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An Expert System Application for Desertification Risk Monitoring

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Abstract

This study includes an expert system design for desertification risk field data collection and monitoring. It describes the structure of used expert system, knowledge base and rule base. Expert system was developed using MEDALUS (Mediterranean Desertification and Land Use) method with Esri's Survey123 for ArcGIS geographic information systems application. In this study, a mobile application has been developed to collect field data and assess desertification risk. With this expert system, many people will be able to collect field data and assess the risk of desertification in the region with only using their cell phones.

Key words: Expert System, Desertification Risk Monitoring System, MEDALUS, Geographic Information System, Survey123 for ArcGIS.

1. Introduction

Expert system is an information-based decision support system. It is a tool to help in decision making. Expert system is a software system that models decision making process of experts. It is not based on an algorithm and it searches data entered in the knowledge base. It activates information and continues to analyze further. [1]

Based on current literature reviewed, desertification risk monitoring systems are multi disciplinary in nature and very difficult. Field data collection and desertification risk assessment effectively is very important.

In this study, an expert system was developed to monitor desertification risk of an area, based on rule base using MEDALUS method.

2. Desertification Risk and Assessments

Desertification is an ecological degradation and productivity decrease process as a result of physical and climatic changes, biological, political, social, economic and cultural factors and their mutual interactions, especially in arid, semi-arid, arid by - sub-humid and humid by - drought and semi-humid areas and in Mediterranean climate zones regardless of drought and humidity land characteristics. [2]

According to the United Nations Convention to Combat Desertification (UNCCD), 70% of the world's drylands outside deserts are already degraded. 24 billion tons of fertile top soil disappear every year. Due to drought and desertification, each year 12 million ha are lost, where 20 million tons of grain could have been grown. It affects 1,2 billion people directly. 135 million people of

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this are under serious risk and 10 million people were forced to migrate due to land degradation/desertification from the areas where they lived [2].

Turkey is among the countries that will be greatly affected by the increase in non-arable land and climate change due to its geographical position, geological structure, topography and climate. According to World Desertification Risk Map, significant part of Turkey is vulnerable to desertification.

Desertification monitoring is a continuing process with assessments, effects and reactions. Assessment is a phase when results of monitoring interpreted. Factors below needed for a successful monitoring [2]:

- Accuracy and correctness of information,
- Indicators representing the land changes,
- Elimination of expensive and difficult to monitor indicators,
- Monitoring same areas at same time intervals with same methods,
- Determination of actions to monitor,

2.1. ***Record keeping and controlling accuracy. MEDALUS Mediterranean Desertification and Land Use Method***

The Environmentally Sensitive Area (ESA) approach is a widely applied methodology to evaluate and map the sensitivity of land to desertification. The main advantages of the ESA are the flexibility in the use of the input variables and the robustness of the approach to quantify the sensitivity of land to desertification. The outcome of the ESA model is a composite index of environmental quality called ESAI (Environmental Sensitive Area Index). ESAI ranges from 1 (the lowest land sensitivity to degradation) to 2 (the highest sensitivity to degradation). The ESA method has been extensively validated at several sites in southern Europe, in middle and Far East and in Africa [3].

The MEDALUS method identifies regions that are a ESAs. In this model, different types of ESAs to desertification can be analyzed in terms of various parameters such as landforms, soil, geology, vegetation, climate and human actions. Each of these parameters is grouped into various uniform classes and weighting factor is assigned to each class. Then four layers are evaluated soil quality, and management quality. After determined indices for each layer, the ESAs to desertification are defined by combining the four quality layer. All the data defining the four main layers are introduced in a regional geographical information system (GIS), and overlain in accordance with the developed algorithm which takes the geometric mean to compile maps of ESAs to desertification [4].

Table 1. Types of ESAs and corresponding ranges of indices.

Type	Subtype	Range of ESAI
Critical	C1	>1.53
Critical	C2	1.42-1.53
Critical	C3	1.38-1.41
Fragile	F1	1.37-1.33
Fragile	F2	1.32-1.27
Fragile	F3	1.26-1.23
Potential	P	1.22-1.17
Non affected	N	<1.17

3. Desertification Risk Monitoring Expert System Developed

The expert system developed determines the risk of desertification, using MEDALUS method with the data collected in the field and using the Survey123 for ArcGIS program. As a result of desertification evaluation of the area, the risk scores emerges with a location of the area on the map.

3.1. Esri Survey123 for ArcGIS Application

Survey123 for ArcGIS is a simple and intuitive form-centric data gathering solution that makes creating, sharing, and analyzing surveys possible. It is a mobile app that enables employees to capture answers in the field. It quickly designs powerful surveys and publish them into ArcGIS. Answers from the field can be analyzed in ArcGIS to support decision making [5].

3.2. User Interface

User interface provides communication between user and the program. User interface allows expert system program to control knowledge base and add/remove rule. Users access the system by using the user interface, select values for each desertification indicator and send to evaluation. Survey123 for ArcGIS mobile app user interface is shown at Figure 1 below.

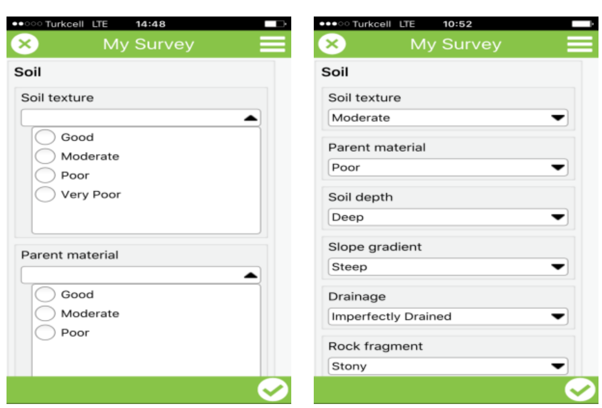

Figure 1. View of user interface

3.3. Knowledge Base

Knowledge Base is created with the knowledge of one or more experts on a topic. There are 49 rules of the expert system developed. Some rules are seen in Table 2. These rules have been grouped by themes.

Table 2. Rules used to calculate desertification risk

Criteria	Indicator	Class	Score	Description	Explanation
Soil	**Texture**	1	1	Good	L, SCL, SL, LS, CL
		2	1.2	Moderate	Sc, SiL, SiCL
	Parent Material	1	1	Good	Limonstone, Dolomite, nonfriable sandstone, hard limestone
		3	2	Poor	Friable calcareous day, day, sandy formation, alluvium and colluviums
	Depth	1	1	Deep	>0.75 m
		2	1.3	Moderate	<0.75-0.3 m
		4	2	Very Shallow	<0.15 m
Vegetation	**Fire Risk**	1	1	Low	Bare land, Perennial, agricultural crops
		2	1.3	Moderate	Annual agricultural crops
	Erosion Protection	1	1	Very High	Evergreen forests
		5	2	Very low	Annual agricultural crops, vines
		4	1.8	Low	Decidious perennial, agricultural crops (almonds, orchards)
Climate	**Rainfall**	1	1	High	>650 mm
		2	1.3	Moderate	<% 650 mm - % 280 mm
	Aridity	1	1	Extremely low	<50
		2	1.1	Very Low	>50-75
		3	1.2	Low	>75-100
	Aspect	1	1	Northwest	
		2	1	Northeast	

3.4. Inference Mechanism

Role of the inference mechanism is to interpret the knowledge base and control. Inference mechanism is a unit where meaningful inferences are made by using the rules. Inference mechanism transfers the inferences obtained to the user by using data in the Knowledge Base and the rules. According to the MEDALUS method, calculation of desertification risk is made by taking the geometric mean of the indicators shown in the following table (Table 3).

Table 3. Desertification risk calculations

Risk Type	**Risk Formula**
Soil Quality Index (SQI)	(texture * parent material * rock fragment * depth * slope * drainage)$^{1/6}$
Vegetation Quality Index (VQI)	(fire risk * erosion protection * drought resistance * vegetation cover)$^{1/4}$
Climate Quality Index (CQI)	(rainfall * aridity * aspect)$^{1/3}$
Management Quality Index (MQI)	(land use intensity * policy enforcement)$^{1/3}$
Environmentally Sensitive Areas Index (ESAI)	(SQI*CQI*VQI*MQI)$^{1/4}$

Desertification risk score and type are shown after entering values for indicator (Figure 2).

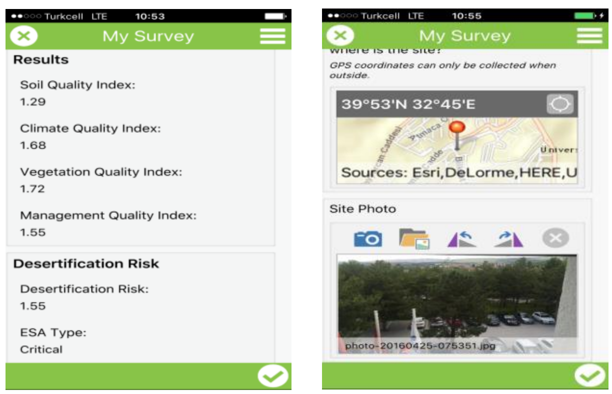

Figure 2. Desertification risk score and type view

3.5. Description Unit

Description unit is the section where the results obtained are reported to the users by the expert system. The data collected in the field are transported to the internet site from the mobile phone and a can be seen on a map (Figure 3).

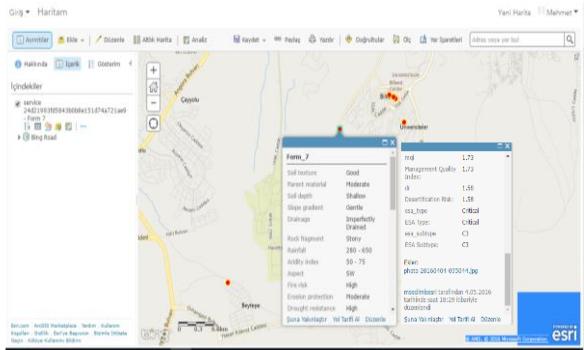

Figure 3: View of field data on the internet map

Conclusions

Desertification risk assessment and monitoring systems are multi-disciplinary in nature and complex. Accurate field data collection and multi-criteria desertification risk assessment effectively is very important. In this study, an expert system was developed to determine desertification risk of an area, based on MEDALUS method. A mobile application software has been developed using the Survey123 for ArcGIS program to collect data in the field and assess desertification risk. As a result of desertification evaluation of the area, the risk scores emerges with a location of the area on the map.

This expert system makes it easy to collect field data and assess the risk of desertification in the region with only using cell phones. Eficient field data collection is very important for successful desertification risk assessment. This study, through use of geographic information systems and mobile communication technology adds innovation to studies in this area.

References

[1] Şahin, İ., Hanefi, M. Ve Akça, Ö., An Expert System Approach for Evaluation of Credibility Score. Journal of Polytechnic 2011: 14 (1): 79-83.
[2] National Strategy and Action Plan to Combat Desertification 2015-2023, General Directorate of Combating Desertification and Erosion, Turkey, 2015.
[3] Salvati, R., Salvati, L., Corona, P., Barbati, A., Ferrara, A., Estimating the sensitivity to desertification of Italian forests. Journal of Biogeosciences and Forestry 2015: 8: 287-294.
[4] Afifi, A., Gad, A., Refat, A., Use of GIS and Remote Sensing for Environmental Sensitivity Assessment of North Coastal Part, Egypt. Journal of American Science 2010: 6(11): 632-646.
[5] Esri, http://www.esri.com/products/survey123