CONSIDERATIONS ABOUT THE REDUCTION OF MARSHES IN SOUTHERN OLTENIA

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ABSTRACT:
The past three decades saw a significant decline of the area covered by marshes in southern Oltenia, the main reason being human intervention in order to expand agricultural areas. The present study aims to analyze the spatio-temporal evolution of swampland, while seeking to capture the main negative environmental consequences, too. Several sets of data have been used in order to quantify the spatio-temporal evolution, that is data obtained through satellite images, from the Corine Land Cover database and by means of cartographic mapping. The results obtained showed that in the past three decades the marshes in the analyzed area have shrunk by more than 50%, primarily replaced by the expanding agricultural areas, with primarily ecological negative consequences.

Key-words*: swampland, environment, southern Oltenia, human impact.*

1. INTRODUCTION

Marshes are ecosystems that belong to the wetlands, which are universally viewed as some of the most productive terrestrial ecosystems (Gibbs, 2000). According to the Ramsar Convention on Wetlands, wetlands are defined as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters "(Article 1.1 of the Convention text). Therefore, marshes are one of the most important components of inland wetlands, with key ecological and social functions.

The loss or the deterioration of these wetlands may cause major environmental disruptions. The most important negative consequences that stand out include physical and chemical changes in the soil, changes in the hydrological conditions, the decline of biodiversity, the loss of organic nutrients, the release of large quantities of CO_2 in the atmosphere, etc. (Wright, 2009). It is estimated that during the twentieth century, over 50% of the specific types of wetlands have disappeared in many areas worldwide (Europe, North America, Australia and New Zealand) and many others have deteriorated extensively (Millennium Ecosystem Assessment, 2005).

Marshes (along with other types of wetlands) play an essential role from the ecological point of view (as a habitat for the development of specific biota), but they also have a major role in providing balanced environmental conditions such as alleviating climate change, pollution control, water purification, helping lower the risk of floods and nutrient retention in the soil (Wright & Reddy, 2001; Wright, 2009). For a better perspective, for example, it is estimated that approximately 25% of total anthropogenic CO_2 emissions are absorbed by marshes (and other types of wetlands), forests and meadows, which are important natural reservoirs for storing these emissions that enhance the greenhouse effect (Wijkman & Rockstrom, 2013, p. 97).

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Swamplands can also play a vital role in tempering the climate conditions of a particular territory, by regulating moisture balance and thermal regime. Such is the case of the analyzed area, southern Oltenia. This area has undergone in the past few recent decades an acceleration of territorial aridity (Peptănatu, Sîrodoev & Prăvălie, 2013; Prăvălie, Peptănatu & Sîrodoev, 2013), in the synergistic context of changes in land use, in geographical landscapes (Dumitraşcu, 2006), and in global climate change (Prăvălie, 2013). It is also very important to note that in the analyzed region, swampland plays a critical role in terms of biodiversity. According to the Ramsar list of wetlands, three wetland areas of international importance are located in the respective region (Bistreţ, Blahniţa and Calafat - Ciuperceni – Danube areas), with a variety of vegetation and wildlife (especially migratory birds species).

The present study attempts to analyze, from the perspective of the spatio-temporal, the situation of wetlands (swampland) in southern Oltenia in the past few decades, by means of satellite and cartographic analysis tools.

2. DATA AND METHODS

The study area is bounded by administrative criteria, spanning a total of 113 territorial-administrative units (**Fig. 1**). The Western and Eastern boundaries are bounded by satellite images, on which was realised a part of the analysis of this study. It covers 736,723 ha and the biggest part is located in the Oltenia Plain, with the exception of the Northwestern part, located in the Getic Plateau.

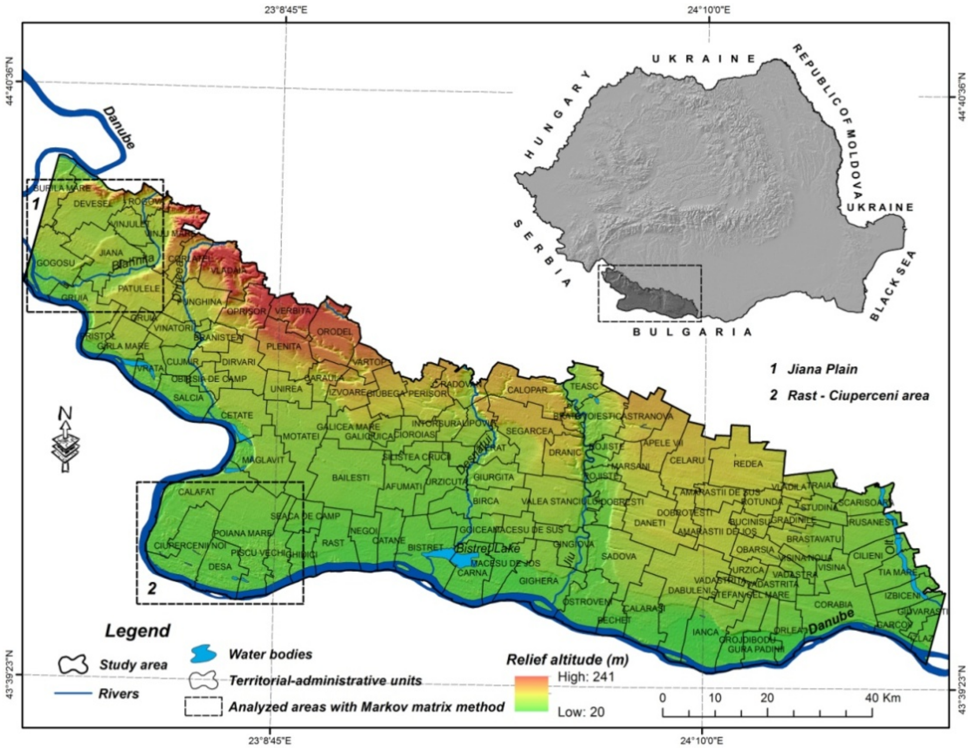

Fig. 1 Location of study area in Romania

Three sets of data were used in a comparative approach in order to analyze the spatio-temporal evolution of swampland, that is data obtained by means of satellite, from the Corine Land Cover database and data obtained by cartographic mapping.

As far as remote-sensing means are concerned, the global basis of satellite data glovis.usgs.gov has been used to obtain Landsat 4-5 TM satellite images from the years 1990 and 2011 (path 184, rows 029 and 030). The images were taken during the summer season, depending on their availability in relation to cloud formations (July 11, 1990 and August 22, 2011).

The analysis of swampland by means of satellite images was conducted using the NDWI digital index (Normalized Difference Water Index), an index developed by the Gao (1996) in order to determine the water content in vegetation by means of the principles of physics. It is calculated using the formula: NDWI = R_{NIR} - R_{SWIR} / R_{NIR} + R_{SWIR}, where, in the case of TM satellite images, R_{NIR} and R_{SWIR} correspond to band 4 (0.78 - 0.90 μm) and band 5 (1.55 - 1.75 μm), respectively (Jackson et al., 2004).

In theory, NDWI values may range from -1 to +1, but in reality these values are rarely achieved. The negative values designate dry, moisture-less areas (or areas with a negligible water content), while positive values mean areas with moisture content. In this case, the positive peaks values are reached, these characterizing water surfaces (rivers, lakes) (**Fig. 2**). It is very important to note that the analysis of swampland (for 1990 and 2011) was conducted at the upper limit of the + 0.1 value (the limit that designates areas with moisture content) at the level of wetlands limits, delineated from the Corine Land Cover database, 1990 edition. This analysis, at the level of the Corine 1990 marsh limits, was necessary because the values above the 0.1 NDWI limit also represent the water content of the vegetation (especially forest vegetation with higher moisture content).

The analyzed satellite data were compared with other data from the Corine Land Cover database, used to analyze swampland during 1990-2006. In addition, cartographic investigations were conducted on the fluctuation of swampland in the past three decades, in this case resorting to topographic maps, 1:25,000 scale, 1981 edition, and ortophotomaps, 1: 5,000 scale, 2008 edition (NACREA, 2008).

Finally, the Markov transition matrix methodology (Land Use Transition Matrix) was used in order to accurately understand the causes and the context of the fluctuation of this category of wetlands, a method commonly used in the analysis of spatio-temporal changes in the land use (Petit, Scudder & Lambin, 2001; Rimal, 2011). The data processing was performed using ArcGIS 10.1 software.

3. RESULTS AND DISCUSSIONS

The analysis of the spatio-temporal evolution of swampland, as demarcated by the NDWI, highlights a significant decrease in size during 1990-2011 (**Fig. 2, 3**). While by 1990 these areas amounted to a total 20,654 hectares, by 2011 they had shrunk to 4,965 hectares, meaning a decline of close to 75% over a two-decade span. According to the method of remote sensing, the greatest losses occurred in the Southern part of the study area, especially in the Danube floodplain. Significant losses also occured in the Western part, in the Jiana Plain (**Fig. 1**), as well as along the Jiu river.

The analysis of data from the European Data Platform Corine Land Cover reveals drastic decreases of marshland surfaces (**Fig. 4**). During a time span of 17 years, these surfaces have shrunk by over 90%, respectively from 40,686 hectares by 1990 to 2,936 hectares by 2006. In this situation, the decline occurred in an almost uniform pattern across the entire area analyzed. However, it should be noted that there may be some errors in the Corine database, possibly hinted at by the fact that the declines by 2006 were very high compared with the situation by 1990. Thus, a more reliable way to quantify the fluctuation of this category of wetlands in recent decades is their mapping from available cartographic materials (**Fig. 5**).

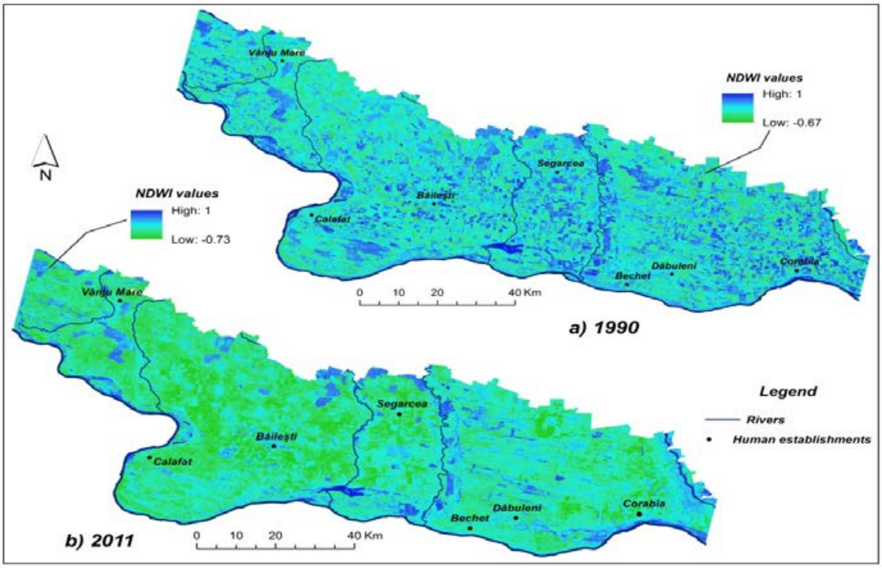

Fig. 2 The spatio-temporal evolution of the NDWI (1990-2011) in the analyzed area (a, b)

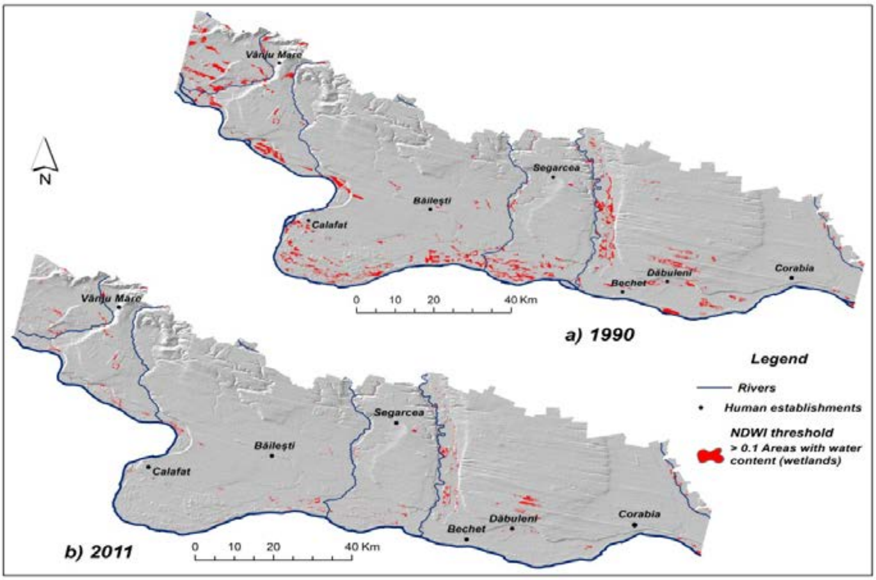

Fig. 3 The fluctuation of swampland by 1990 and 2011 (a, b), demarcated by means of NDWI above 0.1

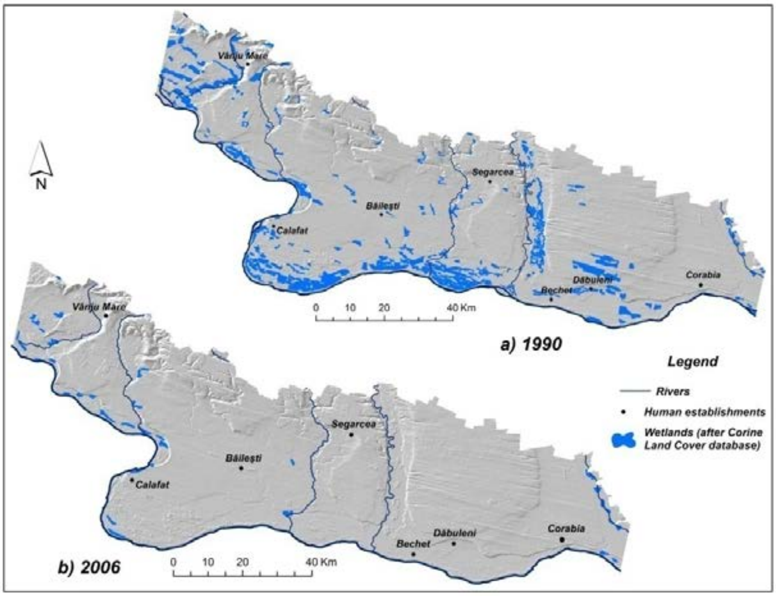

Fig. 4 The spatio-temporal evolution of swampland by means of Corine Land Cover database (a, b)

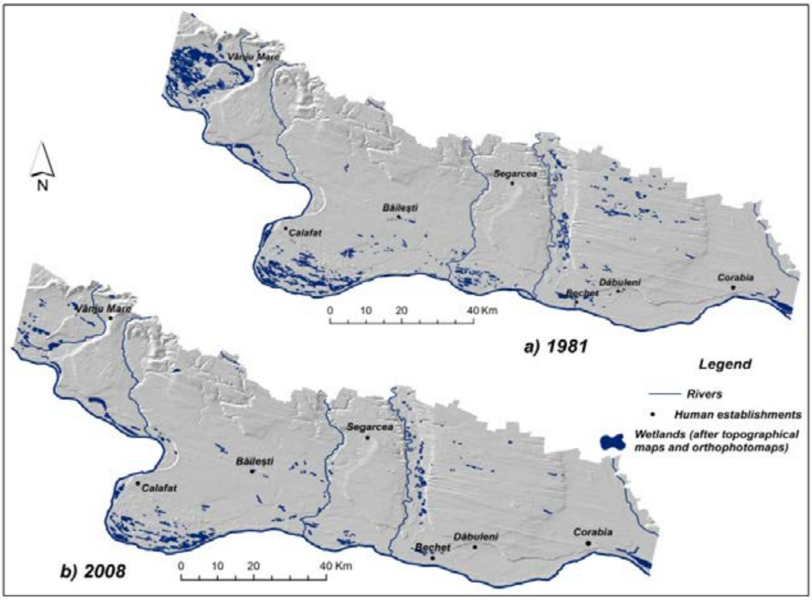

Fig. 5 The spatio-temporal evolution of swampland by means of topographic maps and orthophotomaps (a, b)

According to cartographic investigations (topographic maps, 1981, and orthophotomaps, 2008), marshland shrank during 1981-2008 by 52%, that is from 12,057 hectares in 1981 to 6,234 hectares in 2008. The biggest losses were recorded in areas part of the following landforms: the Jiana Plain and the Băileşti Plain (the Southern central part of the study area, West of the Jiu river) (**Fig. 5**). Significant areas have disappeared in the Danube floodplain, too, especially in the cape Rast - Ciuperceni area and South of the Bistreţ lake.

Assuming that this methodology for obtaining and analyzing the data is the most reliable, an attempt was made to match the temporal fluctuations of marshland surface to the territorial-administrative units encompassed by the area of analysis (**Fig. 1**).

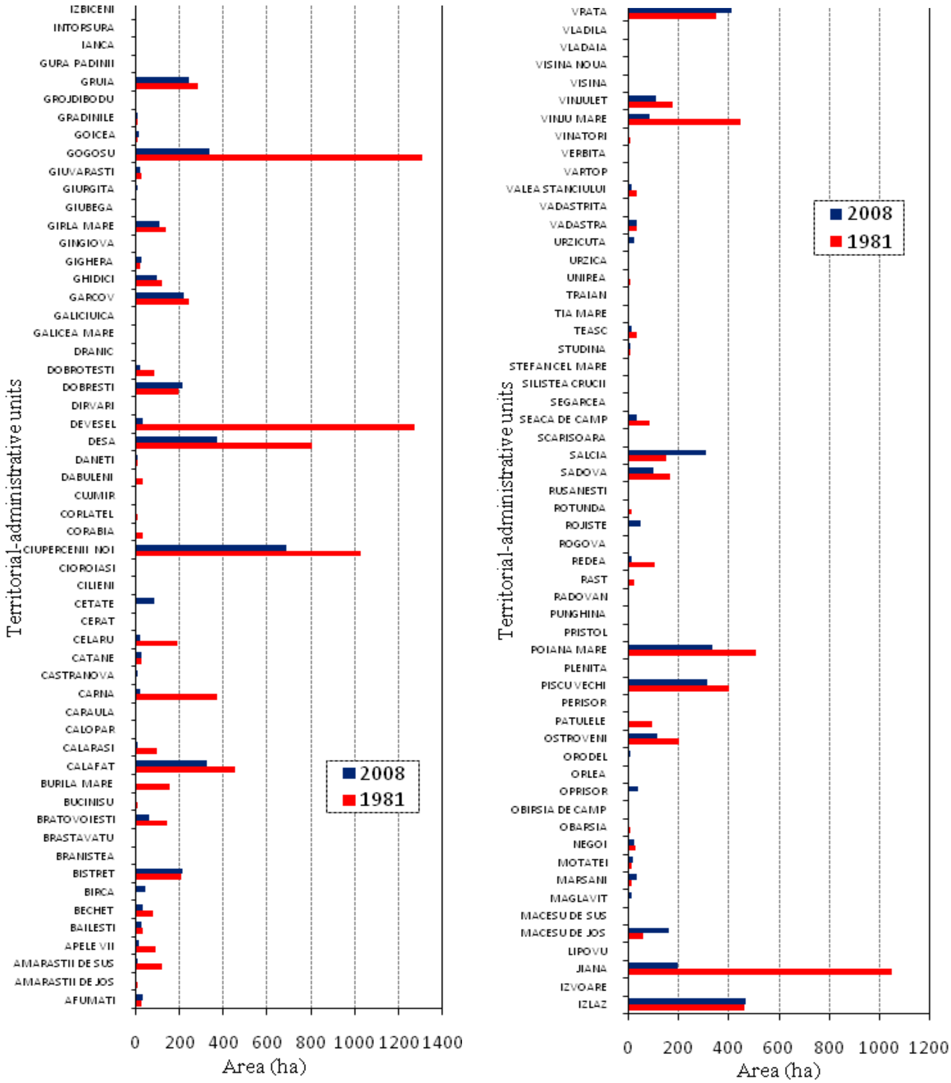

Fig. 6 The temporal evolution of swampland during 1981-2006, at the level of the territorial-administrative units

The results revealed that, out of the 113 administrative units, 47 units (42%) underwent a decline of swampland surface, 22 (19%) recorded slight increases, while 44 (39%) of territorial units recorded no changes because of the absence of swampland in the two landmark years (**Fig. 6**).

The biggest losses were recorded for the following administrative units: Deveselu (1,241 ha), Gogoşu (976 ha), Jiana (852 ha), Desa (432 ha), Vânju Mare (360 ha), Carna (348 ha) and Ciupercenii Noi (340 ha), and the main cause is related to human drainage interventions meant to expand the agricultural areas.

Although there are differences in the data obtained by the three methods, it is certain that the trend of wetland surfaces (marshes) in the past two - three decades is decline. The main cause of the drastic changes occurring in these ecosystems is the human factor, as man intervened aggressively by changing land use. Wetlands, especially marshes, gradually disappeared after 1970, when drainage and embankment work stepped up in order to expand agricultural areas (Dumitraşcu, 2006).

In order to assess the extent of the expansion of agricultural areas at the expense of wetlands, the Markov transition matrix methodology was used, as it provides detailed information on the spatial and temporal changes of the various categories of land use / cover. This method was applied in two areas of study, namely Jiana Plain area and the cape Rast – Ciuperceni area (**Fig. 1**). The two examined areas were divided into 8 sub-areas in terms of land use, by 1981 and 2008. The case studies were chosen because in those areas the evolution (losses) was the most intense and the marshes in those areas are included, alongside other types of wetlands, among wetlands of international importance (according to the Ramsar list of wetlands).

Regarding the interpretation of the results (**Table 1**), it should be noted that the matrix assessment is conducted on both the horizontal and on the vertical. The data in the row categories (horizontal) indicate the expansion in surfaces to the detriment of the data in the vertical columns. Losses are shown in the columns (vertical), so, the difference between the losses and the gains represents the positive or negative balance of the surfaces of land categories, during the two landmark years. The intersecting values of the same categories of land mean unchanged surfaces in the analyzed period.

Table 1. Change in areas (ha) of the type of land use (1981 – 2008) in the area of the Jiana Plain, based on Markov methodology

Land use type/ Forest species	*Bodies of water*	*Agricultural*	*Build areas*	*Marshes*	*Sandy areas*	*Forest vegetation*			*Total 2008*
						Poplar	*Acacia*	*Oak*	
Bodies of water	1.2	0.2	-	-	-	-	-	-	1.4
Agricultural	28	23819.8	87.4	3646.3	61.4	137.7	747.5	42	28570.1
Build areas	-	152.3	1227.2	5.2	-	-	1.1	-	1385.8
Marshes	0.3	122.1	0.5	705.9	-	1.4	0.5	0.5	831.2
Sandy areas	-	112.5	-	5.7	9.3	8.2	-	-	135.7
Poplar	-	52.4	-	5.2	-	336.3	0.4	-	394.3
Acacia	7.7	469.6	0.9	49.3	-	0.1	2825.5	0.3	3353.4
Oak	5.4	44.5	-	14.4	-	-	0.2	664.6	729.1
Total 1981	42.6	24773.4	1316	4432	70.7	483.7	3575.2	707.4	35401

Thus, in the case of the Jiana area it can be noted that the greatest loss of wetland areas during 1981-2008 occurred in favor of agriculture, with agricultural lands expanding by 3,646 hectares to the detriment of wetlands (**Table 1**). One may also notice slight expansion to the detriment of agricultural land (on the horizontal) following the abandon of certain arable lands, but these gains are insignificant compared to the losses. So, the total balance loss-gain indicates that wet surfaces have lost a total of 3,524 ha to agricultural land (mostly farmlands), in this case study.

The situation of the second case study, the Rast-Ciuperceni area, is similar (**Table 2**). Swampland suffered initial losses of 1,747.5 ha to agriculture, but an area of 500 ha has been recovered, so the total losses amounted to 1,247 ha. In this case, the recovery of the marsh areas on relatively large surfaces is due, on the one hand, to the more limited human interventions in this part of Southern Oltenia (the degree of human intervention is reduced, especially along the Danube in this section), and on the other hand, to the proximity of the Danube which floods this area throughout the year.

Table 2. Changes in areas (ha) of the type of land use (1981 – 2008) in the Rast-Ciuperceni area, based on Markov methodology

Land use type/ Forest species	*Bodies of water*	*Agricultural*	*Build areas*	*Marshes*	*Sandy areas*	*Forest vegetation*			*Total 2008*
						Poplar	*Acacia*	*Willow*	
Bodies of water	11.9	1.9	0.1	0.7	-	0.3	-	-	14.9
Agricultural	166.9	20995.7	55	1747.5	76.3	1030.4	2275.2	6.8	26353.8
Build areas	57	481.3	1665.3	3.8	-	3.9	13.3	-	2224.6
Marshes	116.7	500.4	-	1448.4	0.2	14.8	8	-	2088.5
Sandy areas	0.9	204	-	5	72.6	17.7	9.5	-	309.7
Poplar	4.1	191.1	-	13.1	0.8	1720	28.4	-	1957.5
Acacia	0.3	897.1	12.4	13	2.1	95	6566.7	-	7586.6
Willow	-	6.2	-	-	-	0.3	49.7	83.6	139.8
Total 1981	357.8	23277.7	1732.8	3231.5	152	2882.4	8950.8	90.4	40675.4

It is interesting to note that there has been a loss in the surface covered by water bodies to the benefit of swampland. In fact, in the past three decades, some of these aquatic areas (usually natural ones) transformed into marshland, the most plausible causes being related to the intensification of climate aridisation in the region (frequent and prolonged droughts, the increase of the evapotranspiration regime, etc.) (Prăvălie, Peptănatu & Sîrodoev, 2013).

4. CONCLUSIONS

The severe decline in size of swampland during the past few decades is essentially one of the multidimensional forms of the intensification of territorial aridisation in southern Oltenia. The marshes play an essential role at the local level, especially from the ecological, but also from the social point of view. In this case, their existence is absolutely necessary given that the study area encompasses wetlands of international importance (under the auspices of the Ramsar Convention), in addition to the severe climatic conditions, where the marshes play an important role by tempering the aridisation of the climate.

After using the three methods for the analysis of the dynamics of these types of wetlands, it appears that they have undergone significant changes, primarily in terms of quantity. These transformations (losses of large areas) are mainly due to local anthropogenic causes (their draining), but in some extent to quasinatural global causes (the change of the climatic conditions), all these acting unidirectionally toward the drastic decline in size of these wetlands that have an essential role in preserving the optimal environmental balance of the analyzed area.

REFERENCES

Dumitraşcu, M. (2006) *Modificări ale peisajelor în Câmpia Olteniei* (Landscape changes in Oltenia Plain). Bucharest, Romanian Academy Publishing, 229p.

European Environment Agency. (1990) Corine Land Cover, raster data.[Online] Available from: www.eea.europa.eu.

European Environment Agency. (2006) Corine Land Cover, raster data.[Online] Available from: www.eea.europa.eu.

Gao, B. (1996) NDWI - a normalized difference water index for remote sensing of vegetation liquid water from space. *Remote Sensing of Environment*, 58, 257 – 266.

Gibbs, J. P. (2000) Wetland loss and biodiveristy conservation. *Conservation Biology,* 14 (1), 314-317.

Jackson, T. J., Chen, D., Cosh, M., Li, F., Anderson, M., Walthall, C., Doriaswamy, P. & Hunt, E. R. (2004) Vegetation water content mapping using Landsat data derived normalized difference water index for corn and soybeans. *Remote Sensing of Environment*, 92, 475–482.

Licurici, M. (2011) Human-Induced Environmental Changes and Floodplain Restoration Necessity along the Danube, on the Drobeta-Turnu Severin –Bechet Sector. *Forum geografic. Studii şi cercetări de geografie şi protecţia mediului*, 10 (2), 350 – 363.

Millennium Ecosystem Assessment. (2005) *Ecosystems and human well-being: wetlands and water synthesis*.[Online]Availablefrom:http://www.unep.org/maweb/documents/document.358.aspx.pdf [Accessed 19th May 2013].

NASA Landsat Program.(1990) Landsat TM scenes L5184029_02919900711 and L5184030_03019900711, L1T.USGS, Sioux Falls, 07/11/1990.[Online] Available from: http://glovis.usgs.gov/.

NASA Landsat Program.(2011) Landsat TM scenes L5184029_02920110822 and L5184030_03020110822, L1T.USGS, Sioux Falls, 08/22/2011, available from http://glovis.usgs.gov/.

National Agency of Cadastre and Real Estate Advertising (NACREA). (2008) *Orthophotomaps*, 1:5000.[Online] Available from: www.ancpi.ro.

Peptenatu, D., Sîrodoev, I. & Prăvălie, R. **(**2013) Quantification of the aridity process in south-western Romania. *Journal of Environmental Health Science and Engineering*, 11, 3.

Petit, T., Scudder, T. & Lambin E. (2001) Quantifying processes of land-cover change by remote sensing: resettlement and rapid land-cover changes in south-eastern Zambia. *Int. J. Remote Sensing*, 22 (17), 3435–3456.

Prăvălie, R. (2013) Climate issues on aridity trends of Southern Oltenia in the last five decades. *Geographia Technica*, 17 (1), 70-79.

Prăvălie, R., Peptenatu, D. & Sîrodoev I. (2013) The impact of climate change on the dynamics of agricultural systems in South-Western Romania. *Carpathian Journal of Earth and Environmental Sciences*, 8 (3), 175 – 186.

Ramsar Convention text.[Online] Available from: http://www.ramsar.org/cda/en/ramsar-documents-texts-convention-on/main/ramsar/1-31-38%5E20671_4000_0_ [Accessed 10th May 2013].

Ramsar list of wetlands.[Online] Available from: http://www.ramsar.org/cda/en/ramsar-documents-list- anno-romania/main/ramsar/1-31-218%5E16090_4000_0_ [Accessed 12th May 2013].

Rimal, B. (2011) Urban Growth and Land use/Land Cover Change of Biratnagar Sub-Metropolitan city, Nepal. *Appl Rem Sens J.*, 2 (1), 6-15.

Wijkman, A. & Rockström J. (2013) *Falimentarea naturii. Negarea limitelor planetei (Bankrupting Nature. Denying our planetary boundaries)*. Bucharest, Compania Publishing, 320 p.

Wright, A.L. & Reddy, K.R. (2001) Heterotrophic microbial activity in northern Everglades wetlands soils. *Soil Sci.Soc. Am. J.*, 65, 1856-1864.

Wright, A.L. (2009) Environmental consequences of water withdrawals and drainage of wetlands.[Online] Available from: http://edis.ifas.ufl.edu/ss515 [Accessed 15th May 2013].