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Ursu, Adrian and Chelaru, Dan-Adrian and Mihai, Florin-Constantin and Iordache, Iulian

"Alexandru Ioan Cuza" University, Department of Geography

2011

Geographia Technica, No. 1, 2011, pp. 91 to 100

ANTHROPOGENIC LANDFORM MODELING USING GIS TECHNIQUES CASE STUDY: VRANCEA REGION

Adrian URSU*[1]*, Dan-Adrian CHELARU*[1]*, Florin-Constantin MIHAI*[1]*,
***Iulian IORDACHE*[1]**

ABSTRACT:
Anthropogenic landforms are the result of significant changes in the Earth's crust due to technological development of human society, guided by its economic, social and cultural needs. nthropogenic landforms of the studied area was analyzed using GIS techniques at the general scale, conducting the entire study area maps, and detailed modeling of representative samples in detail. Representing the anthropogenic landforms on the digital elevation model can be very important in studying natural hazards, such as hydrological modeling on flood plains, which could influence the direction of the flood wave. The digital elevation model (DEM) made by traditional methods can not represent the anthropogenic landforms, leading sometimes to a misinterpretation of reality on the ground.

Keywords: *Anthropogenic landforms, GIS techniques, digital elevation model, Vrancea, Romania*

1. INTRODUCTION

Man is a geomorphologic agent that, unlike other agents such as water, ice, wind and volcanoes, is not limited or localized spatially, but rather, it is becoming less and less subject to environmental variables (*Dov Nir,1983*). Human influence on the earth's crust can occur indirectly, by accelerating the action of natural agents (grazing, deforestation, irrigation) and direct (creation of pits, tunnels, landfills, dams, quarries, waste dumps, embankments, excavations).

In recent years an increasing interest on this branch of geomorphology, emphasizing the works belonging to *Gregory and Walling (1979)*, and *Dov Nir (1983)*, *Goudie (1994)*, *Panizza (1994)*, *Radziewicz T. (2006)*, *Dulgheru and Chiaburu (2008)*, *Dragicevic S. and Milevski I. (2009)*.

Anthropic landform is a continuous adjustment to limit natural dysfunctions (irrigation channels, dams, protective embankments,) and for the infrastructure necessary to ensure the flow of resources, energy and information (tunnels, roads, agricultural terraces). On the other hand, socio-economic activities by exploiting the natural potential of the territory introduce new forms of anthropogenic landforms that disturb the dynamic equilibrium of geosystem (operating quarries, dumps, landfills).

2. MATERIALS AND METHODS

***Materials*:**

The materials used in this study are the 1:25000 and 1:5000 topographic maps, 2005 aerial photography and a series of satellite images. The topographic maps with the scale of 1:25,000 were used to obtain the contouring vector file, created by digitizing "on screen", which led to the realization of the digital elevation model (DEM), as well as thematic layers

[1] *„Alexandru Ioan Cuza" University, Faculty of Geography and Geology, 700505 Iasi, Romania.*

needed in the analysis such as main roads, hydrographic network, settlements, anthropogenic landforms etc. Satellite images were used primarily to achieve the necessary land use map to evaluate indirect anthropogenic influence on the relief, while aerial photography were necessary to update the information extracted from other cartographic materials.

***Methods used and problems encountered*:**

The digital elevation model is a continuous form of representation of the topography, and was obtained from the values interpolation of the contours extracted from topographic maps, but not entirely reflect the reality on the ground. Since the method of interpolation is a mathematical function which estimates values of the two curves at altitudes, for a more accurate DEM should be added intermediate contours, as well as some isolines (vector contours) to represent landforms resulted from the human activity.

Making a digital elevation model in accordance with reality, so useful in various types of analysis, is easy to obtain using LIDAR techniques but, due to inaccessibility of these technologies (financial reasons), we searched for a cheaper solution: to correct the DEM made on the contour lines by adding extra digital information.

Thus, in areas with high human intervention, the contour lines are usually represented with interruption and altitude informations are scarce. Also, anthropogenic landforms both positive and negative, except mining, are generally small, making it difficult to highlight them especially if we analize large or rough areas.

In our attempt to represent the anthropogenic landforms in Vrancea region, on the one hand we watched the spatial distribution of anthropogenic landforms and on the other hand more accurate modeling of these landforms, which was made on a number of five samples distributed both in plains, subcarpathian and mountain areas.

For this we've took into account the landforms resulting from construction of road, ship and rail communication routes, as well as agricultural terraces and existing irrigation systems in the plains.

Representation of anthropogenic landforms in the plains was made by adding auxiliary contour lines along the main road and railway communication ways. Because in the first sample we found an irrigation channel that was not passed by on topographic maps made in 1970, it was necessary to update the information from aerial photography. Details were extracted on the channel (height, width and length) from a series of technical documents.

Given the uniformity of altitude of the area, we can say that adding additional information is not that difficult. Thus, we've added four new lines to represent an embankment and six for the navigable channel. Later we made another digital elevation model by interpolating the file that contains recently added isolines.

The new digital elevation model obtained is much closer to reality on the ground, so we can distinguish easily railway embankment, roads from Garoafa village, and Siret-Baragan irrigation channel.

For the subcarpathian areas we have selected three samples: one in Odobesti area where is a complex system of irrigation channels whose representation was made relatively easy by creating more pronounced modulations along channels (the similarity with torrential bodies facilitate their representation) (see **Fig. 2**), another test area at Burca, an area that includes both flood protection embankment, a series of channeled sectors of tributaries on the left side of the river Putna and some type of road embankments, bridges (**Fig. 3**), and the last one in Bîrsesti village where we can find a system of agricultural terraces, reflecting the human ability to adapt to the natural landform conditions (**Fig. 4**).

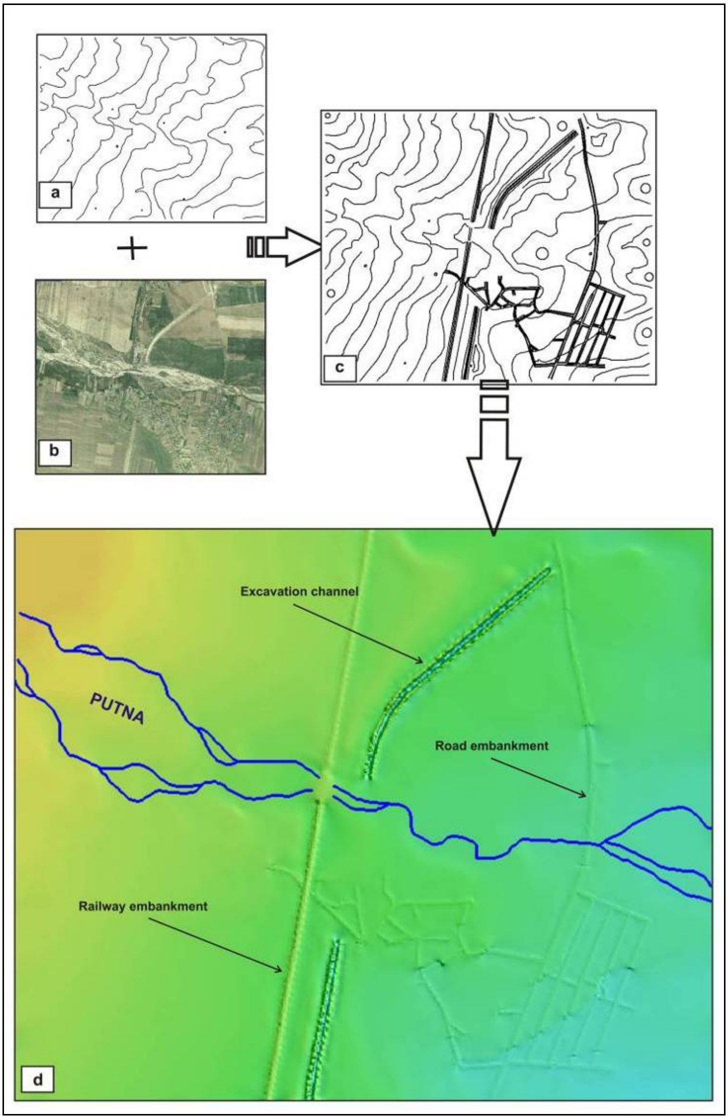

Fig. 1 a – contour lines; b – orthofotomap, year 2005; c – contour lines + isolines resulted from the updated information; d – anthropogenic landforms represented on the digital elevation model.

Note that modeling positive landforms is more difficult than the negative ones by adding auxiliary isolines along the anthropogenic relief, whose values are given according to the proper contour area. The biggest problems we have encountered in the modeling of human intervention in the mountain area where we tried to represent a considerable length of coast road, having a level difference between the base and peak of about 200 m.

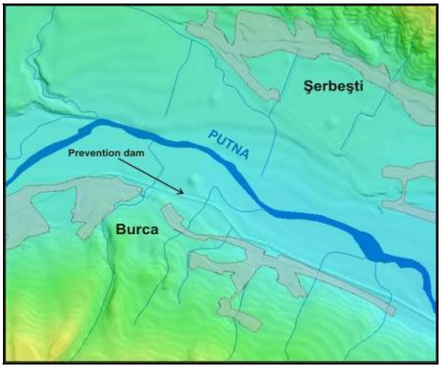

Fig. 2: Anthropogenic landform – irrigation channels in Odobesti area

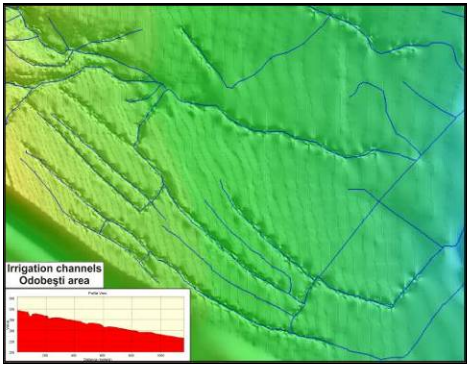

Fig. 3: Anthropogenic landforms – dams, roads or channeled parts of the Putna tributaries in Burca area

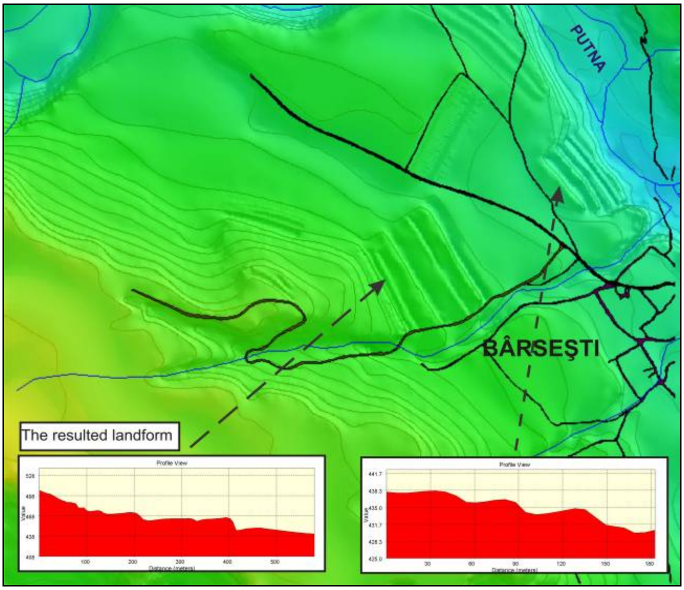

Fig. 4 Agricultural terraces system - Bîrseşti area; Anthropogenic landforms most easily to represented are agricultural terraces. We choose a representative sample in Birsesti village, where agroterraces were a way to exploit the full potential of the land. Methodology used to achieve these anthropogenic landforms is relatively simple consisting of adding altitude contour lines with values equal to the contour to create forms typical terrace. To highlight the results we have added two longitudinal profiles.

Modeling anthropogenic landforms such as a winding road in mountain area proves to be a difficult approach because the resulted landform had to be represented in 3D to illustrate the real situation, resembling a spiral. If in the previous cases was sufficient the addition of the same ”z” value isolines along their length, in this case, to obtain a better result was necessary to add new 3D vectors, whose altitude values varies from vertex to vertex (**Fig. 5**).

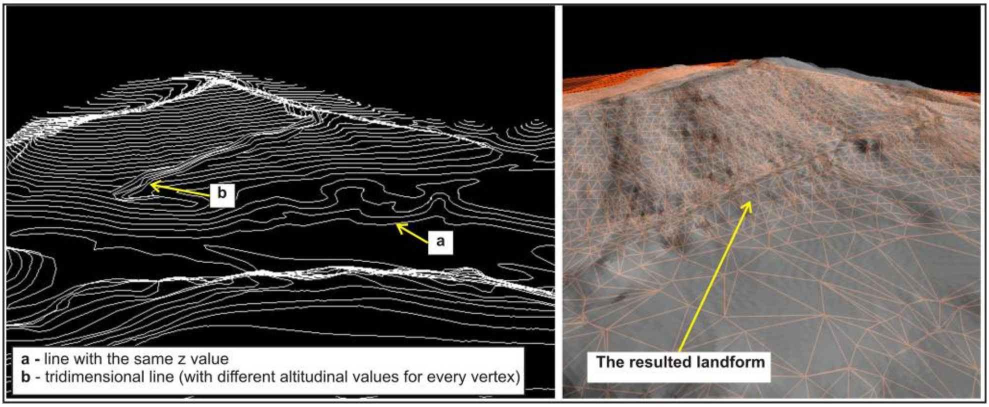

Fig. 5 3D representation of the resulted landform

To achieve the expected results was necessary to add five 3D parallel lines located on 3 altitude levels. Adding a small number of vertexes for each line leads to a coarser 3D modeling, with less time cost, but must be paid an increased attention to the slope value between two line segments for each vertex, that must be similar to the previous and next. A high density of vertexes leads to more accurate 3D modeling, but requires a long working time and attention.

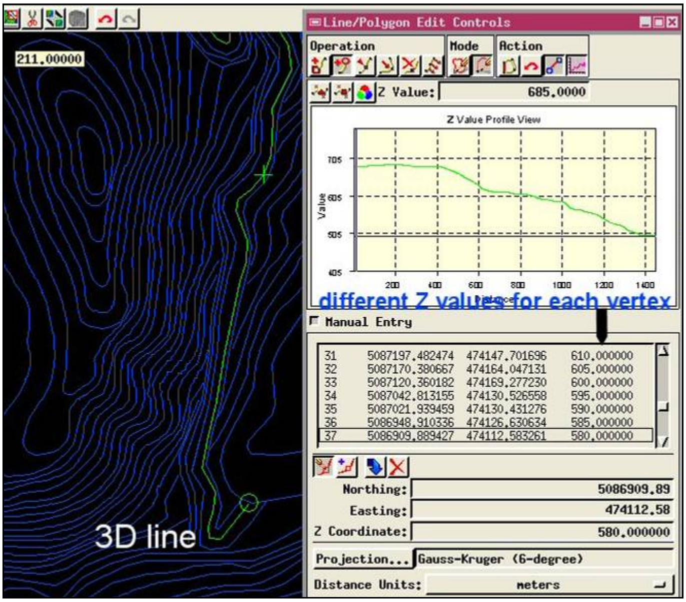

Fig. 6 3D vector line in TNT Mips software work space

Model numbers in this case required the creation of an intermediate TIN layer, with triangles divided by isolines to refine the final result. The result is satisfactory, being noticed a high correspondence with reality, but the creation of similar forms on large surfaces isn’t feasible regarding time required (because of manual input of values – **Fig. 6**).

3. DISCUSSIONS

Besides revealing the direct influence on the landforms we tried to emphasize areas of indirect anthropogenic influences on the landforms. Thus, we integrated information on land use that can help estimate the indirect influence of information on the intended changes of the landforms (**Fig. 7**).

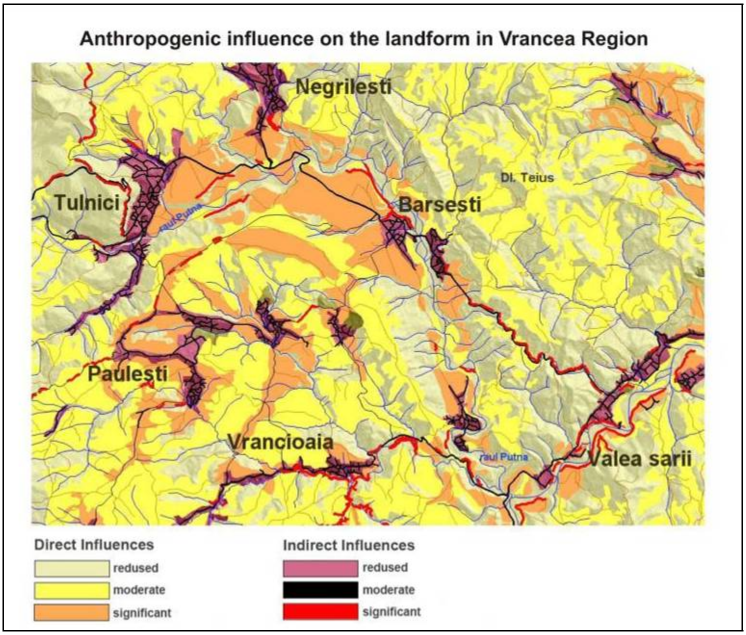

Fig. 7 Different types of anthropogenic influence on the landforms in Vrancea Region

Thus we considered that the type of forest use shows an indirect influence on the minimum landforms, pastures and hayfields an average, arable land major indirect influence and fruit growing areas make the transition to direct influences, often emphasizing the occurrence of agricultural terraces system.

On the other side we took into account the inhabited areas, roads and embankments and excavations, canals, spoil banks, dams, and these were classified according to their magnitude, then we built them on a single map that can be observed below. Note that this type of representation emphasizes the strong anthropic areas compared with natural ones.

In terms of spatial differentiation imposed by the distribution of anthropic forms stands that they are most commonly found within the settlements, where they made artificial plotting housing:embankments, passageways and channels for drainage. In this case, anthropogenic influences are direct and significant on the landforms.

Settlements development involves reducing the natural permeability of the soil or even the creation of impervious surfaces (a phenomenon known as soil sealing and recognized as one of the major problems of degradation of soil cover) percolating water is much lower or even zero, and hence resulting in an increased risk of floods.

Direct and indirect anthropogenic influences deriving from the specific activities of various economic sectors (agriculture, industry, transportation, etc.) are different from one region to another within the study area. Thus, in the mountain area, deforestation and grubbing, overgrazing, misuse of land, favored slope degradation processes (areolar erosion) and linear, landslides, mud flows, etc. Afforestation also represents indirect influences on the landform. Detection of spatial changes in the level of afforestation can help in the estimation of the runoff coefficients on the slopes, and the danger of flood occurrence (*Costea and Haidu, 2010*).

Anthropogenic influences on the landforms due to agriculture are more significant in the subcarpathian area and plain.

Some agricultural practices with geomorphologic effects on the studied region are: “uphill-downhill” plowing, now widespread , and large share of maize monoculture, leaving the soil uncovered fora large period of time and do not provide good coverage of the land (dimensions are spaces between the lines of 0.4 - 0.5 m), thus exposing the soil to erosion processes.

An ancient measure of mitigating erosion phenomena is the slope terracing (*Dov Nir, 1983*). In Vrancea region, agricultural terraces are not widespread, having a higher proportion of the area around the Bîrsesti and Vidra villages.

In plain areas, where the main land use is field crops, use of irrigation is a common practice, and this affects both surface water (used as power sources of irrigation channels) and groundwater (by piesometric level and the physico-chemical changes).

Functional arrangements for irrigation water are taken from the Putna River, which splits in multiple channels (Săftoiu, Sturza, Şcoală, Răchitoiu, Pătrăşcani, Boloteşti şi Sârbi – Bătineşti etc). These channels are included in the complex irrigation systems (Putna, Bilieşti-Ciorăşti, Gologanu - Năneşti) covering a total area of over 21,000 ha, and the cumulative length of the network is nearly 150 km (*Ursu, 2009*). The planned Siret - Bărăgan channel should have a length of 208 km between Lake Călimăneşti Siret (Vrancea County) and Lake Dridu the Ialomita (Prahova county), 50 km from the county of Vrancea. It is expected to have a trapezoidal sectional dimensions: the smaller base - 20 m, the sea - 57 m, water column height: 7 m. The Siret - Bărăgan channel, which has several phases of implementation, 2 km is almost complete, it will provide water irrigation for agricultural areas at a lower altitude than this (in the eastern channel).

In the mountainous region, with forest exploitation areas, grazing, livestock, human influences on the landforms occurred and the mining industry, namely the Kliwa sandstone used as construction material. Mining occurs locally in the mountainous valleys, sand and gravel are used for construction of dwellings and access routes operated by the ballast located just Putna River.

Quarrying activities always have considerable impact on the original landforms, because they involve the unearthing of material from an area and accumulating in another area, the negative effects are not limited to the period of operation, and sometimes may worsen if quarrying area is abandoned.

Not only the mining industry has generated new landforms, but also the energy that was imposed on the landscape with the Gresu dam, the river Putna, meant to set up a micro hydroplant. Currently, however, the lake is clogged, hydropower does not work , the dam plays an geomorphological rather than an energy role by changing the quantity of silt from the river Putna.

Communication paths represented by road infrastructure plays a significant role in shaping the microlandforms of mountain region analyzed. Cutting slopes for roads and other structures determined, in most cases, changes in their stability, but also in groundwater flow pattern with effects of "cascading" in the upstream areas of and greater production of debris downstream.

Roads from Carpathian mountains region have necessitated the construction of a large number of embankments and excavations, also in the mountain area there is a road tunnel. This works have destabilized slopes, risk communication channels were exposed to falling rocks, flow landslides and mud.

Anthropogenic spatial distribution of these forms is strongly correlated with the density of the road network and the landforms particularities, mainly concentrated in the Vrancea and Vidra depressions (*Ursu, 2009*).

Fig. 8 Anthropogenic landform at Grumaz

Fig. 9 Rail tunnel built – Tişiţei Gurges

Railroads were an important factor of changes in landforms in the mountain area, especially during themaximum forest exploitation period in the early twentieth century.

At that time there was a vast network of narrow gauge railways used for transporting logs to the processing and retail locations. Its construction required communications networks carrying embankments, excavations, tunnels, stabilization of slopes in almost all the mountains, many of these forms being visible nowadays.

Fig. 10-11 Siret – Bărăgan channel

At present the influence of railways on the landforms is noted only in the field, where it was necessary to the construction of large embankments.

Waterways within the study area are only potential, since the Siret – Baragan channel is a project that would primarily provide water for irrigation, but also it should be navigable for small boats, something that would meet local needs transport.

Due to the conformation of landform high density values of the river system and particularities of road network in the area have been built many bridges and culverts to ensure the flow of road and rail traffic.

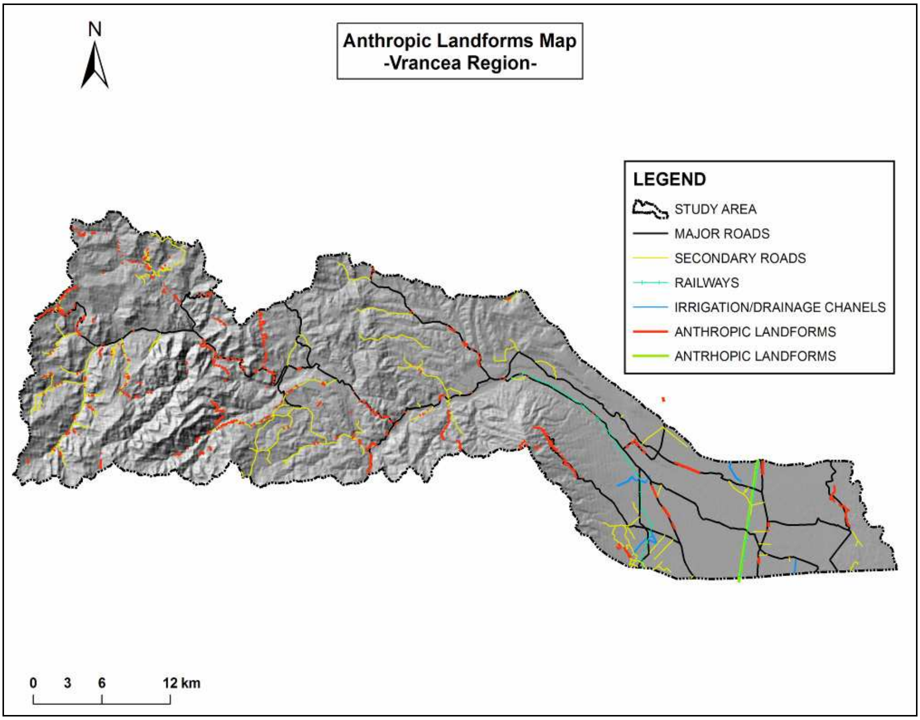

Fig. 12 The general map of anthropogenic landforms in Vrancea region

Anthropic landform is represented by engineering works completed to ensure the water needs for domestic consumption, agriculture and industry, population and land protection against floods and mitigate the risk of these phenomena which are quite common in the study area.

The catchment area has 200 wells in operation which provides most of the necessary water supply for population, industry and livestock.

Slope stability issues arise not only in the areas of quarrying, but in that waste storage areas for landfills serving urban areas. Moreover, cases of soil and water pollution are possible if these landfills are not managed properly.

The anthropogenic landforms are uniformly distributed within the area of study, the most important are being situated into the contact area. The communication pathways, both road and railways, impose new characteristics to the landforms. Land reclamation works, though less numerous, are present in lower areas, respectively in the plains.

CONCLUSIONS

In conclusion, we believe that anthropogenic influence on the landforms is significant in Vrancea region. We note that indirect anthropic influence had effects especially in the past in the mountain area, while direct influences have a relatively balanced distribution over the entire studied area, differing according to geographical tranzition and the needs of human settlements: irrigations and drainage channels in the plain region, agricultural terraces in subcarphatian region, embankments, excavations and tunels in the mountain region.

Representation of digital elevation models of these landforms are necessary as required, if we consider that the studies of natural hazards (particularly hidrological) are directly influenced by any variation in the surface topography, and thus, our approach prove viable.

AKNOWLEDGEMENTS

This work was partially supported by the European Social Fund in Romania, under the responsibility of the Managing Authority for the Sectoral Operational Programme for Human Resources Development 2007-2013 [grant POSDRU/CPP 107/DMI 1.5/S/78342]".

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