Land cover related to natural landscapes in the eastern part of Romania (The Romanian Side of Prut Basin)

Cobertura do solo relacionado às paisagens natural da prte leste da Romênia (A porção romena da Bacia de Prut)

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ABSTRACT
In this research land cover is the observed (bio)physical cover on the earth's surface, as in european documentation of *LAND COVER CLASSIFICATION SYSTEM (LCCS): CLASSIFICATION CONCEPTS AND USER MANUAL*. This analisys is based on Corine Land Cover 2000 methodology approved in 27 countries of EU. Corine Land Cover 2000 (CLC2000) is produced by the European Environment Agency (EEA) and its member countries in the European environment information and observation network (Eionet). It is based on the results of IMAGE2000, a satellite imaging programme undertaken jointly by the Joint Research Centre of the European Commission and the EEA. CLC2000 shows the land cover changes in ecosystems such as forests, lakes, pastures etc. and the impact of human activities (such as housing, food production, transport etc.) on land use. Forty-four land cover classes are used to map changes over time, all of which tell their own story of how decisions made across Prut basin in eastern part of Romania, have led to alternations in the landscape. The standard CLC nomenclature includes 44 land cover classes, grouped in a three-level hierarchy. Five main categories are "artificial surfaces", "agricultural areas", "forest and semi-natural areas", "wetlands" and "water bodies". The study area is very important because actually is a part of the eastern border of NATO and EU, with many geopolitically implications in state cooperation between Romania and Republic of Moldova sharing natural resources of Prut basin. Further analysis of spatial relations between land cover and soil cover can overview changes in evolution of these geographic factors in the last 20 years, also the impact on the environment.
Keywords: Land Cover, landscapes, Prut, Romania

1. INTRODUCTION

The purpose of this paper is to present the current situation of land use in the Prut basin, the least researched area in Romanian geographical literature. To achieve this purpose a modern method of inventory of land use type set at European level, fits all EU Member States was used. Working method called Corine LandCover (CLC) is the demarcation of areas within the characteristic of land use classes that support using high resolution satellite images and a unique legend. This legend details the types of use of each major class, for each setting a single code is classified by levels, according to Bossard et al. (2000, p. 6-75).

Corine Land Cover 2000 (CLC2000) is produced by the European Environment Agency (EEA) and its member countries in the European environment information and observation network (Eionet). It is based on the results of IMAGE2000, a satellite imaging programme undertaken jointly by the Joint Research Centre of the European Commission and the EEA. CLC2000 shows the land cover changes in ecosystems such as forests, lakes, pastures etc. and

the impact of human activities (such as housing, food production, transport etc.) on land use. Forty-four land cover classes are used to map changes over time, all of which tell their own story of how decisions made across Prut basin in eastern part of Romania, have led to alternations in the landscape. The standard CLC nomenclature includes 44 land cover classes, grouped in a three-level hierarchy. It was selected, briefly, in Table no. 1., part of the "*Corine Land Cover Technical Guide - Addendum 2000. Technical Report No. 40*" nomenclature and established only those classes with types of land use which are contained in the Prut river basin.

1.1-The CORINE land cover project.

The land cover project is part of the CORINE programme and is intended to provide consistent localized geographical information of the land cover of the 12 Member States of the European Community. Heymann et al. (1994, p. 8-28) consider that the project is necessary for the following reasons:

- preliminary work on the CORINE information system showed that information on land cover, together with information on relief, drainage systems etc., was essential for the management of the environment and natural resources; information on land cover therefore provides a reference source for various CORINE database projects;

- in all the countries of the Community, the information on land cover available at national level is heterogeneous, fragmented and difficult to obtain.

At Community level, in the CORINE system, information on land cover and changing land cover is directly useful for determining and implementing environment policy and can be used with other data (climate, inclinations, soil, etc.) to make complex assessments (e.g. mapping erosion risks).

The benefits of using a single joint project to meet both Community and national (or even regional) "needs considerably influenced the general features of the land cover project: scale, area of the smallest mapping unit and nomenclature" (MEYER, TURNER, 1994, p. 195).

2. STUDY AREA

General physical and geographical characteristics of the Prut basin are summarized below, to highlight the close link between the various components of the geographical environment and enhancement of the so-called land use types.

Prut basin is located in eastern part of Romania (Fig. 1). The evolution and geographical aspects are related to those of the Moldavian Plateau. The surface of the Prut basin occupies 10970 sq km in Romania (ATLAS OF ROMANIA WATER CADASTRE, 1964) (Fig. 2).

Also according to the Geographical Monography of Romania (1969) space analyzed overlaps three structural units: Moldavian

Platform (up to Fault Falciu-Plopana), Barlad Platform (between faults Falciu-Plopana and Adjud-Oancea) and Covurlui Platform, presenting each with a socket fluted formations covered by a blanket, with monoclinic willing parties

The *landscape* is presented as a series of large interfluves, hills separated by wide valleys, carved in monoclinic sedimentary blankets. General inclination of the relief is south-south-east and is in line with the orientation of major valleys, reflecting an obvious adaptation to the structure. Monoclinic structure favored the emergence of positive and subsequent valleys. Main steps to be taken in morphology, have values of 300-500 m in the north-west, 300-400 m in the central part, 150-200 m in the north-east and south and have a relatively balanced distribution. Altitudes above 500 m are few and isolated, and the „low rates meet along the Prut river corridor (130 m Oroftina, Ungheni near 32 m and 15 m to the confluence to the Danube in south part)" (BĂCĂUANU, 1968).

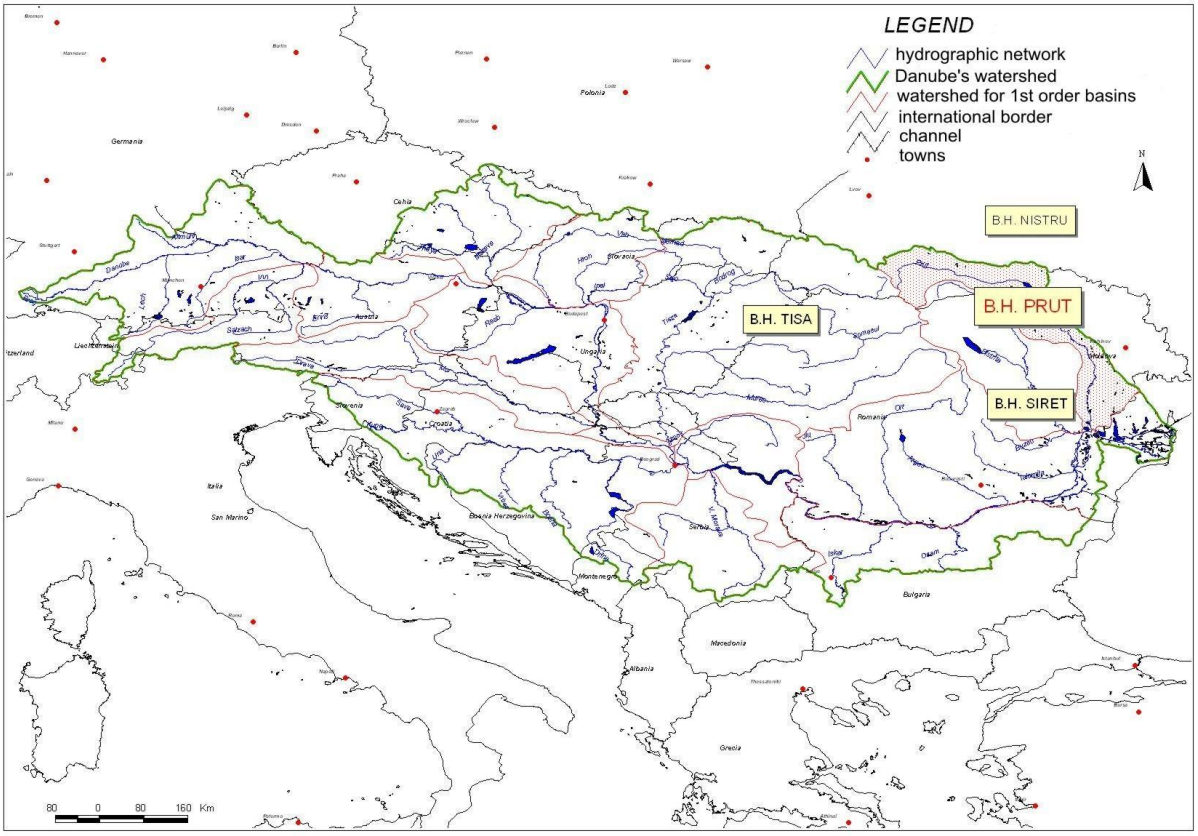

Figure 1 *- Position of Prut basin within Danube basin (source for GIS shp. vector: www.geo-spatial.org)*

Due to its extra-Carpathian region away from the influence of air masses from Atlantic Ocean, but the wide-open action of air masses with continental origin in the east, northeast and north, the Prut basin receives moderate amount of annual precipitation. This basin is directly exposed to continental air masses in the air from the west to lowering the surrounding physical geographical units, frequently suffer föehn processes, so precipitation is low, generally

around 500 mm (564 mm to Rădăuţi in north part and 529.4 mm to Iasi in central part) (MOLDAVIAN PLATEAU, 1980).

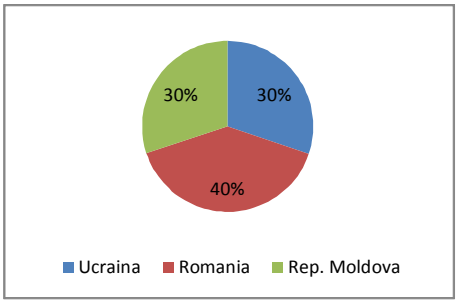

Figure 2 *- Surface distribution of Prut basin by country in which it extends.*

3. METHODS AND MATERIALS

The land cover items will be identified at points whose geographical locations are determined by random sampling. The stratification can be done according to the land cover items and/or according to geographical regions.

The input parameters for the random sampling procedure are the digital land cover map and the amount of random sampling points for each stratum. In the first phase of the procedure, strata are selected and the amount of points to be drawn in every selected stratum is determined. In the second phase the sampling points are drawn, i.e. their geographical location within each land cover unit is determined. The selection method guarantees that every point represents the same area size in its stratum. The validation procedure yields the surface of the wrongly identified area as a percentage of the total area surface for each stratum as well as for the total area to be validated. By stratifying a sample, it is possible to minimise the standard error of the total sample. Moreover the size of the sample „can be determined for each stratum separately according to the expected variation in every stratum" (URSU et al., 2006, p. 193-198).

In the CLC 5 land cover classes were established:

(1) artificial surfaces,
(2) agricultural areas,
(3) forests and seminatural areas,
(4) wetlands
(5) water bodies.

To apply this methology, GIS facility was used. This analysis combine morphometrical results and land use inventory in GIS methodology. These integrated GIS systems are mostly provided by a vector database manager, designed to work together with raster data. A proper design of the GIS engine for CORINE Land Cover mapping is required to reach the high performance levels one needs in operations typical of an integrated system as computer aided photo-interpretation, or the updating of a vector based database on basis of imagery.

After applying the Corine Land Cover (CLC) methodology we found that in the Prut basin 5 landscapes classes can be distinguished. Namely: class I (artificial surfaces), class II (agricultural area), class III (forests and land semi), class IV (wetlands) and fifth class (water bodies). In total, 16 types of landscapes were

differentiated regarding land use: 112, 121, 211, 222, 231, 241, 242, 243, 244, 311, 313, 322, 324, 333, 411 and 511 (Table 1).

Table 1 - Land cover classes established in the "*Corine Land Cover Technical Guide - Addendum 2000. Technical Report No. 40*" nomenclature which are found in the Prut basin

CLASS I. Artificial Surfaces		
1.1	Urban fabric	
	112	Discontinuous urban fabric
1.2	Industrial, commercial and transport units	
	121	Industrial or commercial units
CLASS II. Agricultural Areas		
2.1	Arable land	
	211	Non-irrigated arable land
2.2	Permanent crops	
	222	Fruit trees and berry plantations
2.3	Pastures	
	231	Pastures
2.4	Heterogeneous agricultural areas	
	241	Annual crops associated with permanent crops
	242	Complex cultivation patterns
	243	Land principally occupied by agriculture, with significant areas of natural vegetation
	244	Agro-forestry areas
CLASS III. Forests and Seminatural Areas		
3.1	Forests	
	311	Broad-leaved forest
	313	Mixed forest
3.2	Scrub and/or herbaceous vegetation associations	
	322	Moors and heathland
	324	Transitional woodland-shrub
3.3	Open spaces with little or no vegetation	
	333	Sparsely vegetated areas
CLASS IV. Wetlands		
4.1	Inland wetlands	
	411	Inland marshes
CLASS V. Water Bodies		
5.1	Inland waters	
	511	Water courses

These types are grouped into 10 categories with higher taxonomic rank: urban structure (1.1), industrial units, commercial and transport (1.2), arable land (2.1), permanent crops (2.2), pasture (2.3), heterogeneous agricultural areas (2.4), forest (3.1), shrubs (bushes) and/or herbaceous plant associations (3.2), open areas with little or no vegetation growing season (3.3), interior wetlands (4.1) and inland (5.1).

Items to be considered when defining a particular type of environment vary depending on the degree of human impact. Thus, for mountain areas where anthropic intervention is weak, defining components are: topography, climate elements (in particular heat deficit) and plant communities.

In contrast, for strong antropic regions (such as plateau and plain areas), the capacities of the environment are expressed in the landscape through the use of land. From this point of view we considered CORINE method useful.

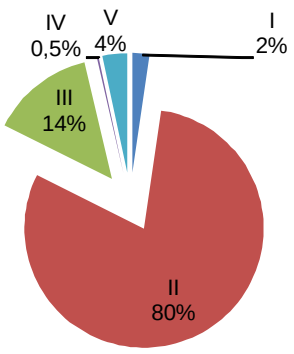

Figure 3 *- Share of areas of the Prut basin (Romanian sector) - classes determined by the Corine LandCover 2000 methodology (see class names in Table 1)*

Share of areas of the Prut basin (Romanian part) by classes determined in Corine Land Cover 2000 methodology is shown in Fig. 3. It is noted that the class II, appropriate agricultural land, has the highest prevalence, occupying 81% of the basin. One can notice a 3% of the area is occupied by water bodies in the fifth class, due to the numerous lakes and ponds in the middle part of the basin.

Application is illustrated on a map that was originally developed to 1: 50,000 scale and to a modified scale to illustrate this study especially (Fig. 4).

4. RESULTS AND DISCUSSIONS

Specific urban structure represented by *discontinuous urban fabric* (landscape type No. 112) is characteristic for both of the Prut river settlements (19 villages) and settlements in tributaries (total of 145 municipalities).

Maximum extension of this landscape is reported in the cities of Iaşi, Galaţi, Botoşani, Tg. Frumos and Dorohoi. Smaller spaces corresponding to the villages in the municipalities listed above from north to south. Local conditions favored early development of settlements. For example, Cucuteni which was important spiritual center since the Neolithic.

These conditions are reflected in the high density of population and settlements, especially along the valleys. Some of the most extensive territorial settlements are concentrated there: cities of Iaşi on Bahlui river, Victoria and Dorohoi on Jijia river and Husi on the Prut river.Most settlements are located, in whole or in part, on terraces and meadows (e.g. Iaşi, Galaţi, Vutcani, Gorban, Folteşti etc.), but also in interfluves (such as Darabani, Pomârla) or in depression areas (Huşi, Fălciu). Because of building space is expanding on slopes or interfluves the deep fragmentation within the urban fabric staple varies between 0-90 m in Iaşi, Galaţi 0-50 m, 5-20 m in Huşi and 20-40 m in Botoşani. In some cases there are slope

stability problems (e.g. Tirighina near Galaţi or Barnova near Iaşi).

The villages located on river side valleys, on hillsides or in small interfluves are looking diffuse. In turn, the villages of small depressions are easily compacted. Along Prut river characteristic villages are elongated, with linear orientation between the national road and dam parallel to the Prut river meadow inside. The landscape is a natural factor that determined the shape and size of settlements.

Habitat has maximum amplitude (100 m) for Iaşi (including components localities); the minimum altitude of the location of built space is 15 m (in the Smârdan village) and a maximum of 120 m (in the Barnova village). A close amplitude value is recorded for Botosani and its component municipalities, in north part of basin.

Related to location of settlements on the forms of relief, slope inclinations are low (0^o-10^o) for those located on the Prut river terraces, while values increase for extended habitat on slopes and/or interfluves.

Industrial and commercial units (landscape type No. 121) are found in several settlements of Romanian part of Prut basin, as Botosani, Săveni, Husi, but with area smaller than 25 ha, which led to their elimination. Higher surface areas within the cities are in Galaţi and Iaşi.

Non-irrigated arable land (landscape type No. 211) is present at all localities of the studied basin, either around or inside them. Non-irrigated arable land areas within the area exceeding 25 hectares are located on land with quasihorizontal slopes or reduced to 8^o-11^o (bridge of terraces, where the geological substrate is sand, also the meadow and some gentle slopes) and fragmentation depth of 50-60 m, as for instance in eastern town Galaţi, southwest and east of the area dominated by the city of Iaşi and south of Huşi.

Category of *permanent crops, fruit trees and vine plantations* (landscape types No. 221 and 222) occupy relatively large areas on the southern and eastern slopes of the basin. This categories predominate in east (left side of Bahlui river from the spring area to the confluence with Bahlueţ), southern and south-east (on the Siret-Prut intefluve, in the Cotnari area). Landscape type No. 222 refers to fruit trees and plantations of berry bushes, but it should be noted that the area examined, the overwhelming majority of areas within included here are taken only by fruit trees. Most important areas stand out around the village of Jijia Plain and Huşi Depression.

Grasslands (landscape type No. 231), a category that includes grassland and woodland (all 231) occupy larger areas in the northern half of the area and especially between Sitna and Jijia valleys, but mostly west of Jijia. Area not exceeding 25 meters are around towns, but they were similar - in this analysis - with other types of landscapes, according to the rules imposed in the CORINE methodology. Most of the pastures are weak wooded, including isolated trees and bushes or shrubs.

As pastures and wooded meadows occupy different landforms, the depth of fragmentation and gradient are also varied: 80-200 m Darabani (slopes of the 9^o-14^o), 160-220 m Jijia Valley (3^o-20^o), 140-220 m in Iaşi (11^o-15^o), 100-240 m in Huşi (6^o-12^o), 40-120 m south of Vlădeşti (0^o-11^o), 140-220 m in Galaţi (10^o). Slopes of this landscape were characterized by different orientations.

Relief features has resulted in a clear mosaic of land use, especially around settlements, the various plots used differently with less than 25 hectares each and can be classified together under heterogeneous agricultural areas. In their annual crops associated with permanent crops (landscape type No. 241) have small areas (north of Iasi, north of Targu Frumos). In contrast, complex cultivation patterns (landscape type No. 242), including cultivated complex model with scattered houses (all 242) is characteristic for areas around settlements, especially between the Prut, Mastacan and Cavadinesti around Galati, etc. Largely occupying terraces, relief energy values are lower: 40-80 m in Cavadinesti (4^o-9^o), 20-60 m in Vlădeni, 60-140 m on the Prut river in south of Oancea (4^o-10^o). There are higher values that bring local planning issues to discuss.

Land principally occupied by agriculture with significant *areas of natural vegetation* (landscape type No. 243) is extended throughout the basin, the most significant areas within the right of Jijia, north of Bahlui, north and south of the Mastacan and Foltesti on right bank of Prut, south of Husi. Depth fragmentation has a fairly wide range of variation comparable to that noted for the complex cultivation patterns. Locating these landscapes (243) on terraced bridges is reflected by low slopes inclinations (0^o-5^o), for example Mastacan. However, terrace leading to sectors of slope inclination increase to 7^o-9^o. The specifics, these landscapes do not generally make trouble to slopes stabilisation.

In turn, *land agro-forestry* (landscape type No. 244) occupies small spaces, being located for example on Siret-Prut interfluve to George Enescu village, or to Darabani the right bank of Prut. Relief energy has values between 80-150 m, with maximum values on interfluves, where the slopes inclinations have values between 8^o-9^o. The landscape is affected by individual landslides especially in the upper Jijia basin and the Baseu basin.

Deciduous forests (landscape type No. 311) occupies the high hills northern and eastern of Prut basin and consists primarily of beech, or beech and birch (the dominant species). The largest area with this type of landscape is located on the interfluve between the Prut and Siret, but north of Darabani. Forests are fragmented agricultural area in the Bahlui basin from Tg. Frumos to the west of Iaşi, in the east.

Moors and heathland areas (landscape type No. 322) are found in small areas or at the forest edge (landscape types No. 311, 313), such as north-east of Targu Frumos, north of Harlau, east of Iasi, either in the pasture or surrounded by agricultural land. These landscapes are located in particular on slopes with frequent

landslides. Relief energy varies from 40-100 m and 160 m west of the northern Bahlui-Jijia Depression. Slopes have gradients with minimum values of 6^o and 10^o, local maximum even higher, but often with average values of 7^o-8^o. The presence of hedges (hawthorn, blackberry, dog-rose, blackthorn) is a special contributor to the stability of these slopes, which, in most, no other use may be given.

Specific landscape with *transitional woodland-shrub* (landscape type No. 324) is present in large areas with forest (right side of Jijia, south-east of Targu Frumos etc.) or within the pasture (e.g. east of Botosani). Finally, smaller areas are disseminated among other landscapes, some of them being determined by the evolution of landscape in the history of anthropogenic influence. The relief fragmentation values is predominant above 50 m, reaching even 80-100 m in south-east of Targu Frumos. Slopes inclinations generally have values of 9^o-11^o, but can reach to 15^o.

Sparsely vegetated areas (landscape type No. 333) correspond in particular to degraded lands. Such landscapes are located on tributaries of Jijia river, near Iasi town, etc. Relative absence of vegetation is a factor contributing to the evidence of current active geomorphological processes that lead to continuous degradation of these areas.

Wetlands (landscape type No. 411) include premises clearly delineated wetlands, and wetlands in the meadow area, reclaimed from the sea and land subject to periodic flooding due to fluctuations of lake level near the surface. Such wetlands are found in flat areas with excess groundwater from the vicinity of the Prut, as the southern Rogojeni village (Şovârca pond), the swamp around the lake north of Vlădeşti, Măicaşu, wetlands south of the Chiraftei village (near Mastacan) and north of Foltesti (Covurlui pond) or Zătun wetland east of Galaţi.

Water bodies (landscape type No. 51) correspond with naturally occurring lakes and ponds, but also anthropogenic (such as in special ponds and ponds) containing fresh water. Area representative for such land use is Jijia plain. This unit is added to Prut south corridor, from junction with Jijia until flowing into the Danube.

Inland waters (landscape type No. 511) correspond to larger rivers (the Prut); because the minimum width to include the watercourse in this category is 100 m. They include sand and gravel accumulated along the river, which totals more than 25 ha. Therefore, not all the Prut was within the landscape type No. 511, but only the sectors corresponding to these conditions. It is noted that included areas within this type after the junction with Jijia, whose contribution rate determines the classification, and the surface of the landscape to increase progressively downstream, and especially after the junction with Elan river

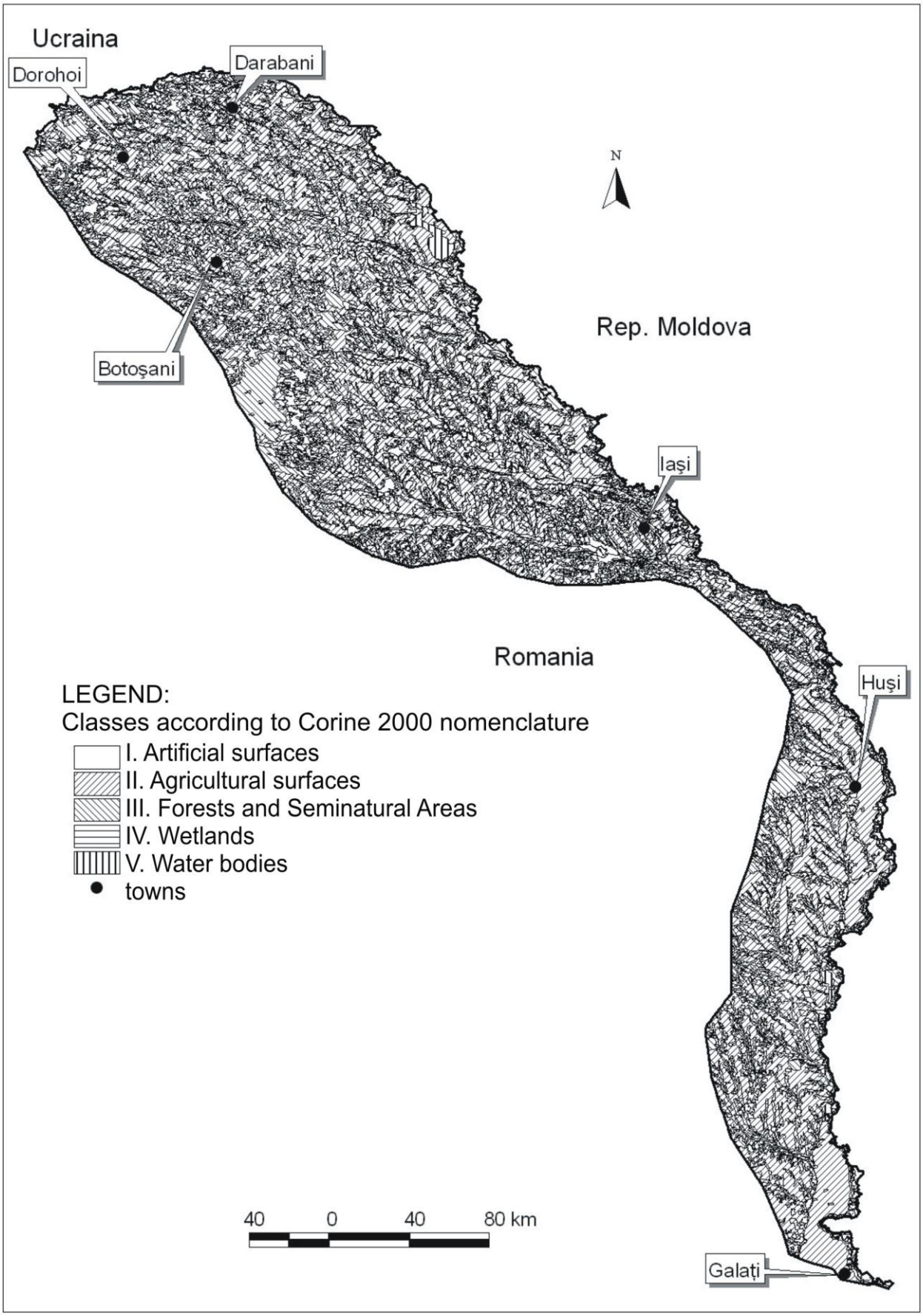

Figure 4 *- Spatial distribution of land use classes determined by CORINE LANDCOVER method in Prut basin*

5. CONCLUSIONS

It is noted that, due to geographical features of the Pruit basin, the methodology applied by CLC, can give directions how the land can be used in the best way. This contributes largely to the methodology for determining the classes/subclasses both qualitatively and quantitatively, by imposing certain percentages for usage, which results in a strict hierarchy of landscapes.

REFERENCES

ATLAS of Romania Water Cadastre, v. 1, Hydrographic network. Bucharest: The State Comitee of water, 1964. 350p.

BĂCĂUANU, V**., Moldavian Plain.-geomorphologycal study**. Bucharest: Academy Publishing House, 1968. 211p.

BOSSARD, M., FERANEC, J., OTAHEL, J., Corine Land Cover Technical Guide - Addendum 2000. **Technical Report No. 40**, Copenhagen (EEA), p. 6-75, 2000.

GEOGRAPHICAL Monography of Romania, v. 1, Physical Geography. Bucharest: Academy Publishing House, 1969. 280p.

HEYMANN, Y., STEENMANS, C. H., CROISSILLE, G., BOSSARD, M. **Corine Land Cover. Technical Guide.** Luxembrug: Office for Official Publications of the European Communities, 1994. p. 8-28.

MEYER, W. B., TURNER, B. L. **Changes in Land Use and Land Cover: A Global Perspective.** Cambridge: Cambridge University Press, 1994. 195p.

MOLDAVIAN Plateau. Bucharest: Scientific and Encyclopaedic Publishing House, 1980. 225p.

URSU, C., STOLERIU, L., SFÎC, V., ROSCA, B., Adapting the Corine Land Cover nomenclature to the land use specifity in Romania. **Geographia Technica**, n.1, Cluj Napoca, p. 193-198, 2006.