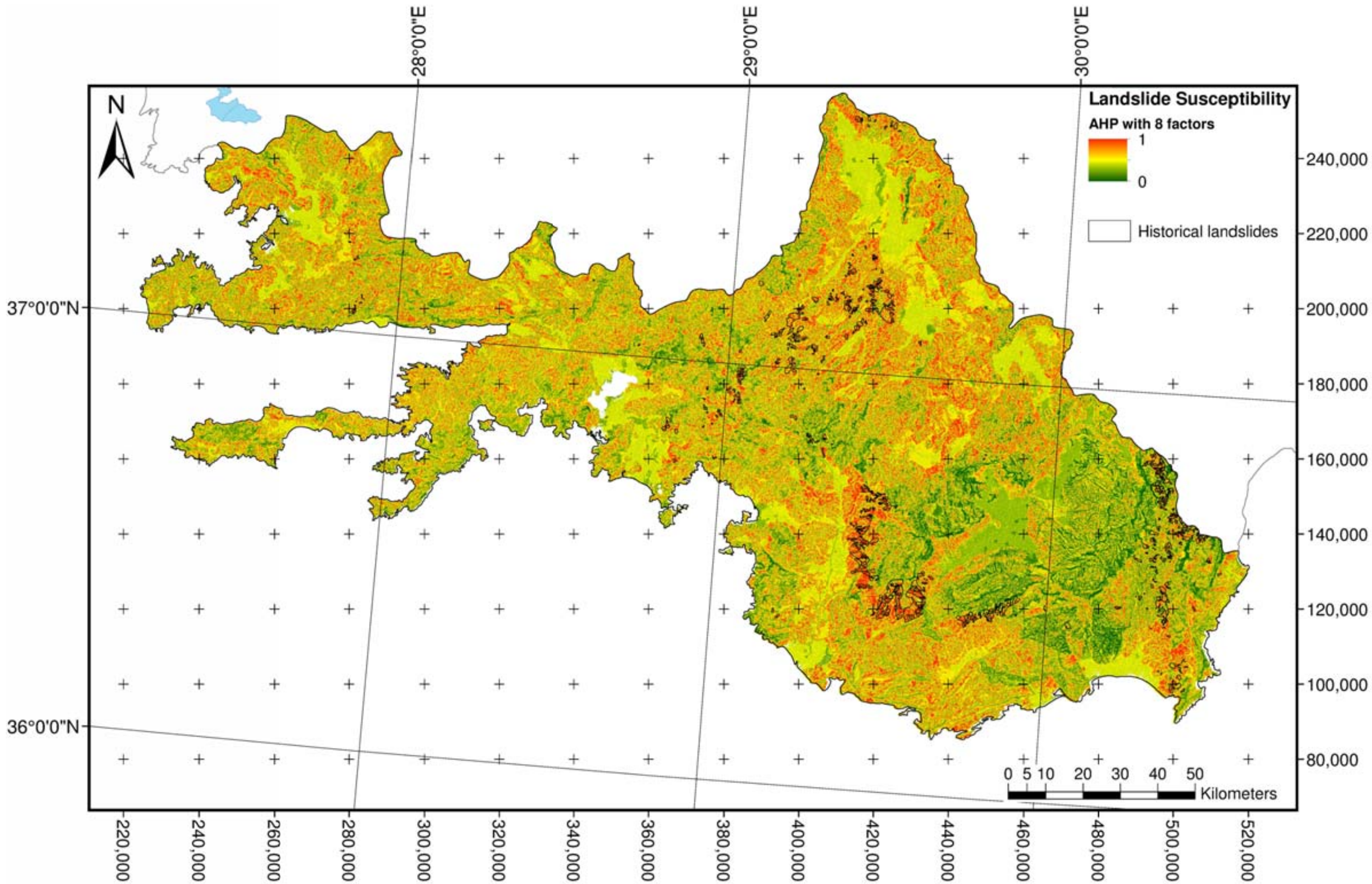


Figure B.13 Unclassified landslide susceptibility map for Watershed-8 (with 8 factors).

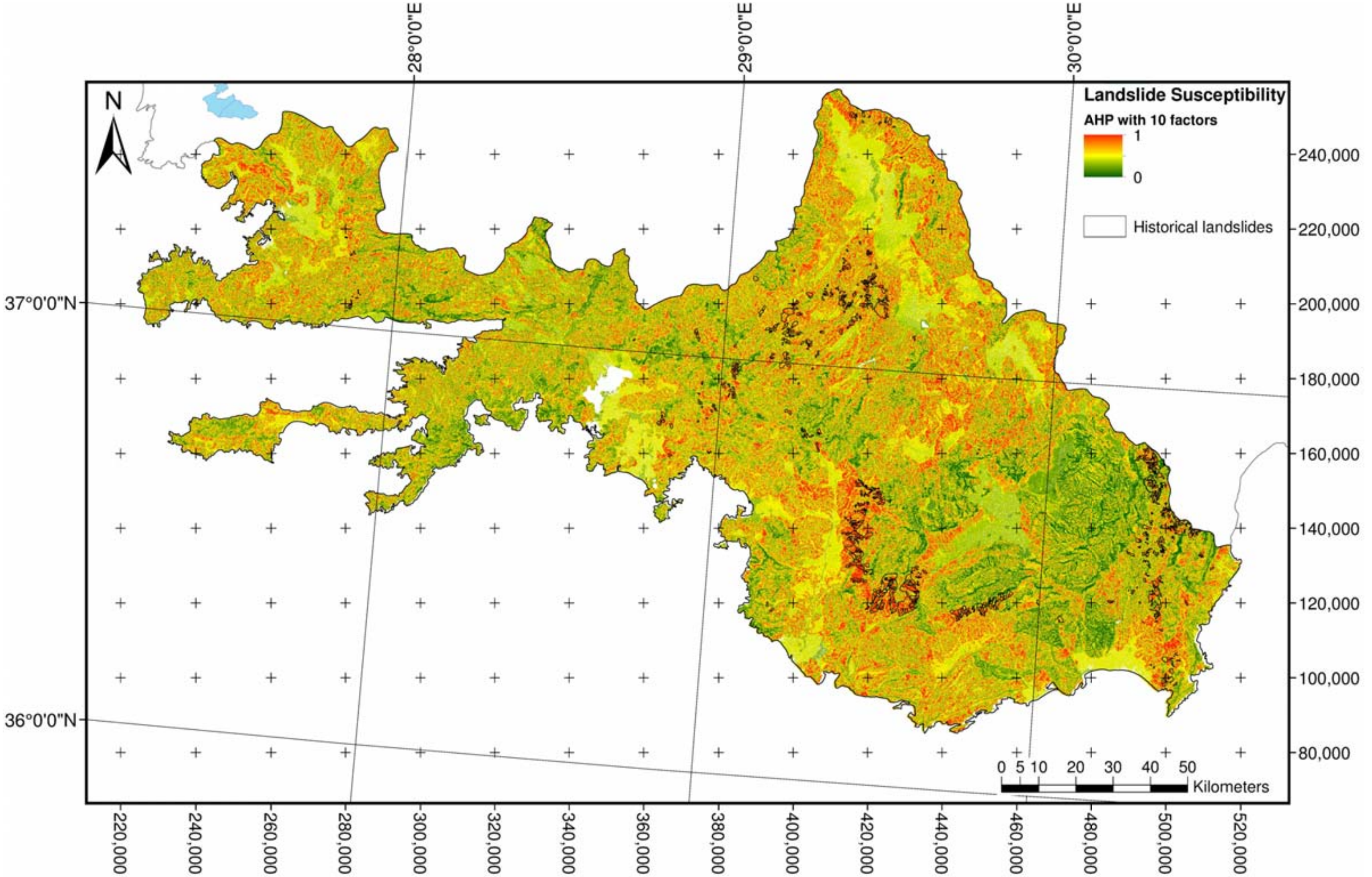


Figure B.14 Unclassified landslide susceptibility map for Watershed-8 (with 10 factors).

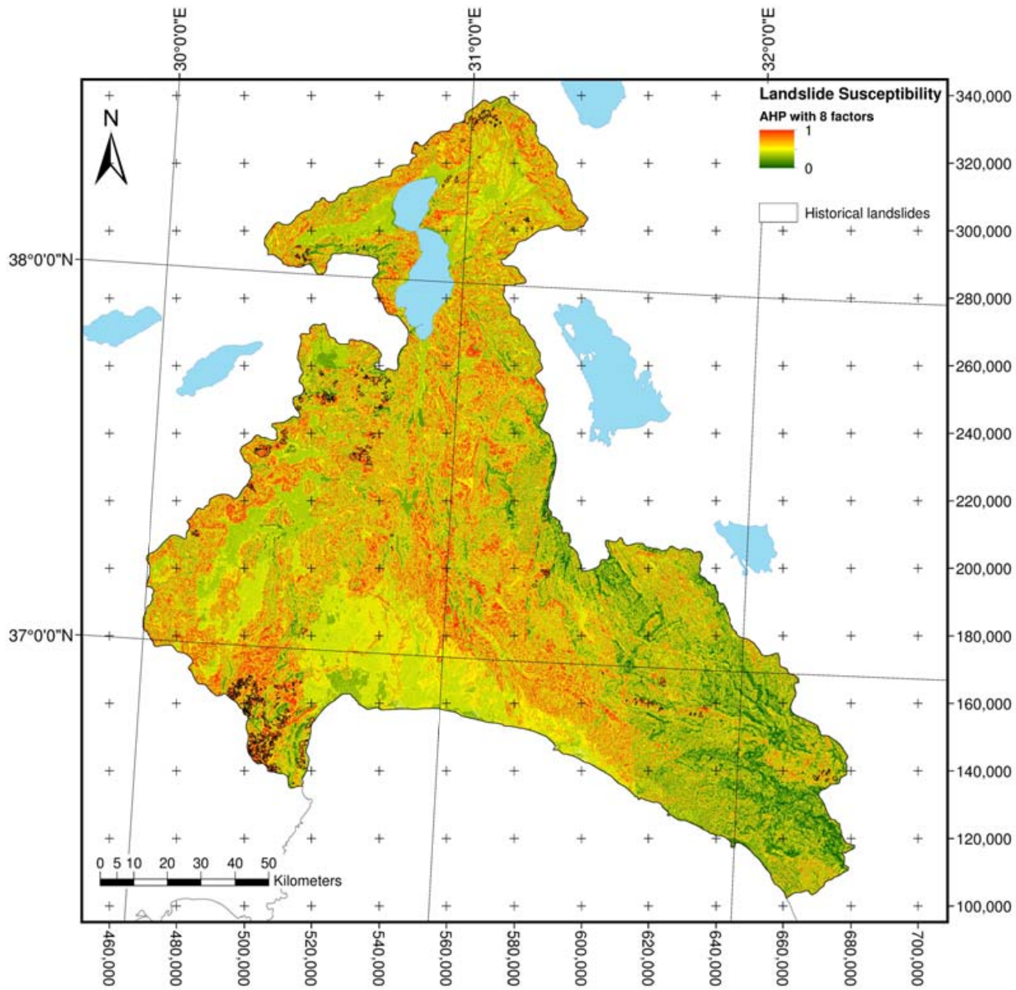


Figure B.15 Unclassified landslide susceptibility map for Watershed-9 (with 8 factors).

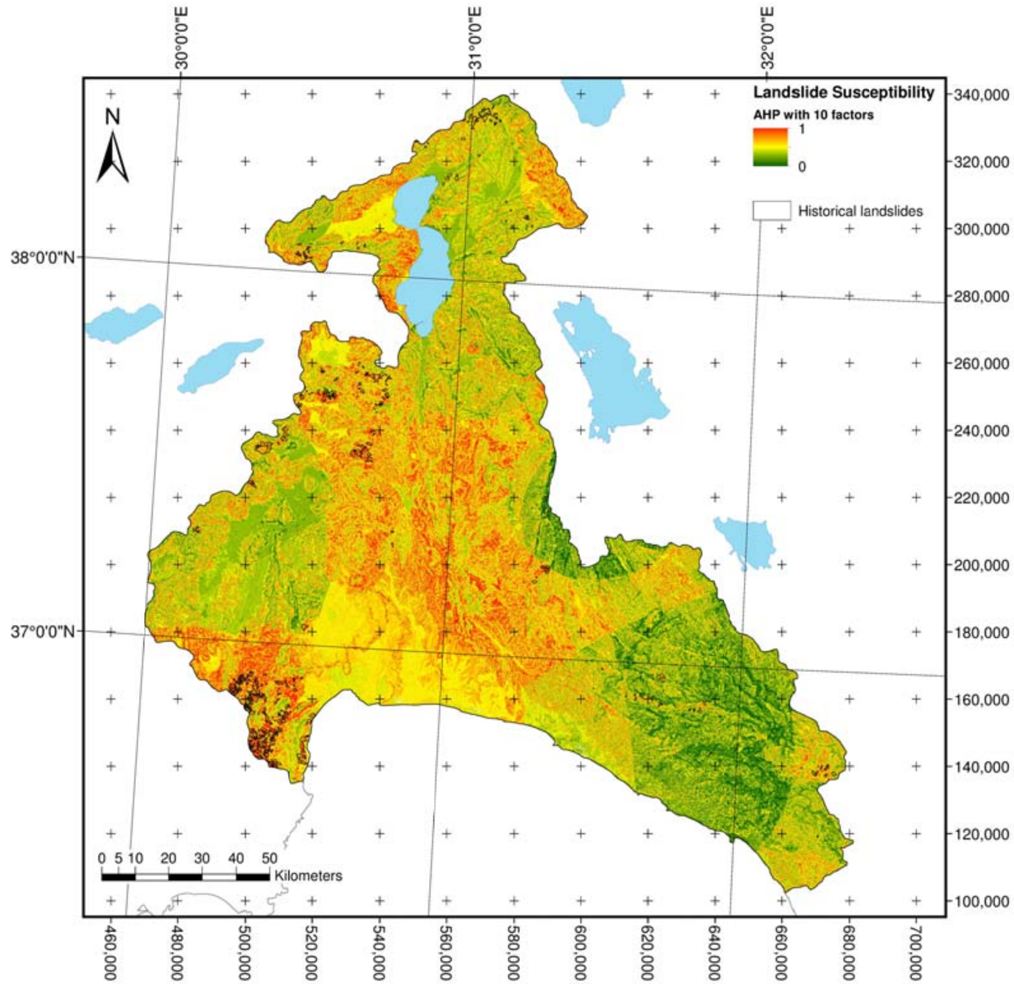


Figure B.16 Unclassified landslide susceptibility map for Watershed-9 (with 10 factors).

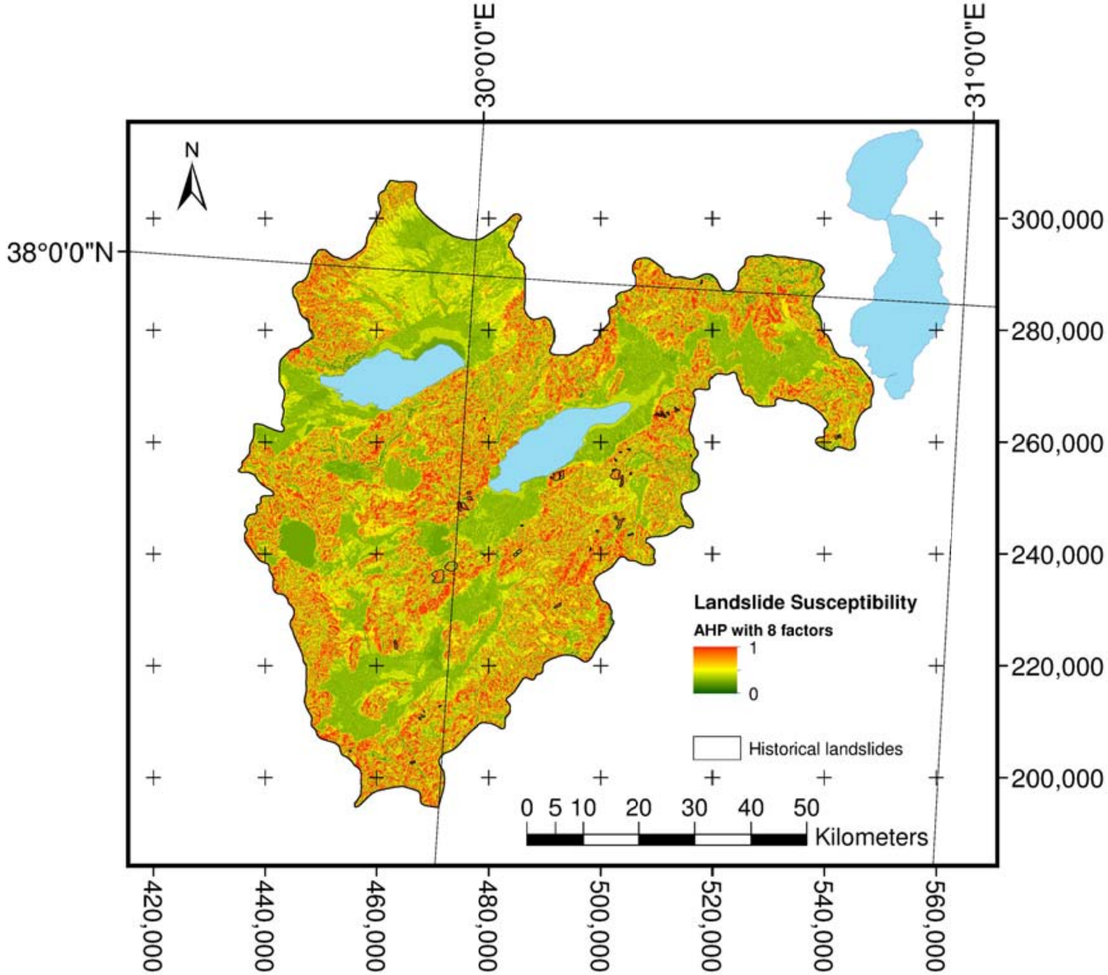


Figure B.17 Unclassified landslide susceptibility map for Watershed-10 (with 8 factors).

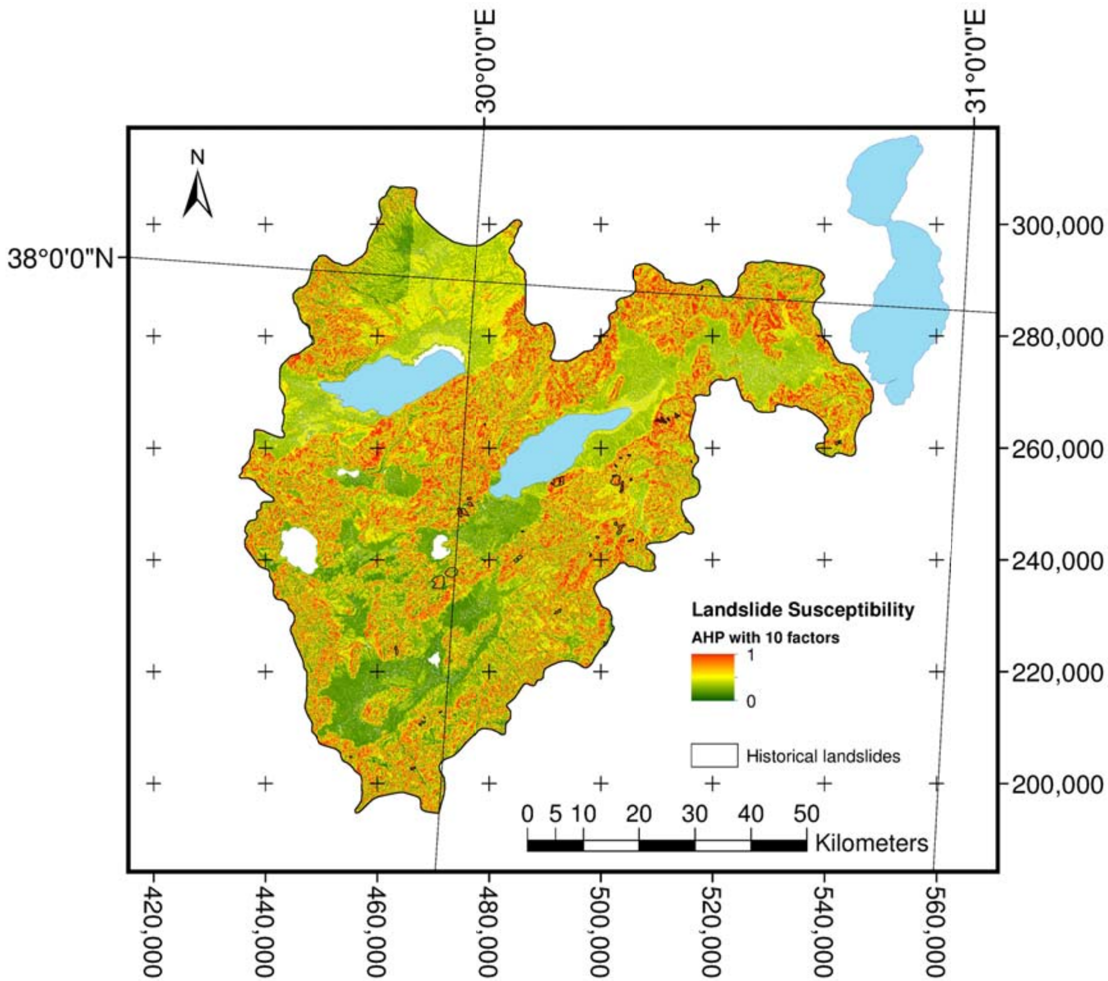


Figure B.18 Unclassified landslide susceptibility map for Watershed-10 (with 10 factors).

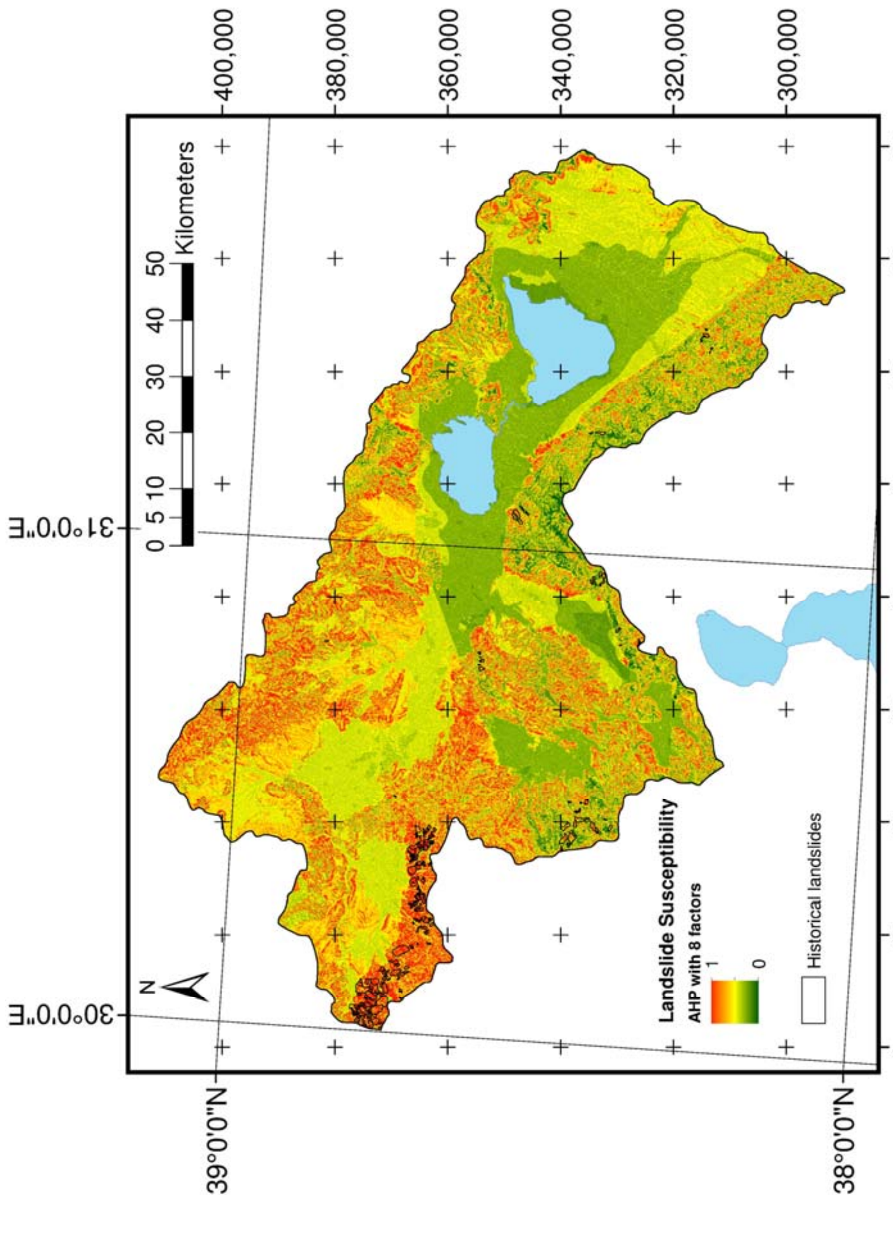


Figure B.19 Unclassified landslide susceptibility map for Watershed-11 (with 8 factors).

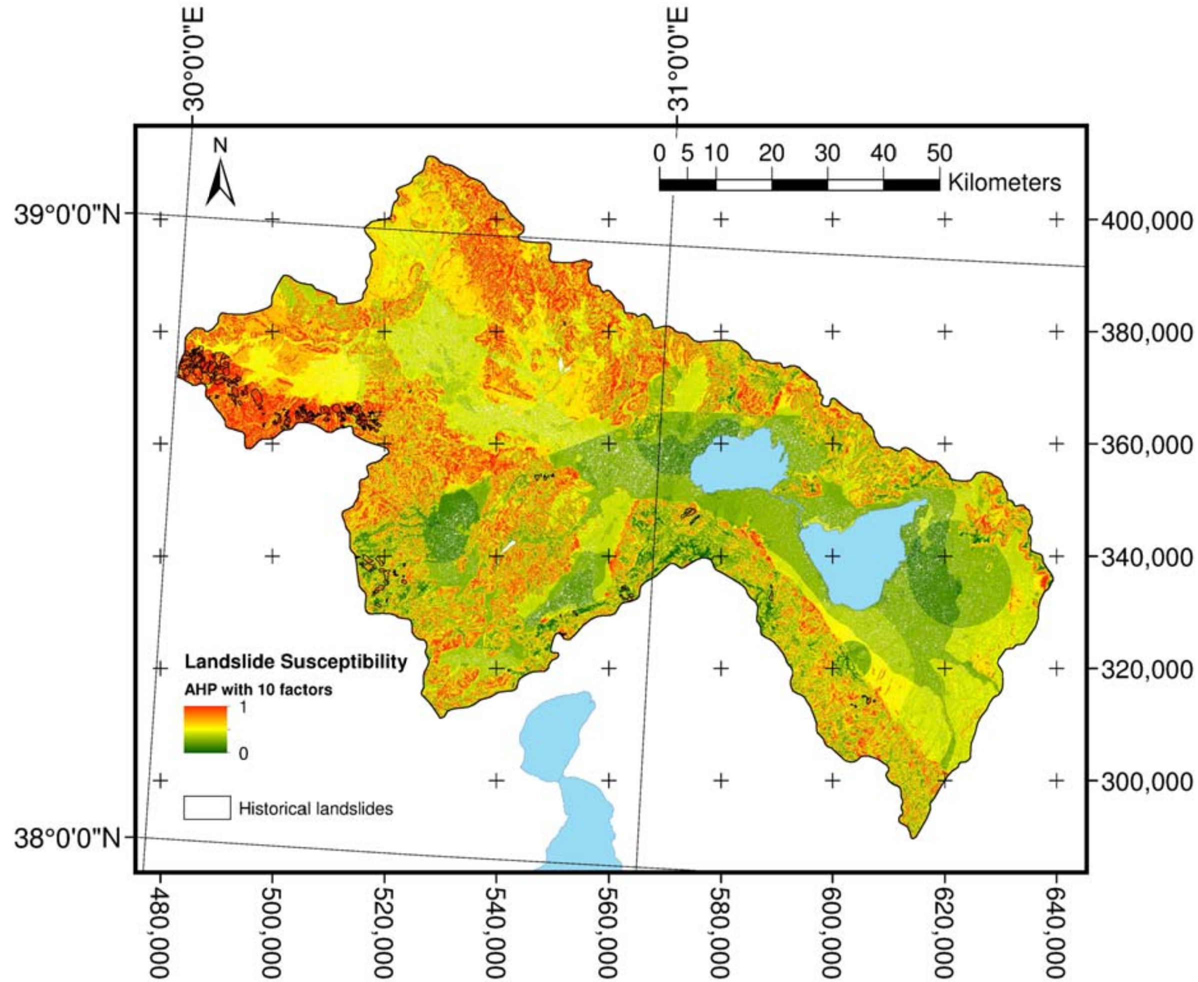


Figure B.20 Unclassified landslide susceptibility map for Watershed-11 (with 10 factors).

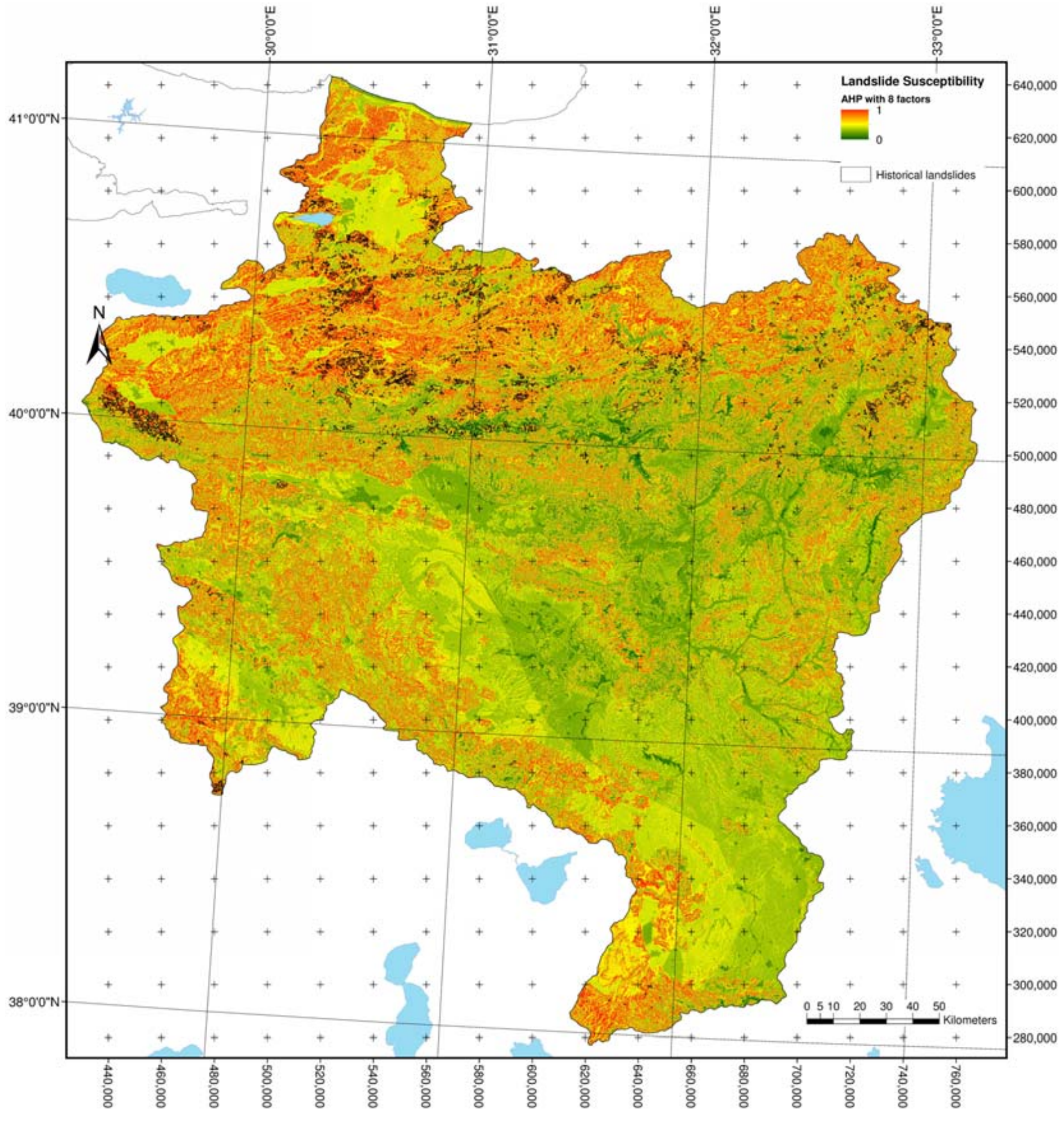


Figure B.21 Unclassified landslide susceptibility map for Watershed-12 (with 8 factors).

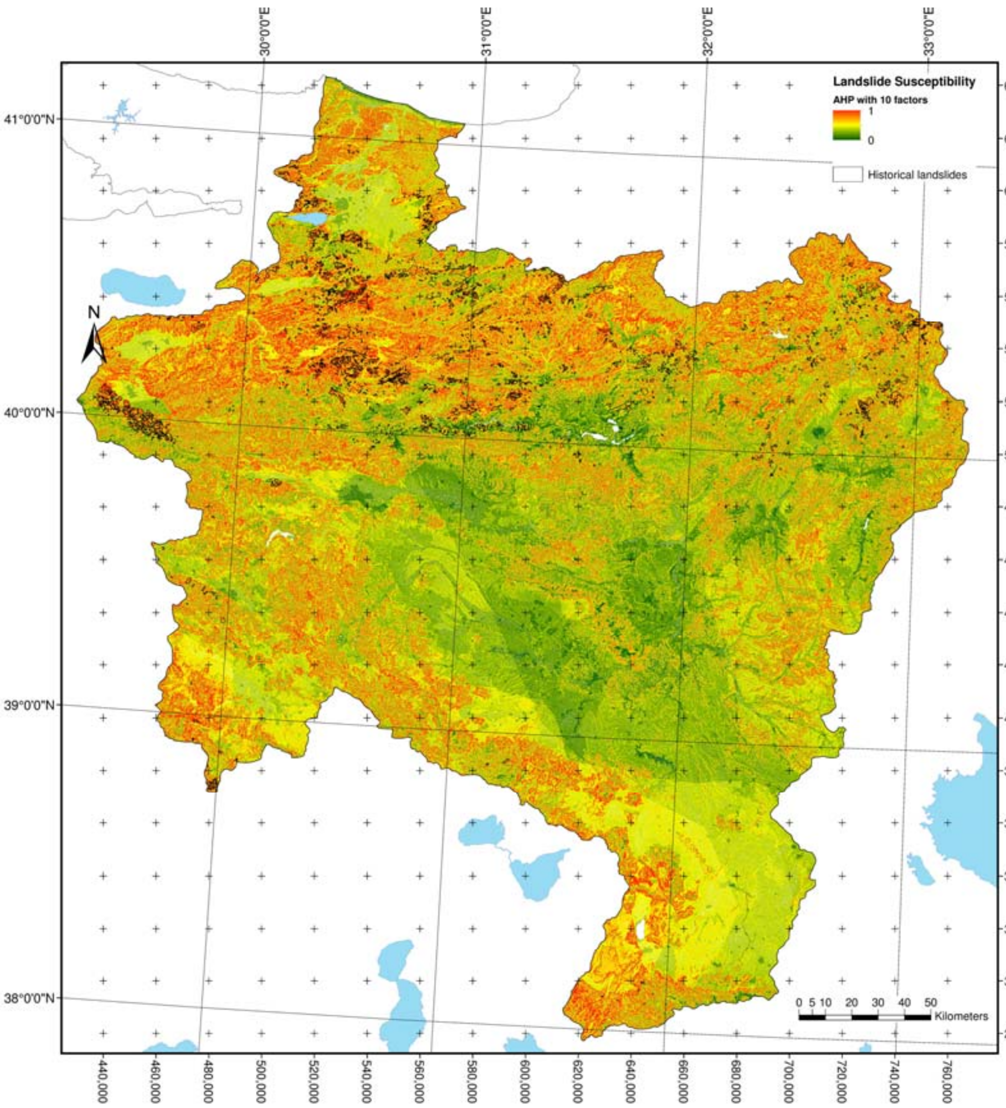


Figure B.22 Unclassified landslide susceptibility map for Watershed-12 (with 10 factors).

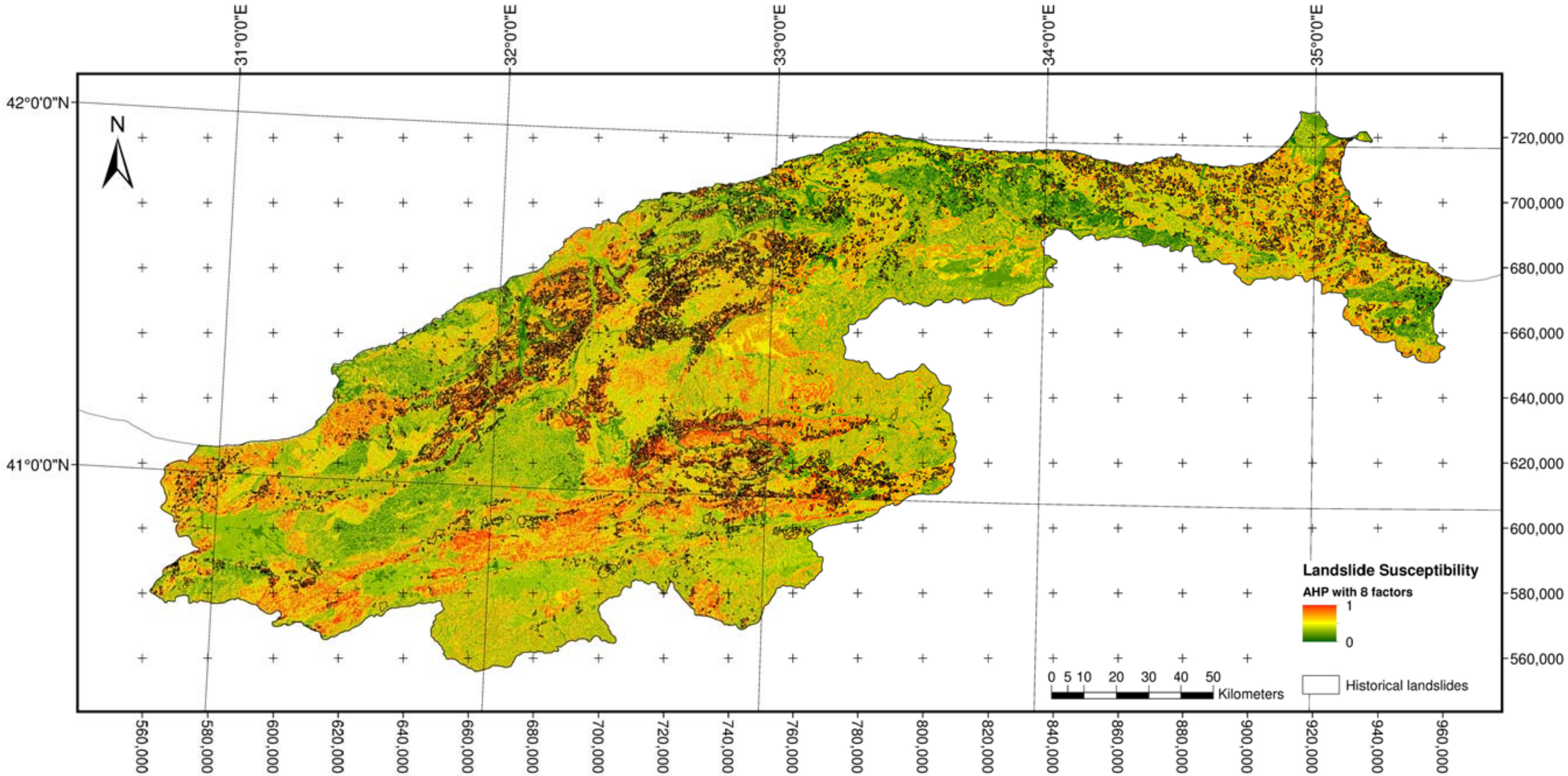


Figure B.23 Unclassified landslide susceptibility map for Watershed-13 (with 8 factors).

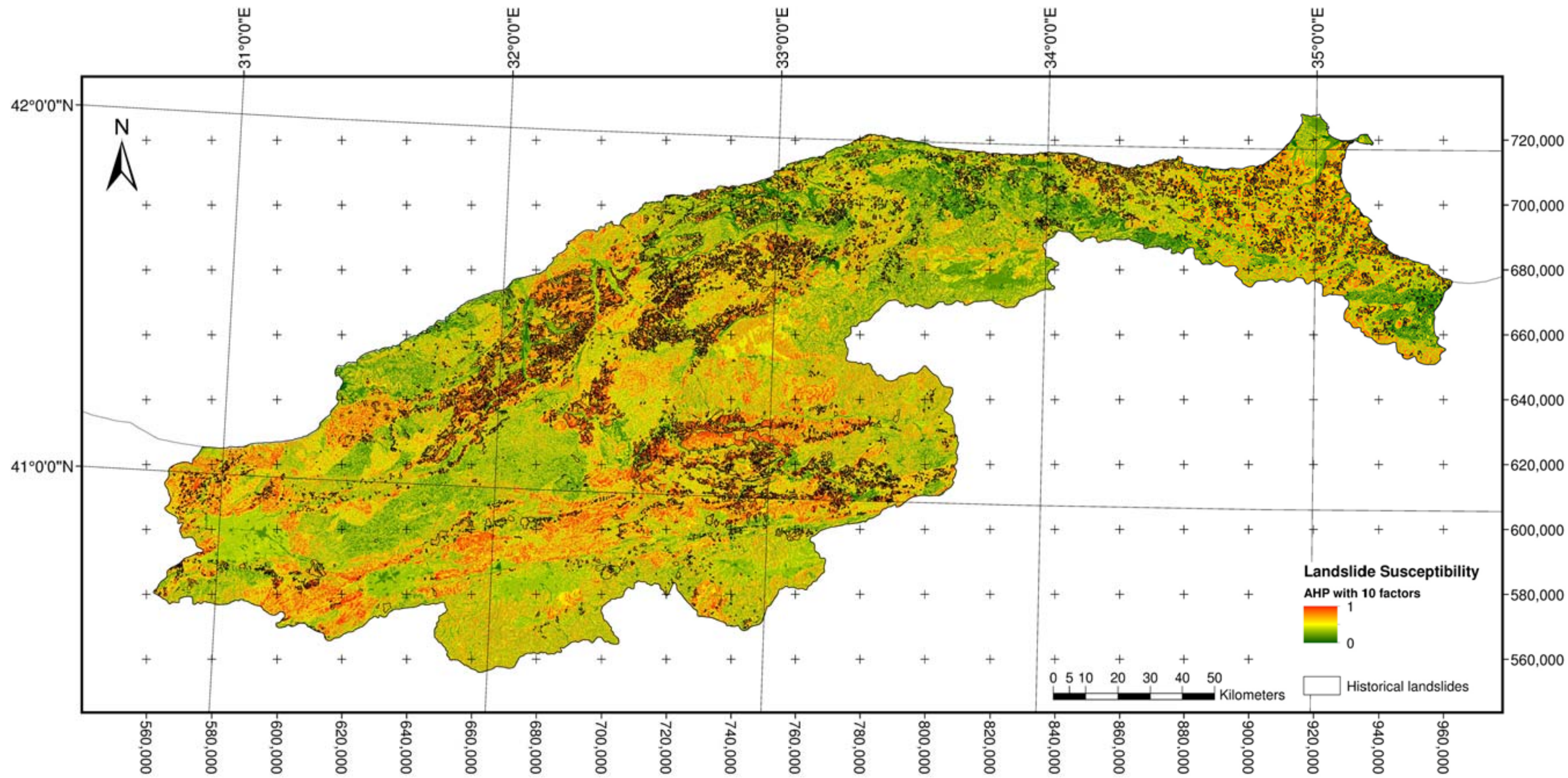


Figure B.24 Unclassified landslide susceptibility map for Watershed-13 (with 10 factors).

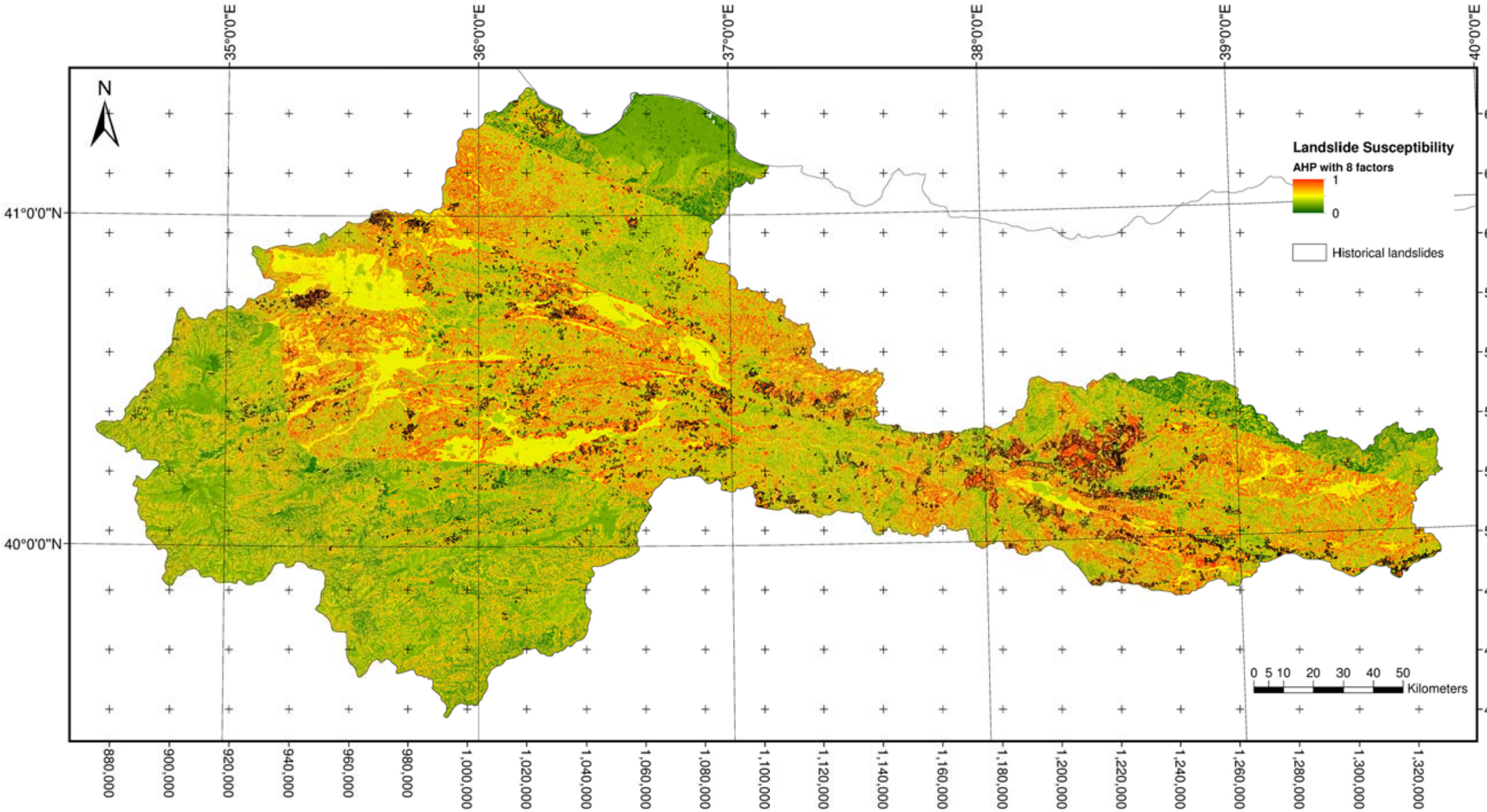


Figure B.25 Unclassified landslide susceptibility map for Watershed-14 (with 8 factors).

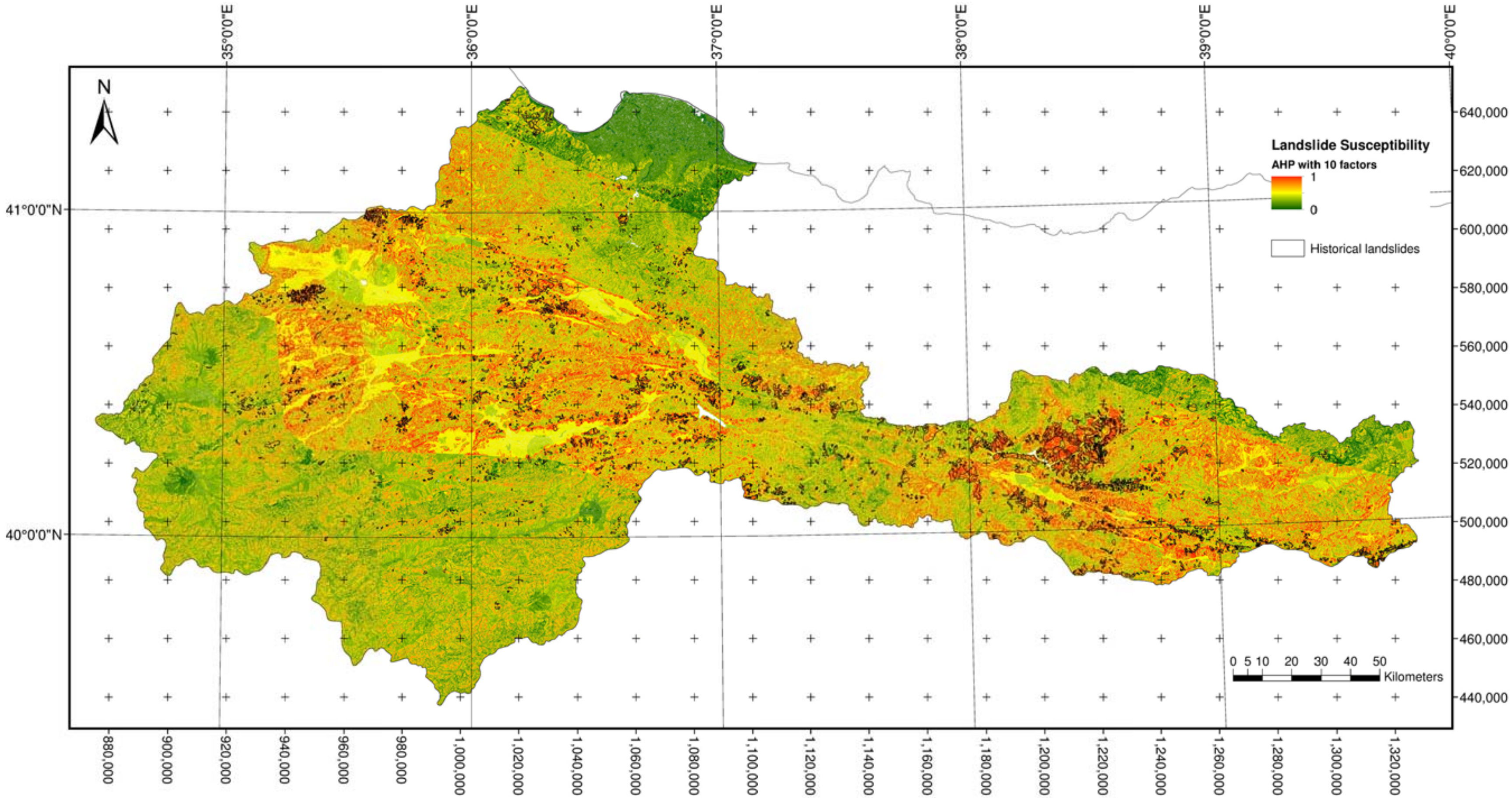


Figure B.26 Unclassified landslide susceptibility map for Watershed-14 (with 10 factors).

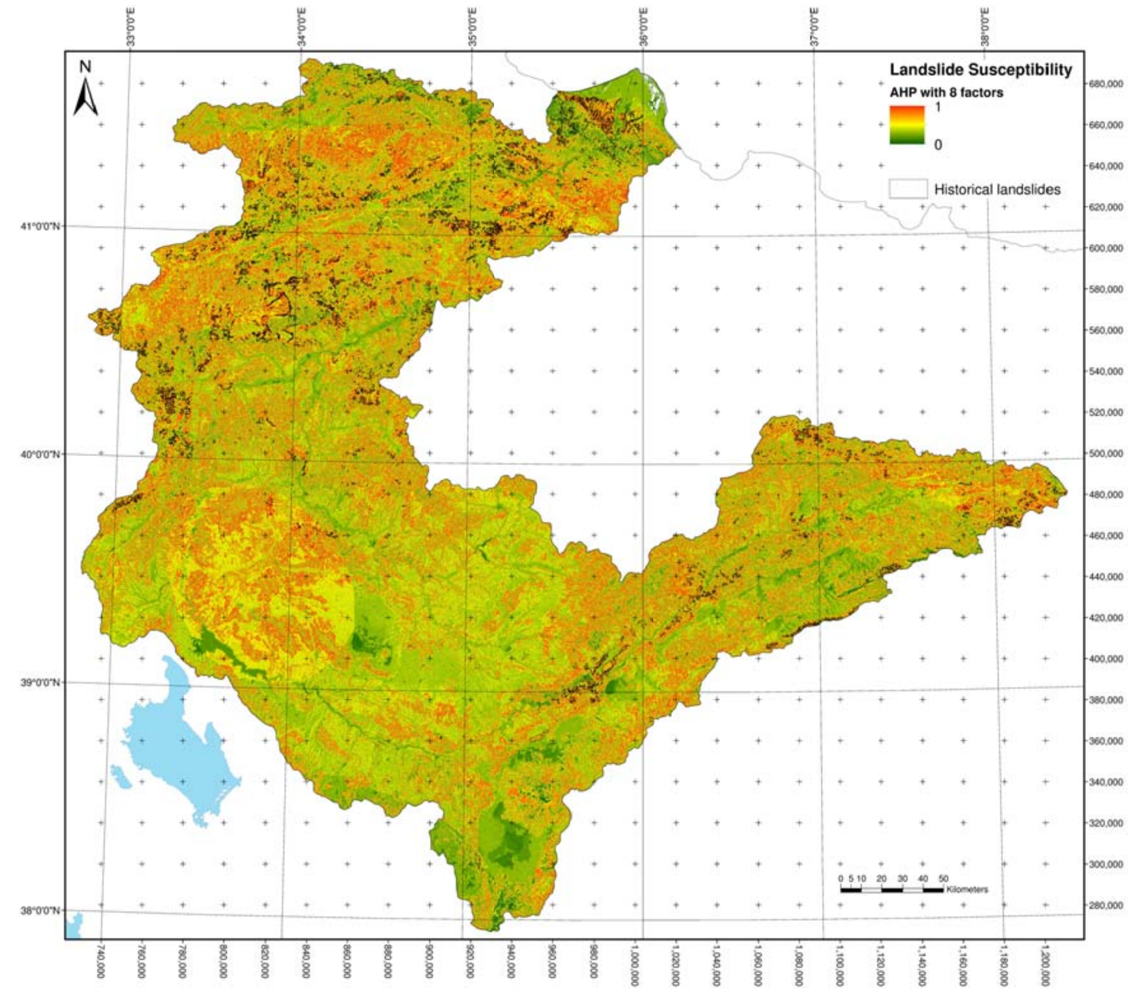


Figure B.27 Unclassified landslide susceptibility map for Watershed-15 (with 8 factors).

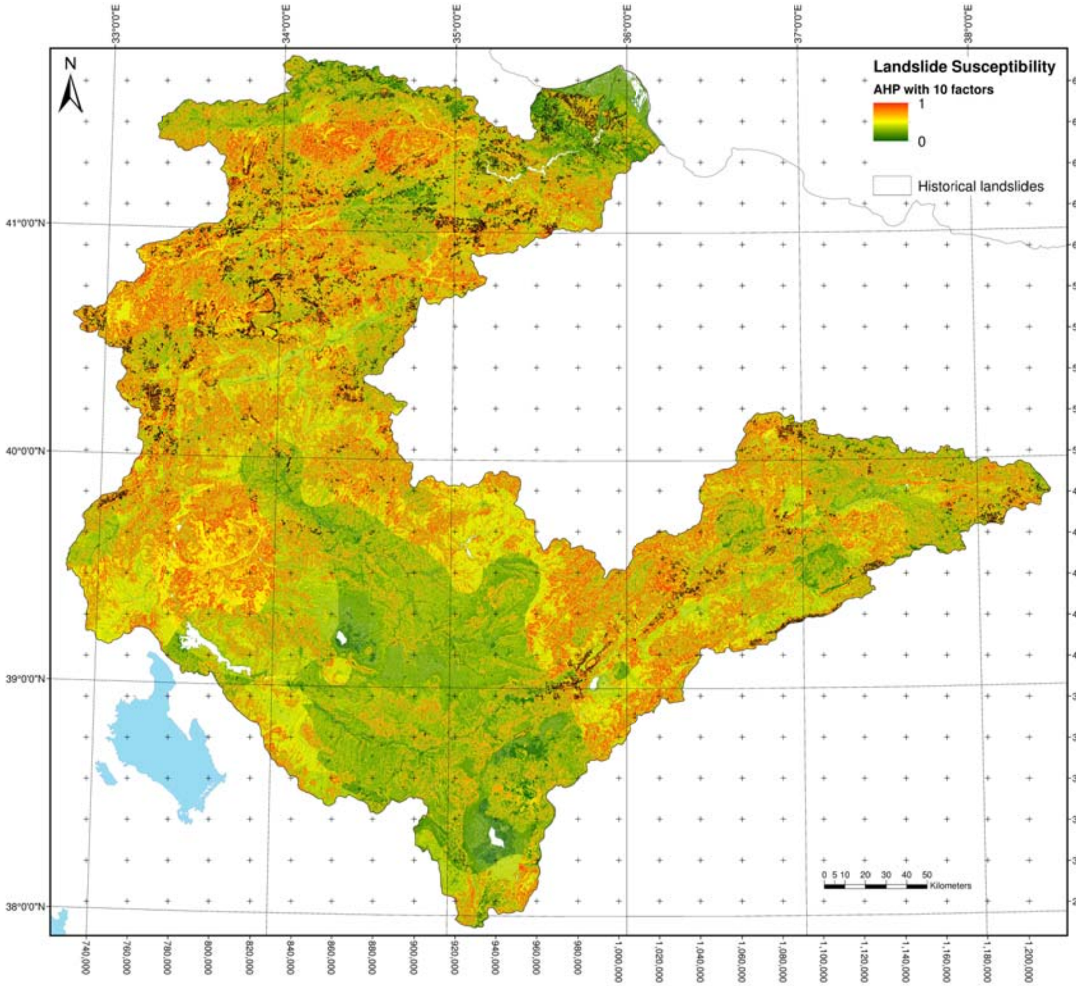


Figure B.28 Unclassified landslide susceptibility map for Watershed-15 (with 10 factors).

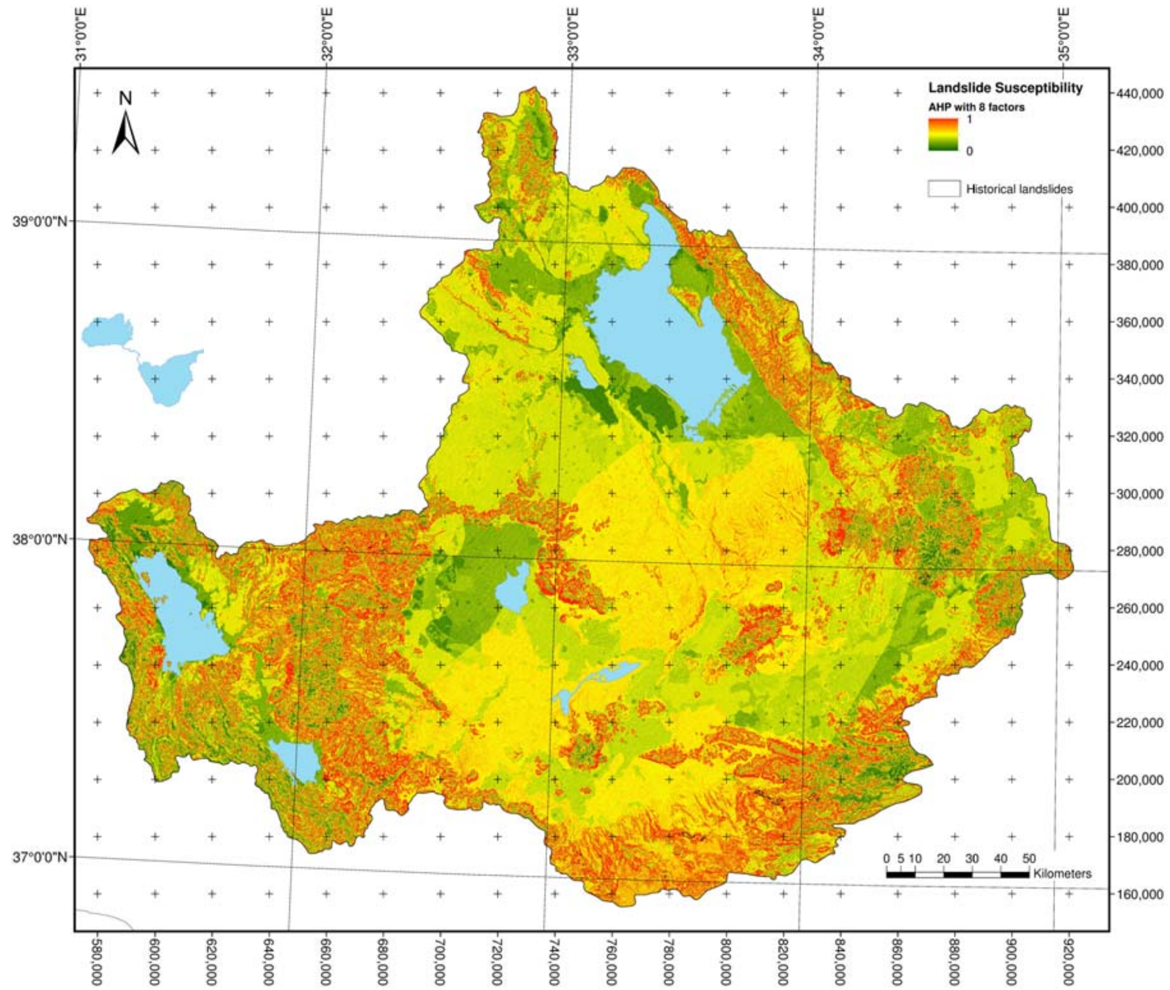


Figure B.29 Unclassified landslide susceptibility map for Watershed-16 (with 8 factors).

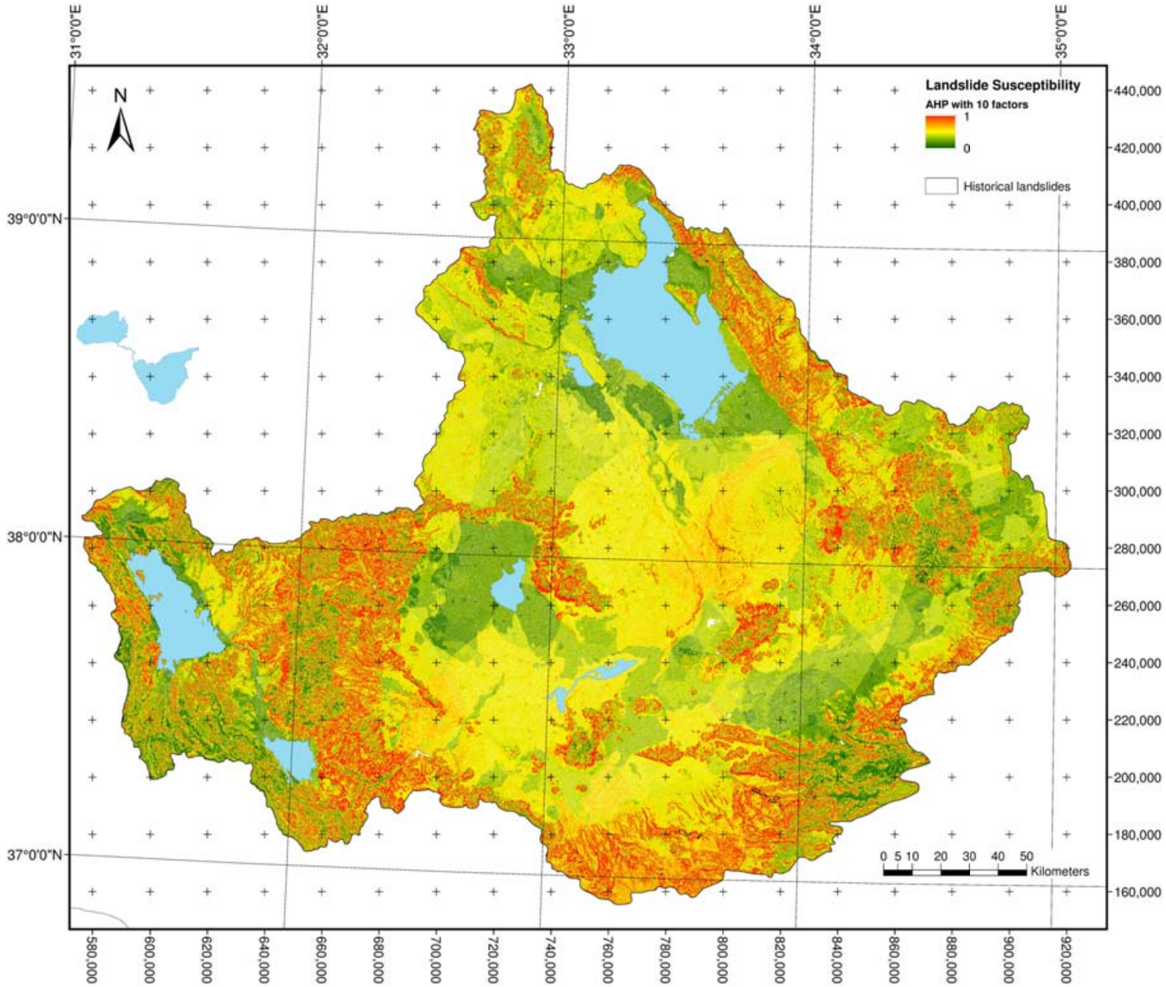


Figure B.30 Unclassified landslide susceptibility map for Watershed-16 (with 10 factors).

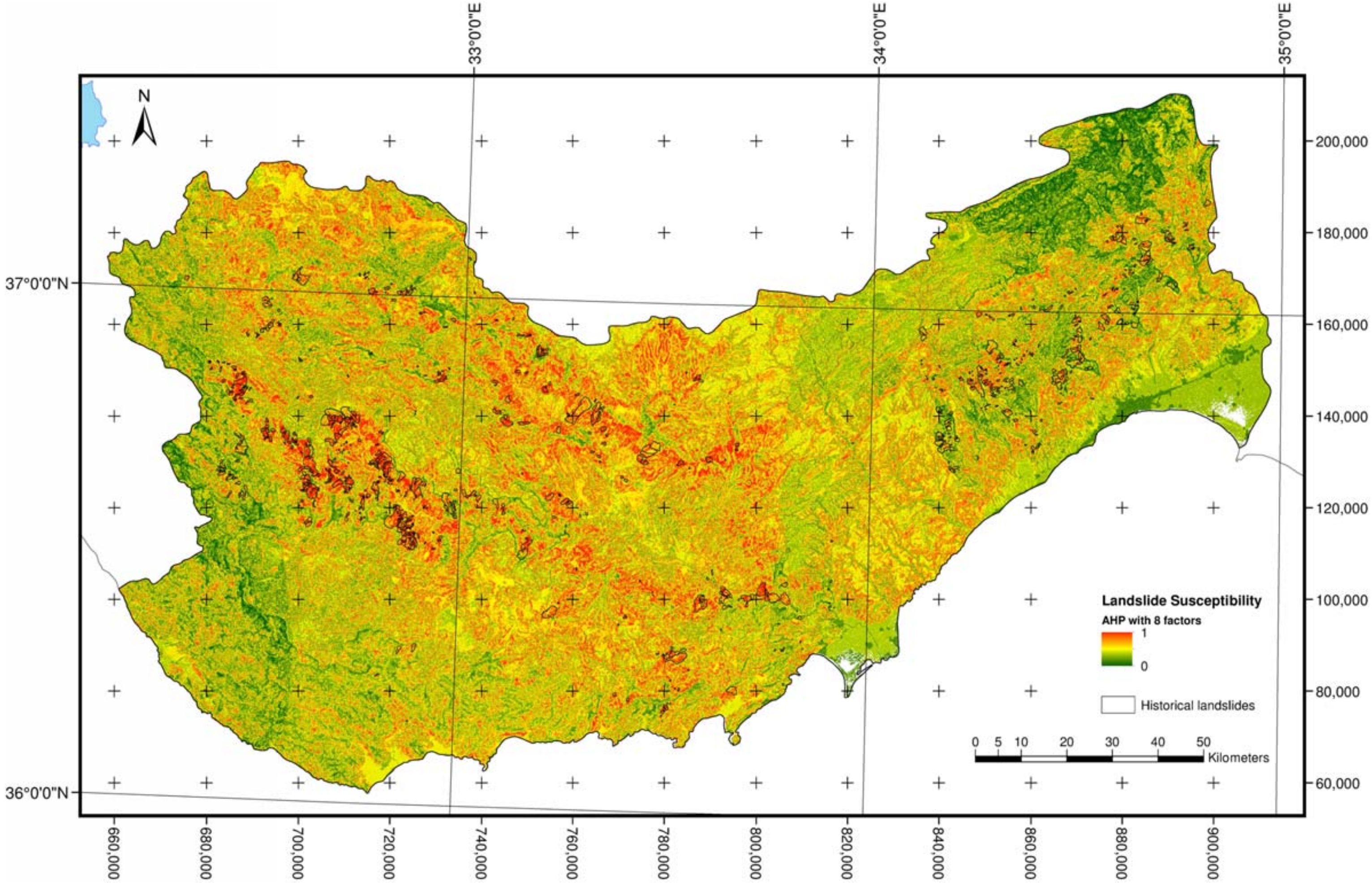


Figure B.31 Unclassified landslide susceptibility map for Watershed-17 (with 8 factors).

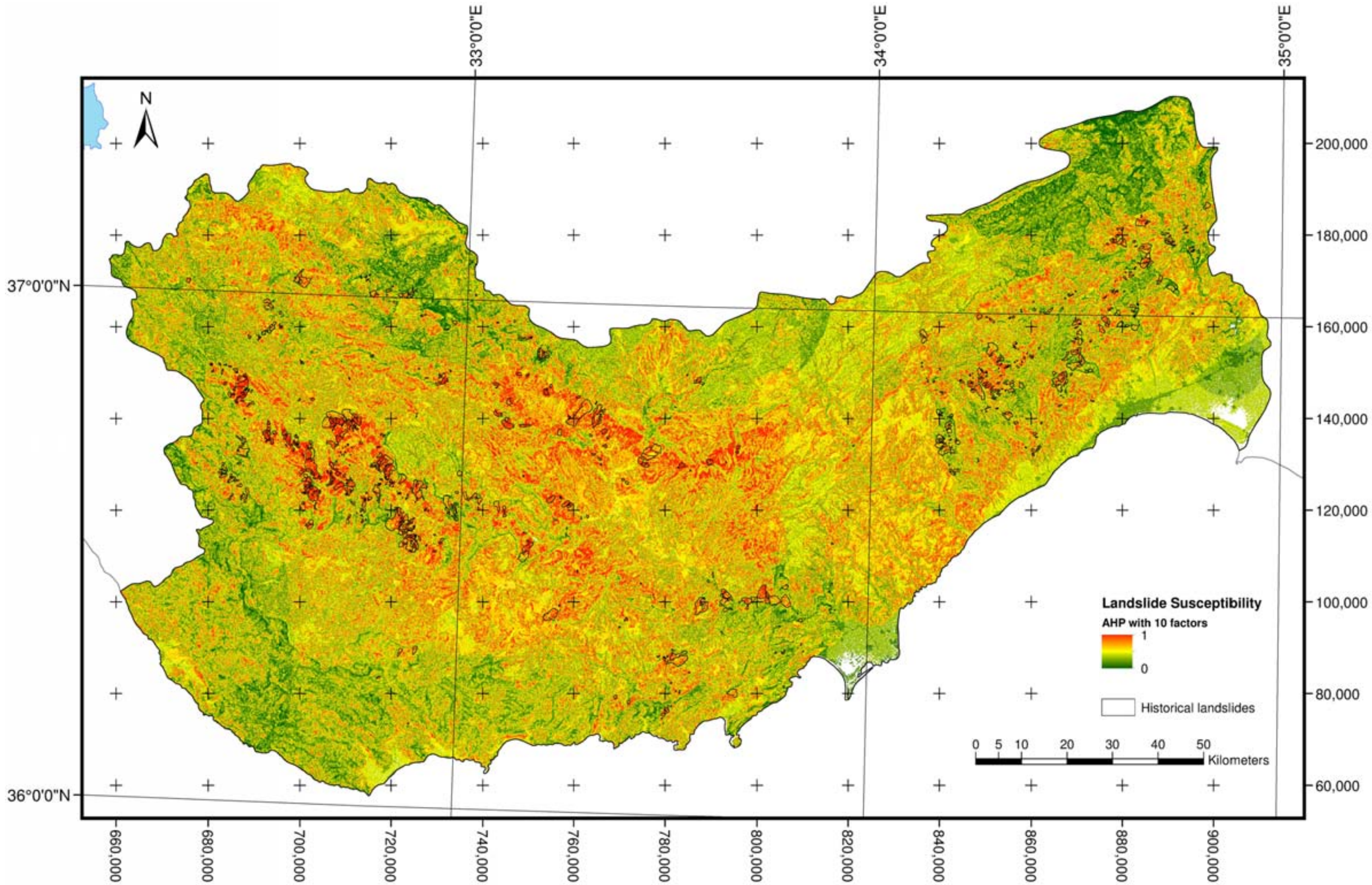


Figure B.32 Unclassified landslide susceptibility map for Watershed-17 (with 10 factors).

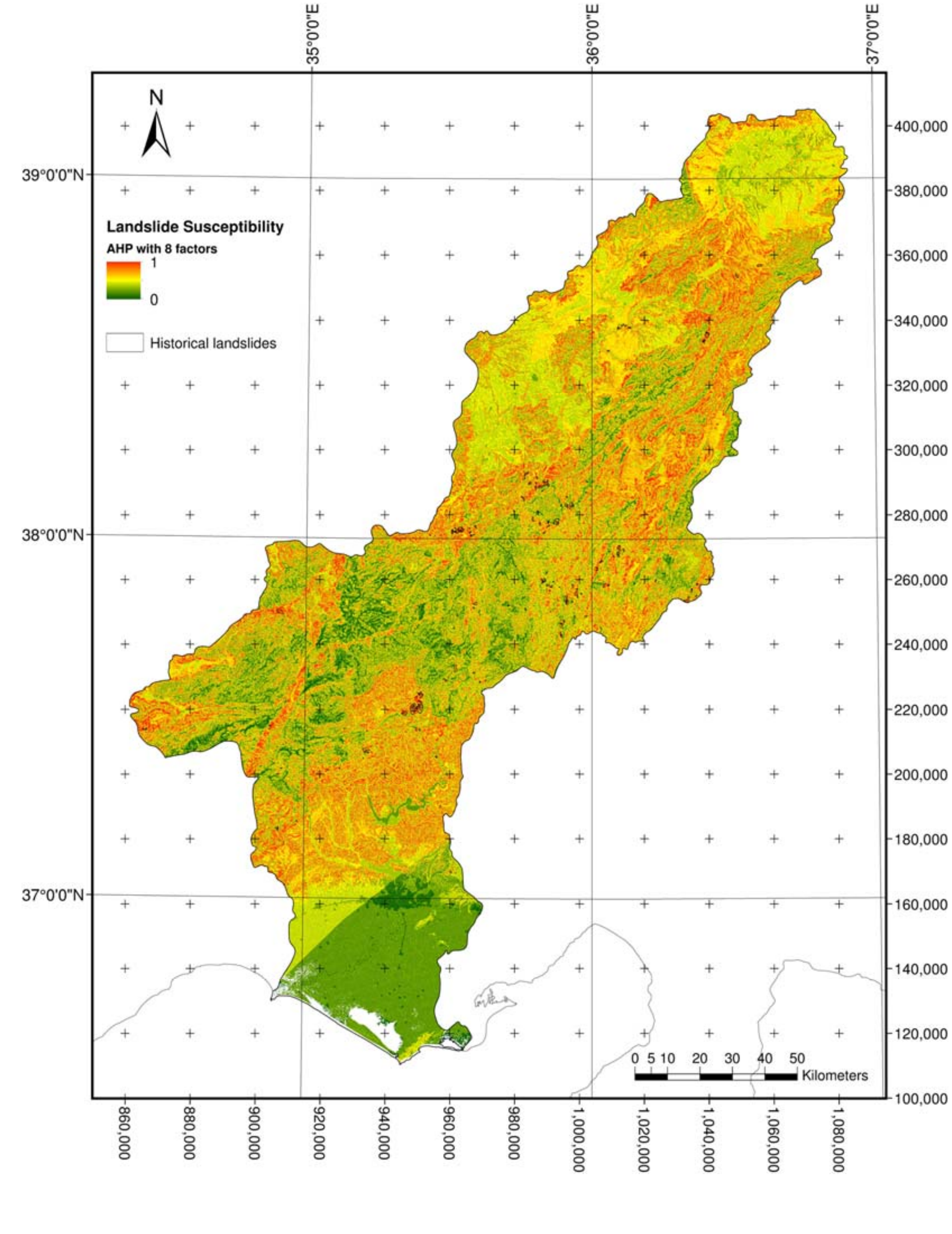


Figure B.33 Unclassified landslide susceptibility map for Watershed-18 (with 8 factors).

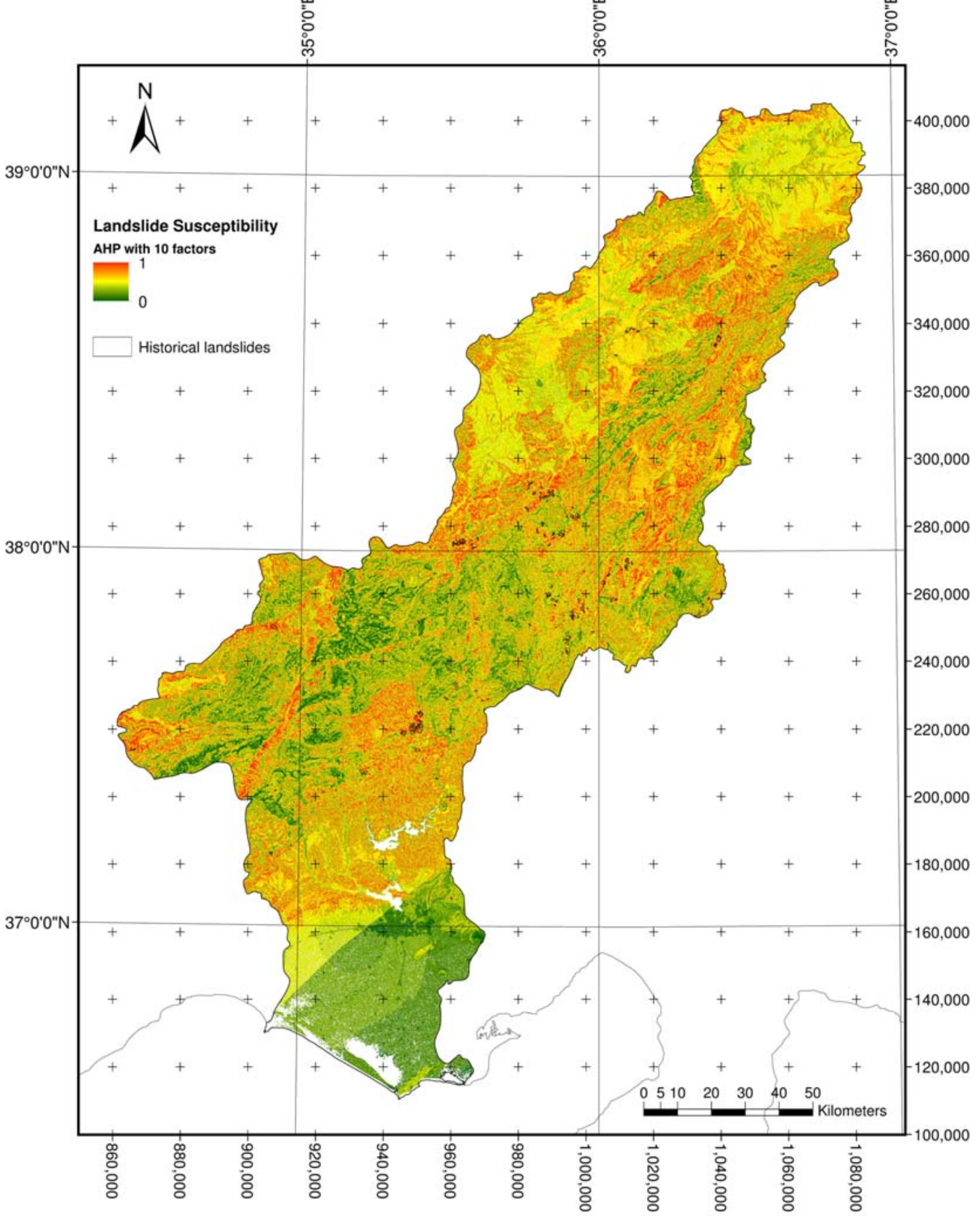


Figure B.34 Unclassified landslide susceptibility map for Watershed-18 (with 10 factors).

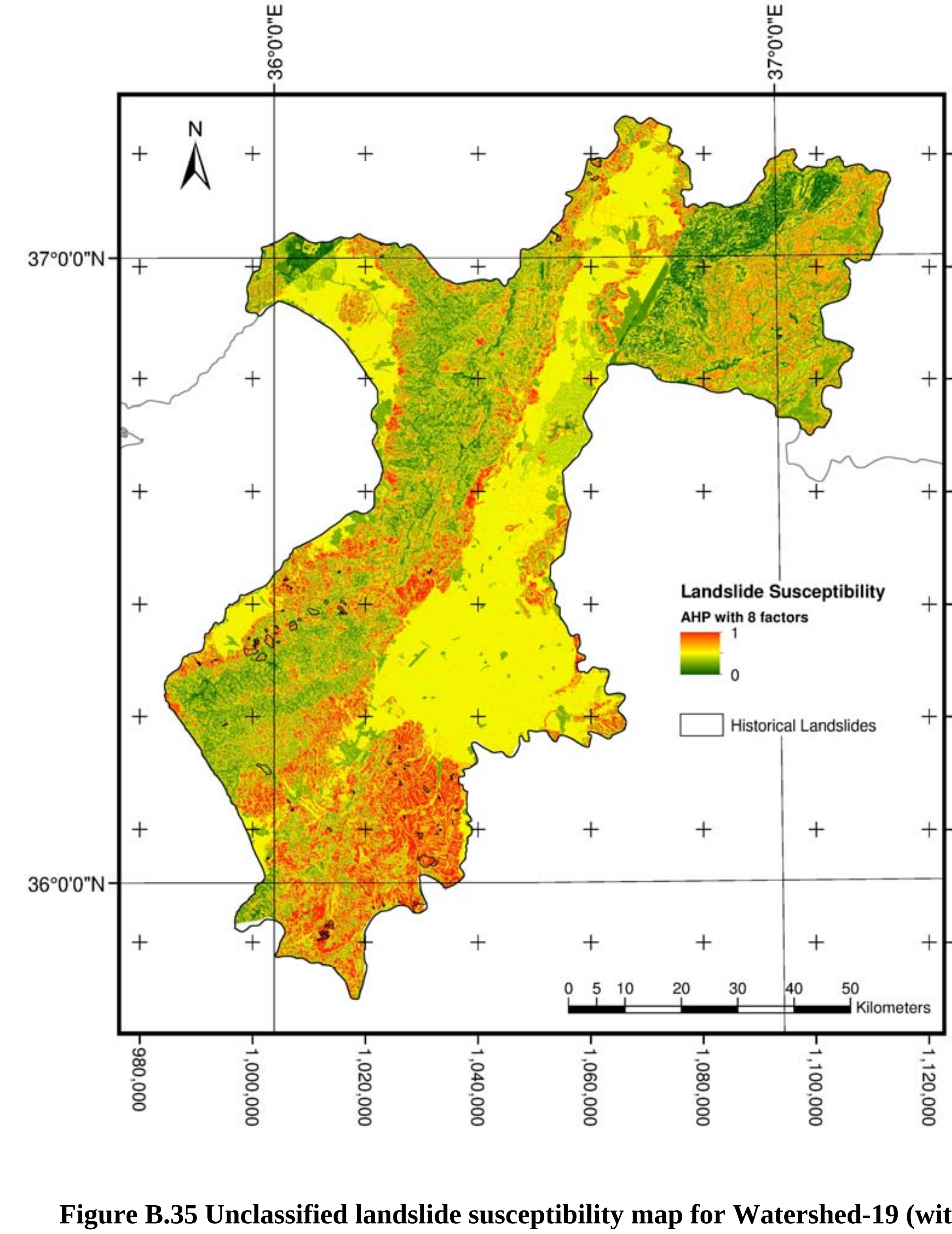


Figure B.35 Unclassified landslide susceptibility map for Watershed-19 (with 8 factors).

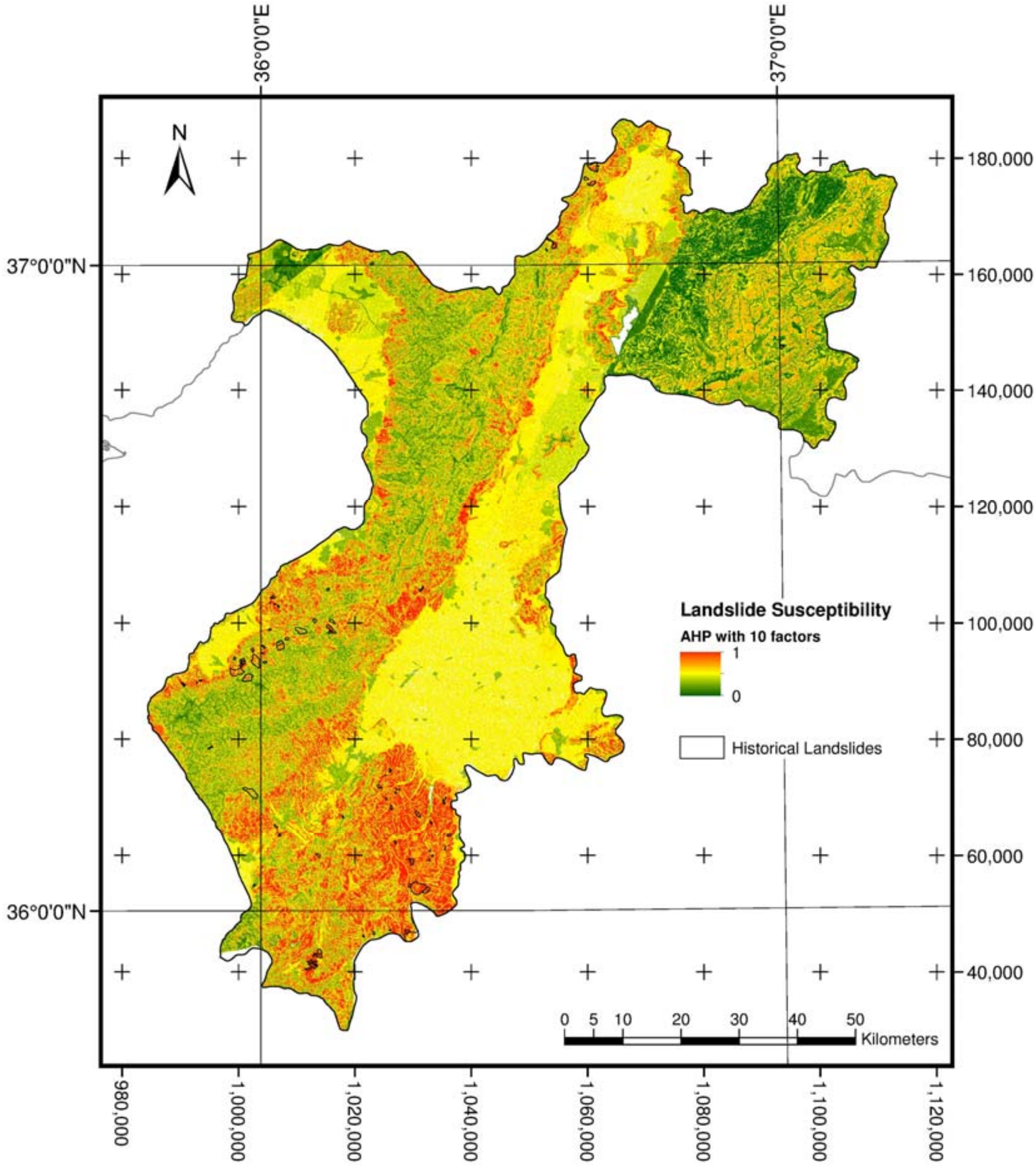


Figure B.36 Unclassified landslide susceptibility map for Watershed-19 (with 10 factors).

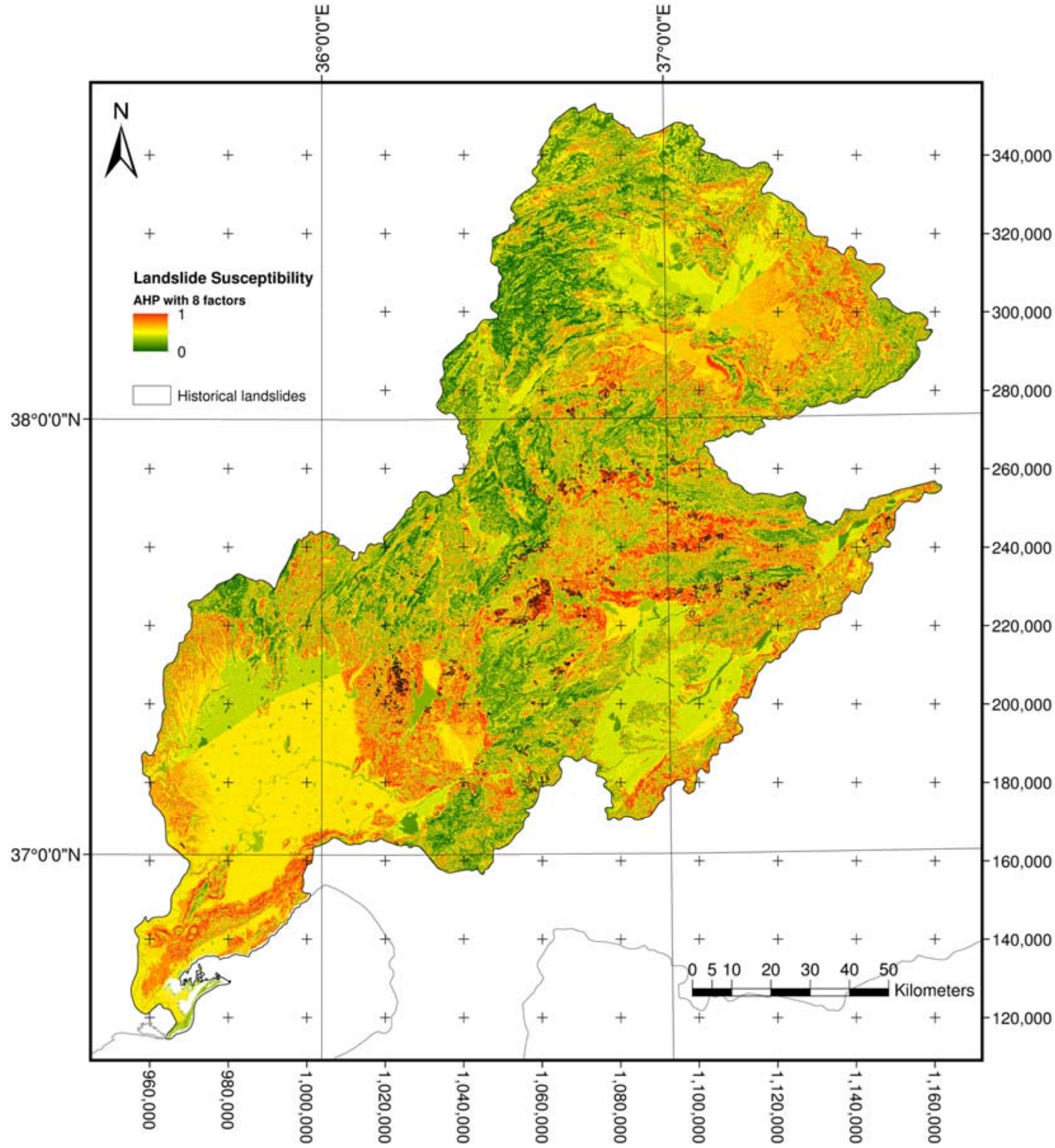


Figure B.37 Unclassified landslide susceptibility map for Watershed-20 (with 8 factors).

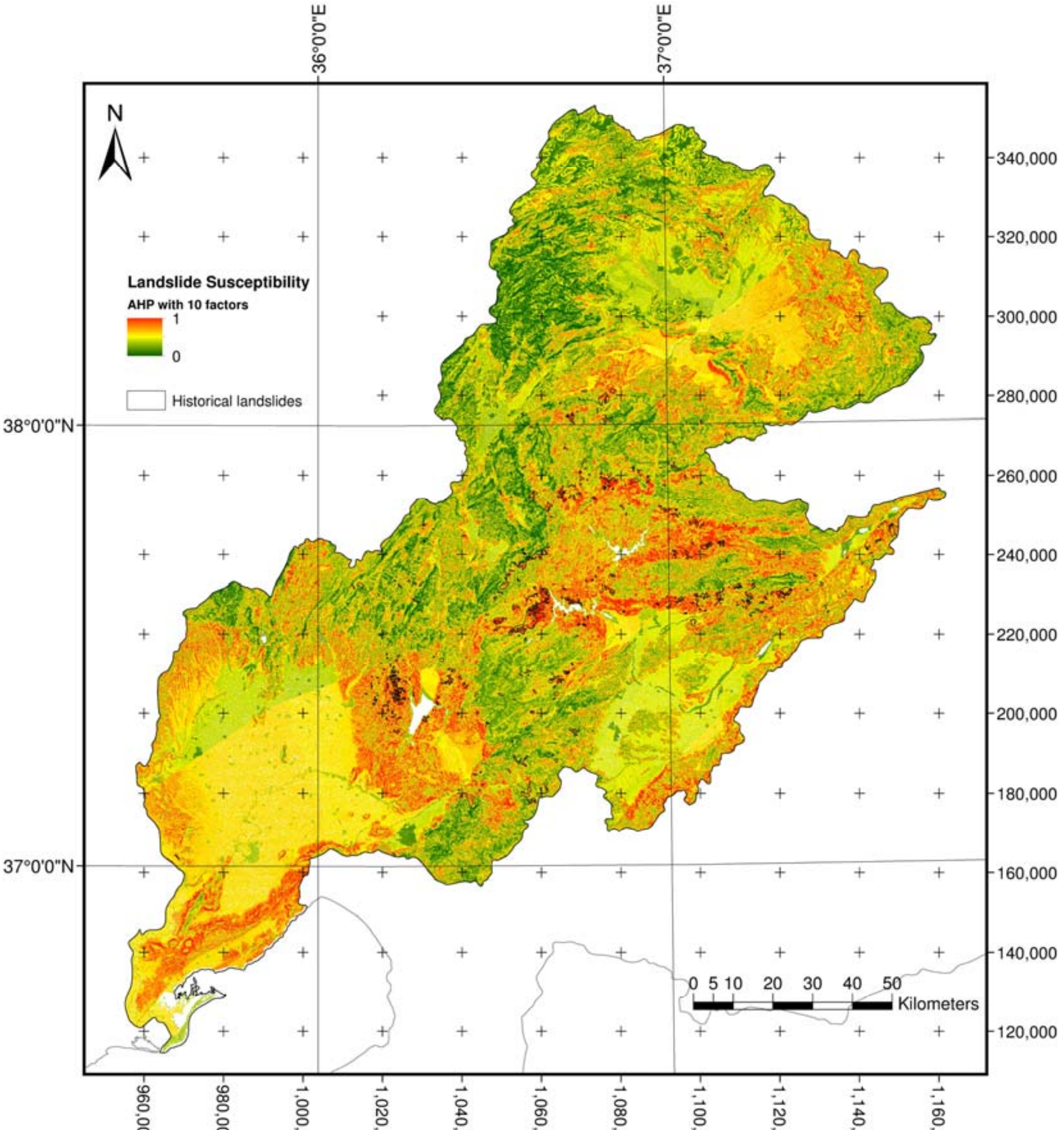


Figure B.38 Unclassified landslide susceptibility map for Watershed-20 (with 10 factors).

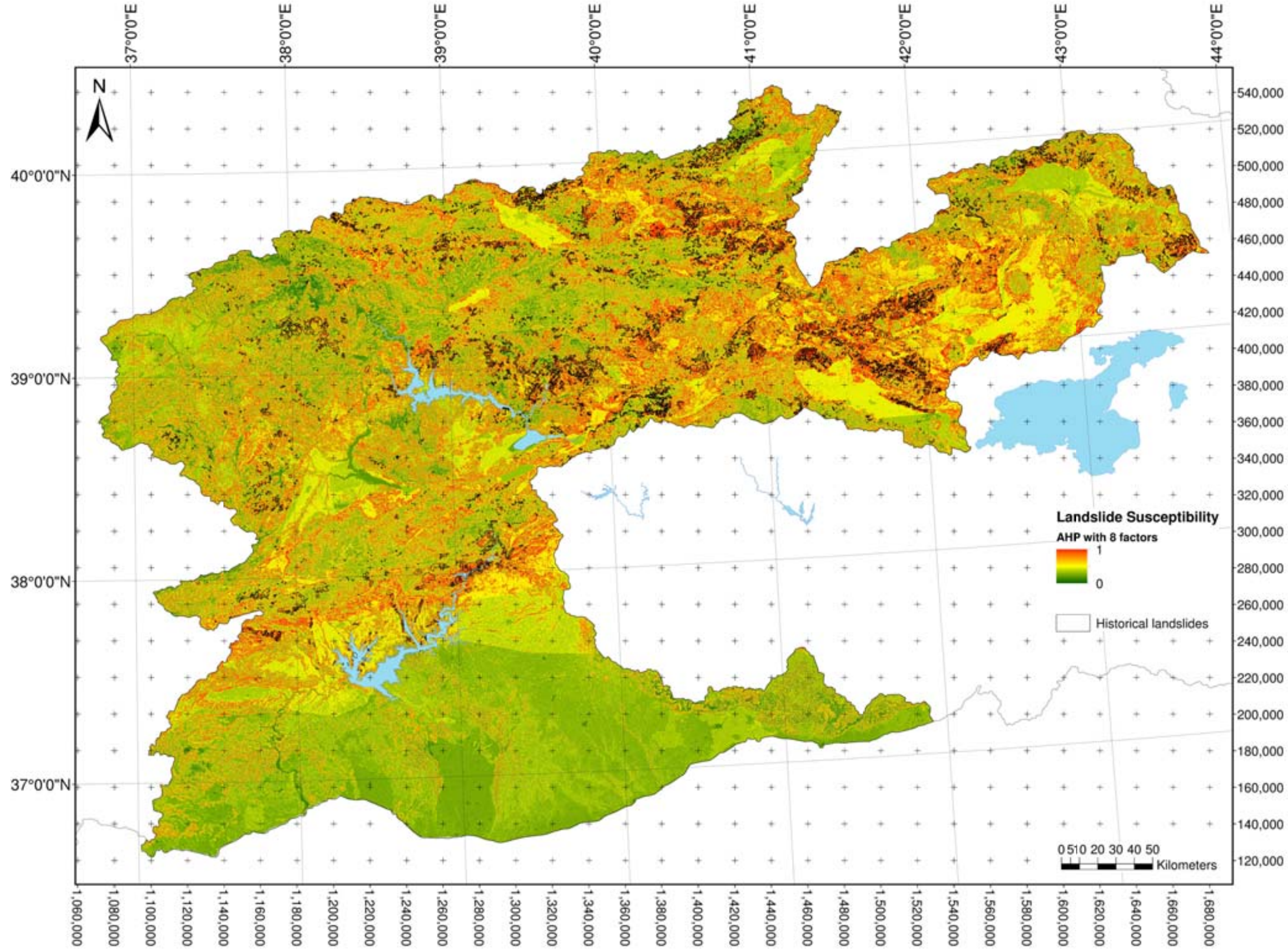


Figure B.39 Unclassified landslide susceptibility map for Watershed-21 (with 8 factors).

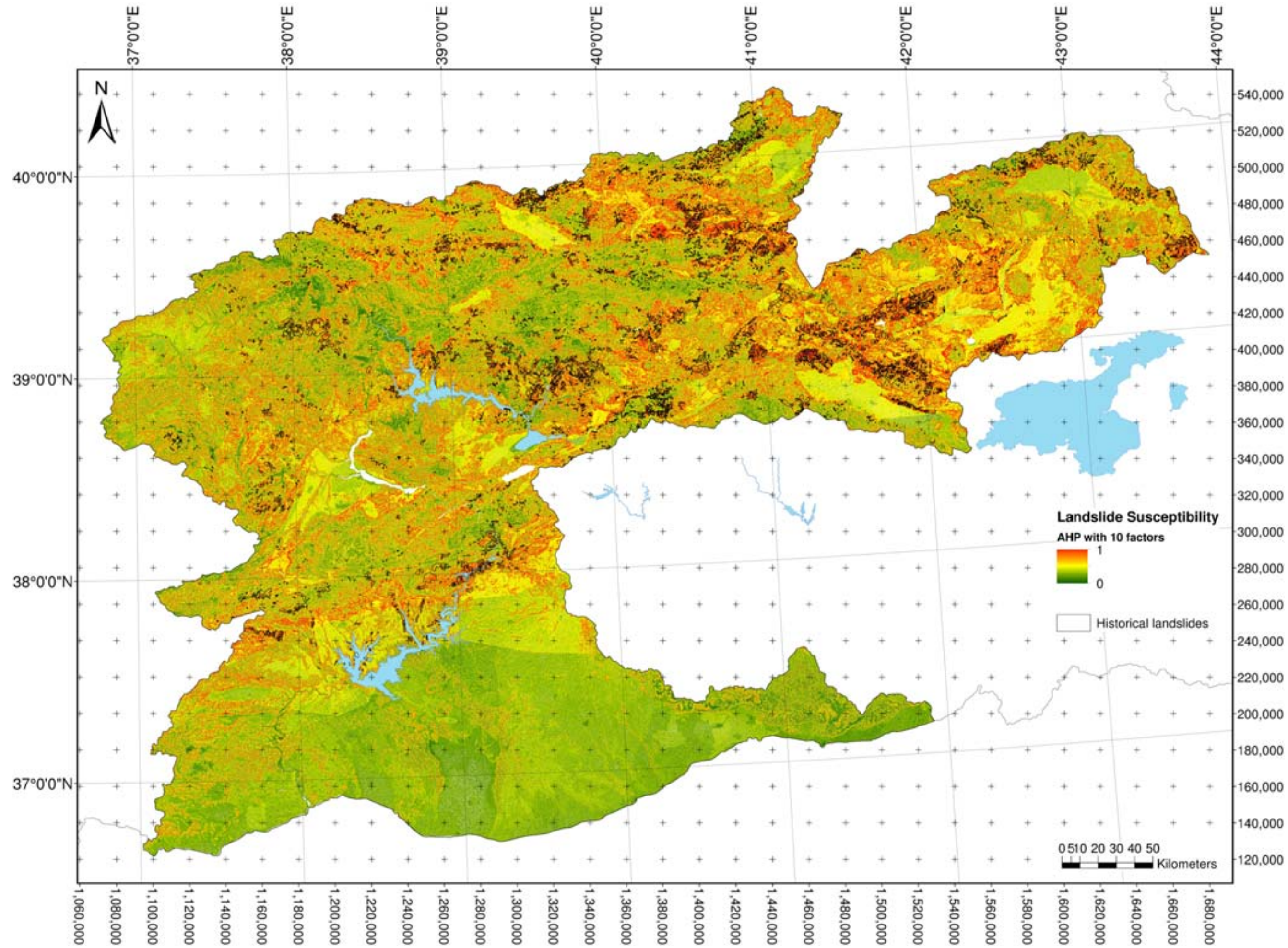


Figure B.40 Unclassified landslide susceptibility map for Watershed-21 (with 10 factors).

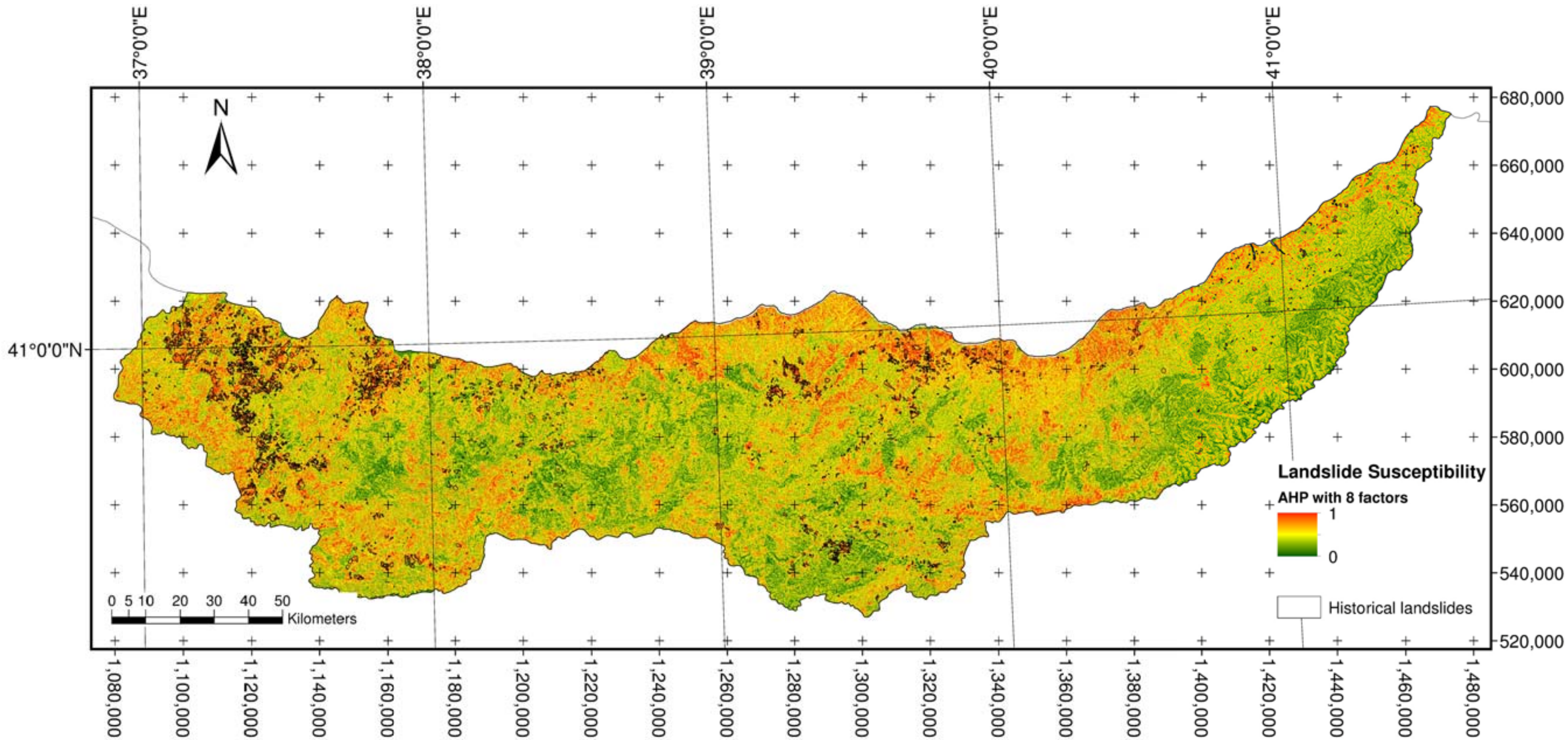


Figure B.41 Unclassified landslide susceptibility map for Watershed-22 (with 8 factors).

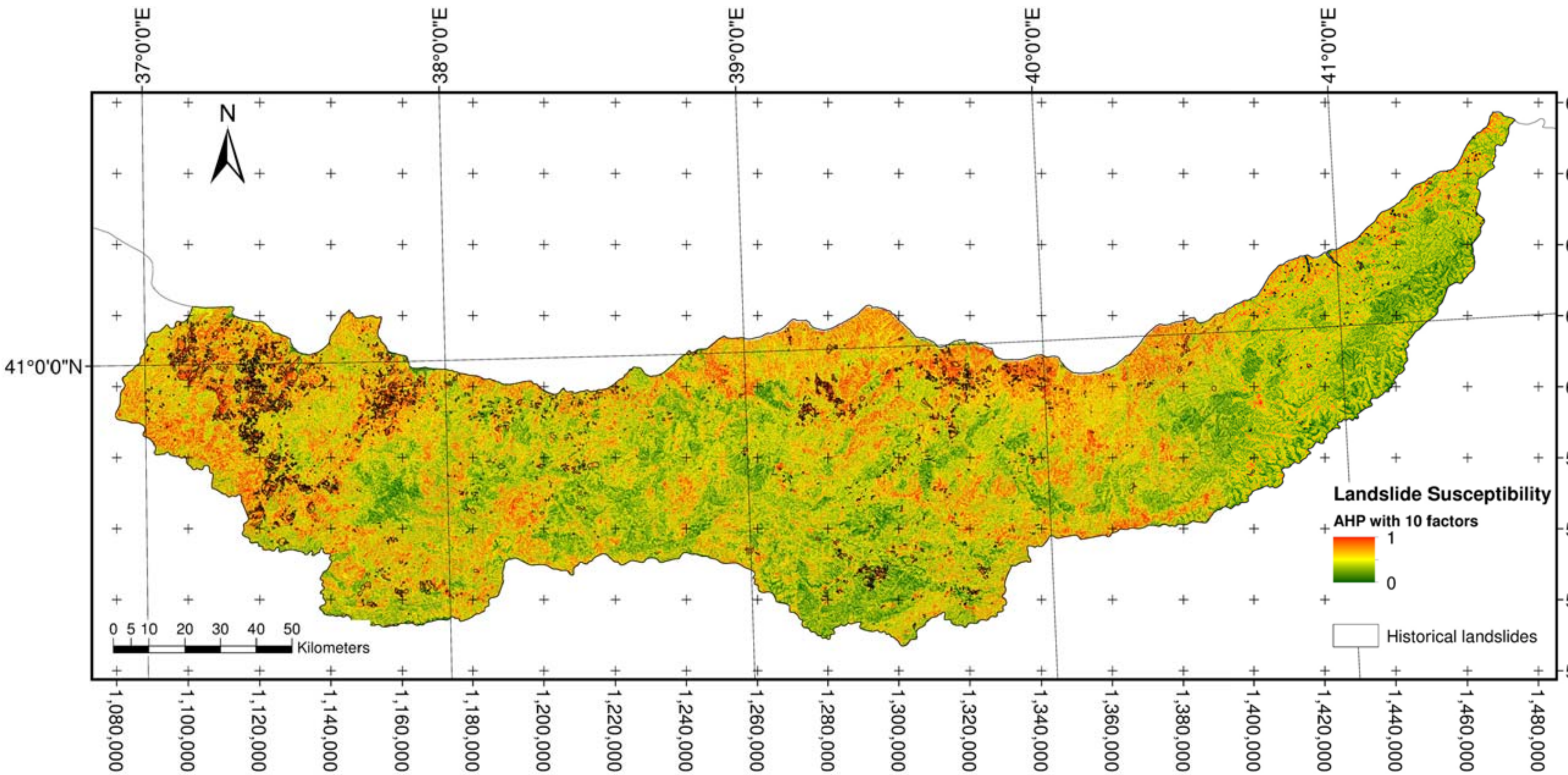


Figure B.42 Unclassified landslide susceptibility map for Watershed-22 (with 10 factors).

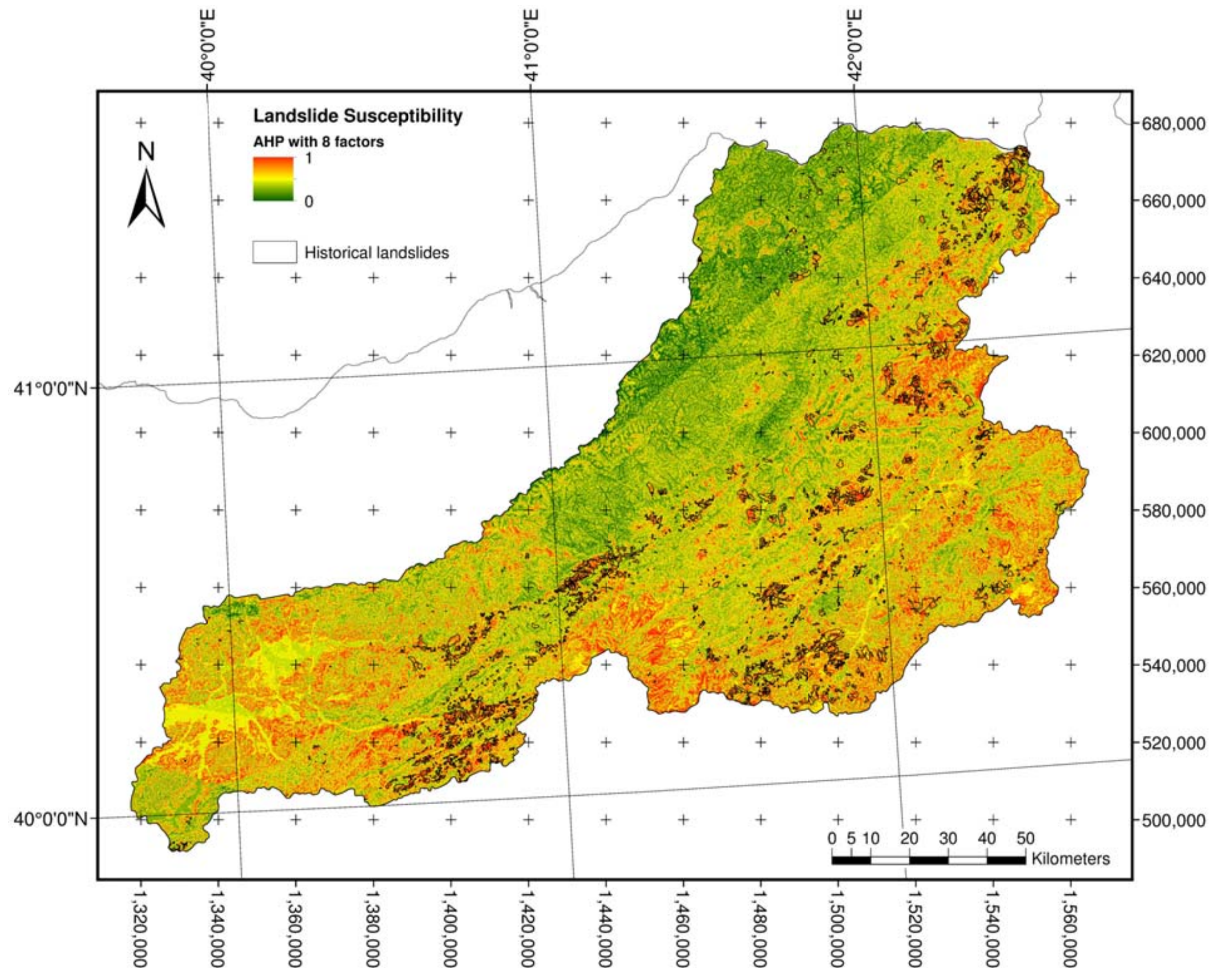


Figure B.43 Unclassified landslide susceptibility map for Watershed-23 (with 8 factors).

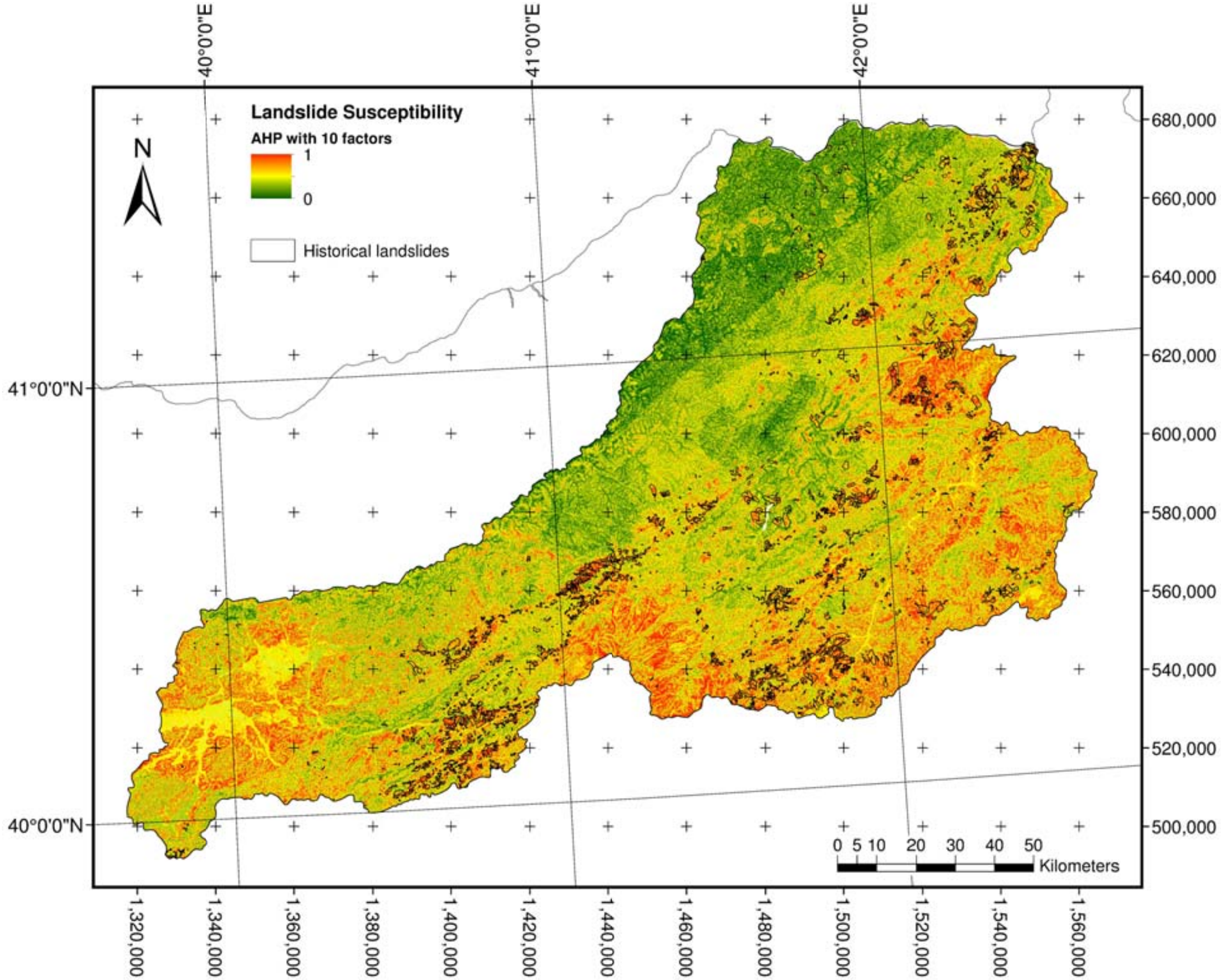


Figure B.44 Unclassified landslide susceptibility map for Watershed-23 (with 10 factors).

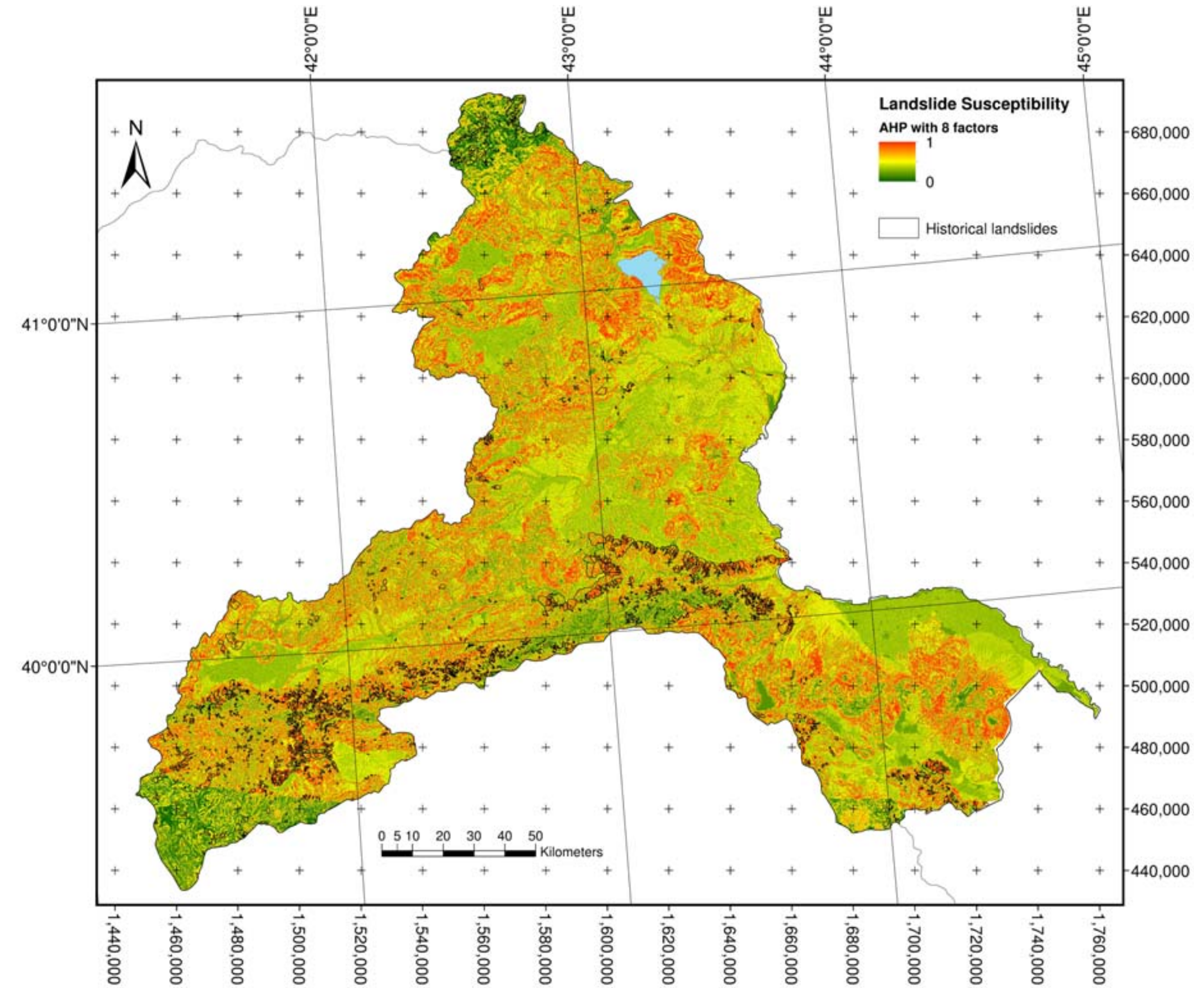


Figure B.45 Unclassified landslide susceptibility map for Watershed-24 (with 8 factors).

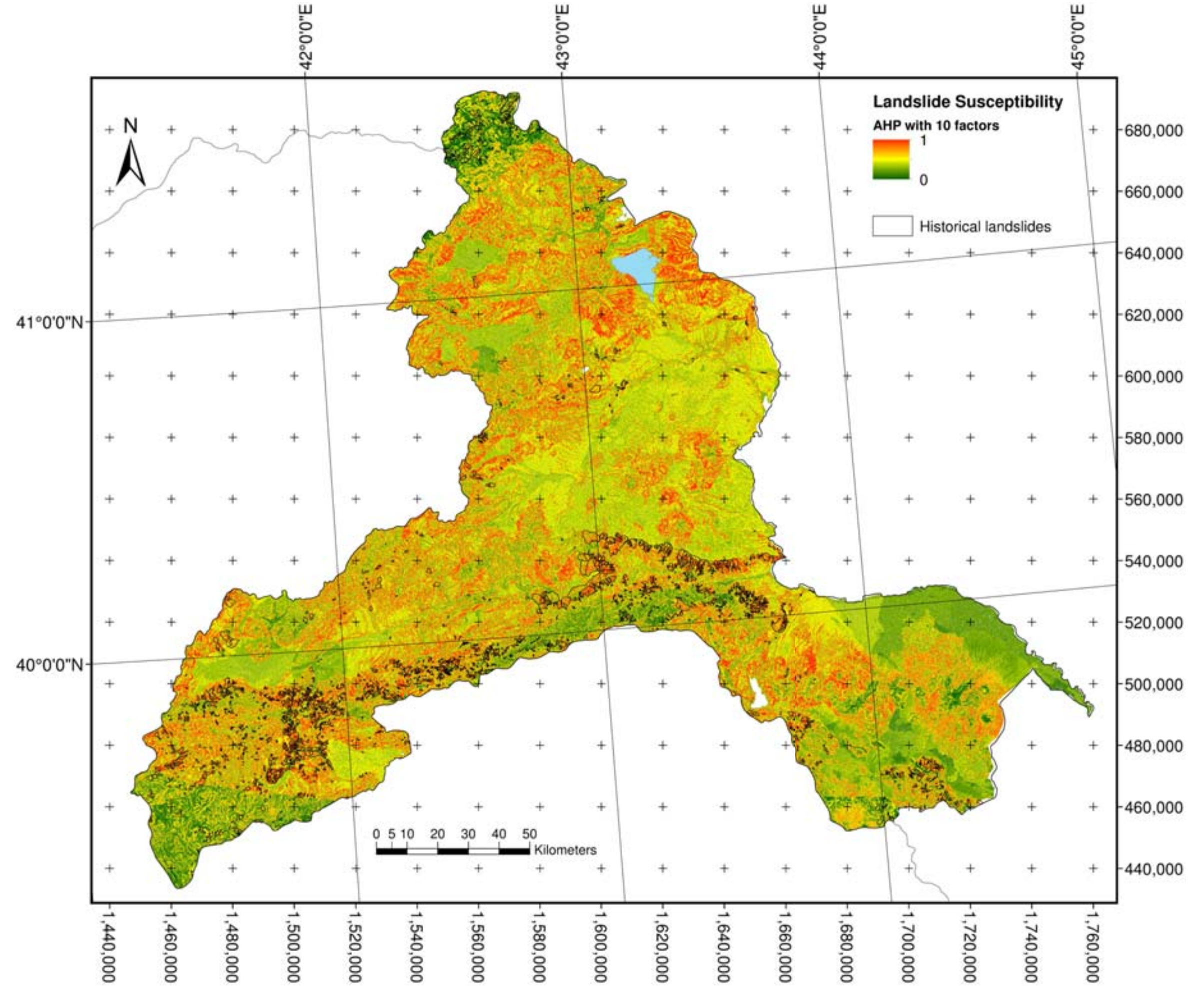


Figure B.46 Unclassified landslide susceptibility map for Watershed-24 (with 10 factors).

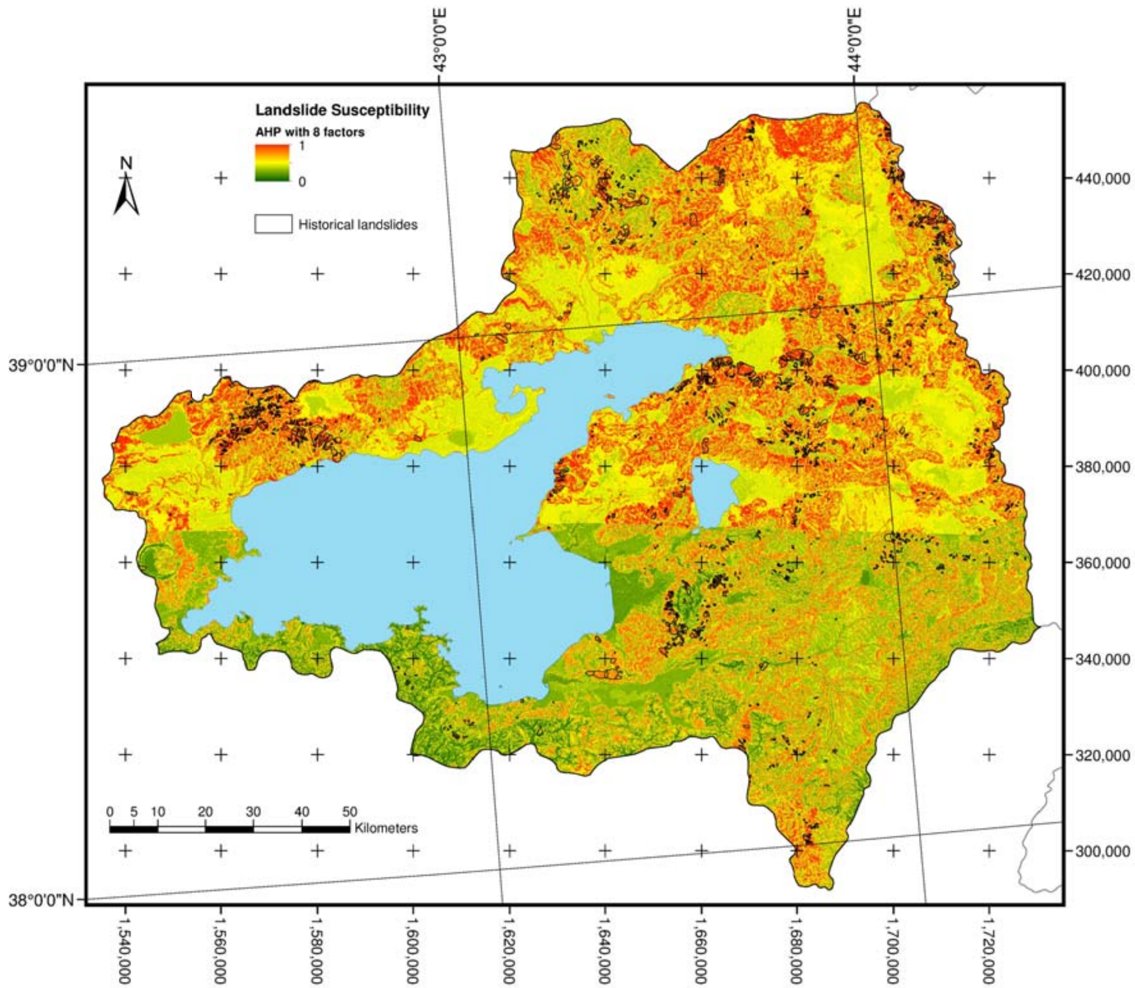


Figure B.47 Unclassified landslide susceptibility map for Watershed-25 (with 8 factors).

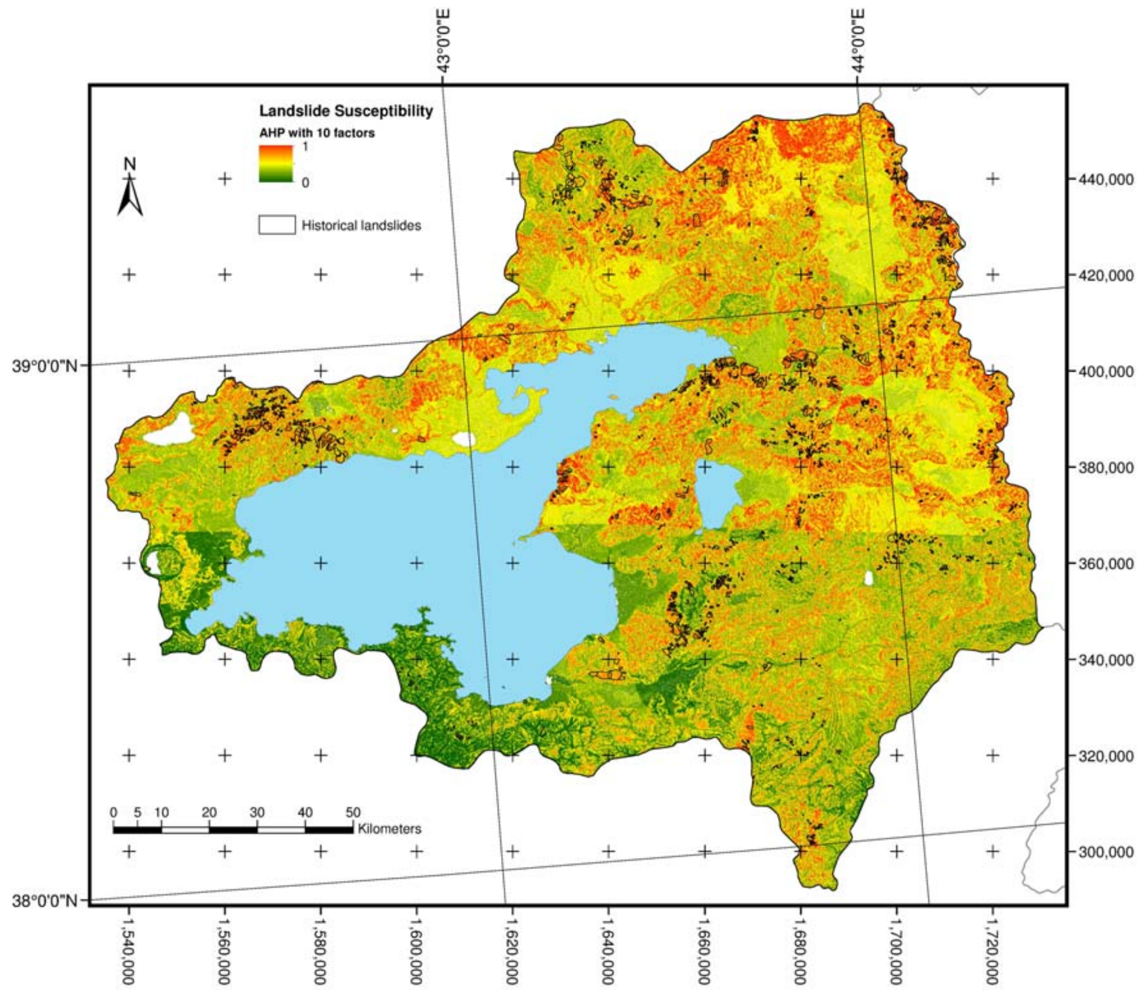


Figure B.48 Unclassified landslide susceptibility map for Watershed-25 (with 10 factors).

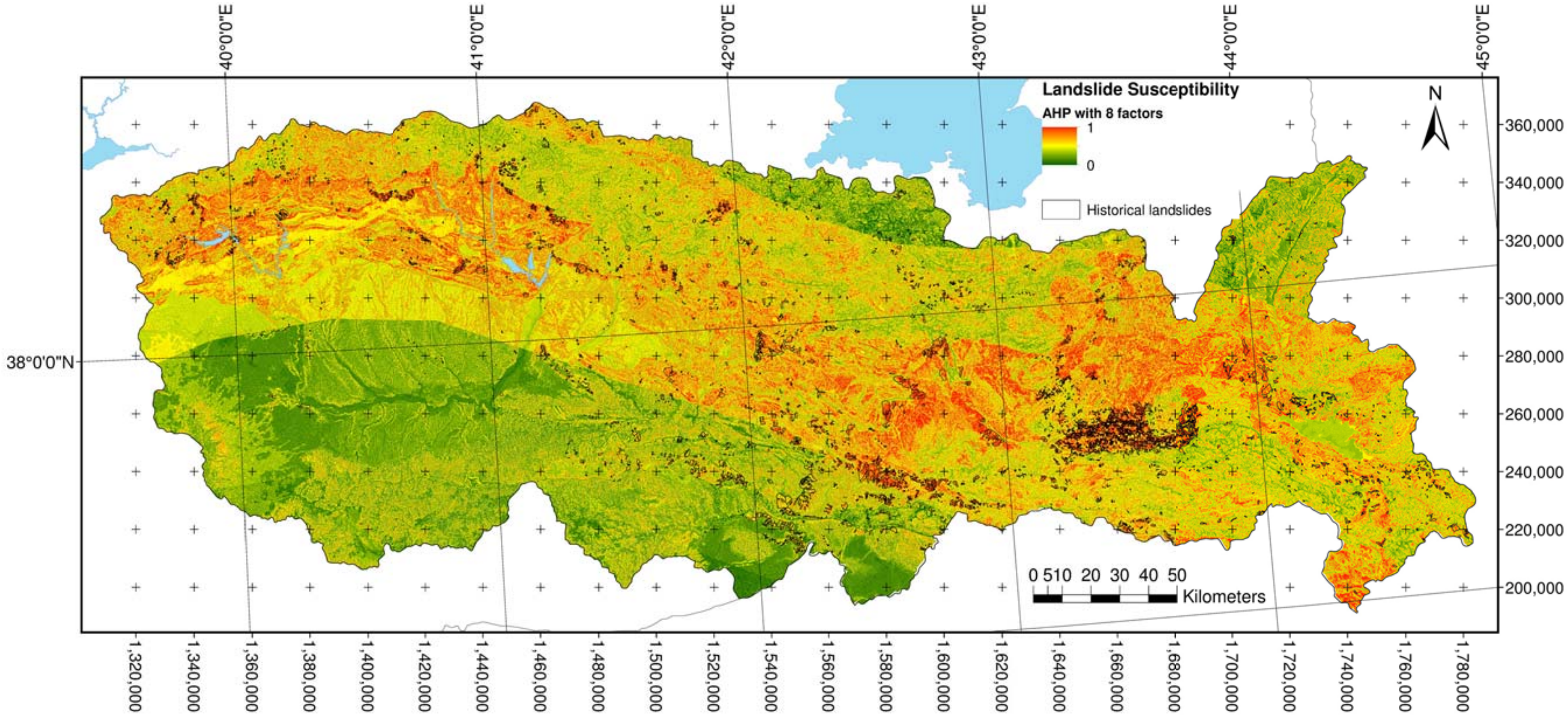


Figure B.49 Unclassified landslide susceptibility map for Watershed-26 (with 8 factors).

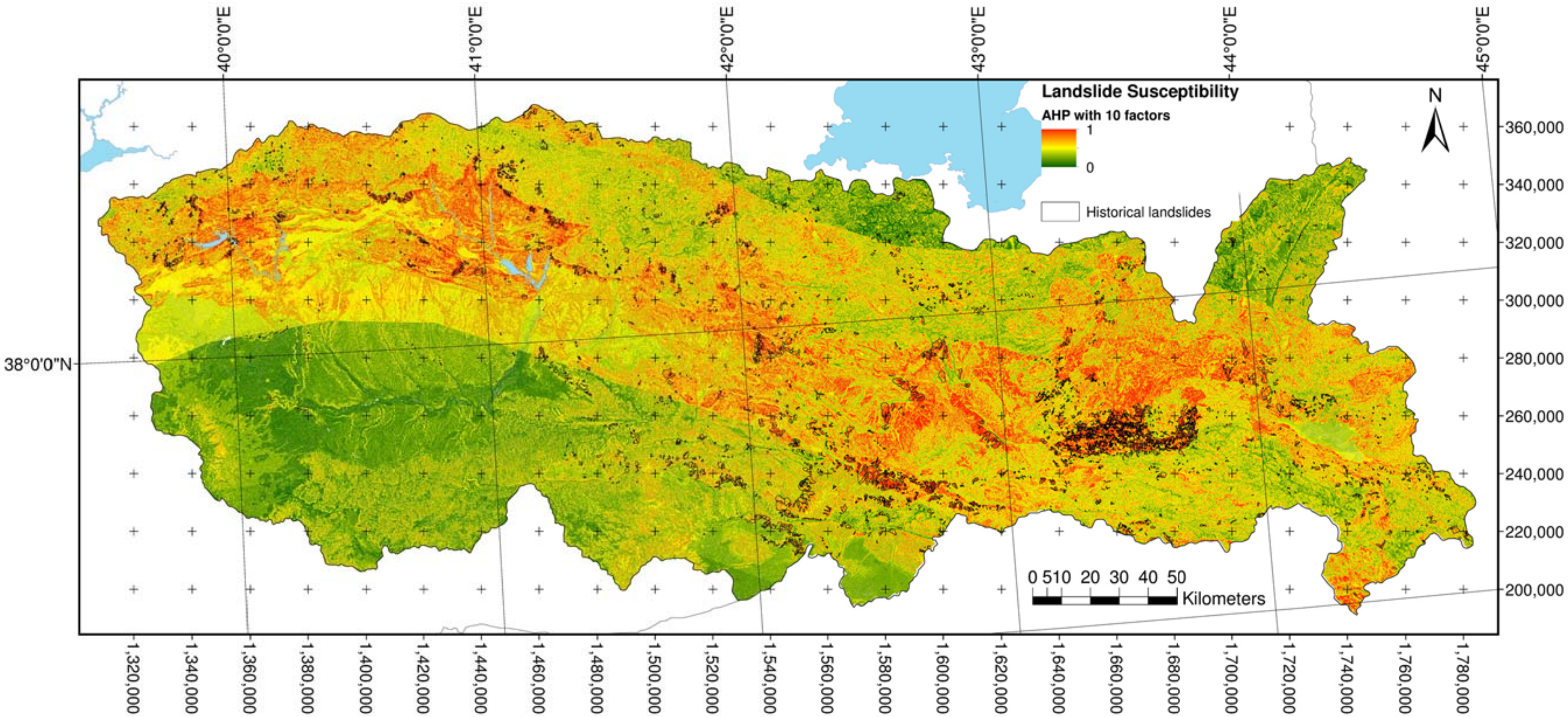


Figure B.50 Unclassified landslide susceptibility map for Watershed-26 (with 10 factors).

APPENDIX C

Table C.1 Synthetically classified lithologies of Turkey.

Lithology Name	*Syhthetically Classified Lithology Name*	*No*
Water bodies	Water bodies	0
Alluvial fan, slope debris, moraine etc. Undifferentiated quaternary Beach and dune	Young deposits	1
Andesite Andesite, basalt	Andesite	2
Undifferantiated andesite, pyroclastics etc. Undifferentiated volcanic rocks	Undifferentiated volcanic rocks	3
Basalt Basalt, spilite, etc. Basalt, spilite Basalt, spilite, andesite etc. Undifferentiated basic and ultrabasic rocks	Basalt	4
Dacite Dacite, rhyolite, rhyodacite	Dacite	5
Gabbro Gabbro, diabase	Gabbro	6
Gneiss Gneiss, schist Migmatite, gneiss	Gneiss	7

Table C.1 Synthetically classified lithologies of Turkey (continued).

Lithology Name	*Syhthetically Classified Lithology Name*	*No*
Undifferentiated continental clastic rocks Continental clastic rocks Continental clastic rocks (coaly)	Continental clastic rocks	8
Carbonate rocks Lacustrine carbonate rocks	Carbonate rocks	9
Carbonate and clastic rocks Carbonate and clastic rocks (continental in places) Carbonate rocks and clastic rocks in places Clastic and carbonate rocks Clastic and carbonate rocks (blocks and volcanic rocks in places) Clastic and carbonate rocks (flysch) Clastic rocks Clastic rocks (continental in places) Clastic rocks, carbonate rocks in places	Clastic and carbonate rocks	10
Limestone Neritic limestone Pelagic limestone Pelagic limestone, clastic rocks, radiolarite, chert etc.	Limestone	11
Lacustrine limestone, marn, shale	Limestone, marl, shale	12
Cherty marble Marble Marble, schist in places	Marble	13

Table C.1 Synthetically classified lithologies of Turkey (continued).

Lithology Name	***Syhthetically Classified Lithology Name***	***No***
Amphibolites		
Schist, calcschist etc.		
Contact metamorphic rocks		
Quartzite, marble		
Quartzite, quartzschist		
Schist, quartzite, marble etc.		
Schists		
Metaclastic and metacarbonate rocks		
Metagranitoids	Metamorpic rocks	14
Metamelange		
Metaultrabasic rocks		
Metavolcanic rocks		
Schist, phyllite etc.		
Schist, phyllite, marble, metabasic rocks etc.		
Schist, porphyroid		
Undifferentiated gneiss, metagranite, schist, marble, amphibolite etc.		
Undifferentiated gneiss, migmatite, metagranite, schist, amphibolite etc.		
Flisch	Flisch	15

Table C.1 Synthetically classified lithologies of Turkey (continued).

Lithology Name	*Syhthetically Classified Lithology Name*	*No*
Pelagic limestone, radiolarite, chert, clastic rocks etc. (ophiolitic sheet in places) Pelogic limestone, radiolarite, chert, shale etc. (volcanic rocks in places) Sheeted dyke complex Ophiolitic melange Pillow lava and sedimentary rocks Serpentinite Subophiolitic metamorphic rocks Dunite Gabbro, dunite etc. (cumulative rocks) Harzburgite Peridotite	Ophiolitic rocks	16
Phyllite	Phyllite	17
Pyroclastic rocks Pyroclastic rocks (ophiolitic sheet in places)	Pyroclastic rocks	18
Travertine	Travertine	19
Granite, granodiorite Granitoids	Granitoid	20
Volcanic and sedimantary rocks	Volcanic and sedimentary rocks	21
Evaporite sedimentary rocks	Gypsum	22
Diorite, tonalite Monzonite Syenite	Plutonic rocks	23

APPENDIX D

PIXEL COUNTS FOR WATERSHEDS

Table D.1 Pixel counts in and out of historical landslide boundaries for Watershed-2.

Bin	***8 Factors (out of LS)***	***8 Factors (in LS)***	***10 Factors (out of LS)***	***10 Factors (in LS)***
0	0	0	0	0
0.1	1679	0	1511	0
0.2	31326	1	84043	0
0.3	156088	4	487323	3
0.4	376831	60	611688	43
0.5	512888	223	914240	262
0.6	589329	413	370454	641
0.7	484393	681	162867	1050
0.8	302601	741	104862	1310
0.9	189457	722	21724	1206
1	116959	277	1116	331

Table D.2 Pixel counts in and out of historical landslide boundaries for Watershed-3.

Bin	***8 Factors (out of LS)***	***8 Factors (in LS)***	***10 Factors (out of LS)***	***10 Factors (in LS)***
0	0	0	0	0
0.1	4226	0	18	0
0.2	48459	0	18339	0
0.3	266626	2	132985	1
0.4	414504	9	377334	2
0.5	592515	26	542082	24
0.6	598083	65	690743	61
0.7	482598	113	580628	131
0.8	317455	115	366986	127
0.9	163288	90	177701	85
1	50499	16	51429	12

Table D.3 Pixel counts in and out of historical landslide boundaries for Watershed-4.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	1818	0	0	0
0.2	5103	0	159	0
0.3	22402	0	19250	0
0.4	132132	0	99924	0
0.5	358808	0	328221	0
0.6	248309	1	311944	1
0.7	162037	12	190899	11
0.8	162694	7	176366	9
0.9	107751	1	86766	0
1	22585	0	10111	0

Table D.4 Pixel counts in and out of historical landslide boundaries for Watershed-5.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	1661	0	1294	0
0.2	6827	0	5618	0
0.3	121036	0	49885	0
0.4	258228	5	197385	0
0.5	538185	9	417898	8
0.6	418300	36	552154	25
0.7	294254	65	376719	79
0.8	222544	80	264557	99
0.9	137330	76	145098	64
1	52241	11	39995	10

Table D.5 Pixel counts in and out of historical landslide boundaries for Watershed-6.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	0	0	0	0
0.2	80	0	19	0
0.3	80479	0	56727	0
0.4	125151	6	134048	6
0.5	249088	4	254751	2
0.6	191959	7	212616	8
0.7	104862	7	110584	12
0.8	62396	12	59185	9
0.9	28198	18	17159	17
1	5142	6	2266	6

Table D.6 Pixel counts in and out of historical landslide boundaries for Watershed-7.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	3534	0	1316	0
0.2	31753	0	15607	0
0.3	192611	0	108541	0
0.4	423911	11	349710	4
0.5	1003777	48	823185	33
0.6	512231	106	776873	104
0.7	419872	180	482639	199
0.8	325709	265	367263	283
0.9	173247	145	183669	147
1	68493	16	46324	12

Table D.7 Pixel counts in and out of historical landslide boundaries for Watershed-8.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	1345	0	0	0
0.2	16443	0	5198	0
0.3	92307	6	68824	0
0.4	331629	19	323233	12
0.5	603158	66	615383	56
0.6	590628	163	644801	154
0.7	371530	301	384018	341
0.8	285988	258	306323	268
0.9	200966	70	171637	59
1	57495	2	32064	0

Table D.8 Pixel counts in and out of historical landslide boundaries for Watershed-9.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	0	0	0	0
0.2	235	0	56	0
0.3	236564	3	166745	3
0.4	367874	41	394021	24
0.5	732179	122	748819	112
0.6	564250	389	624966	365
0.7	308235	619	325053	488
0.8	183409	366	173968	515
0.9	82887	70	50436	124
1	15114	6	6661	6

Table D.9 Pixel counts in and out of historical landslide boundaries for Watershed-10.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	633	0	0	0
0.2	0	0	0	0
0.3	617	0	852	0
0.4	17365	0	30105	0
0.5	273799	0	217350	0
0.6	157660	4	197721	5
0.7	94804	14	106514	20
0.8	73499	23	91702	23
0.9	73561	10	65652	6
1	32858	0	14898	1

Table D.10 Pixel counts in and out of historical landslide boundaries for Watershed-11.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	2868	0	150	0
0.2	11699	0	6879	0
0.3	211493	1	82849	0
0.4	226796	16	242580	16
0.5	175485	18	277771	22
0.6	114192	24	153001	21
0.7	90198	34	98167	43
0.8	63691	81	55118	92
0.9	28933	46	13840	53
1	6432	16	1419	2

Table D.11 Pixel counts in and out of historical landslide boundaries for Watershed-12.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	14363	0	1215	0
0.2	96777	2	33762	0
0.3	439199	17	236198	12
0.4	1803231	80	1306849	51
0.5	2028529	261	2237851	243
0.6	981047	697	1406285	717
0.7	776794	1090	917699	1258
0.8	741093	976	809957	1005
0.9	399497	368	402323	273
1	128796	45	57152	16

Table D.12 Pixel counts in and out of historical landslide boundaries for Watershed-13.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	624	0	127	0
0.2	25449	3	2726	0
0.3	184503	36	73297	12
0.4	474787	270	372163	142
0.5	762034	1022	777510	710
0.6	704723	2161	839424	2266
0.7	614762	3670	669692	4098
0.8	444706	3847	504006	3995
0.9	222900	1353	249937	1228
1	121544	202	67145	118

Table D.13 Pixel counts in and out of historical landslide boundaries for Watershed-14.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	3846	0	239	0
0.2	73315	1	14532	0
0.3	246562	10	150650	6
0.4	777987	57	563216	30
0.5	930280	263	1006125	195
0.6	898104	758	1025020	672
0.7	715649	1351	805044	1346
0.8	547921	1486	660335	1629
0.9	362562	1001	420101	1110
1	302185	161	213123	124

Table D.14 Pixel counts in and out of historical landslide boundaries for Watershed-15.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	1680	0	62	0
0.2	48298	1	16024	0
0.3	457519	35	242134	15
0.4	1749601	242	1365342	175
0.5	2669823	858	2413316	742
0.6	1566643	1783	2121208	1625
0.7	994900	2407	1334068	2471
0.8	1156403	2015	1219141	2283
0.9	1001963	706	970455	808
1	208559	61	173561	66

Table D.15 Pixel counts in and out of historical landslide boundaries for Watershed-16.

Bin	***8 Factors (out of LS)***	***8 Factors (in LS)***	***10 Factors (out of LS)***	***10 Factors (in LS)***
0	0	0	0	0
0.1	1451	0	93	0
0.2	39867	0	9847	0
0.3	460707	2	145531	1
0.4	1252784	3	929192	4
0.5	2087042	9	2045627	8
0.6	1084278	10	1607961	13
0.7	387467	13	531311	19
0.8	346885	22	415937	17
0.9	233827	7	219362	8
1	33645	0	23085	0

Table D.16 Pixel counts in and out of historical landslide boundaries for Watershed-17.

Bin	***8 Factors (out of LS)***	***8 Factors (in LS)***	***10 Factors (out of LS)***	***10 Factors (in LS)***
0	0	0	0	0
0.1	4229	0	133	0
0.2	52661	0	3675	0
0.3	262175	6	91724	0
0.4	501456	26	398305	12
0.5	585571	105	640014	62
0.6	486505	211	629487	218
0.7	367952	267	453936	322
0.8	270980	222	318128	223
0.9	107058	70	107082	73
1	16913	3	13012	2

Table D.17 Pixel counts in and out of historical landslide boundaries for Watershed-18.

Bin	***8 Factors (out of LS)***	***8 Factors (in LS)***	***10 Factors (out of LS)***	***10 Factors (in LS)***
0	0	0	0	0
0.1	287	0	2	0
0.2	6884	0	164	0
0.3	116814	0	40557	0
0.4	396107	0	267561	0
0.5	552031	10	498304	2
0.6	594910	36	699947	34
0.7	431265	64	561354	72
0.8	299045	96	347657	92
0.9	213952	28	213048	40
1	44295	1	26992	0

Table D.18 Pixel counts in and out of historical landslide boundaries for Watershed-19.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	1594	0	308	0
0.2	8202	0	7529	0
0.3	25645	0	21429	0
0.4	126486	1	76112	1
0.5	166441	4	172859	3
0.6	347195	20	332321	14
0.7	122465	30	187837	31
0.8	80268	23	76241	29
0.9	48074	19	51596	17
1	20794	7	20930	9

Table D.19 Pixel counts in and out of historical landslide boundaries for Watershed-20.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	17979	0	7688	0
0.2	102588	0	75580	0
0.3	271994	12	246473	9
0.4	378001	27	374656	20
0.5	544938	77	591230	78
0.6	680947	160	704335	162
0.7	312993	237	318542	241
0.8	169185	223	170978	247
0.9	89620	108	84995	105
1	26853	11	20607	8

Table D.20 Pixel counts in and out of historical landslide boundaries for Watershed-21.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	3596	0	209	0
0.2	202085	5	56727	2
0.3	1332509	65	664256	21
0.4	3985225	443	3488250	293
0.5	3133547	1462	3835745	1308
0.6	1925690	2945	2327503	3092
0.7	1471981	3973	1633306	4355
0.8	1282412	3482	1449236	3749
0.9	904104	1482	902957	1331
1	229027	156	111767	81

Table D.21 Pixel counts in and out of historical landslide boundaries for Watershed-22.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	993	0	6	0
0.2	26454	2	6765	0
0.3	226586	9	161259	8
0.4	504328	60	490529	47
0.5	628801	253	693093	245
0.6	583153	740	657359	740
0.7	421580	1155	455859	1248
0.8	258600	793	241427	788
0.9	126365	157	92587	102
1	33065	10	11041	3

Table D.22 Pixel counts in and out of historical landslide boundaries for Watershed-23.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	4143	0	1567	0
0.2	78962	1	49896	1
0.3	307855	4	231590	2
0.4	486101	48	450725	37
0.5	532687	217	562665	192
0.6	418681	648	509605	666
0.7	281151	1148	329135	1228
0.8	229443	695	238360	691
0.9	130768	152	109056	107
1	22586	11	9776	2

Table D.23 Pixel counts in and out of historical landslide boundaries for Watershed-24.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	94	0	59	0
0.2	11593	0	2208	0
0.3	33303	8	20077	2
0.4	236435	62	123375	37
0.5	664812	220	563534	154
0.6	998130	462	1014401	438
0.7	485626	818	662396	844
0.8	358499	1089	429756	1210
0.9	459022	464	476847	482
1	170219	49	125045	37

Table D.24 Pixel counts in and out of historical landslide boundaries for Watershed-25.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	82	0	30	0
0.2	24833	0	10083	0
0.3	340948	6	68979	0
0.4	483961	47	202202	25
0.5	453338	125	458584	132
0.6	301884	298	600292	342
0.7	191959	436	359904	664
0.8	190586	441	289778	664
0.9	165574	264	190401	257
1	55969	39	28436	17

Table D.25 Pixel counts in and out of historical landslide boundaries for Watershed-26.

Bin	*8 Factors (out of LS)*	*8 Factors (in LS)*	*10 Factors (out of LS)*	*10 Factors (in LS)*
0	0	0	0	0
0.1	5005	0	133	0
0.2	71236	2	34354	0
0.3	685288	37	517642	22
0.4	1198117	176	1236253	125
0.5	1440982	724	1555858	655
0.6	1294432	1224	1416683	1328
0.7	842828	1290	882008	1423
0.8	532656	1049	526744	1066
0.9	271734	513	217918	434
1	79532	67	34199	47

APPENDIX E

ROC CURVES

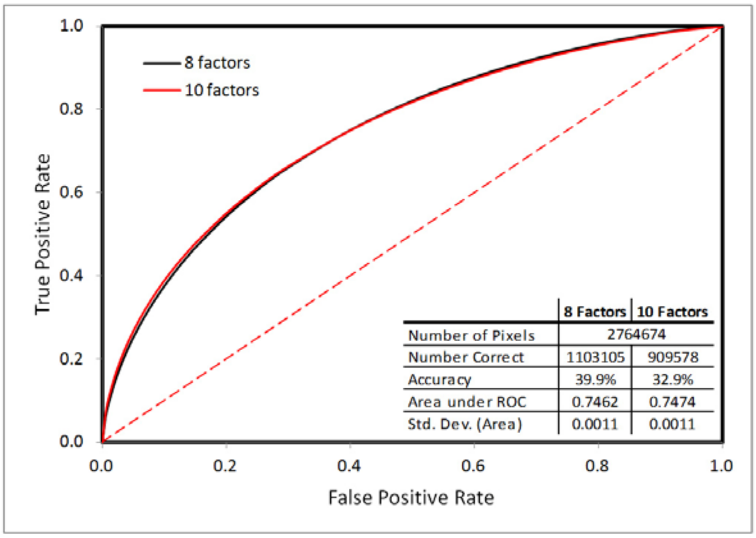


Figure E.1 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-2.

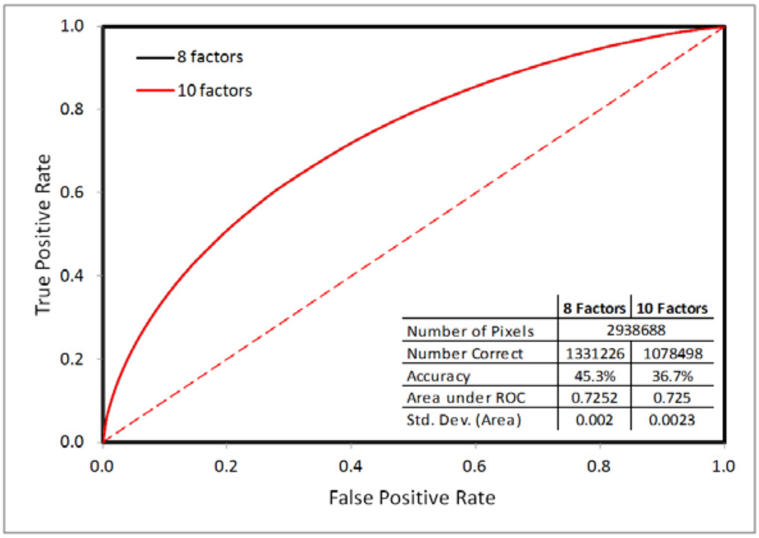
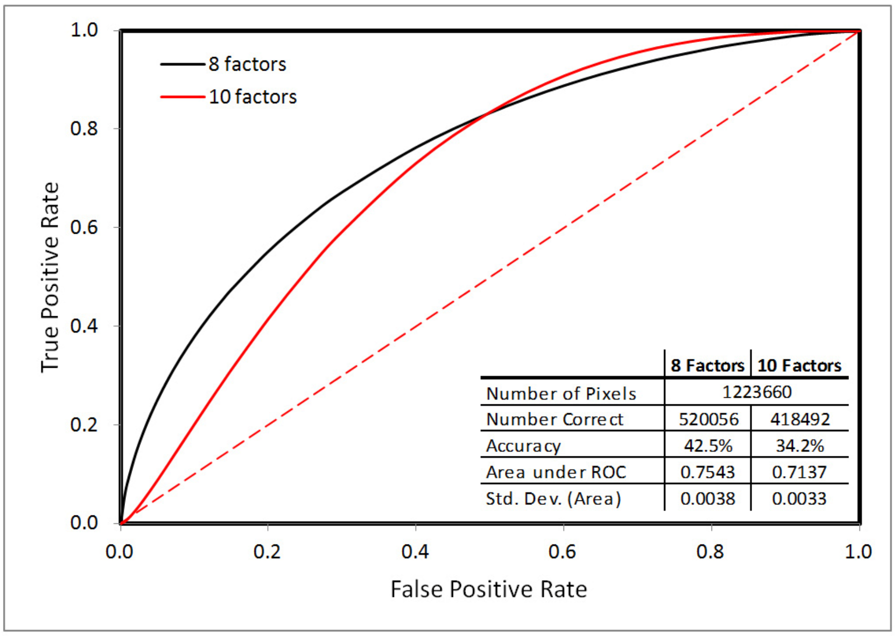
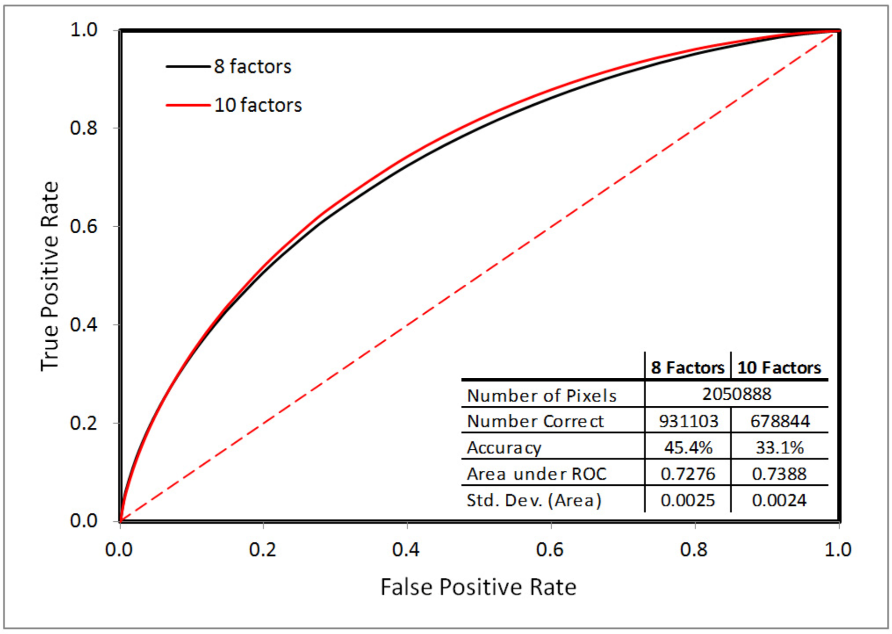


Figure E.2 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-3.



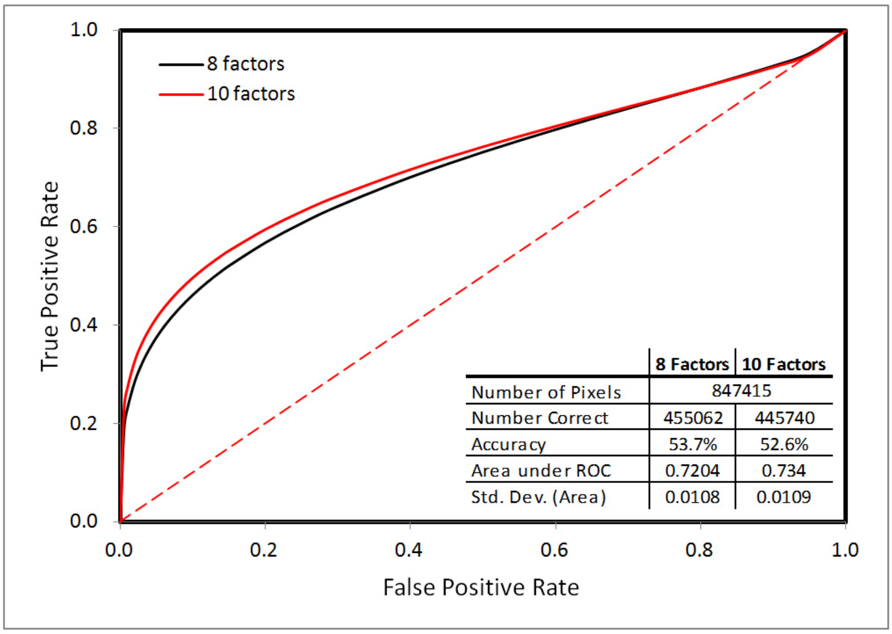
	8 Factors	10 Factors
Number of Pixels	1223660	
Number Correct	520056	418492
Accuracy	42.5%	34.2%
Area under ROC	0.7543	0.7137
Std. Dev. (Area)	0.0038	0.0033

Figure E.3 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-4.



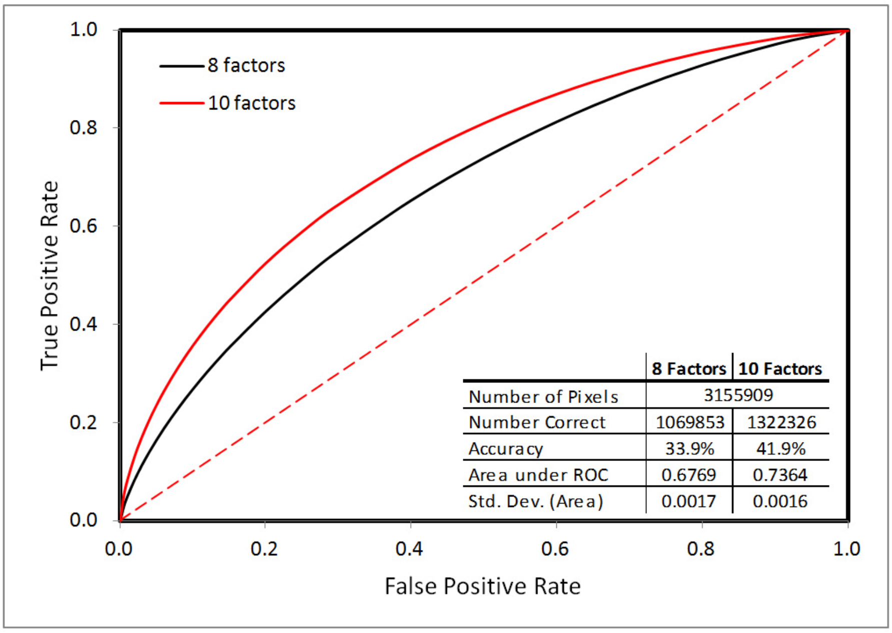
	8 Factors	10 Factors
Number of Pixels	2050888	
Number Correct	931103	678844
Accuracy	45.4%	33.1%
Area under ROC	0.7276	0.7388
Std. Dev. (Area)	0.0025	0.0024

Figure E.4 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-5.



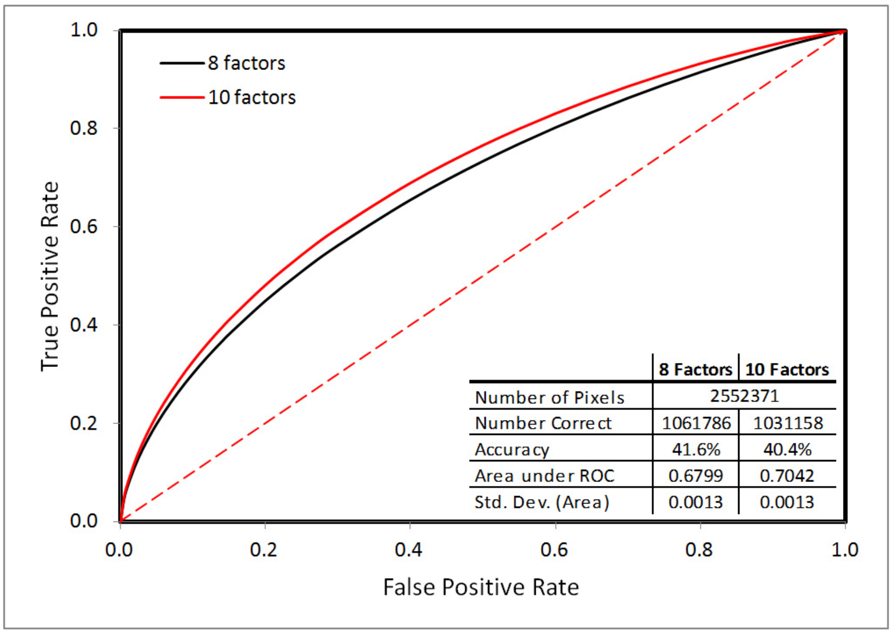
	8 Factors	10 Factors
Number of Pixels	847415	
Number Correct	455062	445740
Accuracy	53.7%	52.6%
Area under ROC	0.7204	0.734
Std. Dev. (Area)	0.0108	0.0109

Figure E.5 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-6.



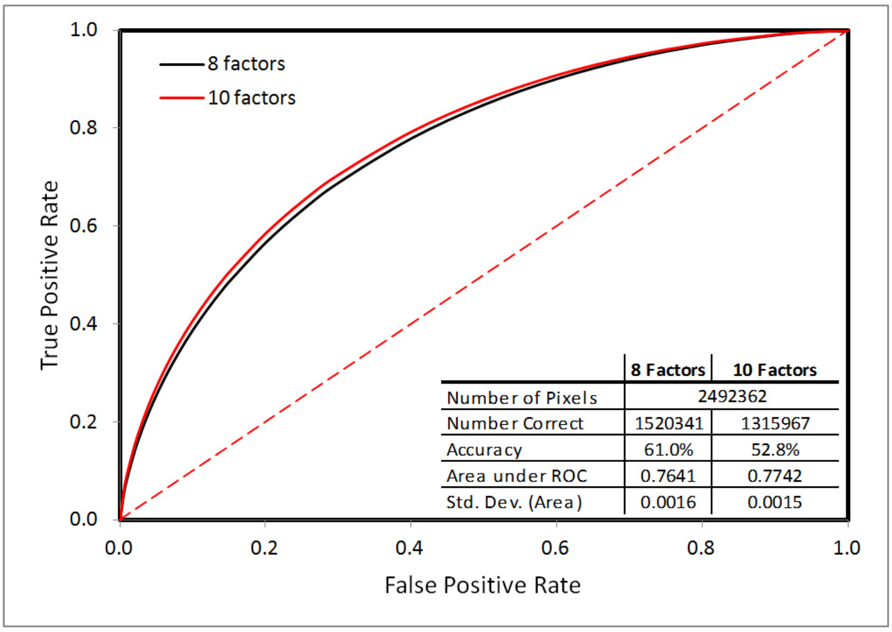
	8 Factors	10 Factors
Number of Pixels	3155909	
Number Correct	1069853	1322326
Accuracy	33.9%	41.9%
Area under ROC	0.6769	0.7364
Std. Dev. (Area)	0.0017	0.0016

Figure E.6 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-7.



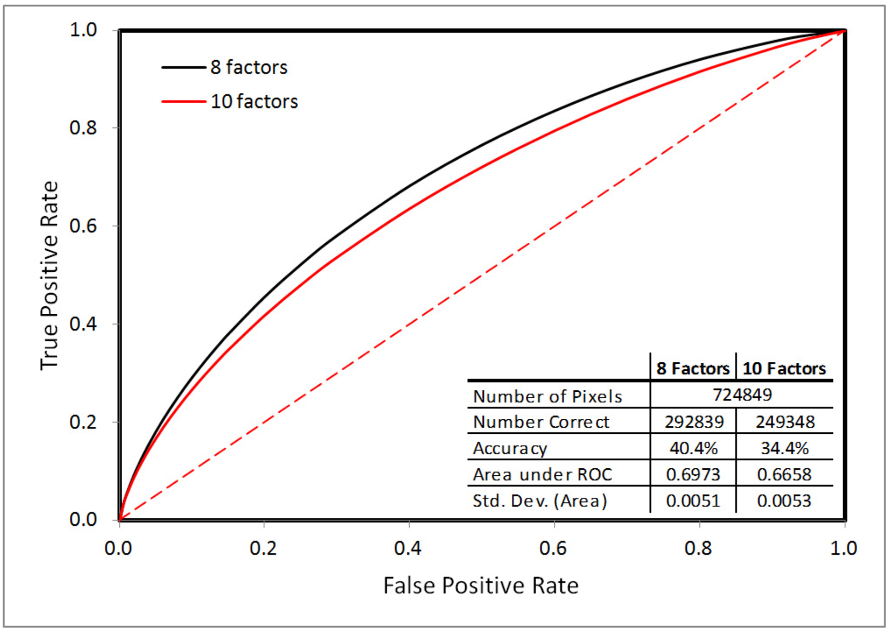
	8 Factors	10 Factors
Number of Pixels	2552371	
Number Correct	1061786	1031158
Accuracy	41.6%	40.4%
Area under ROC	0.6799	0.7042
Std. Dev. (Area)	0.0013	0.0013

Figure E.7 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-8.



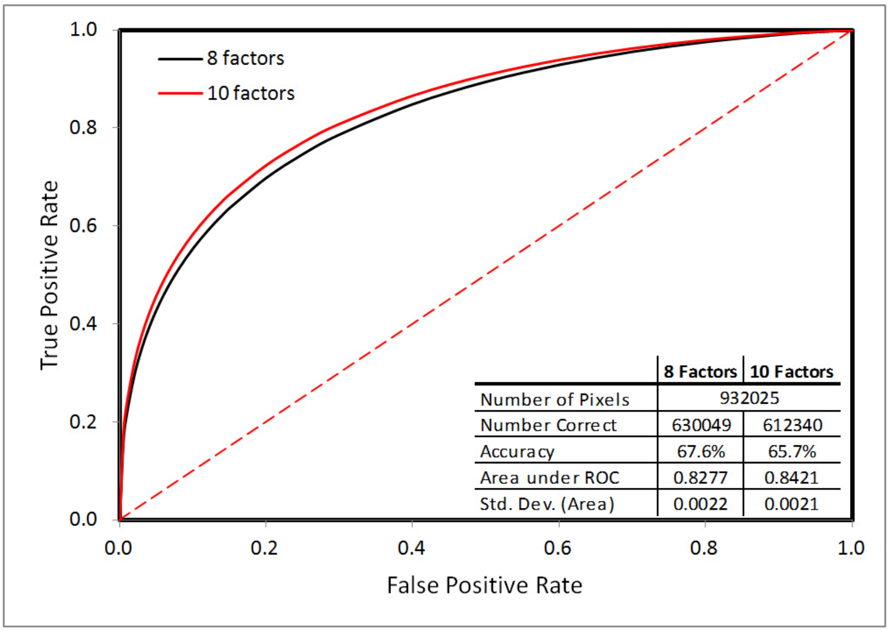
	8 Factors	10 Factors
Number of Pixels	2492362	
Number Correct	1520341	1315967
Accuracy	61.0%	52.8%
Area under ROC	0.7641	0.7742
Std. Dev. (Area)	0.0016	0.0015

Figure E.8 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-9.



	8 Factors	10 Factors
Number of Pixels	724849	
Number Correct	292839	249348
Accuracy	40.4%	34.4%
Area under ROC	0.6973	0.6658
Std. Dev. (Area)	0.0051	0.0053

Figure E.9 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-10.



	8 Factors	10 Factors
Number of Pixels	932025	
Number Correct	630049	612340
Accuracy	67.6%	65.7%
Area under ROC	0.8277	0.8421
Std. Dev. (Area)	0.0022	0.0021

Figure E.10 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-11.

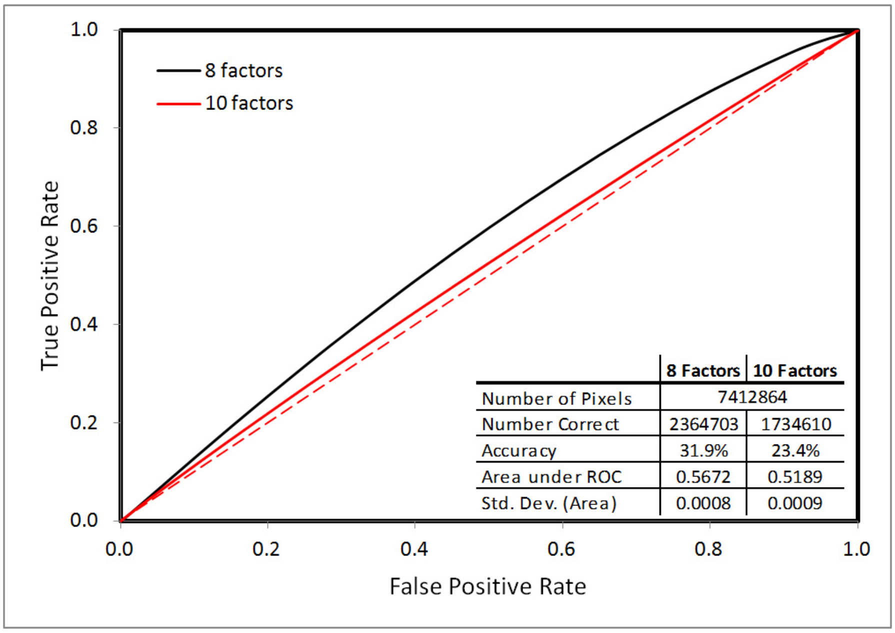


Figure E.11 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-12.

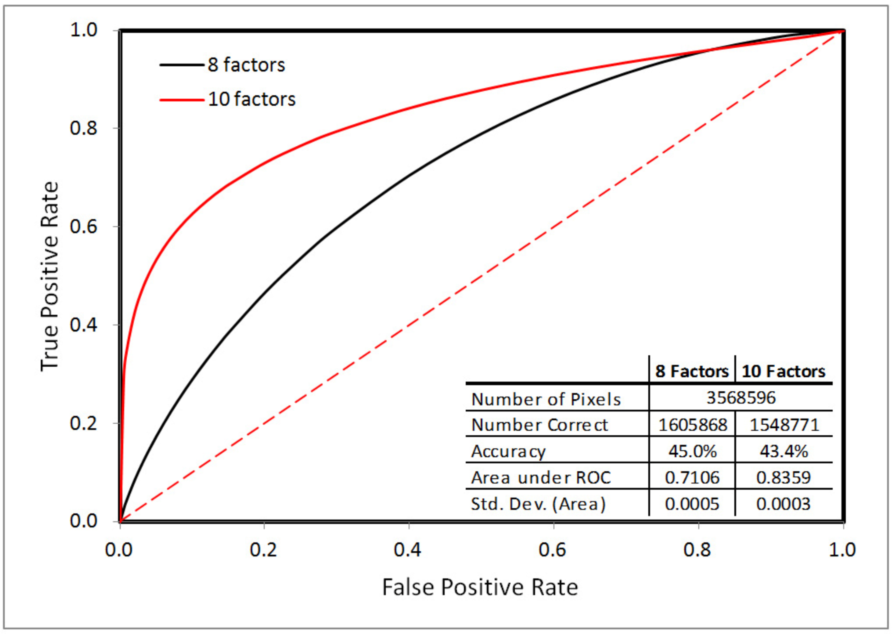


Figure E.12 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-13.

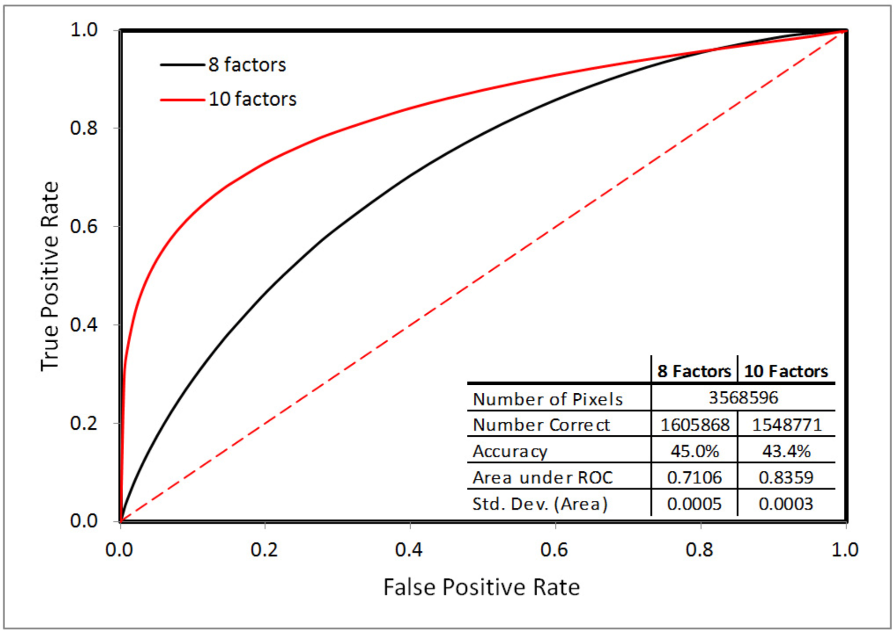


Figure E.13 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-14.

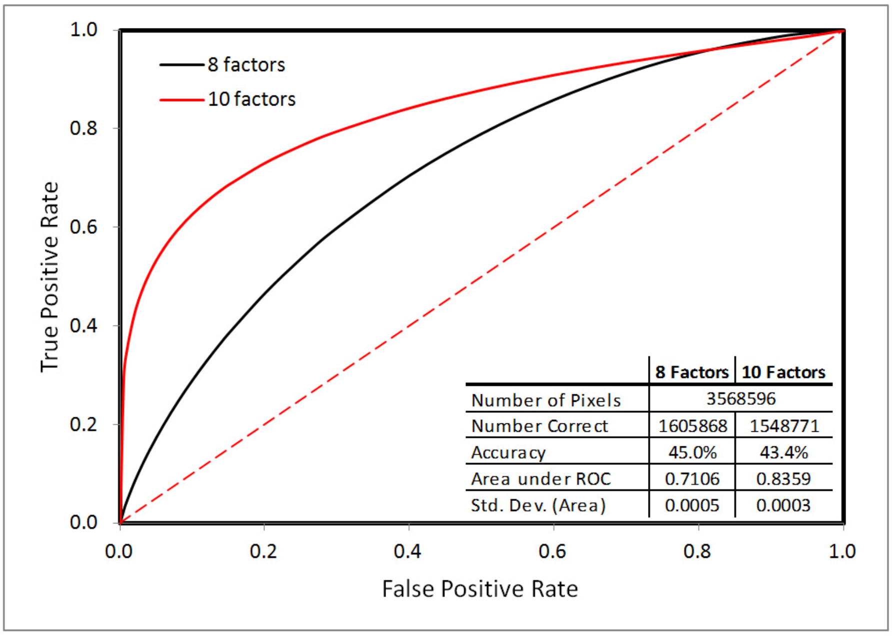


Figure E.14 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-15.

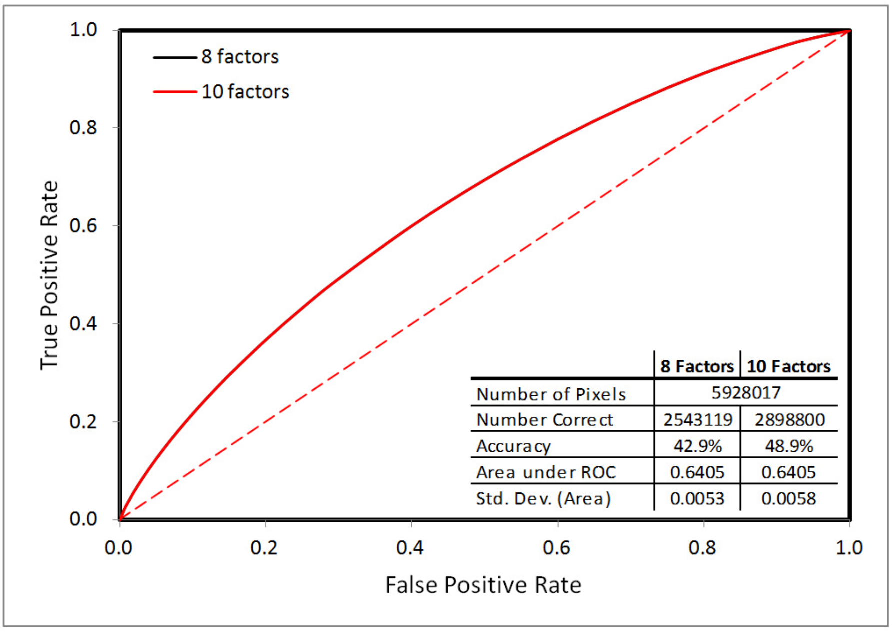


Figure E.15 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-16.

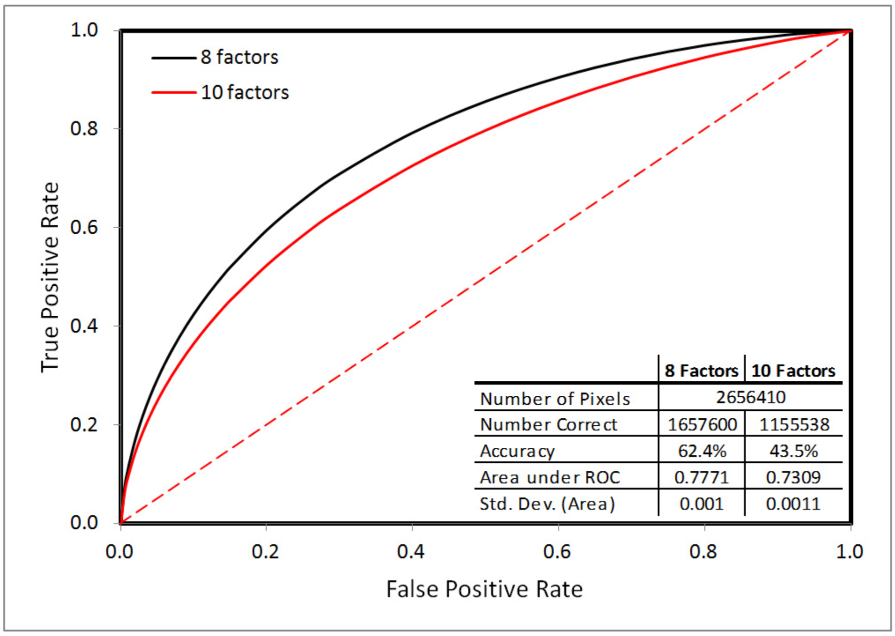


Figure E.16 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-17.

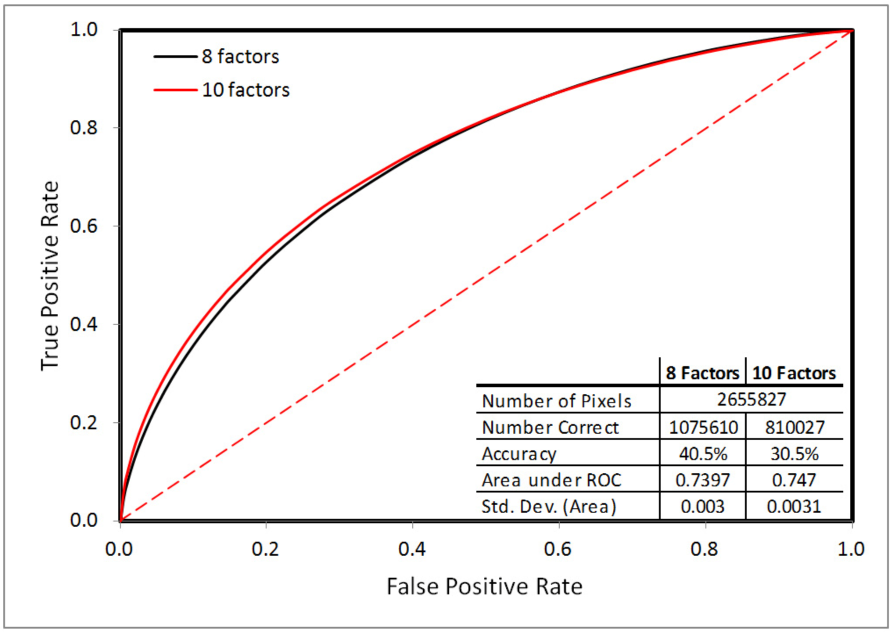


Figure E.17 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-18.

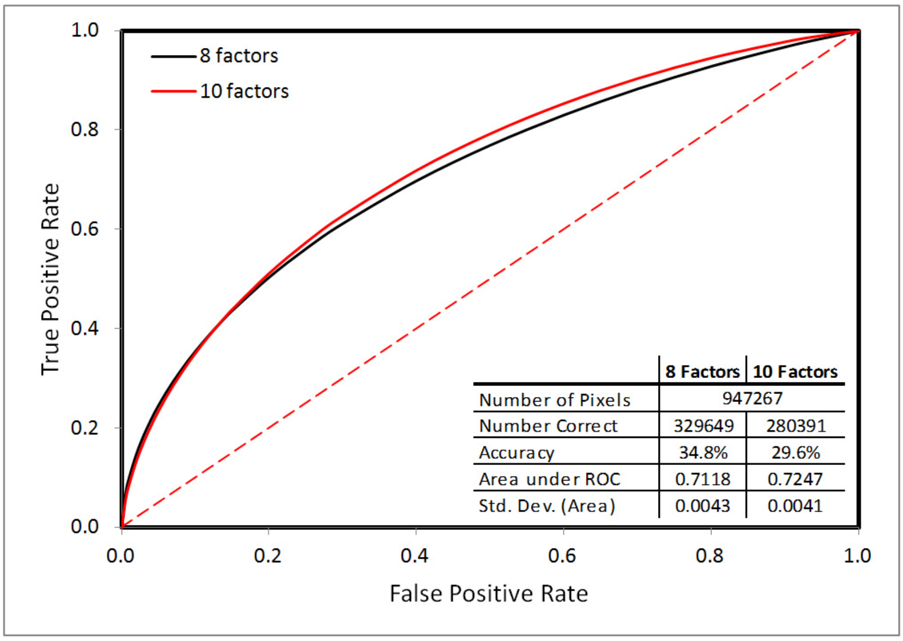
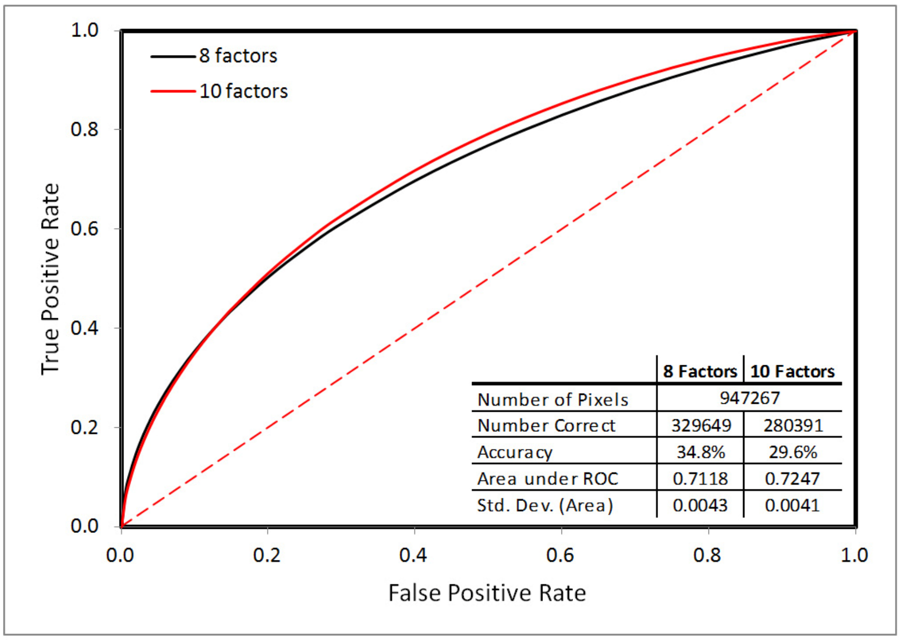
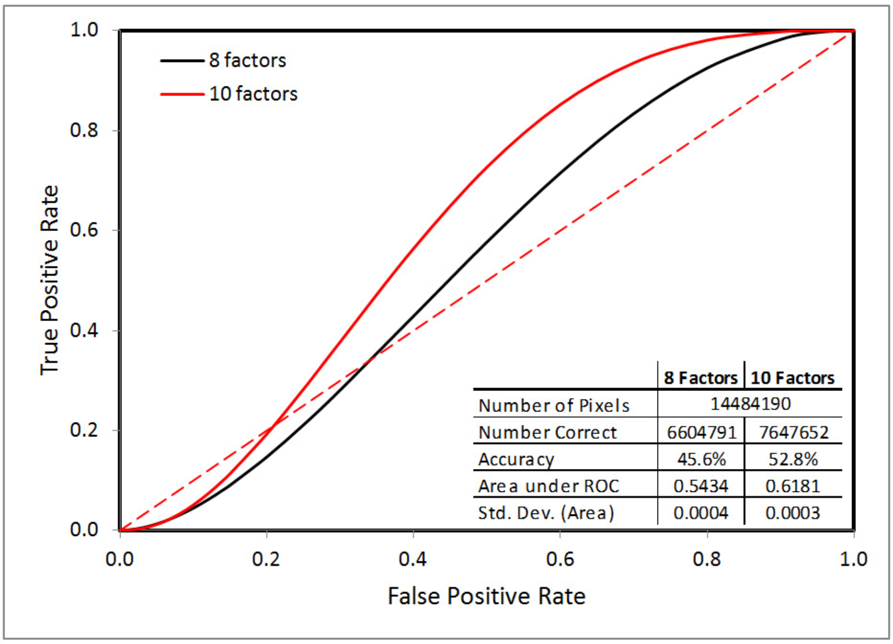


Figure E.18 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-19.



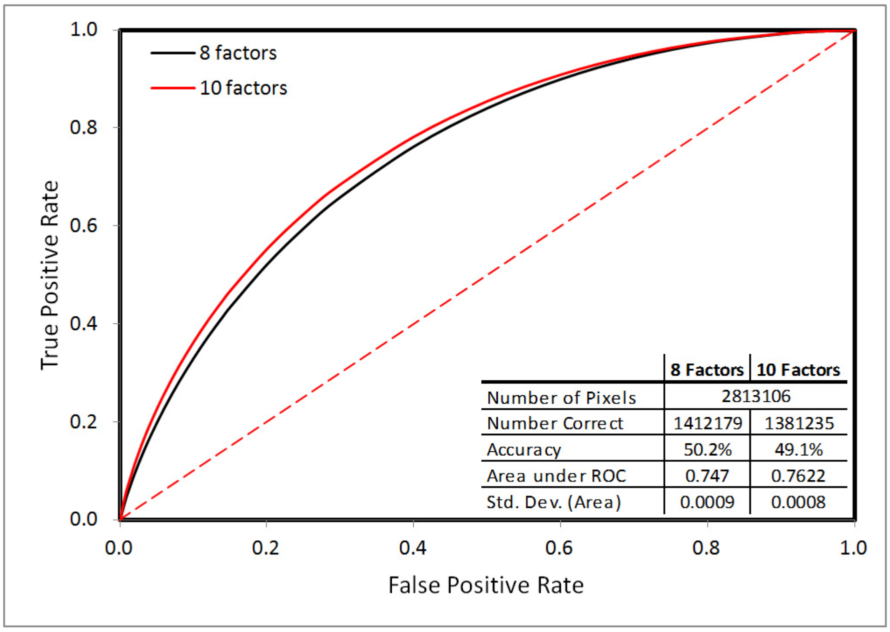
	8 Factors	10 Factors
Number of Pixels	947267	
Number Correct	329649	280391
Accuracy	34.8%	29.6%
Area under ROC	0.7118	0.7247
Std. Dev. (Area)	0.0043	0.0041

Figure E.19 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-20.



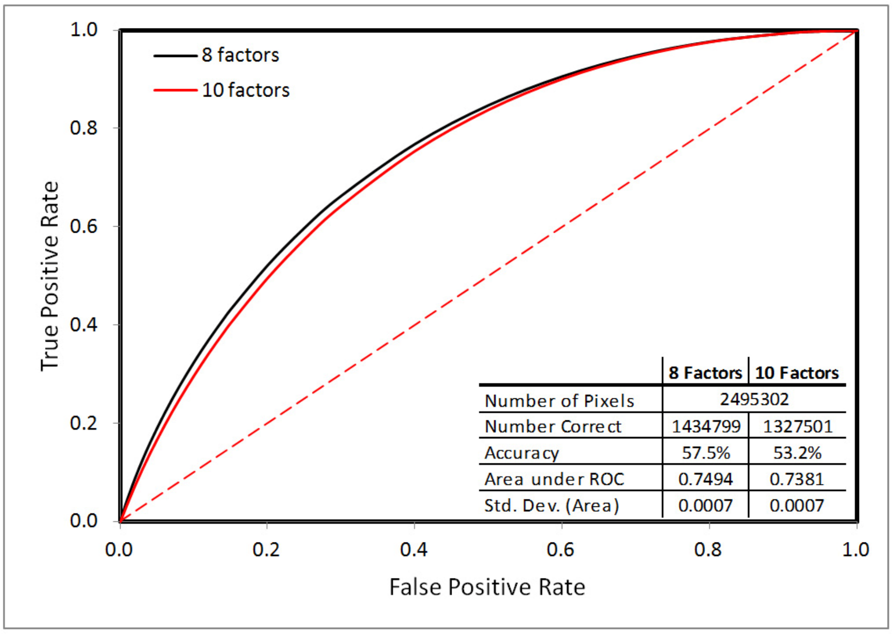
	8 Factors	10 Factors
Number of Pixels	14484190	
Number Correct	6604791	7647652
Accuracy	45.6%	52.8%
Area under ROC	0.5434	0.6181
Std. Dev. (Area)	0.0004	0.0003

Figure E.20 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-21.



	8 Factors	10 Factors
Number of Pixels	2813106	
Number Correct	1412179	1381235
Accuracy	50.2%	49.1%
Area under ROC	0.747	0.7622
Std. Dev. (Area)	0.0009	0.0008

Figure E.21 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-22.



	8 Factors	10 Factors
Number of Pixels	2495302	
Number Correct	1434799	1327501
Accuracy	57.5%	53.2%
Area under ROC	0.7494	0.7381
Std. Dev. (Area)	0.0007	0.0007

Figure E.22 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-23.

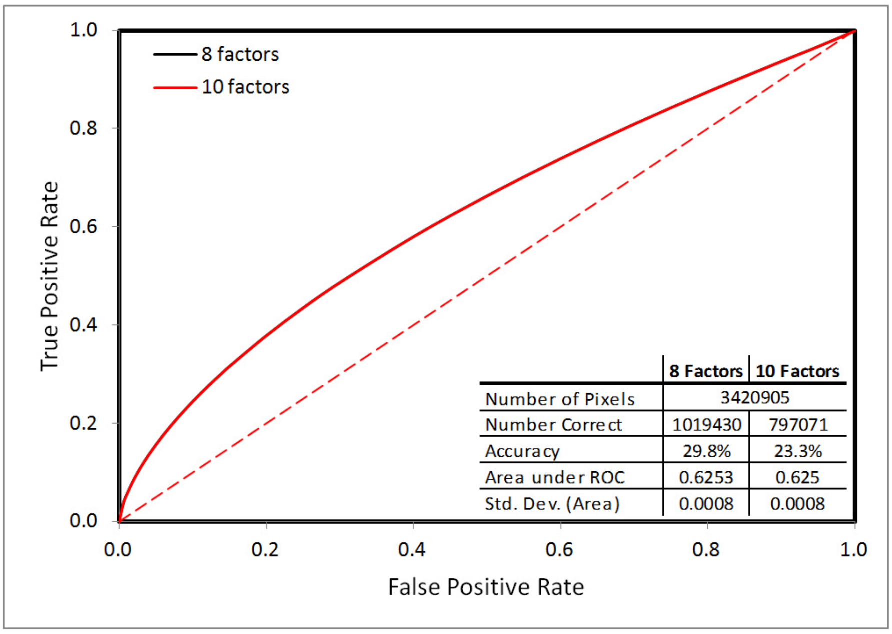


Figure E.23 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-24.

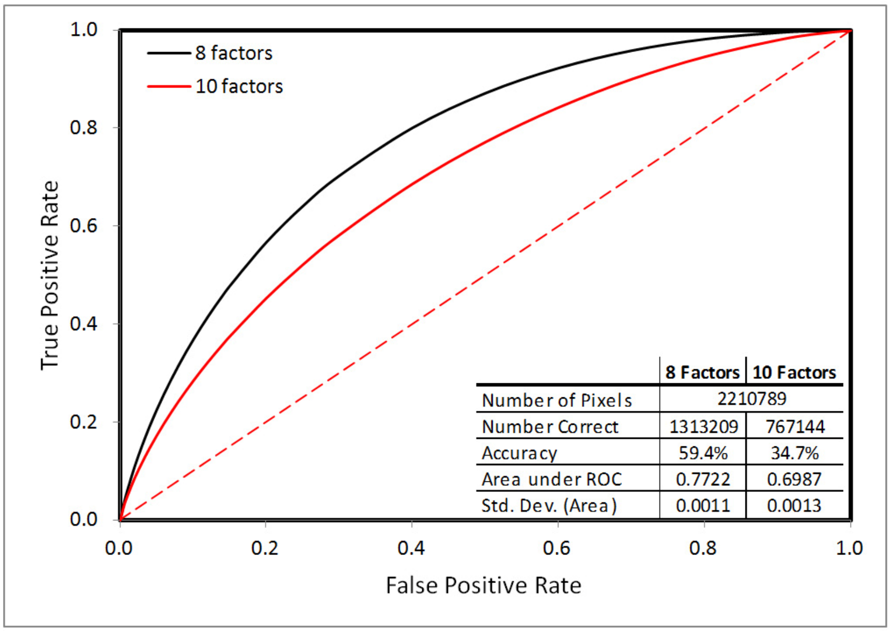


Figure E.24 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-25.

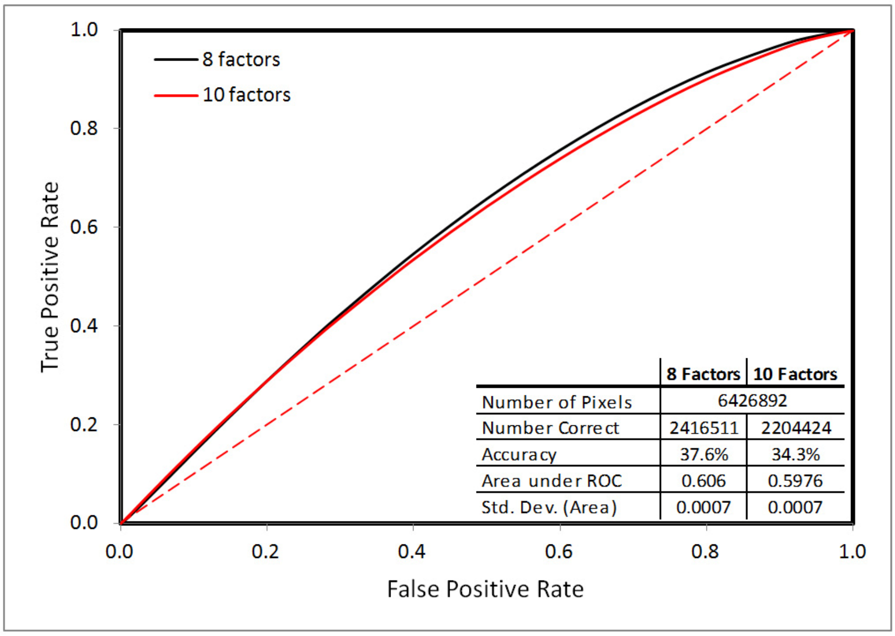


Figure E.25 Receiver Operating Characteristic (ROC) Curve Analysis for Watershed-26.

APPENDIX F

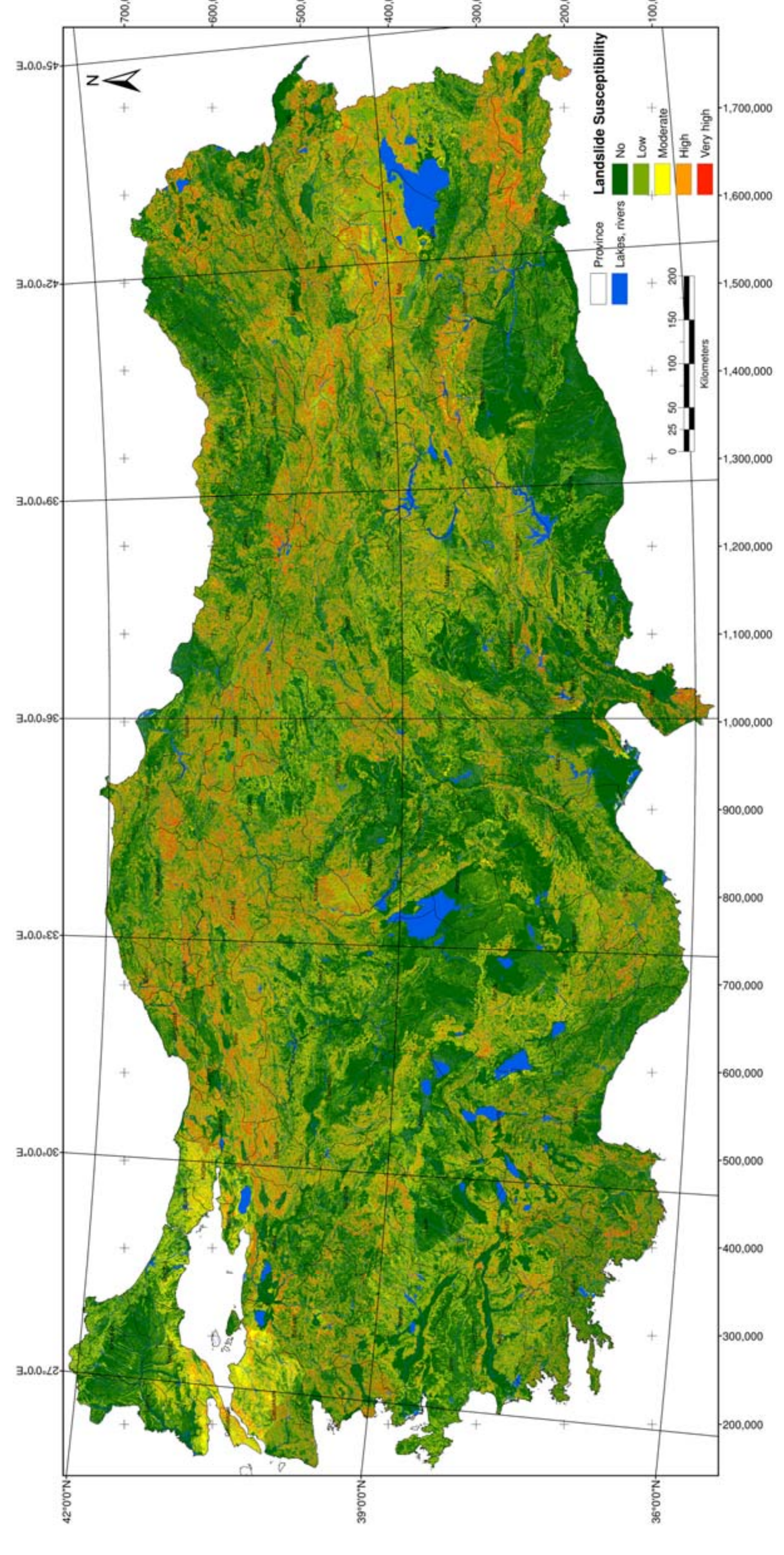


Figure F.1 Landslide susceptibility map for Turkey.

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name	: Okalp, Kıvanç
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EDUCATION

1997 - 2002	Dokuz Eylül University, İzmir BSc,Civil Engineering Department
2002 - 2005	METU, Ankara MSc, GGIT Department
2006 - 2013	METU, Ankara PhD, Geological Engineering Department

WORK EXPERIENCE

Year	Place	Enrollment
2002 November	Başar Engineering	Design Engineer
2005 February	Netcad Group	GIS Specialist
2005 September	Infotech IT Eng.	Coordinator of GIS Projects
2006 November	3B-Plan Engineering	Project Manager
2008 May	HEPP Engineering	Project Manager
2009 October-Present	Beray Engineering	Coordinator of Projects

QUALIFICATIONS

Programming Languages: BASIC, Visual BASIC, MATLAB.
GIS Software: ArcGIS, ArcView, ERDAS Imagine, IDRISI, ENVI, ILWIS, MapInfo, TNTmips, SAGA.
Cad Software: AutoCAD, Autodesk Civil 3D, Netcad.
Engineering Software: Haestad Methods, HEC-RAS, SAP2000, ideCAD, Phase^2.

PUBLICATIONS

Akyürek Z., **Okalp K.**, A fuzzy-based tool for spatial reasoning: A Case study on soil erosion hazard prediction. "7th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environment Science", (2006), p.719-729.

RESEARCH AND DEVELOPMENT PROJECTS

Natural Environment & Anthropogenic Impact on Internal Waters: Integrated Surveillance Methods for Pollution Measurement and Risk Assessment, Project No: 102Y001, Joint study of DEÜ-SUMER (TÜBİTAK, Turkish Team) with NRC Demokritos Information and Technology Institute (Greek Team). Remote sensing expert; Water quality modeling of Mogan and Eymir lakes (Ankara) with remote sensing techniques. 2002-2004.