A LANDSCAPE LEVEL ASSESSMENT OF THE HUMAN IMPACT ON TERRAIN – LAND DEGRADATION AND ECOLOGICAL REHABILITATION

BARNOAIEA Ionuț[1],
IACOBESCU Ovidiu[2],
BARNOAIEA Adriana Roxana[3]

ABSTRACT

The effect of land degradation extends on different levels of landscape management: it affects not only land productivity, but also the structure of the landscape and the ecological interactions between the ecosystems. The objective of the study is to simulate three landscape structures (non degraded landscapes, land degradation affected landscapes, ecologically rehabilitated landscapes) and the comparison between the landscape metrics characterizing each situation. The study area is the Suceava Plateau, North Eastern Romania and the materials used are digital ortophotos and GIS database regarding soil degradation. The methods include using land cover type maps, computation of landscape structure indices in the three situations, comparative analysis of landscape structure values. The results obtained showed that the occurrence of land degradation influenced especially the degree of fragmentation and patch connectivity. Ecological rehabilitation by means of reforestation improves the connectivity of forest patches and increases the diversity measured at landscape level.

Keywords: ***land degradation, ecological reconstruction, fragmentation***

1. INTRODUCTION

The general policy regarding the degraded lands in Europe is to turn them into forest vegetation areas as a way to limit the risks induced by the evolution of the phenomenon, but also to increase the percentage of forest vegetation cover. Romania's task, given by European Union, is to increase its percentage of forest cover from 26.7 % to over 30 %. The available terrains that could be included in this directive are mainly the degraded and non-productive lands, occupied mostly by gully and sheet erosion, land displacements (land slides and mud flows) and industrial and home waste heaps [1].

[1] asist.univ.drd. ing., Universitatea Stefan cel Mare Suceava, Facultatea de Silvicultură, e-mail: ibarnoaie@usv.ro
[2] conf.dr.ing. Universitatea Stefan cel Mare Suceava, Facultatea de Silvicultură, e-mail: oiacobescu@yahoo.com
[3]doctorand, Universitatea Stefan cel Mare Suceava, Facultatea de Silvicultură, e-mail: roxanabarn@gmail.com

The effect of the degradation phenomena occurrence could be found on more than one level. On one hand there is the low or non-productivity of the land itself, accompanied by a disturbance in the surrounding ecosystems functions. The disturbances can also affect the complex relations found within the landscape, creating gaps between the components. Not last, the aesthetics of the landscape are greatly affected, with important effect on the recreational functions of the hilly and mountainous areas within which these processes occur [2][3].

The method used at a broad scale for ecologically rehabilitate this type of lands is the afforestation, sometimes accompanied by hydro technical works within the riverbeds and on the unstable banks and slopes. The result of these works is a modified landscape, with different forest coverage and spatial structure.

The *objective* of the paper is to analyze the effect of land degradation occurrence and ecological rehabilitation on the landscape structure, quantified by landscape structure parameters, on three situations simulated on a test area.

2. MATERIALS AND METHODOLOGY

2.1 Study location and general context

The research is located in the North Eastern part of Romania, in the higher grounds of the Suceava Plateau, in a transition area to the Eastern Romanian Carpathians (fig. 1).

The general characteristic of the landscape in the area that can be revealed by visual analysis is the fragmentation of the land use due to property rights restoration in the past two decades. The arable, pasture and forest vegetation lands were divided through multiple inheritances. This aspect has important consequences on landscape functions.

The land degradation process is represented by the gully erosion in form of ravines and land displacements. The majority of the degradation forms are located in pastures, characterized by the over grazing process.

2.2 Materials

The materials used for building thematic maps of the area are digital aerial images, orthorectified and georeferenced in the Romanian Coordinate System – Stereo 1970, further referred to as *orthophotos*. The images are a part of the material used for general mapping of Romania's agricultural lands, within the Land Parcel Identification Process (LPIS). The parameters of the images are:

- Spatial resolution – 0.5 m
- Date of the flight – 2004
- Spectral domain – visible
- Radiometric characteristics – three band colour images

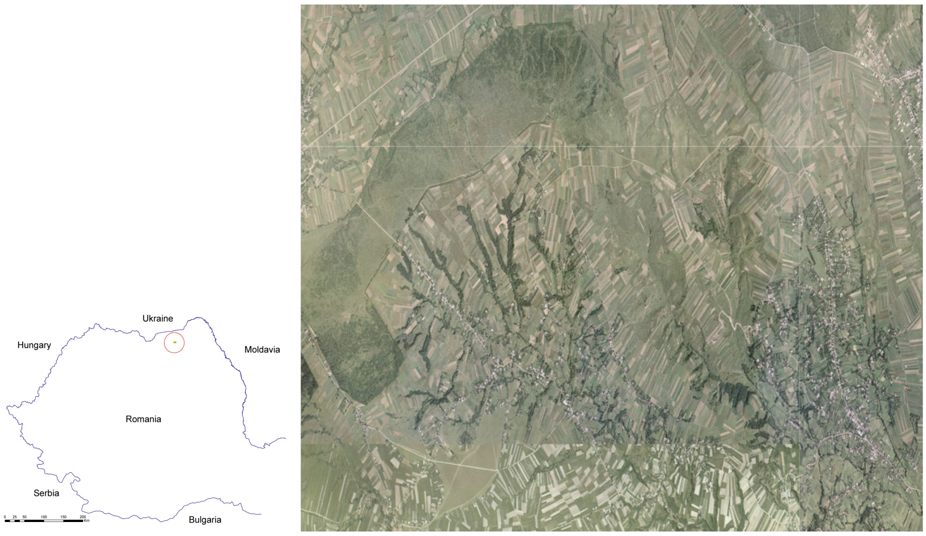

Figure 1: The study general location (left) and the analyzed area (right)

2.3 Methods

The general methodology consists in simulating three different landscape situations in order to observe the influence of land degradation on landscape metrics:

- The actual situation found in the field, with land degradation present in the form of ravines and land displacement, some of them occupied by forest vegetation (I)
- An hypothetical situation in which the areas occupied by land erosion and landslides are considered as a part of the surrounding land cover classes (pastures in general) (II);
- A situation characterized by ecological restoration of all degradation forms; the simulation considers all areas affected by erosion and land displacement as reforested (III).

2.3.1 Land cover delineation

The maps used in landscape analysis were derived by digitization from the color orthophotos of the area. The delineation process was based on visual interpretation of the terrain details and photo-interpretation keys developed in the land degradation mapping stage [1]. The classes of land cover used in the delineation were *settlements* (villages), *forest vegetation*, *arable lands*, *pastures and hayfields, ravines, land displacements*, *roads*

The vector representation in ArcGIS offers the possibility to easily quantify the areas occupied by each class and the parameters of the landscape patterns. For use in *Fragstats* software, the maps were exported as ArcGRIDs – 8 bit signed integer [4].

2.3.2 Landscape structure assessment

In order to quantify the landscape structure, the grid representation of landscape test areas was introduced in *Fragstats* [4]. The application can quantify several patches, class and landscape metrics, as needed for a variety of research purposes. In the present case, the interest is focused on the indicators that quantify the connectivity and the diversity of the habitats present in the study area. The research hypothesis is that landscape structure is significantly affected by land degradation and especially the gully erosion, processes that create “breaks” in the habitat continuity and affect the surrounding ecosystems.

3. RESULTS

The digitization of the limits of land cover classes in the study area shows the general assembly of patches in the characteristic landscape (fig. 2). The forest vegetation is distributed unevenly within the landscape, with high consistency in the North Eastern part. Scarce woody vegetation is present along streams and some gully erosion forms, as a result of natural dissemination from the nearby forests.

More than half of the terrain in the study area is used as pastures and hay fields (52 %). This predominant land use is also related to the highest percentage of land degradation.

Actually, the land degradation phenomenon is almost indissolubly related to this type of land use (only a small percentage of land degradation areas are located in the arable grounds). The forest vegetation cover occupies around 20 % of the whole area, consisting of both scarce and continuous forest vegetation cover (table 1).

Figure 2: The nowadays situation of land cover classes in the study area

The land degradation forms have different areas and different effects on the landscape pattern. The landslides occur on 7.6 % of the total area, unlike ravines that occupy only 0.25 %. The horizontal form of the each degradation type is characteristic: the *landslides* occupy large and compact areas, with low fragmentation of the contour line and the *ravines* have an elongated form, with a high level of ramification. The area/perimeter ratio ranges from 15 to 80 m^2m^{-1} in the case land displacements and the ravines have a ratio between 4 and 39 m^2m^{-1}.

Table 1: Area distribution on land cover classes

Land cover class	Total Area (ha)	%
Settlements (villages)	369,61	10,24
Forest vegetation	727,62	20,16
Arable lands	309,53	8,58
Pastures and hayfields	1881,59	52,13
Roads	37,36	1,04
Ravines	8,96	0,25
Land displacements	274,47	7,60
Total	3609,14	100,00

The landscape diversity indices computed show some differences for the three simulated situations. The highest landscape diversity is recorded in the case of ecologically restored landscapes, followed by the actual situation found in the field. The third place from the point of view of diversity is occupied by the hypothetical situation characterized by the lack of any land degradation. The highest differences can be noticed between situation III (no degradation) and the other two situations.

Table 2: Values of landscape diversity indices for the three simulations

Diversity indices	Shannon	Simpson	Modified Simpson index	Shannon's evenness index	Simpson's evenness index	Modified Simpson' evenness index
I (actual situation)	3.88	0.971	3.537	0.805	0.979	0.734
II (ecological restoration)	3.92	0.974	3.640	0.815	0.982	0.755
III (no land degradation)	3.26	0.912	2.426	0.675	0.919	0.501

In comparing all index values, a strong correlation between the values of each index in the three simulations mentioned. This confirms the conclusions drawn in analyzing the values of each index in particularly, but also shows that the information extracted by using several diversity indices can be redundant.

In the case of landscape proximity and connectivity indices follow, in general, the same pattern observed in the case of landscape diversity. The highest connectivity appears on the restored landscape and the lowest appears in the “no degradation” landscape.

Table 3: Values of landscape proximity and connectivity indices

Landscape indices	Patch cohesion index	Connectance index
I (actual situation)	3.88	0.971
II (ecological restoration)	3.92	0.974
III (no land degradation)	3.26	0.912

4. DISCUSSION

The effect of land degradation can be found on a variety of scales within the affected landscape. Leaving aside the economical problems that can be started by the presence of non productive lands and the natural hazards following the land degradation process, one of the important disturbances caused relates to landscape structure and functions.

The analysis shows the following hierarchy of landscape diversity for the three simulated situation: situation III (no degradation), situation I (present situation) and situation II (ecological restoration). The relatively low difference between the actual situation and the ecological restoration is given by the existence of ravines covered by forest vegetation (the ecological restoration process is started naturally).

The land degradation forms have different effects on the structure of the landscape. The ravines are usually elongated forms, with a high potential of landscape fragmentation. The land displacements have a more compact form and induce a less fragmentation of the landscape. In previous works regarding the evolution of the ravines regressive erosion was observed: the instability of the land is maximum on the ravine origin areas and tends to decrease downstream, where usually we find forest vegetation areas.

The forest vegetation corridors that are created by the afforestation of the ravines are important in habitat connectivity, especially in areas with high human impact. The corridors can be used by macro fauna for shelter and moving towards new feeding grounds. The surrounding grounds benefit from the edge effect induced by the forest vegetation areas, acting like forest shelter belts that create a microclimate [2][5][6].

5. CONCLUSIONS

The comparative analysis of the simulated situations showed the following conclusions:

- The lowest landscape diversity values is characteristic for the case of no land degradation, a case in which the nowadays degraded lands are counted as being a part of the initial land cover;
- The highest diversity accompanies the situation of total ecological restoration of the landscape, incorporating the ravines and landslides in the forest vegetation cover;
- The actual situation is relatively close to the situation of ecological restoration due to a high percent of forested ravines, resulting in corridors along the torrent path;
- The connectivity and cohesion of the landscape would improve significantly by restoring all degraded lands by afforestation, a fact that could increase the favorability of the habitat for the macro fauna.

The research presented in this paper is a "work in progress" and represents the start point of a broad scale approach of the landscape restoration effects in the specific conditions of the Suceava Plateau, North Eastern Romania.

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