Natural Land Patterns Suitable for Wind Farms Placement in Eastern Romania – Case Study: The Padureni – Husi Area

Madalina–Dana Pohrib and Lilian Niacsu

***Abstract*—The interest in obtaining electric energy from ecological sources has intensified in Romania since 1990. In the hilly area of Moldavian Plateau, Eastern Romania, the wind farms represent the most important ecological energy type and thus the necessity to identify the local natural patterns suitable for their placement appears. Using GIS techniques, this paper aims to automatically identify the suitable lands for wind farm placement by integrating the main landscape conditions. The outcome map shows that the fluvial divide ridges present the best conditions on over 330 ha. These stable areas are covered in a proportion of over 60% with arable lands and pastures and present very good road accessibility. Similar to the case of forests and constructed land use types, it is more difficult to change the use category. The agricultural terrains on these fluvial divides and, in a smaller proportion, on some slopes can become a viable solution for a superior economic exploitation of the terrains in this area.**

***Index Terms*—Geomorphological conditions, natural land suitability, GIS, wind farms**

I. Introduction

The interest in obtaining electric energy from ecological sources has intensified in Romania since 1990. On this background, an important activity is to identify the natural patterns suitable for wind farms placement, the most important ecological energy type in the hilly area of Eastern Romania. Considering the morphographic and morphometric characteristics, accompanied by slope processes' dynamics and the existence of a minimum road network that would facilitate the access to the fluvial divide areas, the northern area of Falciu Hills was selected for a such research.

Thus, using GIS techniques, this paper aims to automatically identify the suitable lands for wind farm placement by integrating the input rasters that represent the main landscape conditions.

Manuscript received August 2, 2012; revised September 3, 2012. This work was supported by the project "Development and Support of Multidisciplinary Postdoctoral Programmes in Major Technical Areas of National Strategy of Research – Development – Innovation" 4D-POSTDOC, contract no. POSDRU/89/1.5/S/52603, project co-funded by the European Social Fund through Sectoral Operational Programme Human Resources Development 2007-2013.

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II. The Research Area and Work Method

A. The Research Area

The studied area geographically belongs to the northern part of Falciu Hills, a subunit of the Moldavian Tableland and covers almost 8,900 ha (Fig. 1).

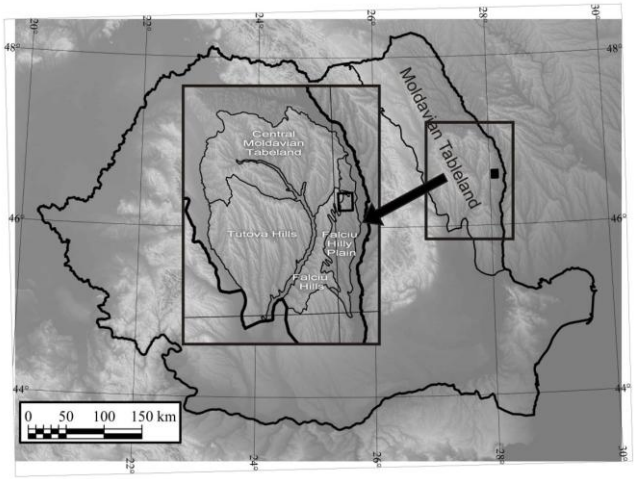

Fig. 1. The position of the study area in the Moldavian Tableland

Morpho-structurally, the Padureni area belongs to the Moldavian Platform. The depositional architecture is characterized by an alternation of Chersonian - Meotian sedimentary bodies of sands, silts and clays, with reduced intercalations of cinerites and sandstones and a gentle dipping of 7-8 m/km NW-SE [1].

From a geomorphological point of view, the research region presents the characteristics of the two physico-geographical regions on whose contact it developed: the northern part of the Falciu Hills, sub-unit of the Barlad Tableland, and the higher area of the Falciu Hilly Plain [2]. Regarding the main morphometric elements, the study area presents the typical features of a transition area, the contact being obvious on the hypsometric, declivity and slope aspects map.

The minimum altitude values decrease below 50 m towards the Prut valley, while the maximum one exceeds 350 m in the north-eastern extremity of the region, with an average value of 166 m.

According to the Geography of Romania [3], the high areas of this region present an average wind speed of over 4.6 m/s with over 7000 h/year with values more than 3 m/s. Otherwise, in the 19th century, there were over 300 wind

DOI: 10.7763/IJET.2012.V4.452

farms in Eastern Romania, more than 65 being located in the Husi area [4].

B. The Work Method

In order to achieve the objective of this study, a methodology framework was created based on a decision tree applied to the input maps in raster format, depending on the current land use type and the main geomorphometric patterns, namely: the geomorphologic map, hypsometric map, slope declivity map, slope aspect map and current land use map.

Each input raster presents the "1" value for favorable conditions and the "0" value for the unfavorable ones. The software chooses for the output raster only the pixels that present favorable conditions for all input rasters.

Under this approach, the SML (Spatial Manipulation Language) application implemented through the TNTmips 7.3 software has been used.

Starting from the current pattern, for each pixel, the software analyses the lands suitable for wind farms placement, considering the following optimal conditions for each input map:

- Only arable, complex arable, vineyards, orchards and pastures are the land use categories suitable for this activity;
- The stable ridges and deluvial slopes affected only by soil erosion are selected among the geomorphologic categories;
- The slope aspect that must be in accordance with the wind direction but also with the main morphographic patterns of the research area and thus, in our case, the NE, E, SE and S slope aspect classes are optimal;
- The declivity classes with values less than 5˚ are suitable;
- The altitude must be over 200 m.

All the input maps were achieved using the same GIS software. The Digital Elevation Model (DEM, 5x5m spatial resolution) and some geomorphometric indicators derived from DEM (hypsometry, slope angle, slope aspect) were obtained on the basis of 1:25,000 topographic maps.

III. Results and Discussions

A. The Geomorphologic Map

The specific landforms are the sculptural ones, with a hilly fragmentation in the west, north-west and north of the region, and a knobby one in the east, south-east and south, typical for a hilly plain (Fig. 2).

Locally, favored by the general monocline structure with a NNW-SSE direction of the Moldavian Plateau, these knobs have an asymmetric aspect, with a slope of the cuesta forehead type (with western orientation), shorter and more abrupt, and the other as the cuesta backside, of eastern orientation, elongated and with a reduced slope.

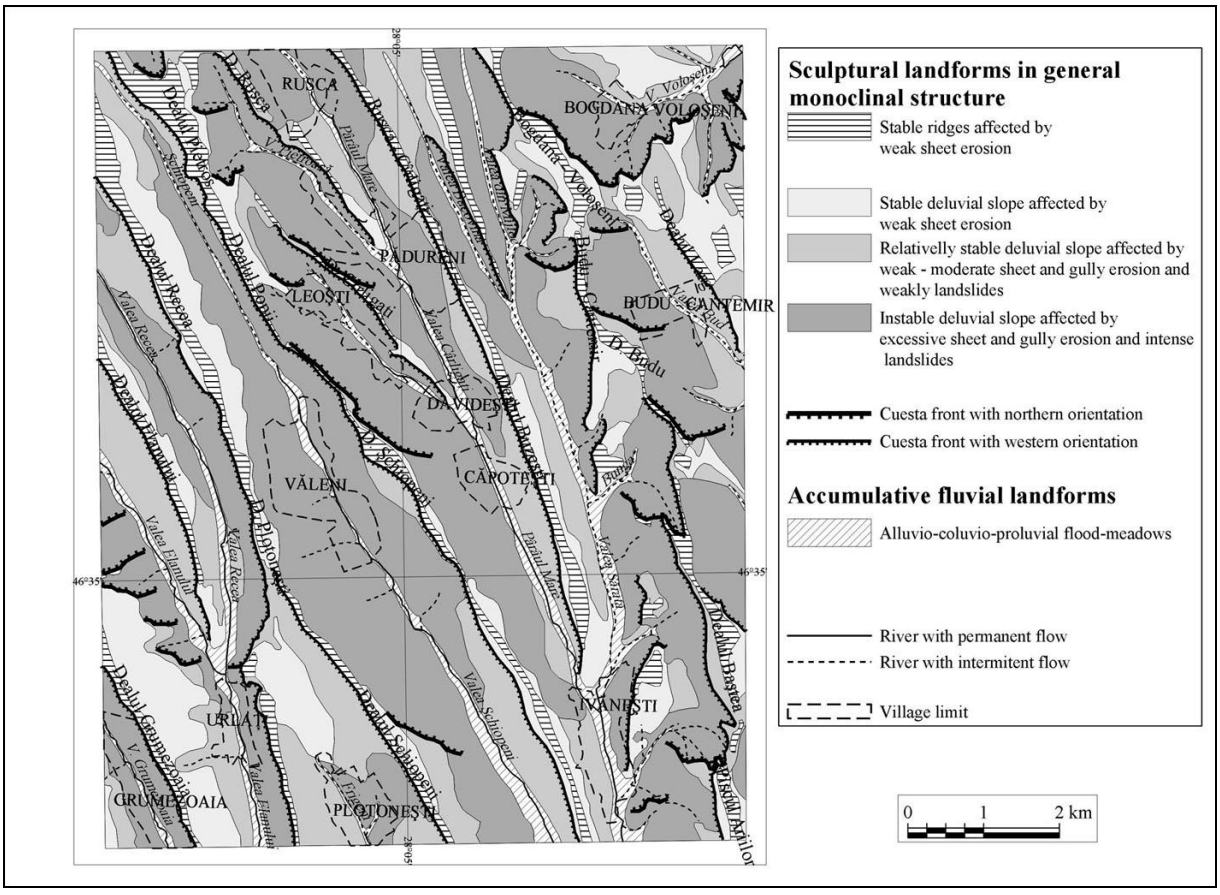

Fig. 2. Geomorphologic map of the Padureni area [5]

B. The Hypsometric Map

The average altitudes have an approximately superposed distribution on the different landforms. Thus, the values decrease from a maximum of 215 m for the divide ridges to

182 m in the case of weakly degraded slopes, 166 m for the moderately degraded slopes, 158 m for the excessively degraded and only 113 m in the case of floodplains (Fig. 3).

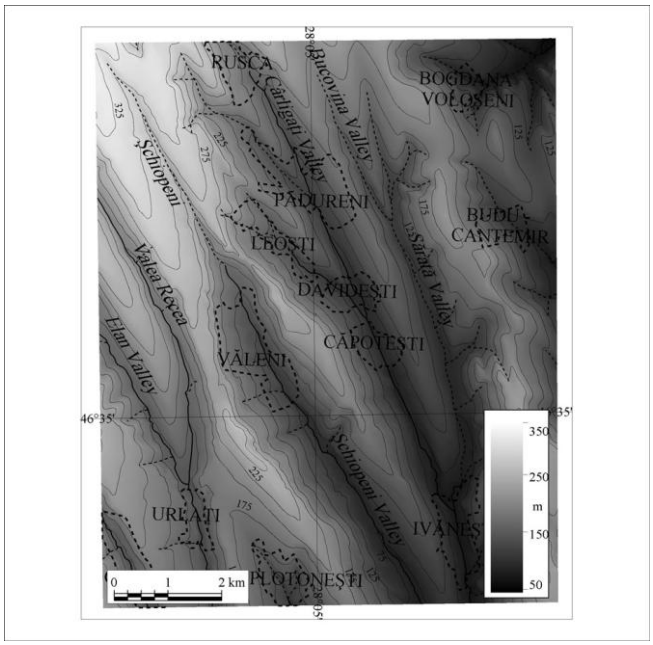

Fig. 3. Hypsometric map of the Padureni area

C. The Slope Declivity Map

In this case, the average value computed for the entire area reaches 6.5˚, with lower values of only 2.2˚ in the case of ridges (Fig. 4).

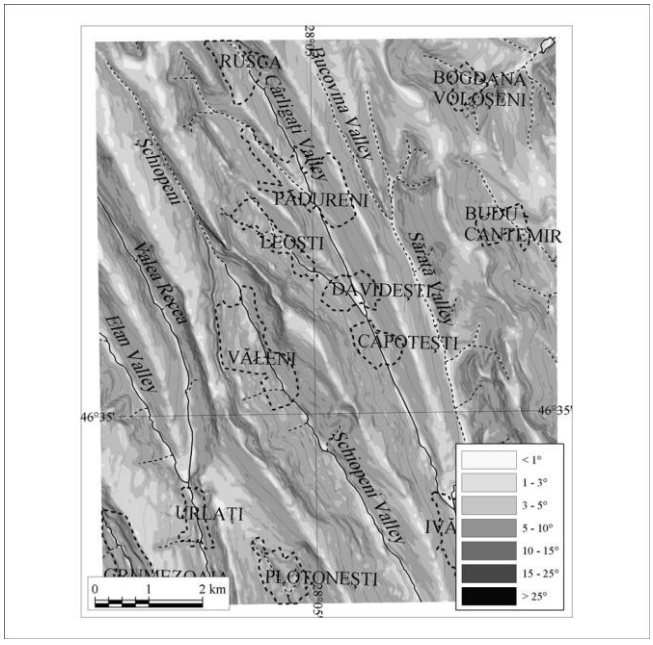

Fig. 4. Slope declivity map of the Padureni area

For the various slopes, declivity values increase considerably up to 3.7˚ for the weakly degraded, 6.1˚ for the moderately degraded and a maximum of 8.8˚ in the case of strongly degraded ones.

D. The Slope Aspect Map

The map shows that the slopes with optimal slope aspect (NE, E, SE and S) for this activity cover over 58.9% of the total area (Fig. 5)

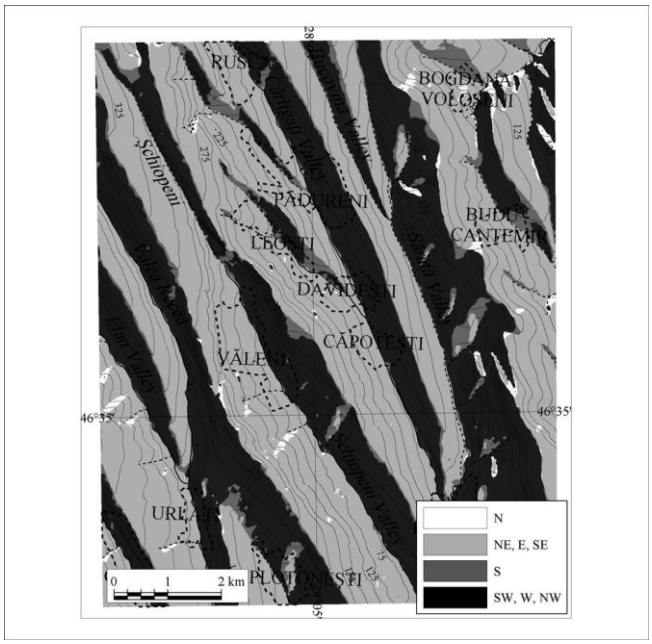

Fig. 5. Slope aspect map

E. The Current Land Use Map

According to the Corine Land Cover methodology [6], arable and complex arable categories dominate the studied area with over 47.3% (Fig. 6).

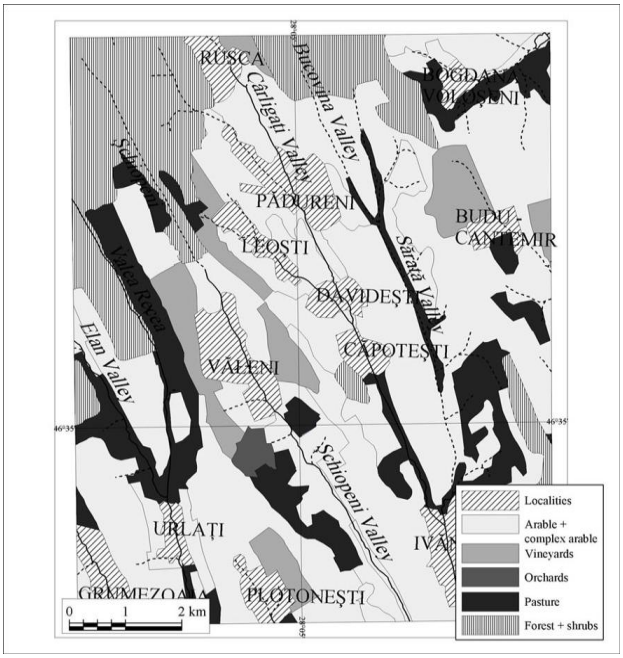

Fig. 6. Land use map of the Padureni area

Forests and shrubs follow with 19.8%, and pastures with 14.4%. Only 10.8% of the lands are occupied by settlements, followed by vineyards with 7.1% and orchards with only 0.5%.

F. The Land Suitability Map for Wind Farm Placement within the Padureni Area

The outcome map shows that only 3.71% (330.2 ha) presents suitability for this activity (Fig. 7).

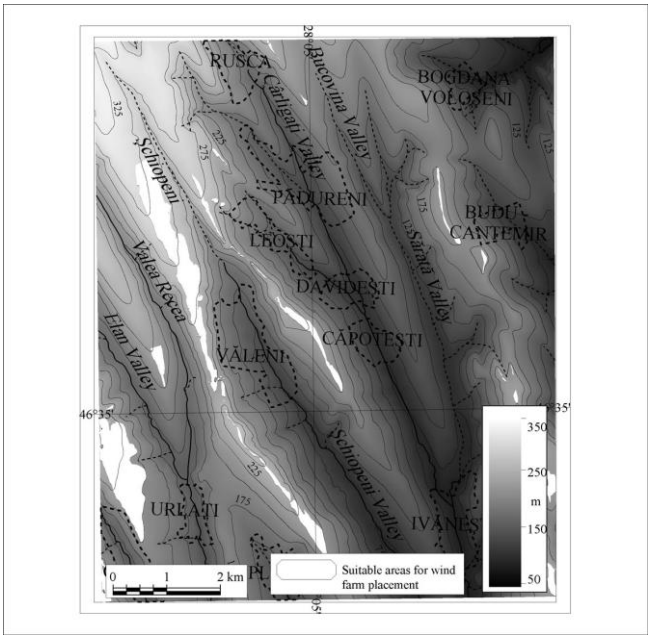

Fig. 7. Land suitability map for wind farm placement in the Padureni area

The results show that the divide ridges in this area present optimal conditions for this activity. Usually, 80% of these surfaces that decrease from the central summit of Falciu Hills occur at over 200 m altitude, due to a general inclination towards SSE.

Relatively optimal conditions occur 135 ha in the case of weakly degraded slopes, but only when these situations are met at the upper part of the slopes, close to the ridge, have a lower declivity, an optimal orientation and present only forms of soil erosion.

In the case of terrains with moderately and excessively degraded slopes, the favorable nature is reduced, mainly due to the low stability they have. Locally, there are other causes that relate to the deficient exposure or sheltering under the conditions of lower altitudes. Due to their position within the landscape, although the slopes and degradation processes' intensity present a highly favorable nature, floodplains also present unfavorable conditions.

IV. Conclusion

The fluvial divide ridges present the best natural land conditions for wind farm placement on an area of over 330 ha. These stable areas are covered with arable lands and pastures in proportion of over 60%, and present very good road accessibility. Similar to the case of forests and constructed land use types, it is more difficult to change the use category. The agricultural fields on these fluvial divides and some slopes can become a viable solution for a superior economic exploitation of the fields in this area.

Acknowledgment

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