*2. National Civil Engineering Symposium*

# Determination of Landslide Susceptibility Based on GIS with MASW Data and Machine Learning Algorithms

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Landslide is defined as a hazardous natural phenomenon that occurs with gravitational mass movements of debris, rock, or soil on a downward slope. .

In Cyprus, landslides which occur with extreme weather conditions such as drought and heavy rainfall can lead to a constant threat to human structures such as buildings, roads, tunnels, and bridges.

The fact that landslides cause serious material damage, especially in the southwest Cyprus, has many studies to be carried out especially Paphos region.

In Cyprus, increasing landslide activity has been shaped by past and present land use planning mistakes such as road construction, and housing.

In a successful urban planning strategy, It is very important to determine landslide risks, as unexpected mass movements might adversely affect structures and roads.

Many researchers and government agencies are trying to produce appropriate tools for planning and decision making to mitigate the negative consequences of landslides

The most useful application to take precautions against landslides is the preperation of landslide susceptibility maps.

Since there is no standard approach for the creation of landslide susceptibility maps, researchers working on landslides use different methods and techniques.

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Researchers working on landslides use different methods and techniques such as Remote sensing, Geographical Information Systems, geological measurements and geophysical measurements in order to measure landslide characteristics.

The objectives of this study are (i) to determine which of the followings are more effective; MASW data or historical records in identifying landslide-prone areas.

(ii) compare accuracy and precision of Random Forest RF and support vector machine SVM methods to perceive better algorithm in determining landslide susceptibility in a semi-arid region,

(iii) To identify the regions where landslide susceptibility is relatively high in the Kyrenia Mountains.

The main motivation for this study is to increase the machine learning approach's ability to predict topsoil stability properties with a multidisciplinary approach based on geophysical measurements and GIS-based algorithmic applications.

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- **Cyrus consists of three units tectonically named as Kyrenia Mountains, Troodos Ophiolite (Troodos Massif) and Mamonia Complex.**

- **This region, termed the Girne Mountains, the Kyrenia Zone or the Beşparmak Zone which is a member of the Alpine-Himalayan belt, has been chosen as the study area for this paper.**

- **Permian and Upper Cretaceous aged marl, limestones, dolomites and marbles are commonly deposited in Kyrenia zone.**
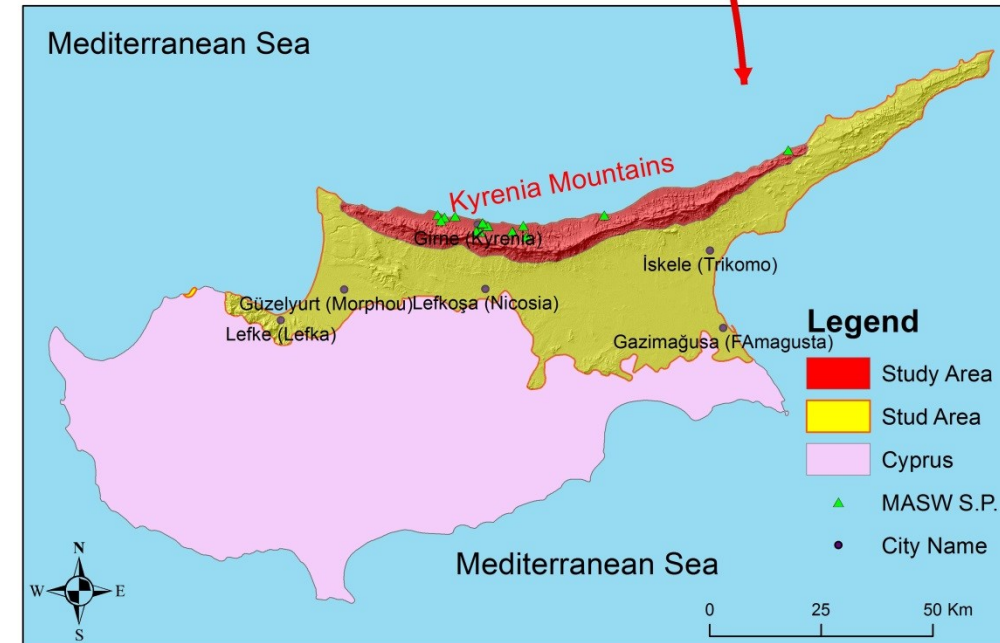
MASW is an active seismic method whereabouts the Rayleigh wave fundamental mode dispersion curve and higher modes are calculated from a seismic record and then inverted to achieve a one dimensional Vs layer model
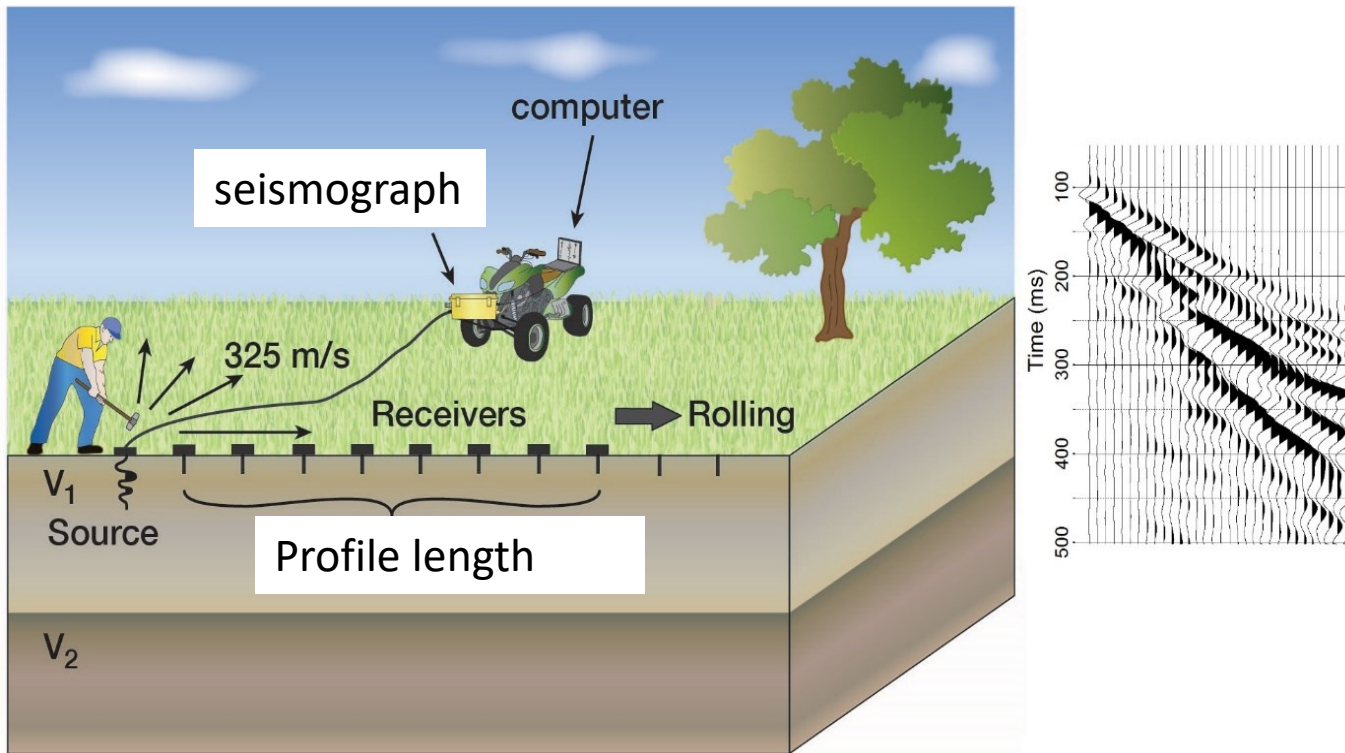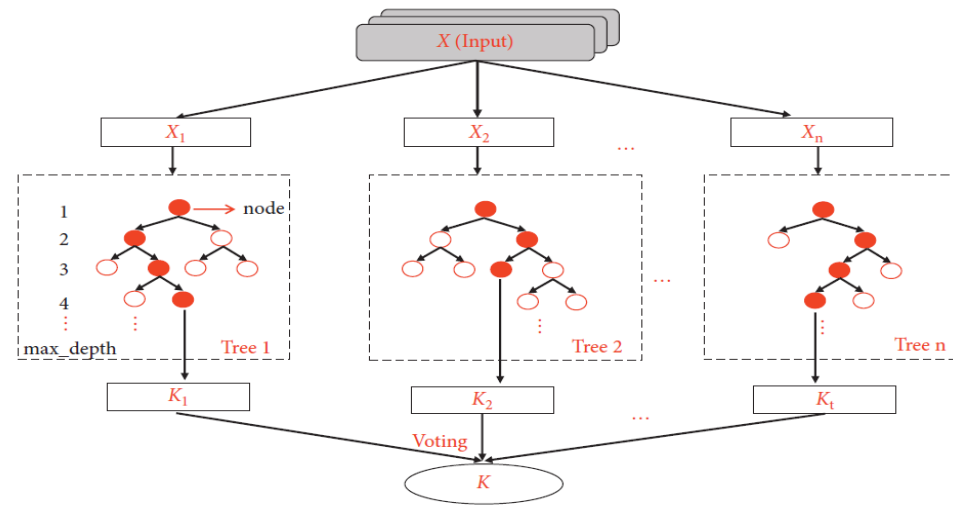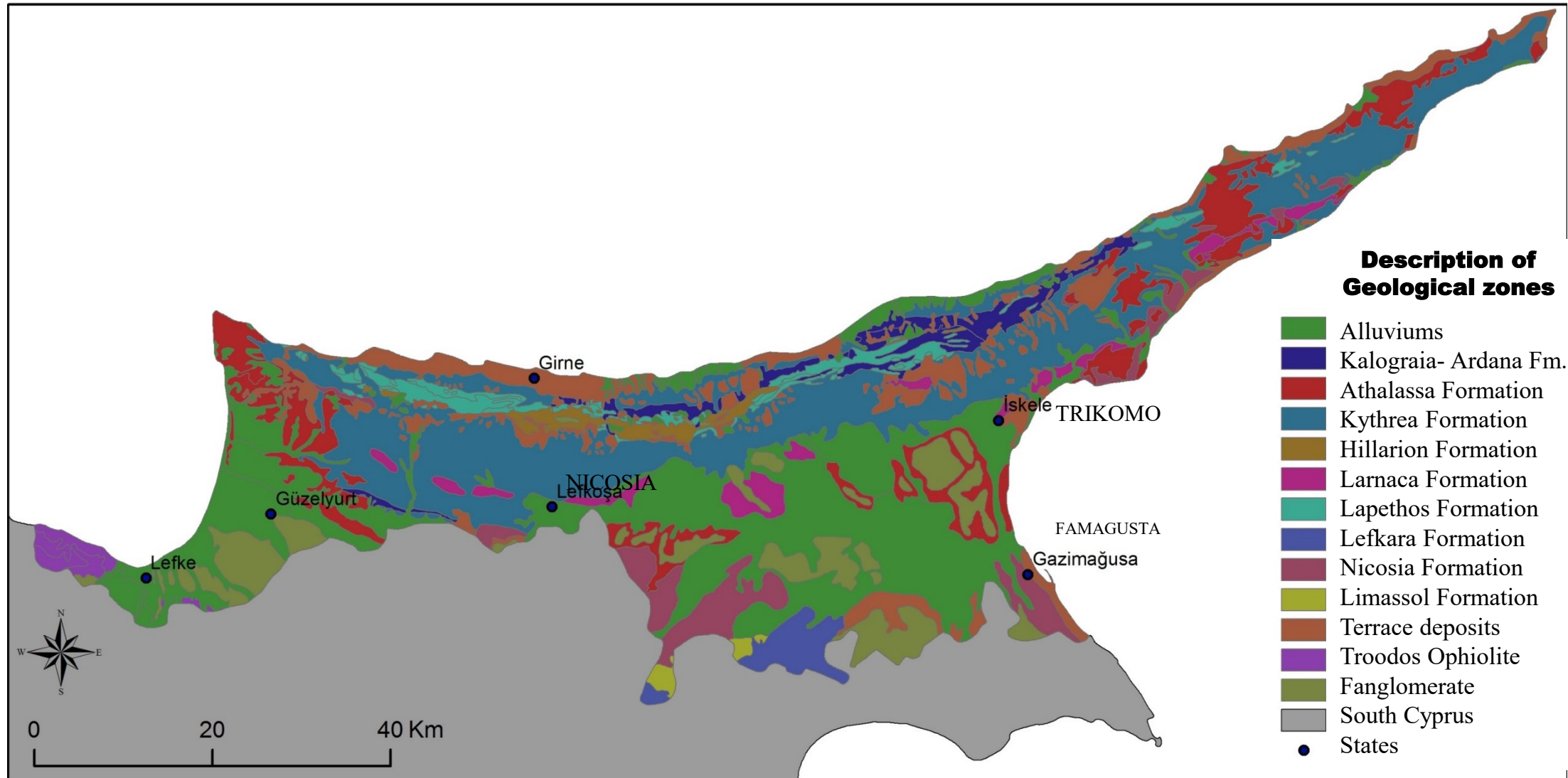


Illustration of the MASW Method in the surveying

Random Forest (RF) was firstly suggested by Breimann in 2001, is a tree-based composite learning algorithm that uses an approach known as bagging, at which point multiple decision tree (DT) are formed using reboot samples of the original data set, which are then consolidated.
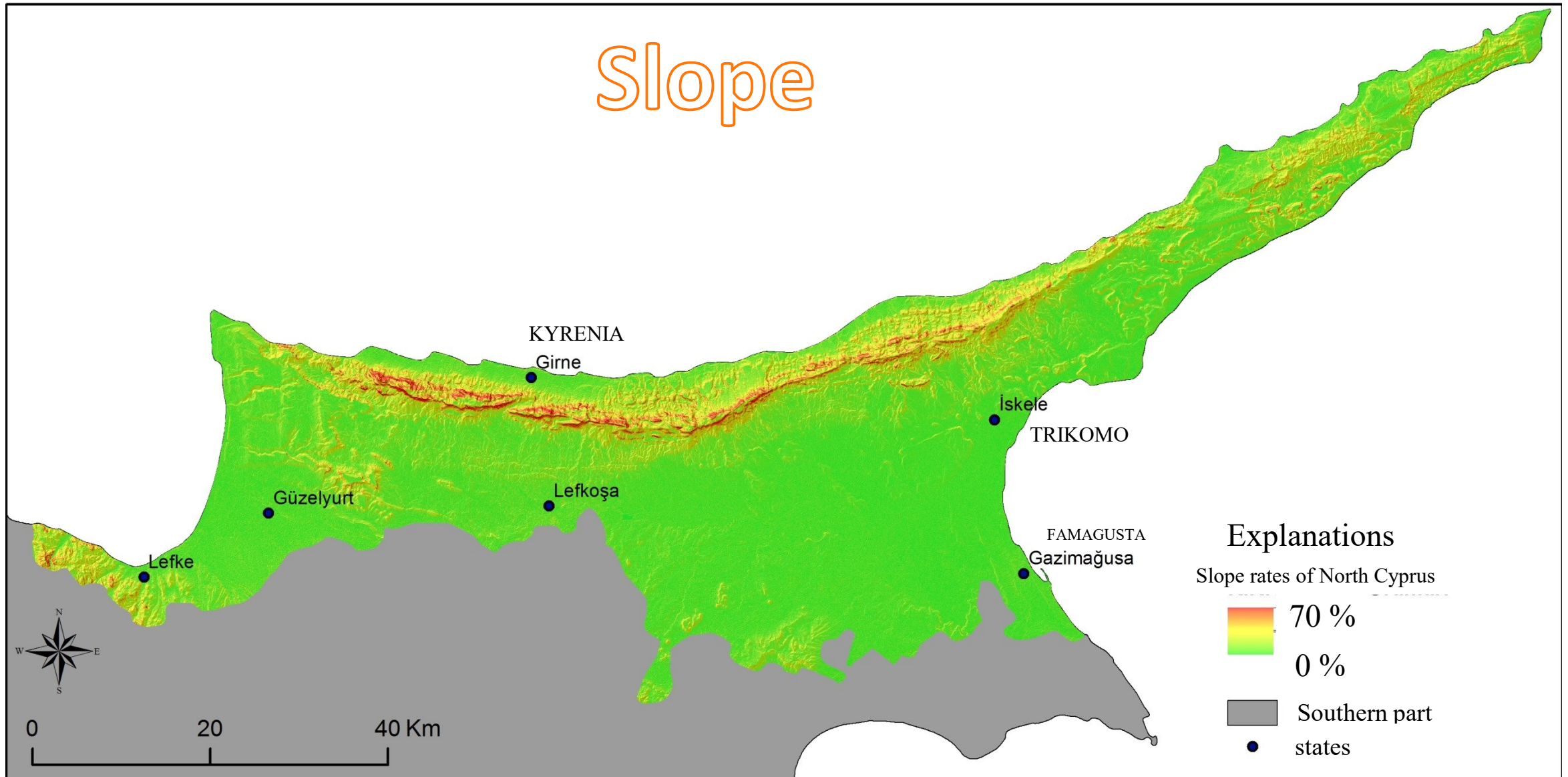


Support Vector Machine (SVM) is administered machine learning modules that widely dispose of classification, regression, or anomaly detection. SVM persist efficiency in high-dimensional spaces (number of the dimensions are higher than number of the samples). A SVM reflects one or few dimensional indivisible data into the high-dimensional featured space to develop special classes. An outcome subspace that maximizes the distance between these classes is then evaluated.
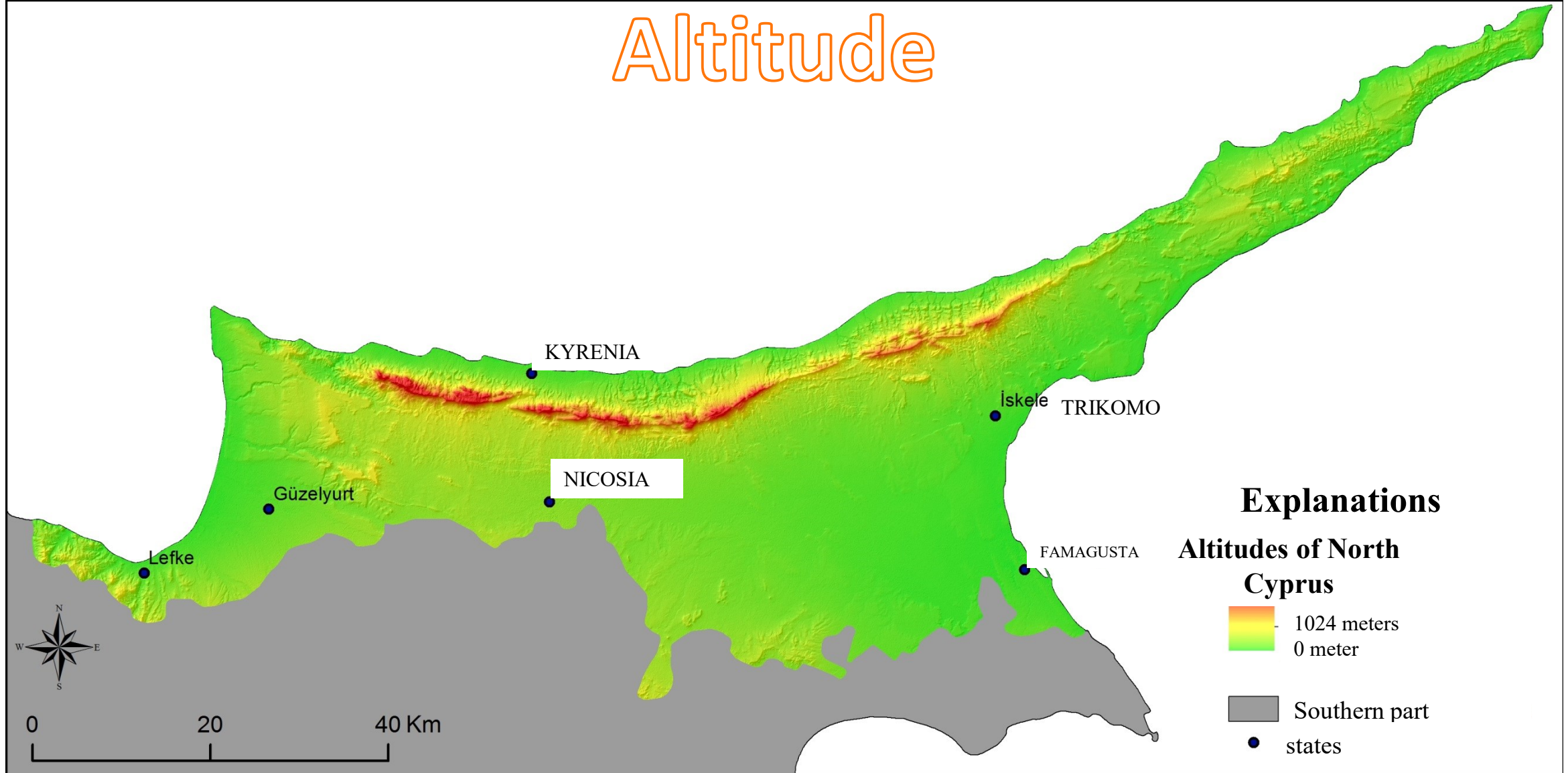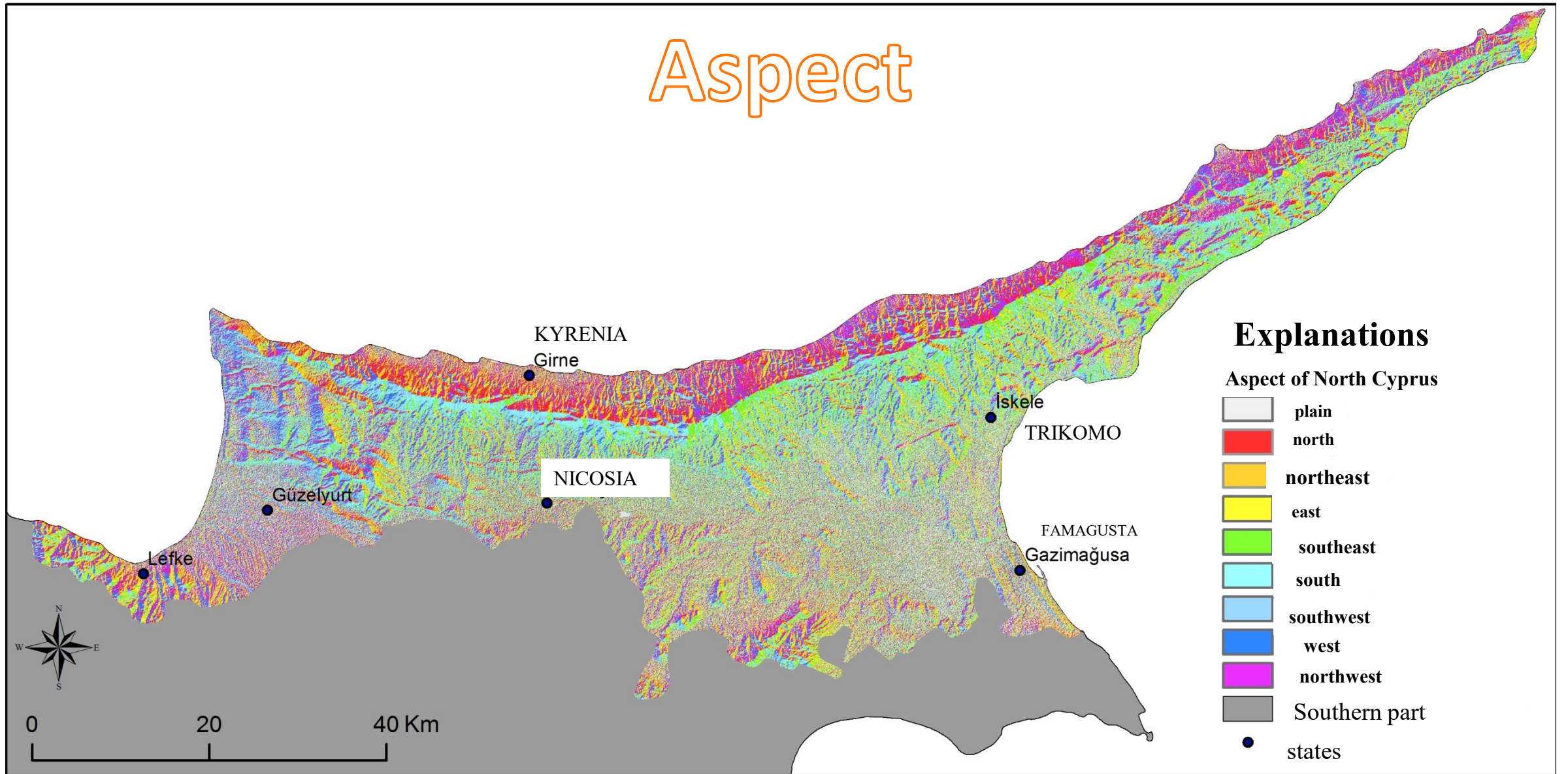
# Geology



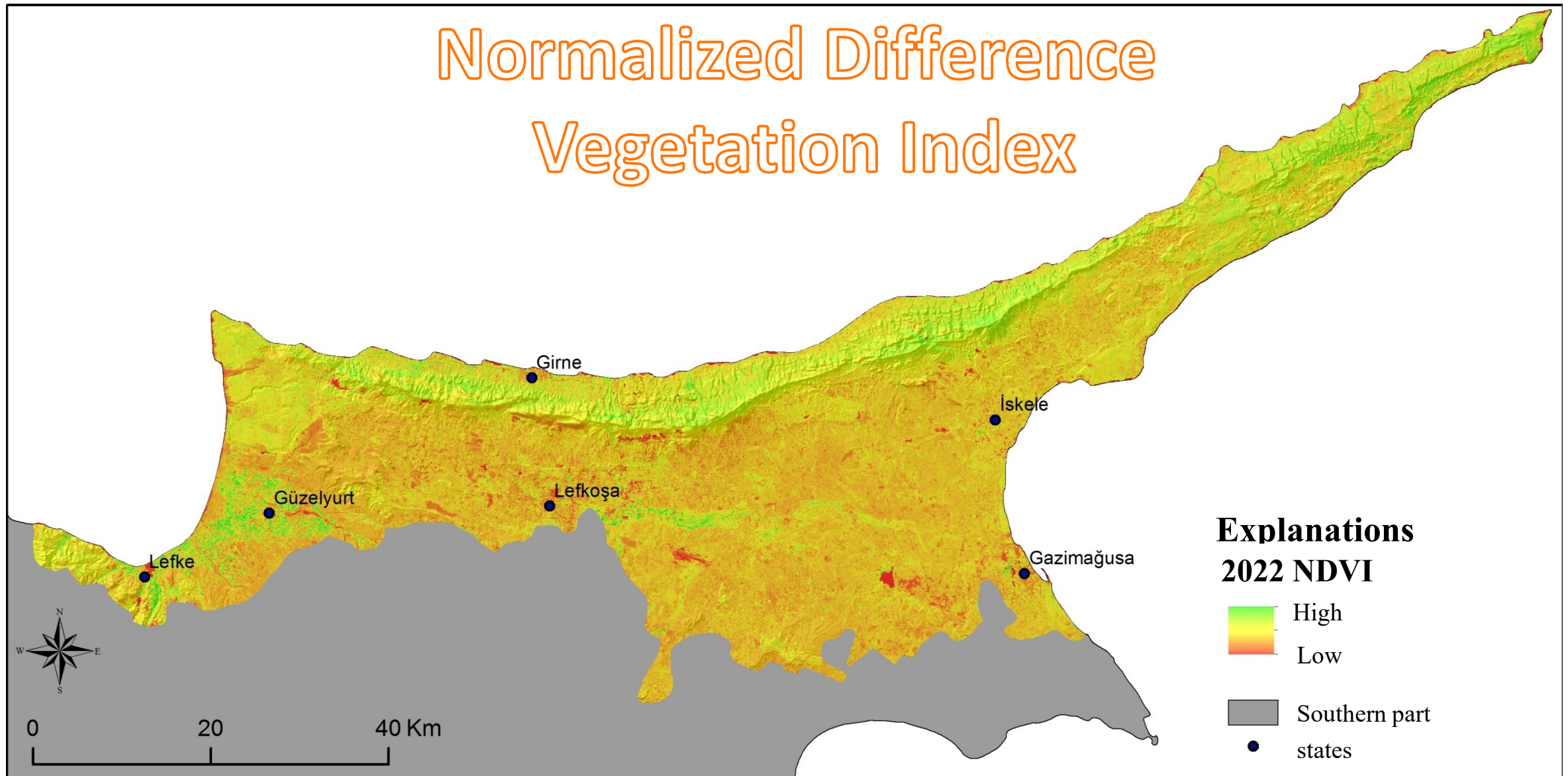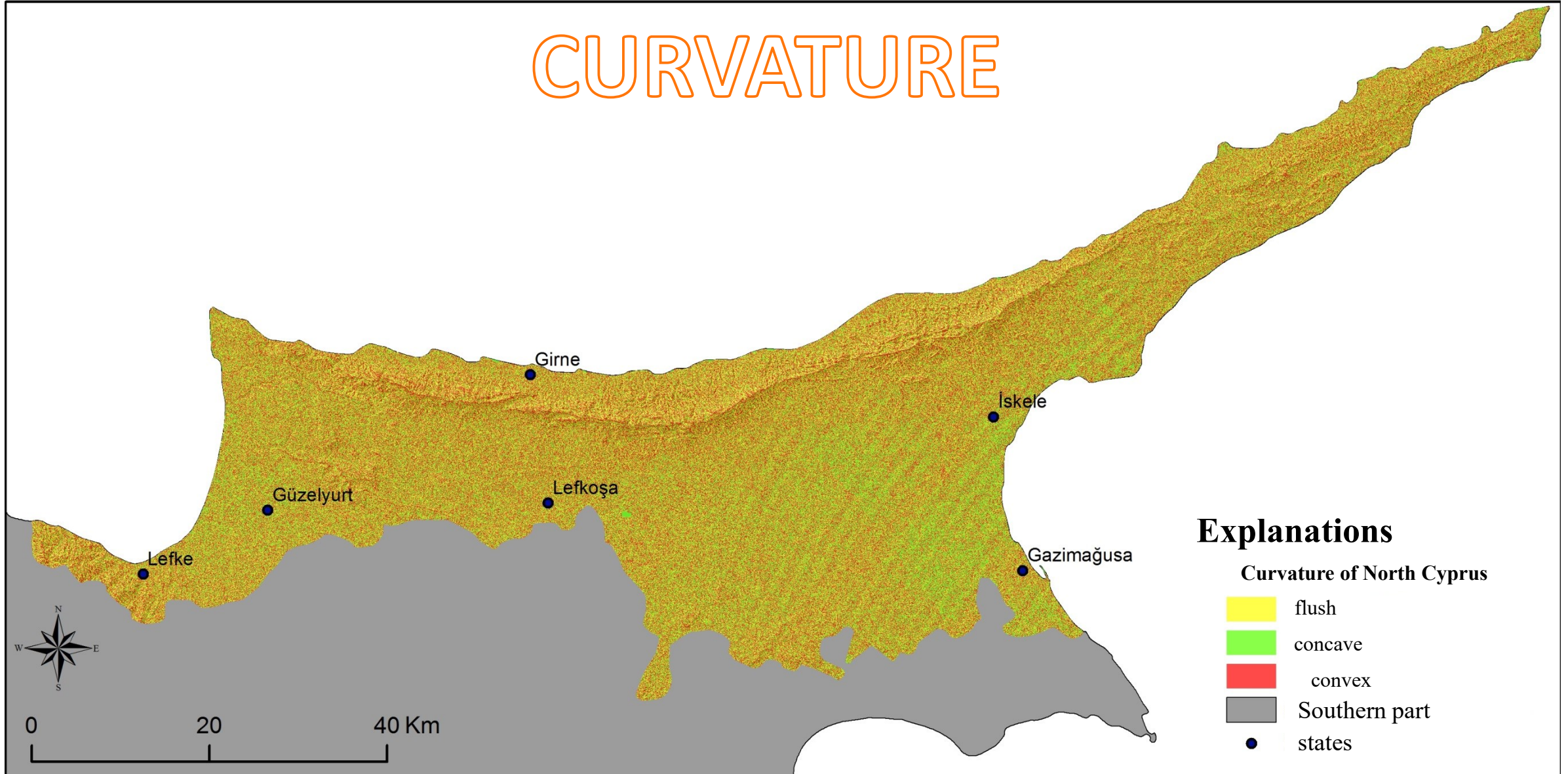**Description of Geological zones**

- Alluviums
- Kalograia- Ardana Fm.
- Athalassa Formation
- Kythrea Formation
- Hillarion Formation
- Larnaca Formation
- Lapethos Formation
- Lefkara Formation
- Nicosia Formation
- Limassol Formation
- Terrace deposits
- Troodos Ophiolite
- Fanglomerate
- South Cyprus
- States

Slope

KYRENIA
Girne

İskele
TRIKOMO

Güzelyurt

Lefkoşa

Lefke

FAMAGUSTA
Gazimağusa

Explanations

Slope rates of North Cyprus

70 %

0 %

Southern part

states

0    20    40 Km

# Altitude



KYRENIA

İskele  TRIKOMO

NICOSIA

Güzelyurt

Lefke

FAMAGUSTA

**Explanations**

**Altitudes of North Cyprus**

1024 meters
0 meter

Southern part

states

0   20   40 Km

Normalized Difference Vegetation Index

# CURVATURE



Girne

İskele

Güzelyurt

Lefkoşa

Lefke

Gazimağusa

**Explanations**

**Curvature of North Cyprus**

flush

concave

convex

Southern part

states

0          20          40 Km

15

The data used for the inversion is the fundamental mode (M0) dispersion curve, which expresses mostly the variation of Vs values in subsurface. For this purpose, SeisImager program used for the converting dispersion curves to the S waves velocities of the layers by inversion process
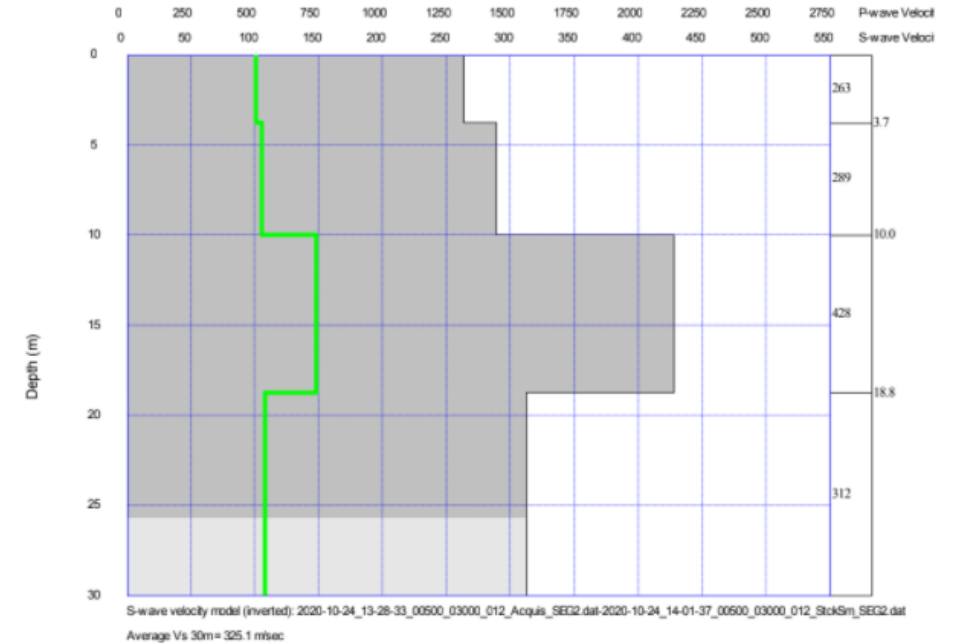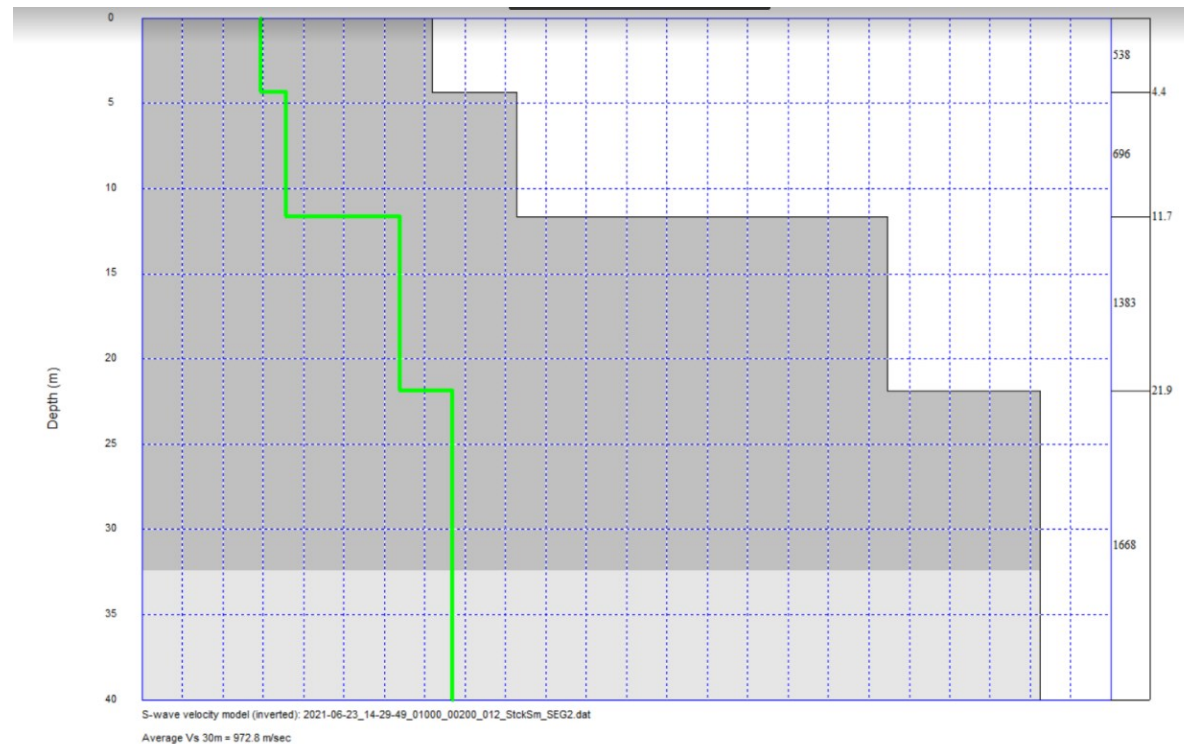


Inverted 1-D Velocity layer model of the selected stations

The MASW method was implemented in four steps. These steps are; data collection in the field, data evaluation, dispersion analysis and the last step is the inversion.

When terms such as "soil structure" or "layered soil model" were used in seismic methods, these models defined the parameters; Primary Wave Velocity Vp, Secondary Wave Velocity Vs, and density ρ.
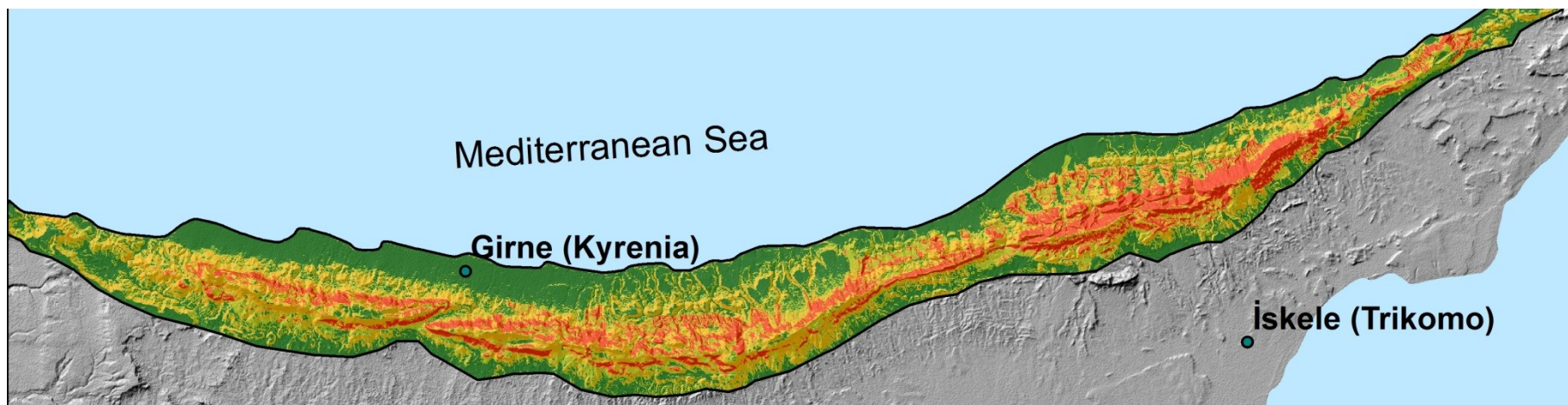
In this project there are 30 different stations where MASW method applied. 18 of this stations have landslide potential and the remaining 12 has no risk for landslide potential.

Support Vector Machine
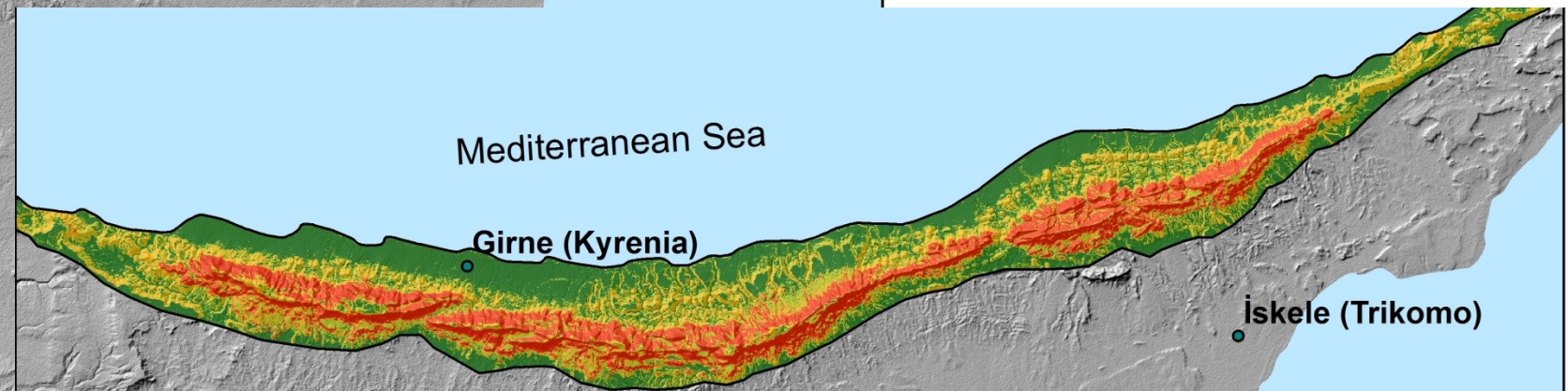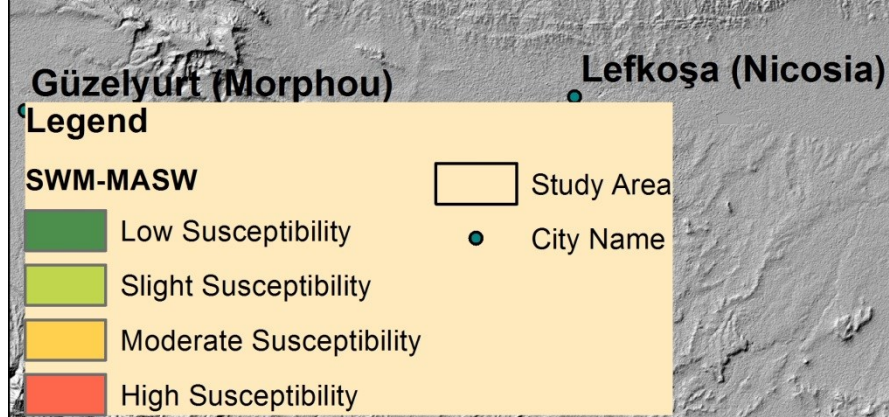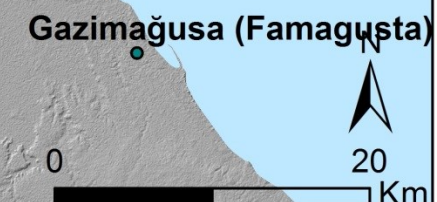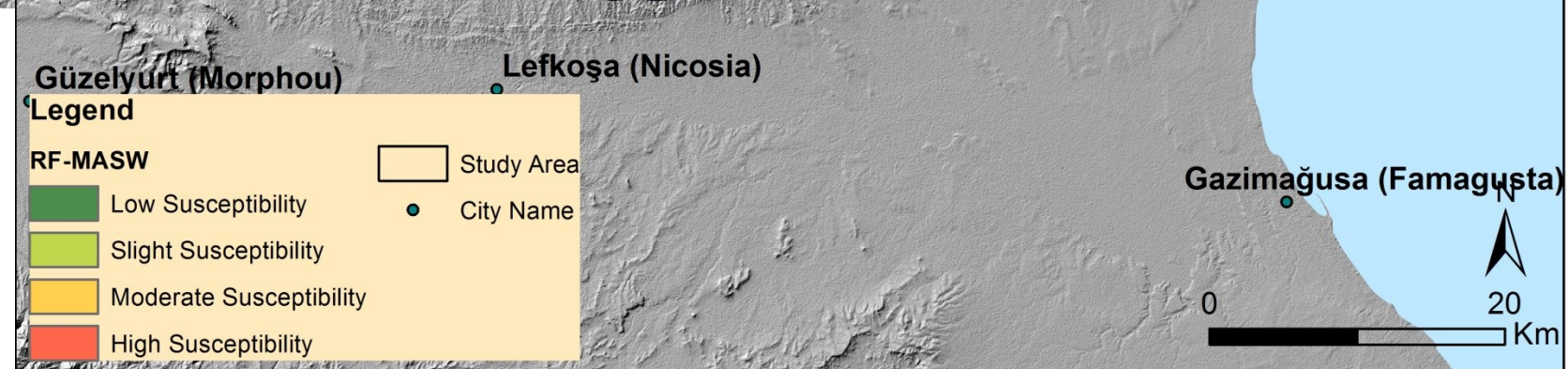MASW
AUC_ROC: 0,724
72%

Random Forest
MASW
AUC_ROC: 0,686
68%

Legend

SWM-MASW

Low Susceptibility
Slight Susceptibility
Moderate Susceptibility
High Susceptibility

Study Area
City Name

Legend

RF-MASW

Low Susceptibility
Slight Susceptibility
Moderate Susceptibility
High Susceptibility

Study Area
City Name

Mediterranean Sea

Girne (Kyrenia)

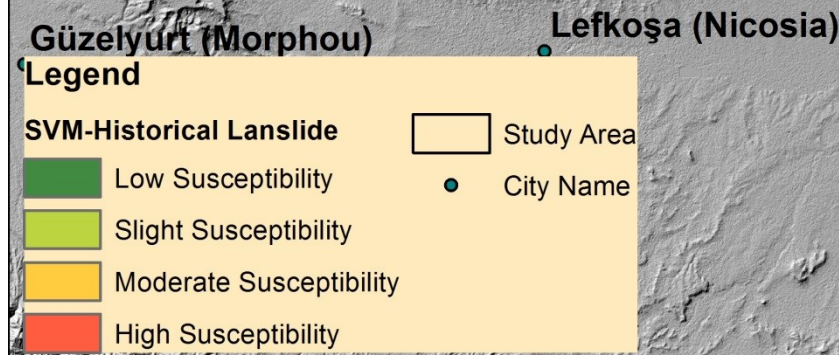İskele (Trikomo)

Güzelyurt (Morphou)

Lefkoşa (Nicosia)

Gazimağusa (Famagusta)

0          20
Km
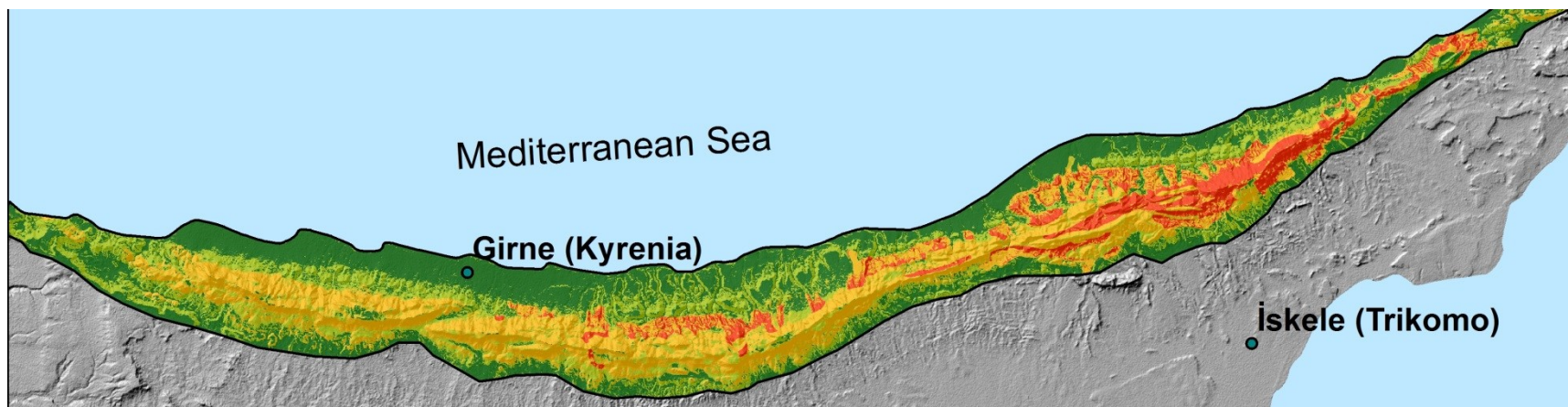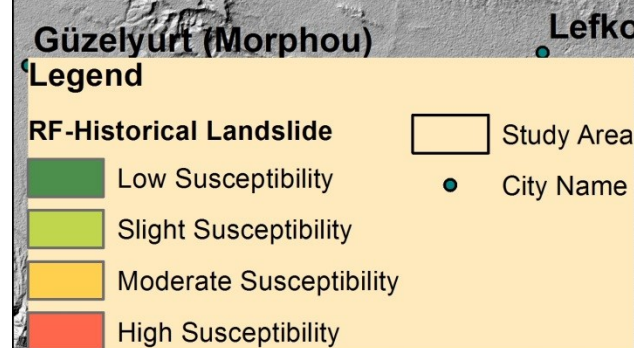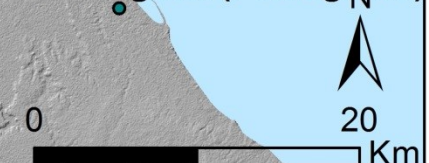
Support Vector Machine
Historical Landslide
AUC_ROC: 0,548
54%
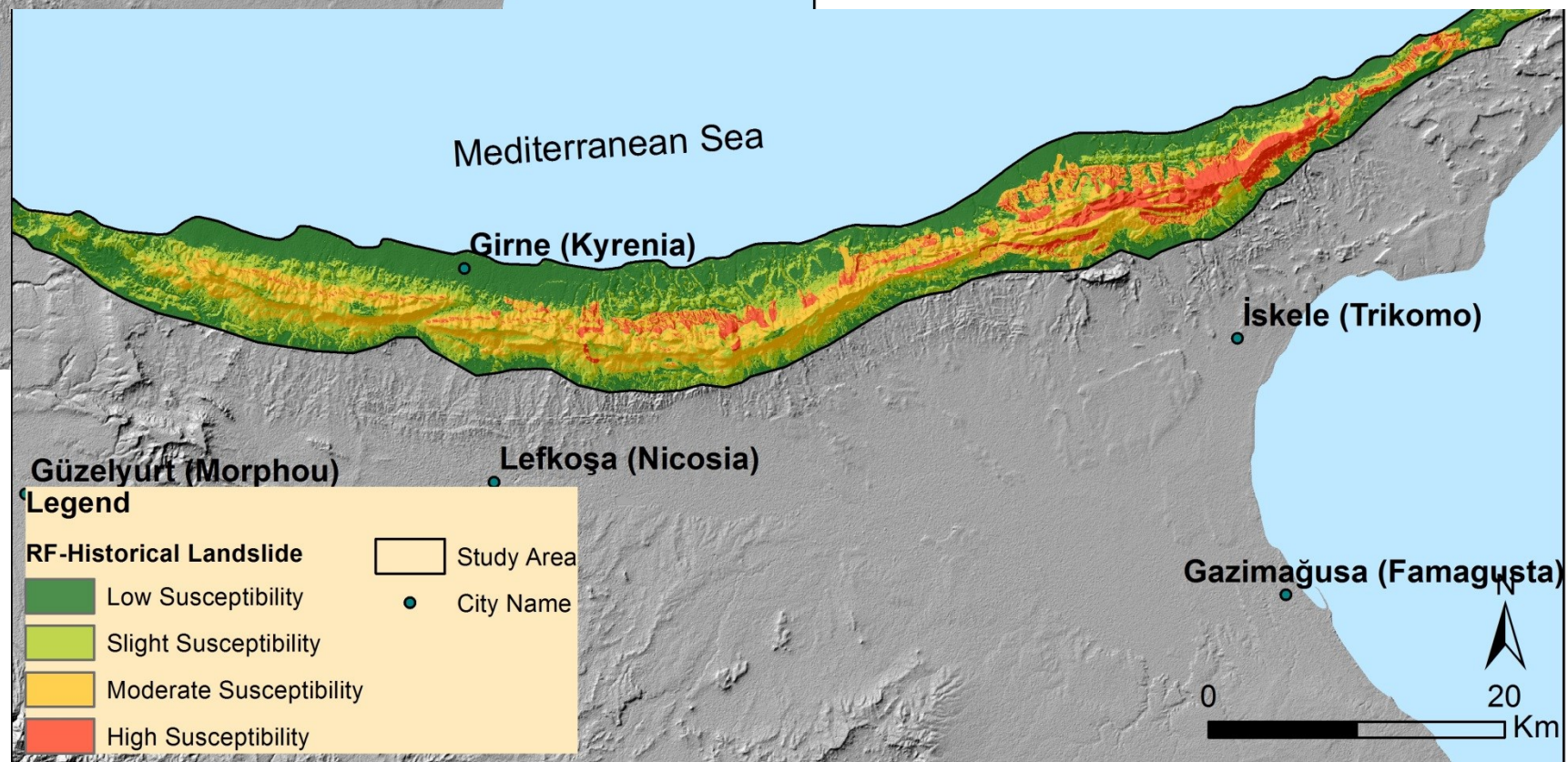
Random Forest
Historical Landslide
AUC_ROC: 0,519
51%

In conclusion, It has been determined that MASW data sets are more effective than historical data for training landslide susceptibility in Kyrenia Mountains.

In the evaluation of the landslide susceptibility in the study area, the SVM algorithm showed more accurate results than RF.

The highest accuracy rate was calculated for the data set trained on the basis of Geographic Information Systems with MASW data and SVM algorithm is 72 % .

As a result, it was determined that the terrace deposits in the north and south of the limestones at the summit of the Kyrenia Mountains are the most sensitive areas for landslides depends on machine algorithms.

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# Thanks For Attendance...