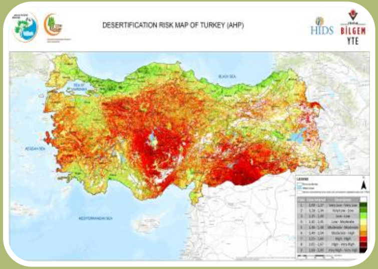
Modeling Studies for **Desertification** and **Soil Erosion** Monitoring in Turkey

Yalın YENER (*)	The Scientific and Technological Research Council of Turkey
Suat ŞAHİN	General Directorate of Combating Desertification and Erosion, Turkey
Günay ERPUL	Faculty of Agriculture, Department of Soil Science and Plant Nutrition, Ankara University

Outline

Basin Monitoring and Evaluation System (HİDS)



Turkey Desertification Model and Risk Map

Dynamic Erosion Model and Monitoring System (DEMIS)

Basin Monitoring and Evaluation System

What is Basin Monitoring and Evaluation System

TÜBİTAK

is a geographical system that evaluates data themes.

System Gains

- Protection and balanced use of natural resources
- Monitoring natural disaster and reduction of damages
- Sustainable watershed management
- Determination of monitoring and prevention policies in sustainable forest management, desertification, soil erosion, land use
- Creation of inter-agency collaboration culture

Turkey Is Planning To Take Stages Step By Step

1

- Desertification
- Soil Erosion
- Flood Control
- Carbon
- Land Use

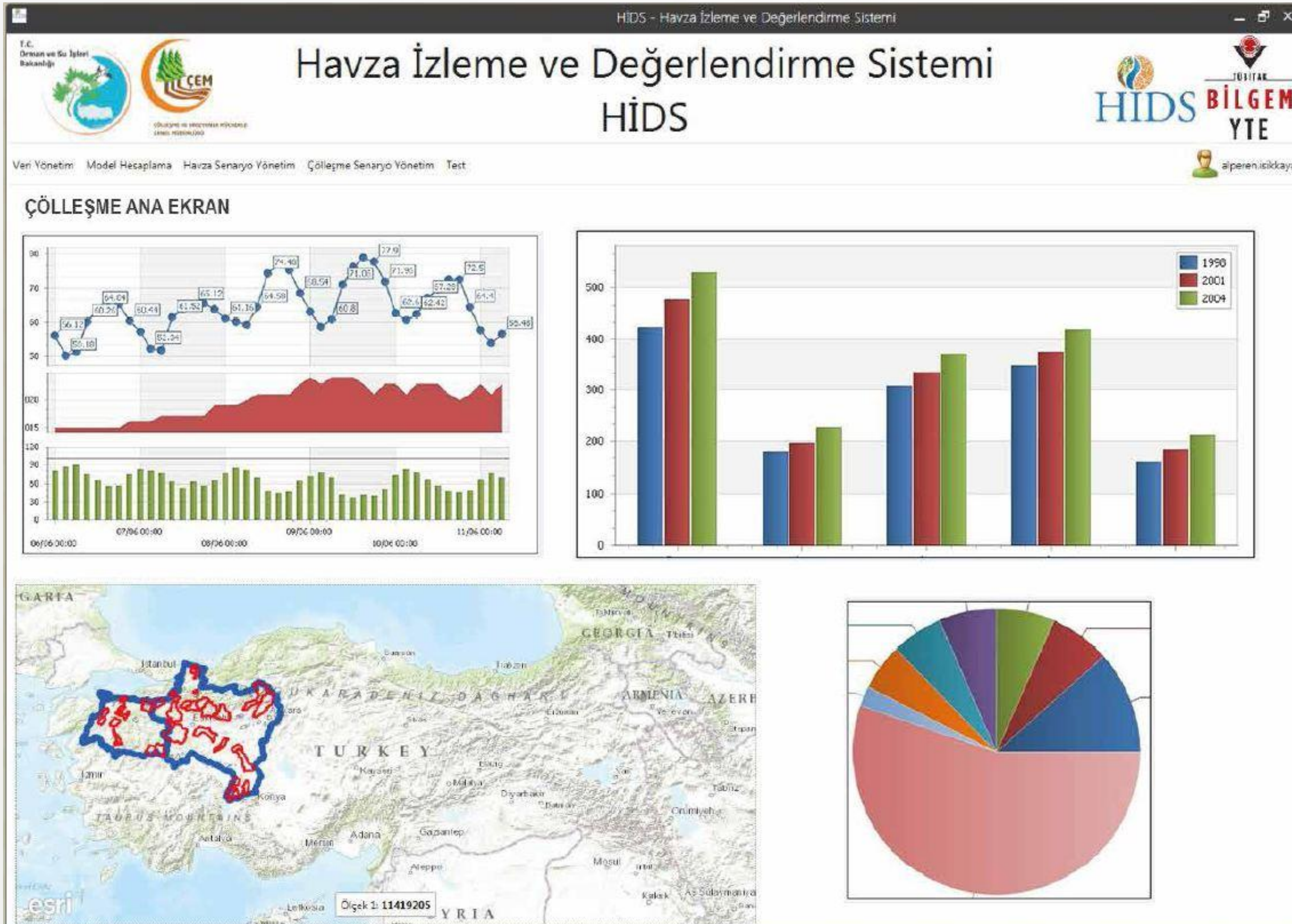
2

- Biodiversity
- Avalanche Control
- Water Management
- Forest Management

3

- Socioeconomic and Cultural Structure
- Meadows and Pastures
- Environmental Management
- Agricultural Management
- Energy
- Coasterl Ecosystem
- Urban Watersheds

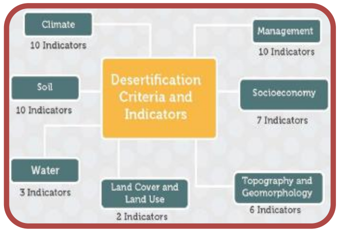
Software Interfaces



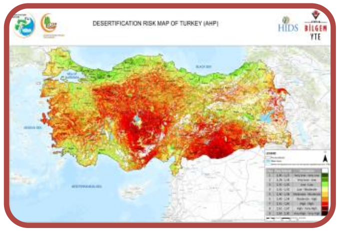
Turkey Desertification Model and Risk Map

Turkey Desertification Model and Risk Map

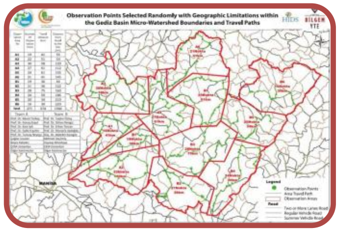
Project Team And Cooperation Culture



Identifying Desertification Criteria And Indicators

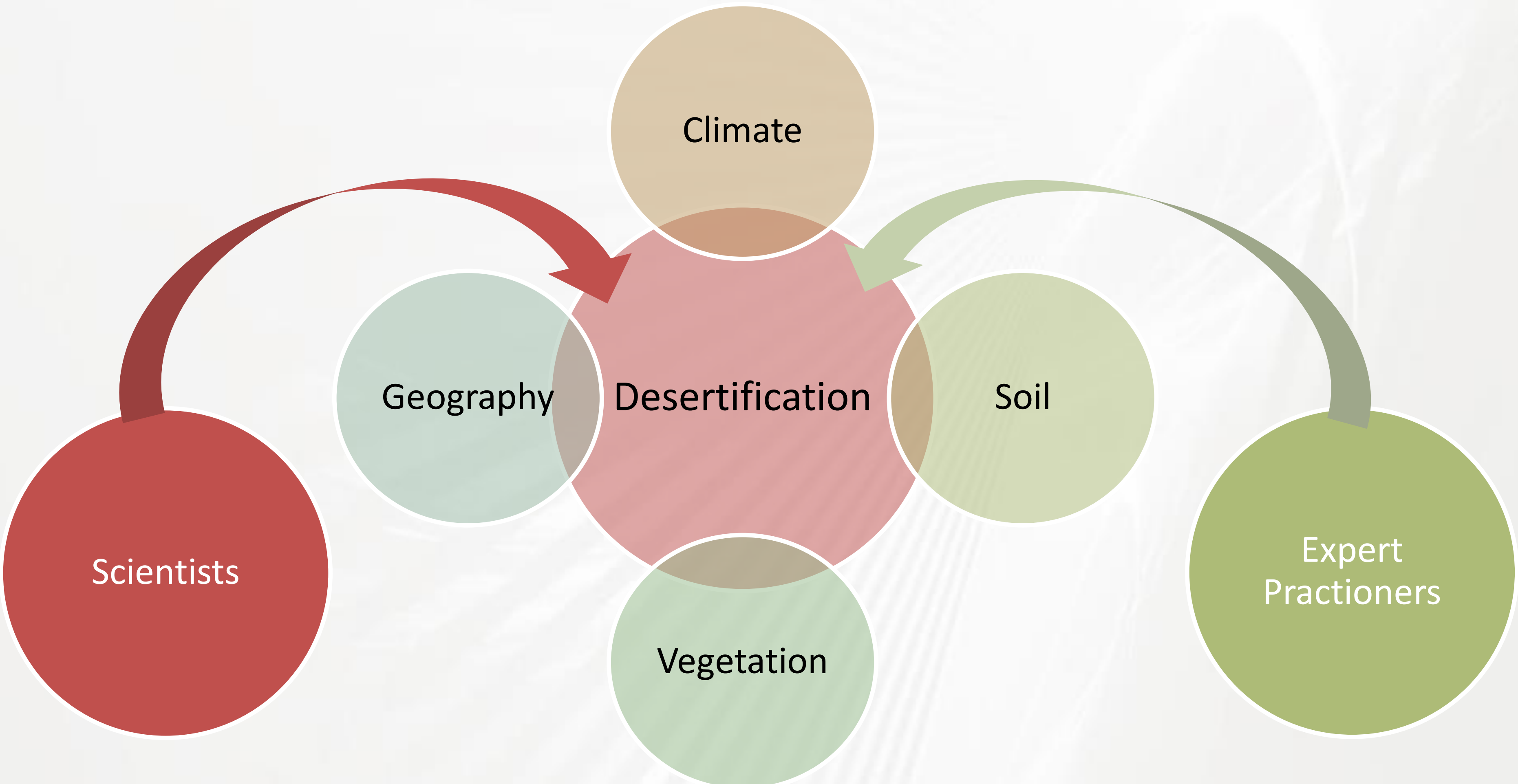


Generating Desertification Model And Risk Map Of Turkey



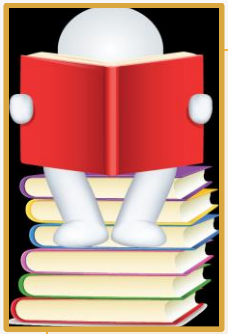
Pilot Field Study

Project Team And Cooperation Culture



Engaging all sectors in accordance with the multi-disciplinary nature of desertification

Literature Review



Relevant Models, Projects, Programmes etc.

Relevant Legislation

Relevant International Agreements etc…

The Result of Literature Review

No	Category	Total Indicators
1	Land Use	26
2	Institutional Approach	76
3	Livestock	9
4	Climate	33
5	Geology and Geomorphology	3
6	Flood	12
7	Socio-Economy	57
8	Water	43
9	Vegetation	50
10	Agriculture	22
11	Topography	5
12	Soil	85
13	Soil Working	11
14	Tourism	3
15	Fıre	9
16	Sustainable Forest Management	122
	Total	**566**

The Process

The Result Of Literature Review: Indicator Pool

Discussing All Indicators

Identifying Draft Indicators: Indicator Cards

Identifying Indicators For Turkey

Identifying Criteria

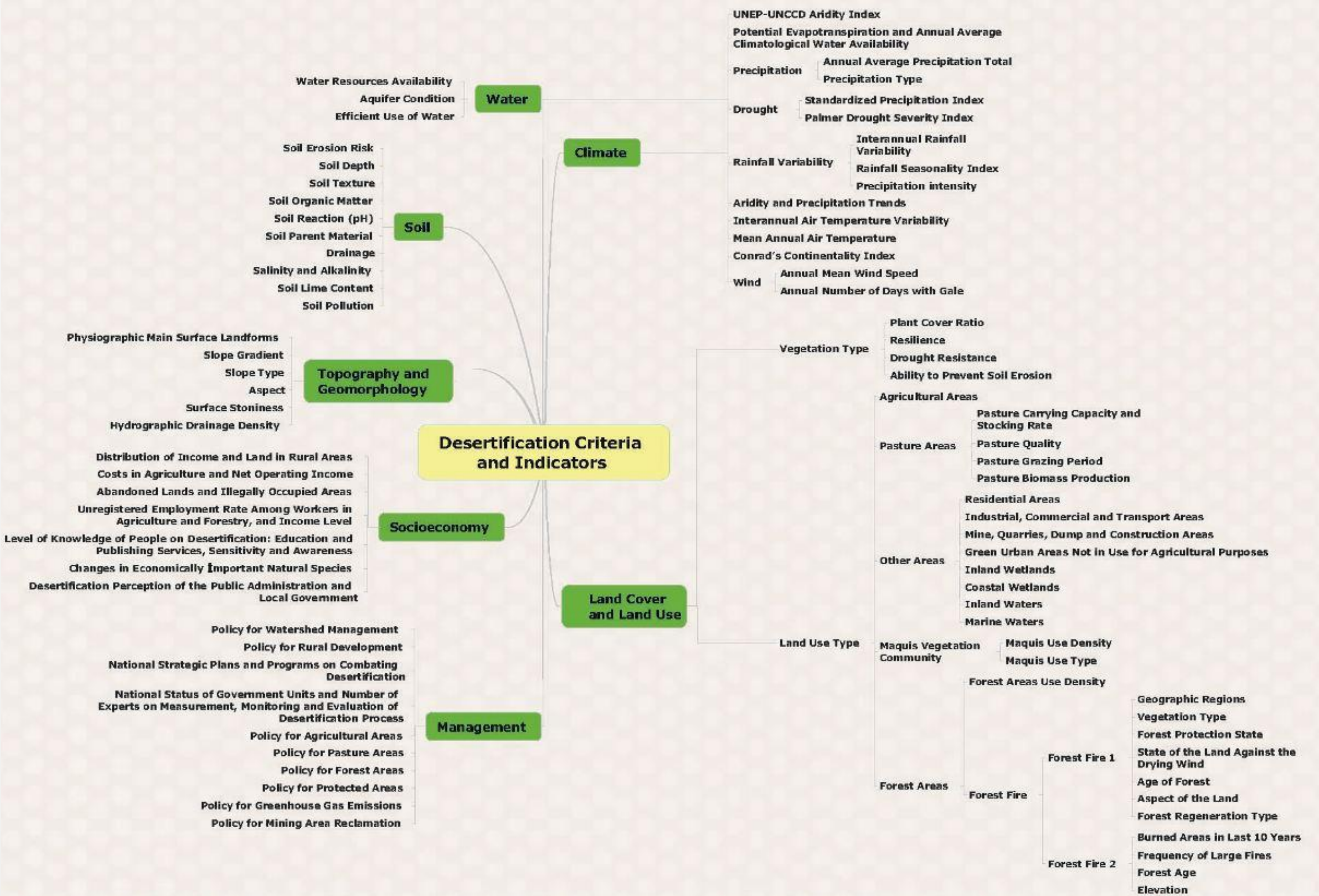
Desertification Criteria

- Climate
- Water
- Soil
- Land Cover and Land Use
- Topography and Geomorphology
- Socio-Economy
- Management

Desertification Criteria adn Indicators

Climate	**10** Indicators
Water	**3** Indicators
Soil	**10** Indicators
Land Cover and Land Use	**2** Indicators
Topography and Geomorphology	**6** Indicators
Socio-Economy	**7** Indicators
Management	**10** Indicators

Desertification Indicators For Turkey



Example: Land Cover and Land Use Desertification Indicators

- **Land Cover and Land Use**
  - Vegetation Type
    - Plant Cover Ratio
    - Resilience
    - Drought Resistance
    - Ability to Prevent Soil Erosion
  - Land Use Type
    - Agricultural Areas
    - Pasture Areas +
    - Other Areas +
    - Maquis Vegetation Community +
    - Forest Areas +

Example: Land Cover and Land Use Desertification Indicators-2

- Land Use Type
  - Agricultural Areas
  - Pasture Areas
    - Pasture Carrying Capacity and Stocking Rate
    - Pasture Quality
    - Pasture Grazing Period
    - Pasture Biomass Production
  - Other Areas
    - Residential Areas
    - Industrial, Commercial and Transport Areas
    - Mine, Quarries, Dump and Construction Areas
    - Green Urban Areas Not in Use for Agricultural Purposes
    - Inland Wetlands
    - Coastal Wetlands
    - Inland Waters
    - Marine Waters
  - Maquis Vegetation Community
    - Maquis Use Density
    - Maquis Use Type
  - Forest Areas
    - Intensity of Forest Use
    - Forest Fire +

Example: Pasture Areas Threshold Values and Scores

Pasture Carrying Capacity and Stocking Rate

Class	Pasture Carrying Capacity and Stocking Rate	Score	Description
1	> 3.00	2.00	Very Intensive Grazing
2	2.01 – 3.00	1.70	Intensive Grazing
3	1.01 – 2.00	1.50	Medium Grazing
4	≤ 1.00	1.00	Normal Grazing

Pasture Quality

Class	Rate (%) of Plants with High Nutritional Value	Score	Description
1	0 – 25	2.00	Weak
2	26 – 50	1.75	Medium
3	51 – 75	1.50	Good
4	76-100	1.00	Very Good

Example: Pasture Areas Threshold Values and Scores

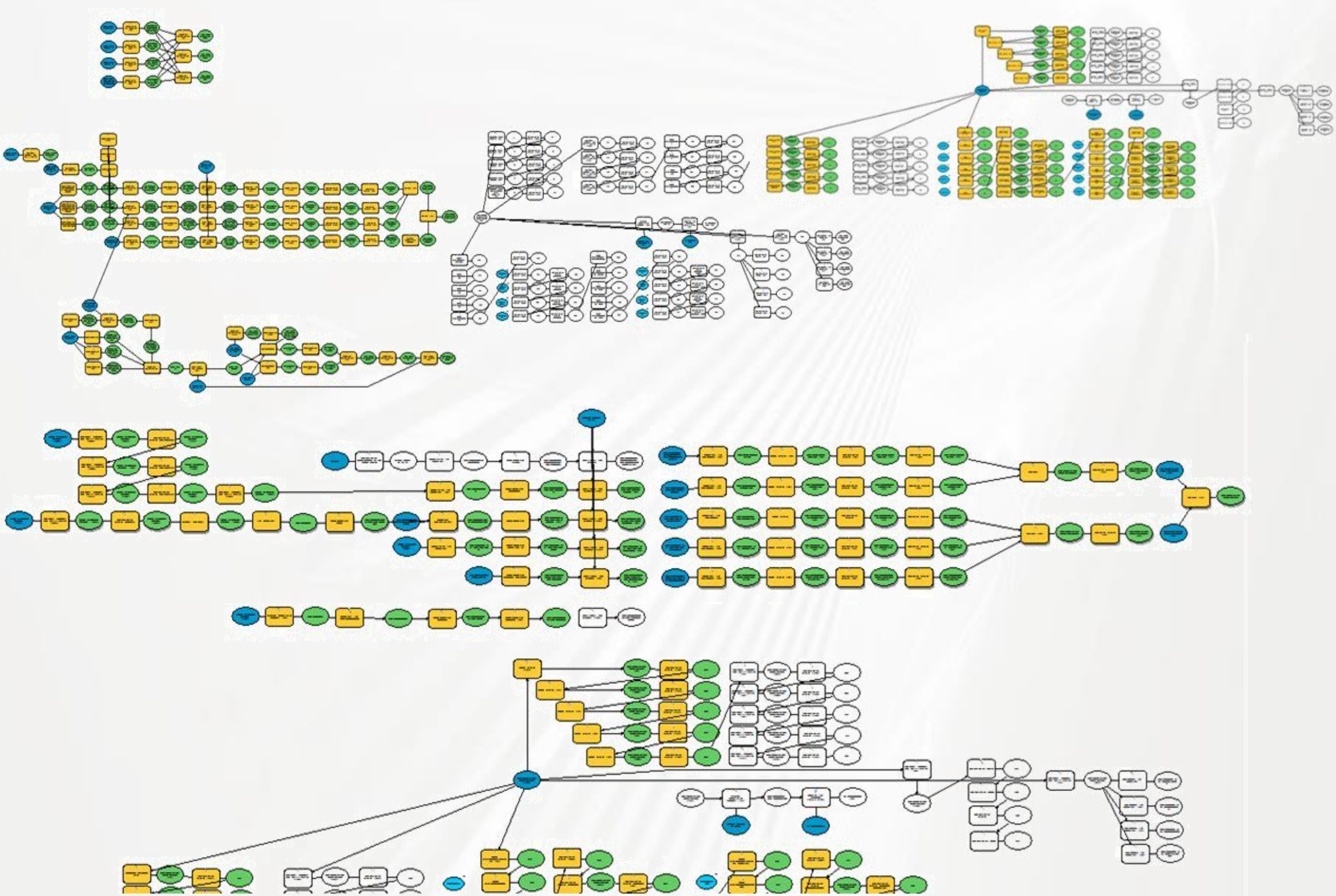
Pasture Grazing Period

Class	Grazing Period	Score	Description
1	Throughout the year	2.00	Very Long Period
2	Grazing other than winter months	1.50	Long Period
3	According to normal grazing period	1.00	Normal Period

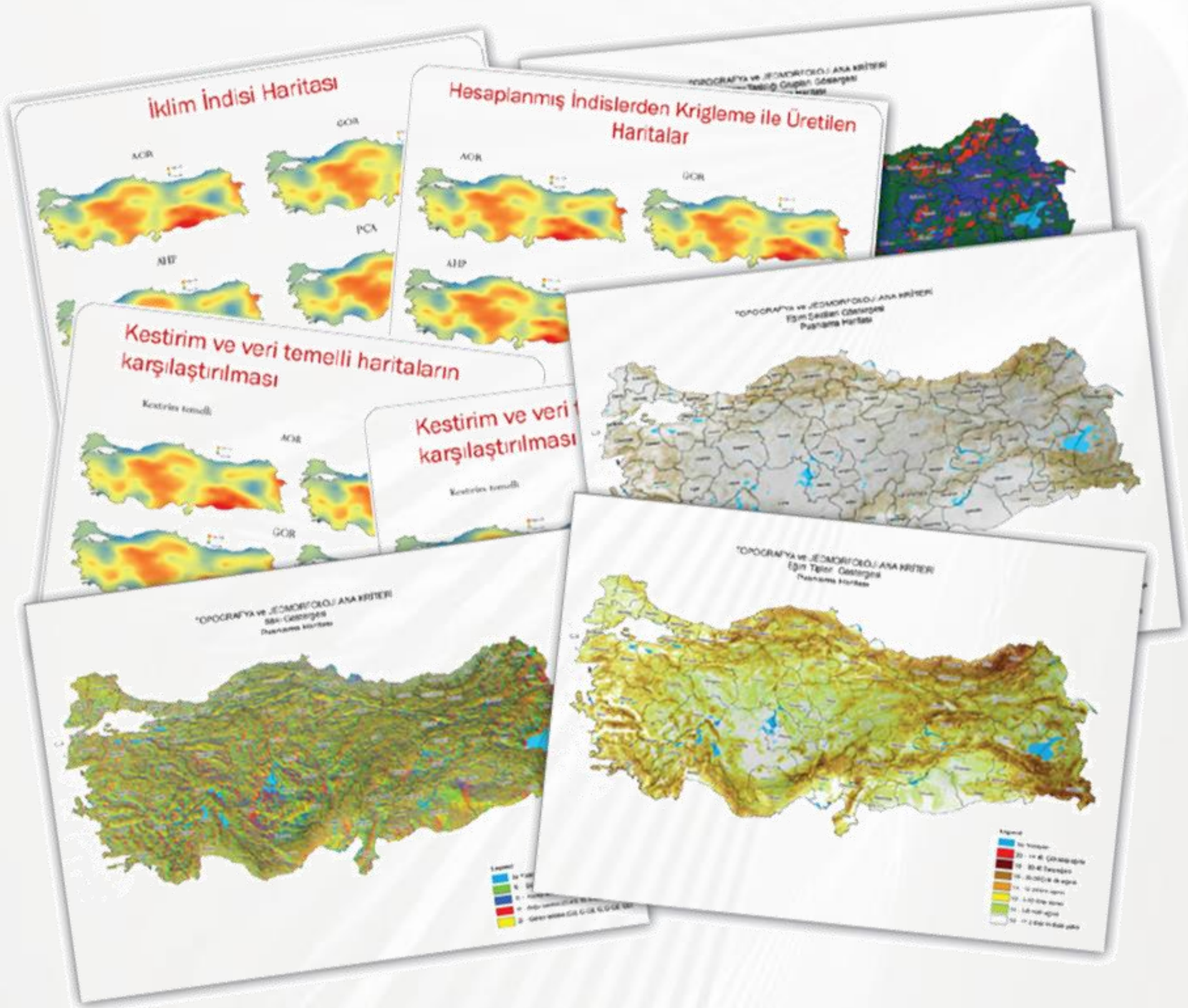
Pasture Biomass Production

Class	Annual Pasture yield (kg / da)	Score	Description
1	< 45	2.00	Very Weak
2	45 – 60	1.75	Weak
3	61 – 90	1.50	Medium
4	> 90	1.00	Good

Example: GIS Model of Desertification Model

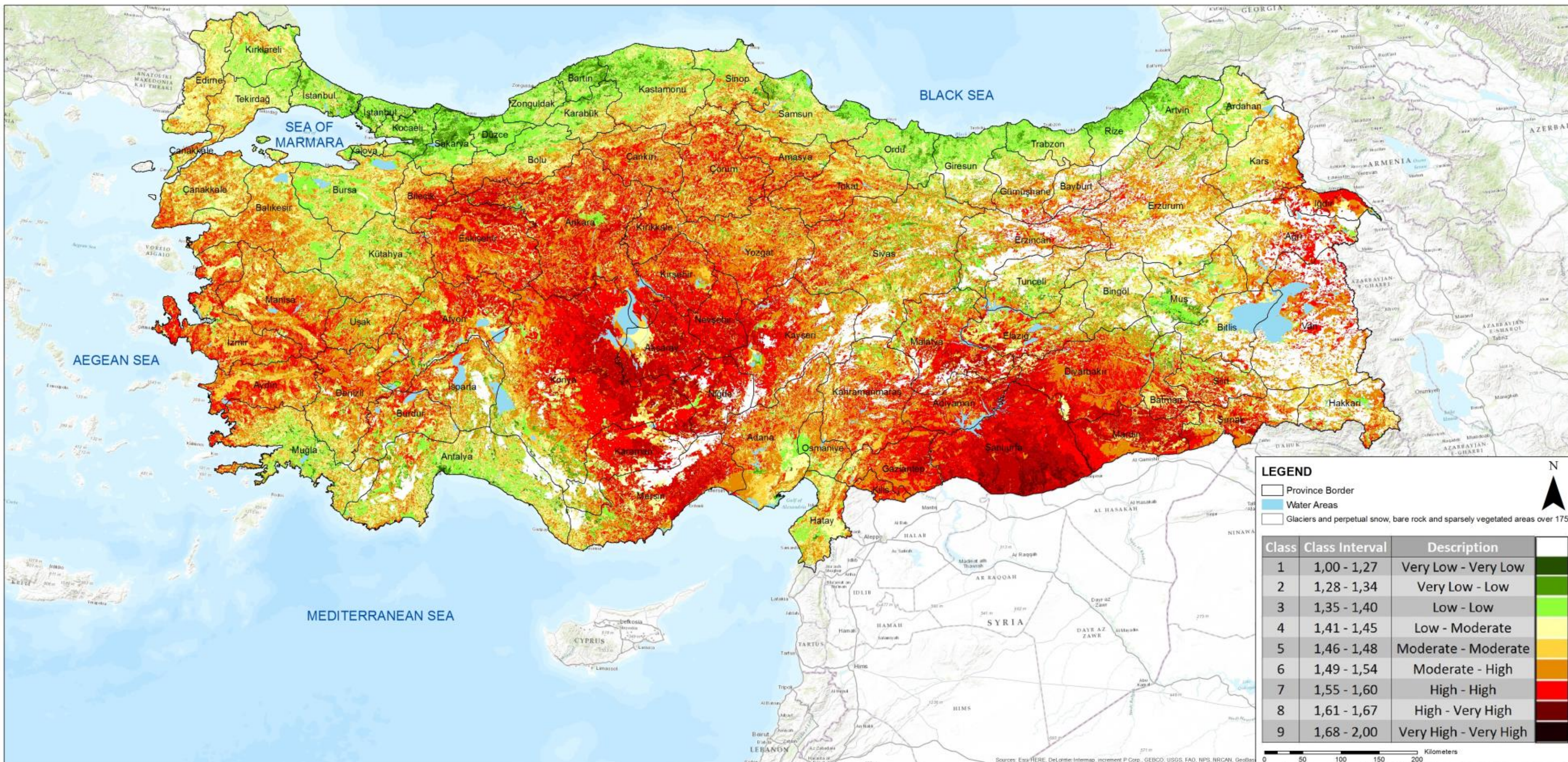


Example: Criteria Maps

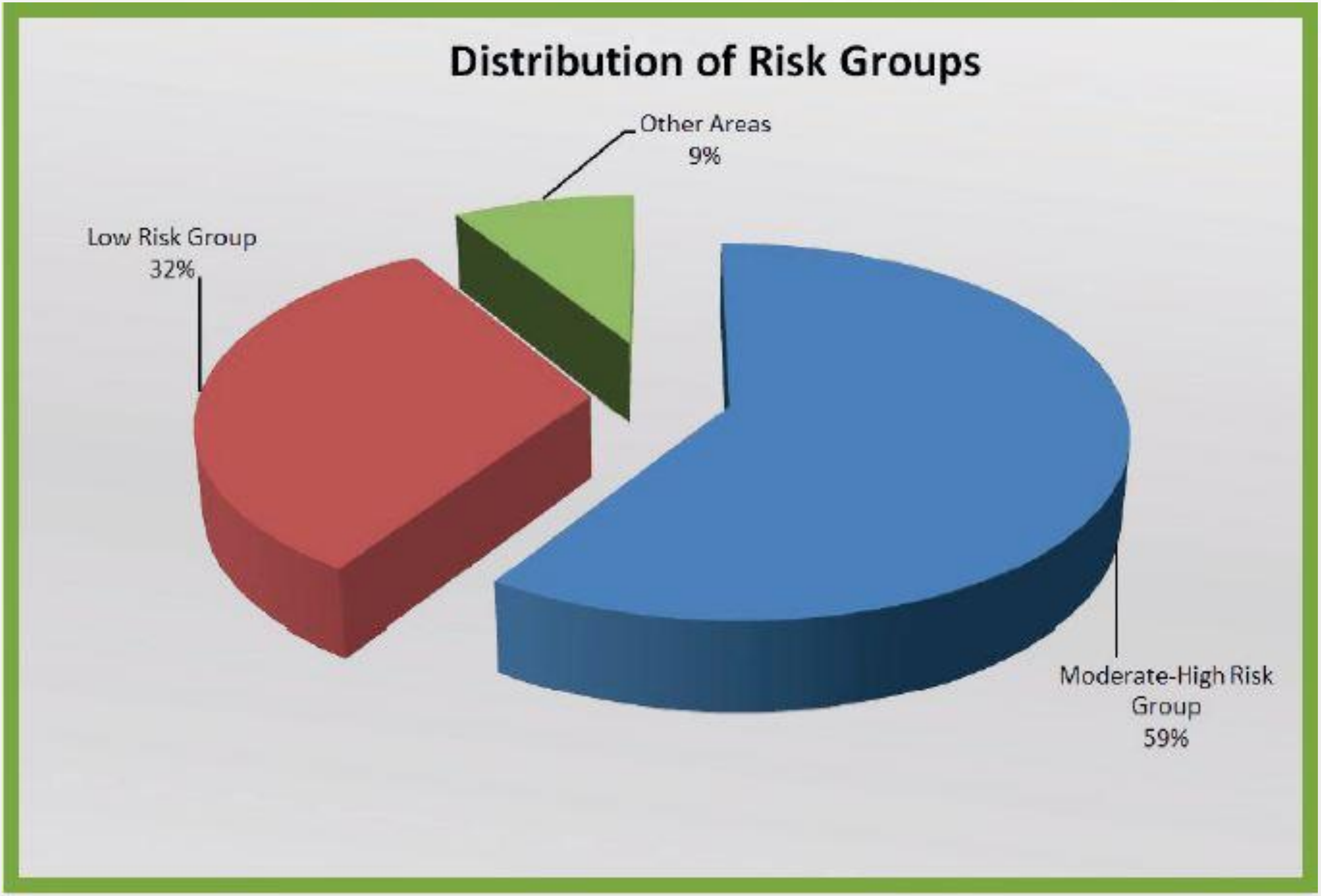


The Desertification Risk Map Of Turkey

DESERTIFICATION RISK MAP OF TURKEY (AHP)

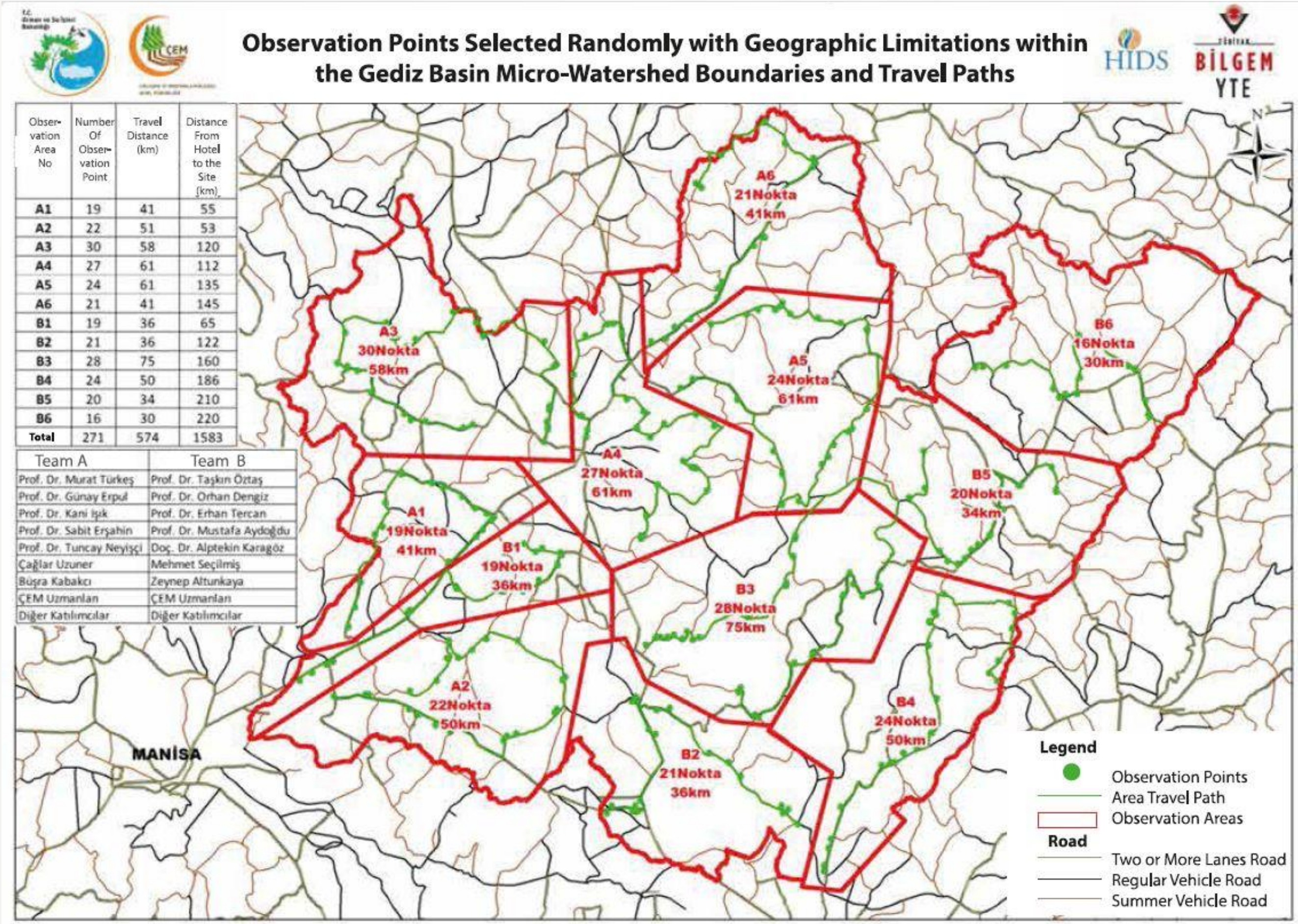


The Desertification Risk Map Of Turkey



Pilot Field Study

The Results Of Pilot Field Study



Observation Area No	Number Of Observation Point	Travel Distance (km)	Distance From Hotel to the Site (km)
A1	19	41	55
A2	22	51	53
A3	30	58	120
A4	27	61	112
A5	24	61	135
A6	21	41	145
B1	19	36	65
B2	21	36	122
B3	28	75	160
B4	24	50	186
B5	20	34	210
B6	16	30	220
Total	271	574	1583

Team A	Team B
Prof. Dr. Murat Türkeş	Prof. Dr. Taşkın Öztaş
Prof. Dr. Günay Erpul	Prof. Dr. Orhan Dengiz
Prof. Dr. Kani Işık	Prof. Dr. Erhan Tercan
Prof. Dr. Sabit Erşahin	Prof. Dr. Mustafa Aydoğdu
Prof. Dr. Tuncay Neyişçi	Doç. Dr. Alptekin Karagöz
Çağlar Uzuner	Mehmet Seçilmiş
Büşra Kabakcı	Zeynep Altunkaya
ÇEM Uzmanları	ÇEM Uzmanları
Diğer Katılımcılar	Diğer Katılımcılar

The Desertification Model Of Turkey resulted in 94 % consistency with 90 % confidence intervals at micro-watershed level.

Dynamic Erosion Model and Monitoring System (DEMIS)

Assessment of Soil Erosion Risk

As a simultaneously running sub-theme of the "National Desertification System", a "Dynamic Erosion Model and Monitoring System" (DEMIS) is complementarily established to predict soil losses at the micro, meso and macro watershed levels.

T.C.
Orman ve Su İşleri
Bakanlığı

DEMIS

TÜBİTAK

- By a model-based approach, the DEMIS aims to assess erosion risk at national level by quantifying erosion in Turkey.
- The outcome of DEMIS is a set of maps that can be used as a support
  - to identifying regions that are vulnerable to erosion
  - to planning conservation measures that are necessary to prevent soil from eroding.

Methodology RUSLE / GIS Technology

- The RUSLE (Revised Universal Soil Loss Equation) technology highly integrated with GIS is used to assess soil erosion risk for this system.
- Why RUSLE ?
- Because
  - it is one of the least data demanding erosion models that has been developed,
  - it has been widely applied at different scales.

Methodology RUSLE / GIS Technology

- The model computes the average annual soil erosion in ton ha^{-1} $year^{-1}$ as a product of rainfall-runoff erosivity factor R, soil erodibility factor K, slope length and slope steepness factor LS, cover management factor C, and support practice factor P

Approach

The methodology then compares the calculated soil loss to the tolerable soil loss for a specific soil type, which is accepted as the level of soil erosion that would still allow a high level of crop productivity in a sustainable and continuous way,

- in order to design the different land use systems and conservation measures

Model

$$A = R \times K \times LS \times C \times P$$

A: predicted soil loss [ton ha^{-1} $yıl^{-1}$]

R: rainfall-runoff erosivity factor [MJ ha^{-1} $yıl^{-1}$ × mm h^{-1}]

K: soil erodibility factor [ton ha^{-1} × ha MJ^{-1} × h mm^{-1}]

L: slope length factor

S: slope steepness factor

C: crop management factor

P: support practices factor

Climatic risk assessment, R

- Rainfall-runoff erosivity factor (R) is determined for all over Turkey using long term daily rainfall data obtained in the stations of the Turkish State Meteorological Service.

$$R = E \times I_{30} = \left[\frac{MJ}{ha} \times \frac{mm}{saat} \right]$$

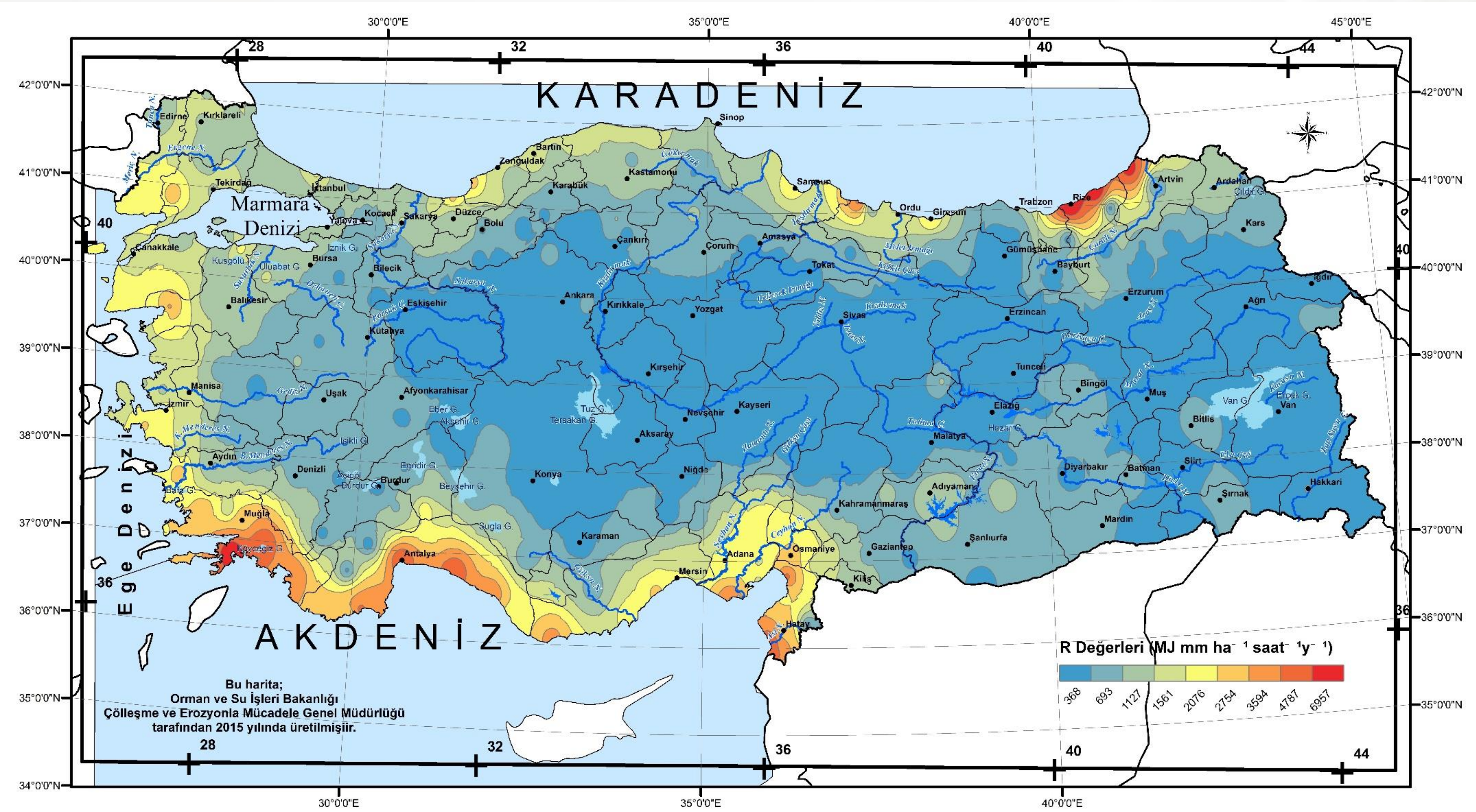
E: the Energy of rainfall [MJ / (ha × mm)]

I: the maximum half-hour rainfall intensity for the storm [mm/h]

T.C. Orman ve Su İşleri Bakanlığı

RUSLE – R Map of Turkey

TÜBİTAK



Susceptibility of soils to the water erosion RUSLE – K)

- Three different equations is made use of calculating soil erodibility factor:

$$K_n = 2{,}767.10^{-7}(12 - OM)M^{1.14} + 4{,}282.10^{-3}(s-2) + 3{,}294.10^{-3}(p-3)$$

(Wischmeier, 1971; Renard et al. 1997)

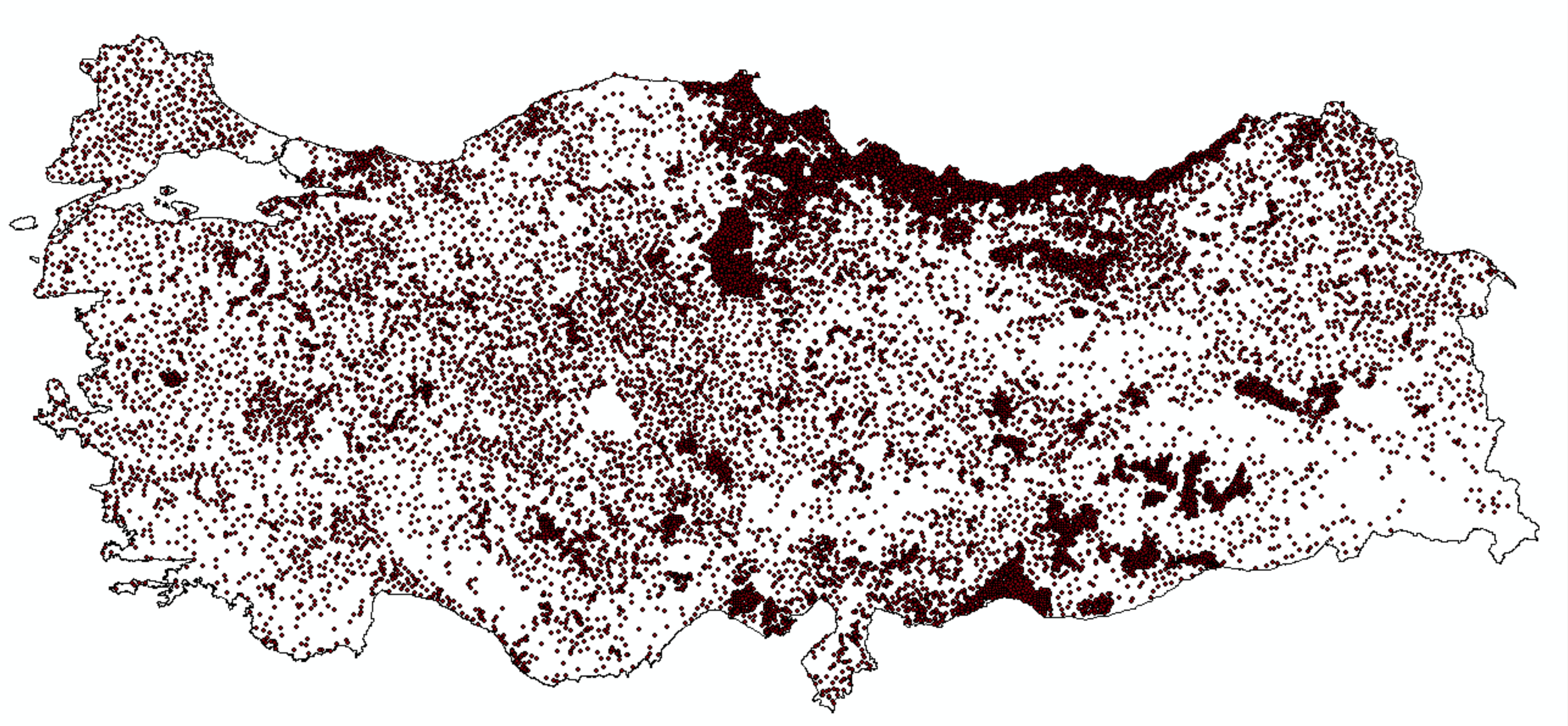
$$K_b = 0{,}0034 + 0{,}0405\exp\left[-0{,}5\left(\frac{\log D_g + 1{,}659}{0{,}7101}\right)^2\right]$$

(Römkens et al., 1986)

$$K_T = 0{,}0293(0{,}65 - D_G + 0{,}24D_G^2)\times\exp\left\{-0{,}0021\frac{OM}{C} - 0{,}00037\left(\frac{OM}{C}\right)^2 - 4{,}02C + 1{,}72C^2\right\}$$

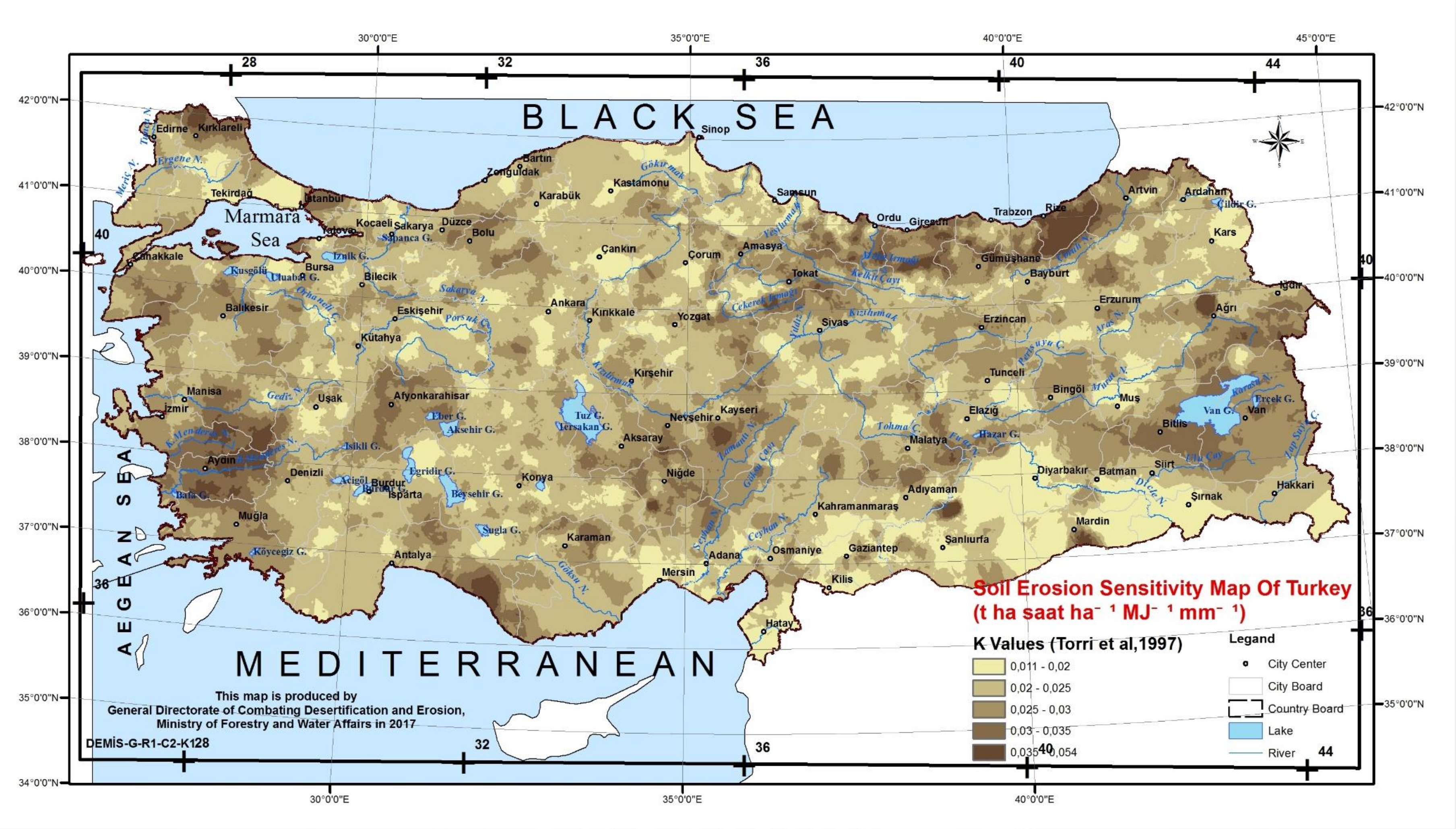
(Torri et al., 1997)

Ground coordinated soil sample data points



- Continuously, more soil data feed back in the system to update maps and relevant analyses.

Soil erodibility (Torri et. al., 1997)



The effect of topography on soil erosion, RUSLE - LS

- Topographic factor described by the multiplication of slope length (L) and slope degree (S) will be estimated from the digital elevation model (DEM) of Turkey. Specifically, it will be based on the flow accumulation and slope steepness.

Flow accumulation

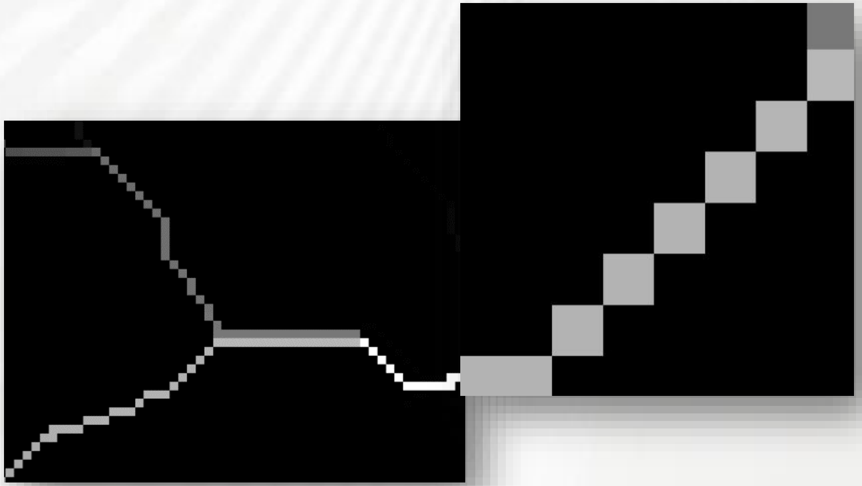
$$LS = \left(\frac{\chi \eta}{22.13} \right)^{0.4} \cdot \left(\frac{\sin \theta}{0.0896} \right)^{1..3}$$

LS: topgraphic factor

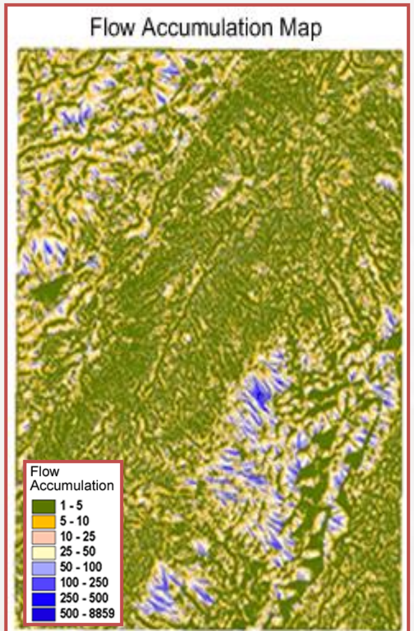
χ: flow accumulation number [ArcView Watershed Delineation]

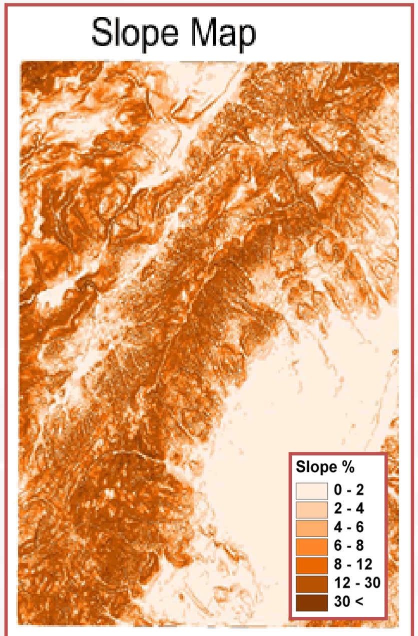
η: cell size

θ: slope degree [º]

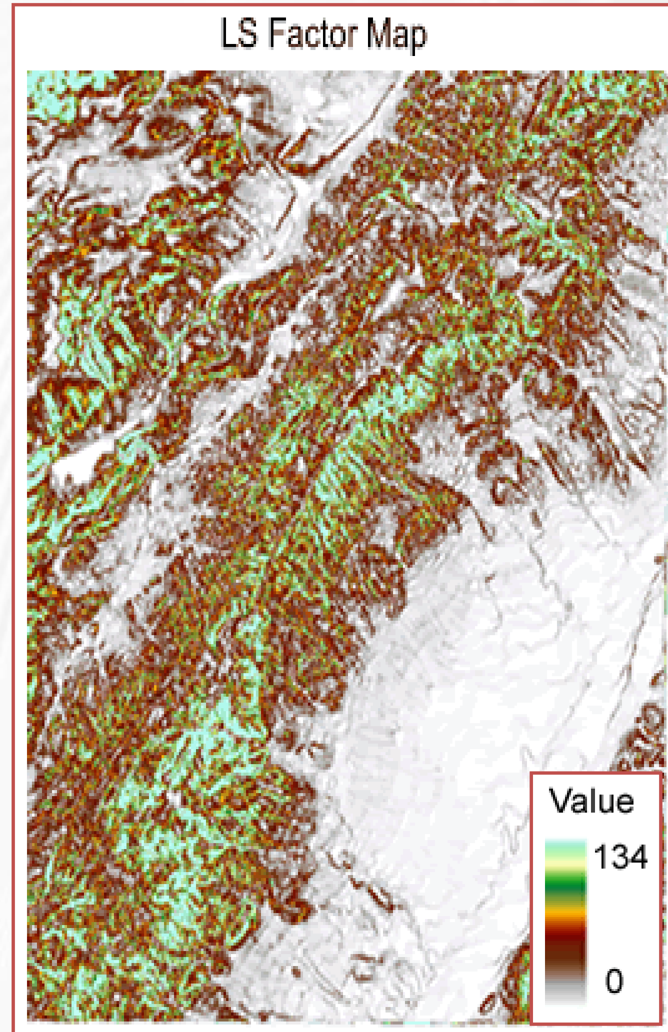


GIS / DEM / RUSLE-LS Map





LS = (Flow Accumulation x Cell Size / 22.13)
0.4 x (sin slope / 0.0896)1.3



Land use / Land Cover Assessment, RUSLE-C

Cover management factor (C), which depends primarily on the cover percentage of vegetation and growth stage, is obtained. Methods is sought for assigning monthly or annual C-values, and using both multi-temporal satellite imagery and land cover database, approximate C-values is determined.

Multi-temporal Satellite Imagery along with CORINE

$$NDVI = \frac{(AVHRR\,2 - AVHRR\,1)}{(AVHRR\,2 + AVHHR\,1)}$$

NDVI: Normalized Difference Vegetation Index

AVHRR1 & AVHRR2: reflectance value channel 1 (visible) & channel 2 (near infrared), respectively

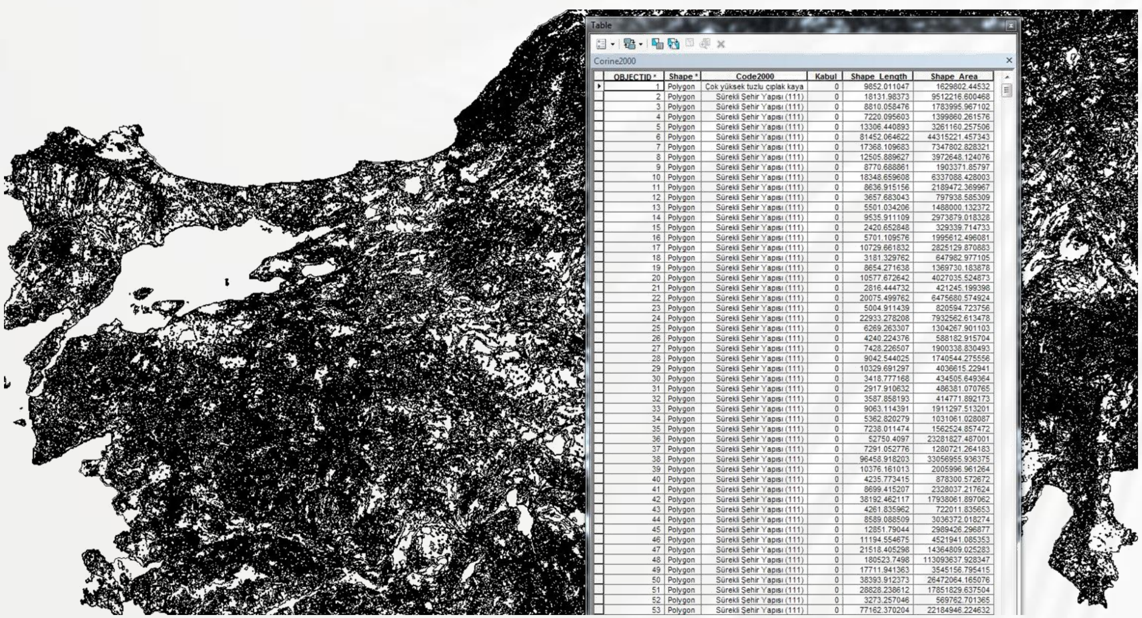
$$C = \exp\left[-\alpha \frac{NDVI}{\beta - NDVI}\right]$$

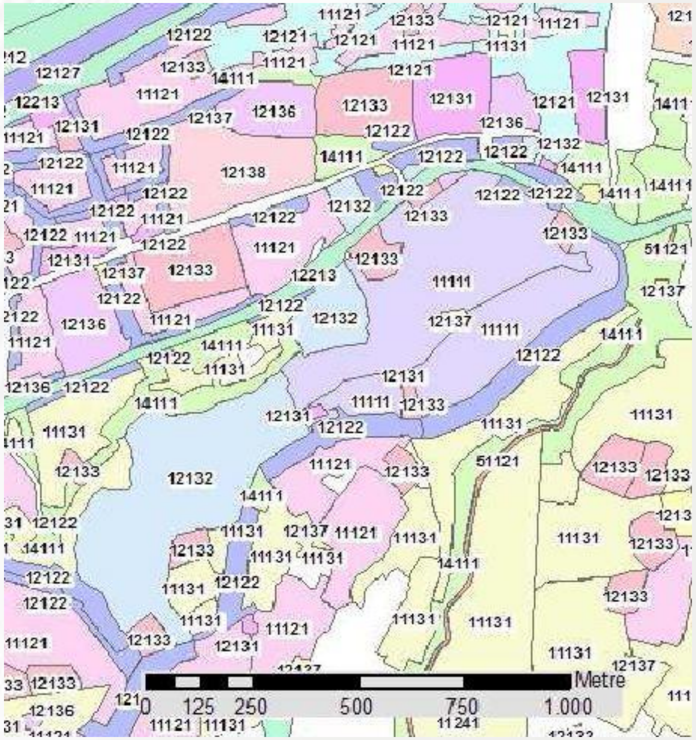
C: crop management factor

α & β: regression parameters

Land use/land cover assessment RUSLE - C

It is being re-generated as CORINE updates (2000, 2006, 2012) being backed up by forestry digital photogrammetry for management



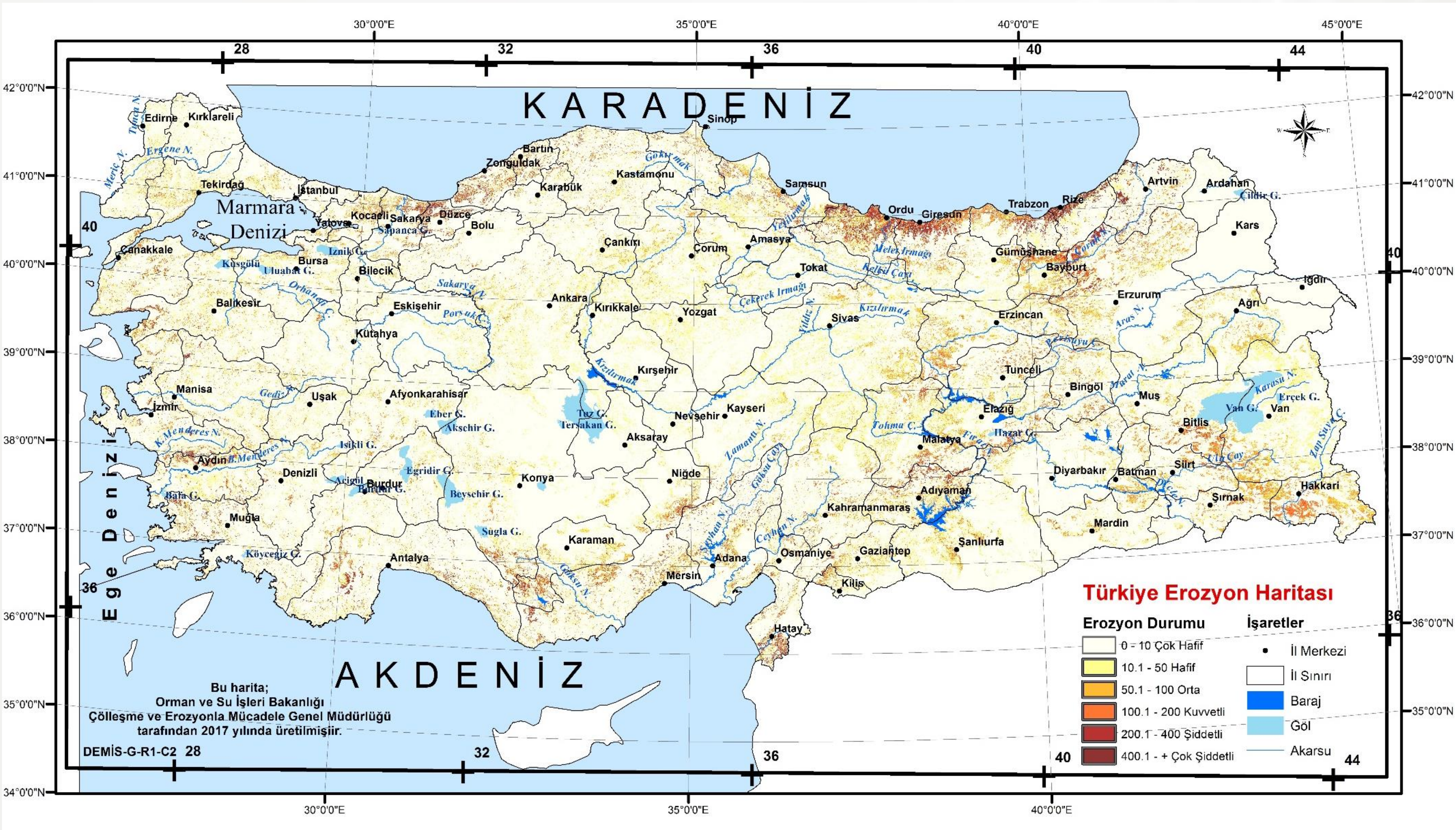


Support Practice Factor, RUSLE - P

The system discerns dam constructions, afforestation, terracing, gully control works etc. as a ‘support practice factor’ being ratio of areas supported over unprotected within a microscale watershed.

National Erosion Map

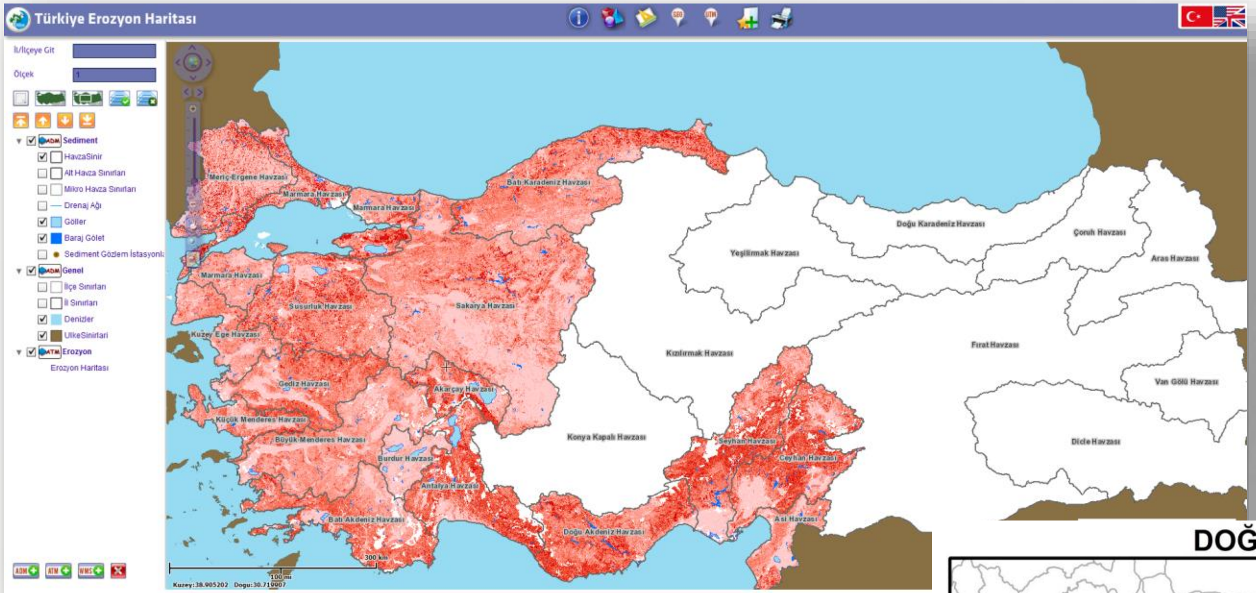
$$A = R \times K \times LS \times C \times P$$



T.C. Orman ve Su İşleri Bakanlığı

National Erosion Map

TÜBİTAK



- The system services at different scales not only to assess soil erosion risk and estimate sediment amount to be delivered to rivers and reservoirs but also to plan conservation measures when necessary.

Thank You

Çukurambar Mah. 1478. Cadde No:22 06100
Çankaya / ANKARA
+90 (312) 289 9 222
yte.bilgem@tubitak.gov.tr
http://yte.bilgem.tubitak.gov.tr/