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Human-Induced Environmental Changes and Floodplain Restoration Necessity along the Danube, on the Drobeta-Turnu Severin - Bechet Sector

Mihaela LICURICI[1]

[1] Department of Geography, University of Craiova, Al. I. Cuza Street, No. 13, Craiova, Romania, Postal Code 200 585, E-mail: mihaela_licurici@yahoo.com

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Abstract

The present paper aims at analysing the human-induced transformations that took place in the Drobeta-Turnu Severin - Bechet sector of the Danube Floodplain during the last two centuries. The research started from the need to obtain a real and comprehensive database concerning the extension, the nature and the characteristics of the topographic-hydrographical, edaphic and biologic structures appeared or modified under human influence, their relation with the changes occurred at the level of the land use and their present functionality. Special attention was paid to the latter transformations occurred after 1989.
The primary types of topographical and hydrographical changes resulted from the geomorphic human activity in the Danube Floodplain are analysed in relation with the land use within this unit.
The analysis of the environmental transformations in the floodplain sector started from cartographic and statistical materials that are relevant for the 19th-21st centuries. For the post-communist period, the valorisation of the Corine Land Cover database allowed for a more detailed analysis of the land use dynamics. The data thus obtained was checked and updated with field observations and measurements, which are mandatory given the fact that the cartographic database shows deficiencies and it is partially outdated.

Keywords: *Danube Floodplain, human-induced environmental changes, land use, floodplain exploitation vs. floodplain valorisation*

Rezumat. Asupra modificărilor antropice ale mediului şi necesităţii restaurării Luncii Dunării în sectorul Drobeta-Turnu Severin – Bechet.

Lucrarea de faţă îşi propune să analizeze modificările antropice care au avut loc în sectorul Drobeta-Turnu Severin - Bechet al Luncii Dunării pe parcursul ultimelor două secole. Cercetarea a pornit de la nevoia obţinerii unei baze de date comprehensive reale cu privire la extinderea, natura şi caracteristicile structurilor topo-hidrografice, edafice şi biologice apărute sub influenţa antropică, la relaţia lor cu schimbările survenite în modul de utilizare a terenurilor şi la funcţionalitatea lor prezentă. O atenţie deosebită este acordată acestor din urmă transformări în perioada de după 1989.
Tipurile primare de modificări topografice şi hidrografice rezultate din activitatea geomorfică umană în Lunca Dunării sunt analizate în legătură cu utilizarea terenurilor în regiune. Studiul transformărilor de mediu din sectorul de luncă a pornit de la materiale cartografice şi statistice relevante pentru secolele XIX - XXI. Pentru perioada post-comunistă, o analiză mai detaliată a dinamicii modului de utilizare a terenurilor a fost posibilă prin valorificarea bazei de date Corine Land Cover. Datele astfel obţinute au fost verificate şi completate cu rezultatele vizitelor de studiu în teren, absolut obligatorii în contextul în care s-a constatat că baza cartografică prezintă deficienţe şi nu este adusă la zi.

Cuvinte-cheie: *Lunca Dunării, modificări antropice ale mediului, utilizarea terenurilor, exploatareai vs. valorificarea luncii*

1. INTRODUCTION

As systemic ensemble, the environment results from the integration of three large equivalent components: that of the ecological or abiotic support, the system of the vegetal and animal communities and the system of the human activities, through which the first two ones are modified, planned and used (Bertrand G., quoted by Roşu Al. & Ungureanu Irina, 1977). This permanent relation between the natural and the social and ethno-cultural aspects is of great importance in the case study area and it must be taken into account when floodplain restoration in the view of sustainable development is approached.

The floodplain sector under study is located in south-western Romania, between the fluvial kilometre 937 - city of Drobeta-Turnu Severin and the fluvial kilometre 677 - town of Bechet, covering an area of ca 86,000 hectares; the sector unfolds on a general west – east direction and it shows asymmetric character as compared to the right bank of the Danube. The width of the proper floodplain

varies, going from a few tens of meters up to more than 14 kilometres (important extensions are noticeable near the settlements of Maglavit, Ciuperceni, and Cârna).

The southern limit is clear, while the northern one displays a sinuous aspect, being marked by settlements (Drobeta-Turnu Severin, Hinova, Batoţi, Ţiganaşi, Gruia, Pristol, Gârla Mare, Vrata, Cetate, Maglavit, Calafat, Salcia, Ciuperceni, Rast, Negoi, Catane, Bistreţ, Cârna, Măceşu de Jos, Gighera, Zăval, Ostroveni, and Bechet) located at the floodplain-terrace geomorphologic contact or on the edge of the neighbouring terrace. Along this alignment, the limit is well underlined mostly by the level differences between floodplain and terraces. From Hinova to Batoţi, as well as near Gruia settlement (Fig. 1), where the terrace scarp touches the flood-prone sector or directly the Danube riverbed, extremely steep banks are noticeable. In such areas, the lateral erosion exerted by the river and the intense erosion led to the appearance of prominent torrential organisms in the loess deposits of the terrace (Badea L., 1967). The same aspect dwells between the settlements of Gârla Mare and Vrata and on the Cetate - Hunia - Maglavit - Basarabi - Calafat line.

Fig. 1. The floodplain – terrace contact near Gruia settlement

On other sectors, the floodplain – terrace limit is unobtrusive and hard to decipher because of the presence of aeolian sand (in the Ciuperceni - Rast – Bistreţ area), or because of deluvial-colluvial glacis accumulation at the base of the terrace.

The floodplain shows a diversity of micro-relief features and it is generally characterised by the presence of longitudinal areas: the sandbank located near the riverbed (the highest part), the middle alluvial plain (partially swampy) and the depressions (swamps and lakes, most of them drained in the past). Significant changes appear locally, generated by enhanced alluviation and by the presence of secondary sandbanks, micro-depressions, active or abandoned canals, islets, dams, sand dunes and alluvial fans (as for example at the confluence with the Jiu or the Blahniţa rivers).

Within the case study area, the relief resulted from the actions conducted by three categories of factors: the fluvial processes that generate and modify the floodplain unit, the aeolian processes that are highly active in the sector, and the human factor, which exerted a major influence during the last hundred years. On a 90 percent of the total surface of the Oltenian Danube floodplain there were realised complex regulation works that led to the levelling of certain depression areas or sand dunes, the precise delineation of a series of ponds transformed into intensive fisheries, the deforestation and plantation of allochthonous fast-growing species. Man-induced landforms appeared - thousands of cubic meters of diggings arranged in a new order acquired well-established functions in the longitudinal and transversal dams that border the floodplain precincts, or in the dams that surround the fisheries, representing new positive landforms in the floodplain. The drainage or the irrigation canals network, or the depressions formerly occupied by lakes (Rast, the Nedeia - Nasta - Sclavog Complex etc.) represent the widespread negative landforms. Subject to these changes, the old morphology of the floodplain is less visible at present, although some of it is preserved in the natural units located near Pisculeţ - Ciuperceni and Vrata - Tigănaşi settlements (Tomescu Viorica, 1998).

The strategic, natural and economic importance of the Danube Floodplain explains the development of human settlements and activities since ancient times and represents the framework of the important landscape changes registered in the region. In the Danube valley, most of the settlements developed at the floodplain - terrace contact, in order to be safe from the inundations that sometimes affected the entire floodplain. Few settlements appeared in the proper floodplain, on the more elevated grounds but, in time, most of them were abandoned and reconstructed at the geomorphologic contact or on the top of the terraces (*Geografia Văii Dunării româneşti*, 1969).

At present, the region includes twenty-nine territorial-administrative units (TAUs), of which three urban centres (Drobeta-Turnu Severin, Calafat and Bechet) (Fig. 2). Their population accounts for 233,594 inhabitants (2007), between a maximum of 107.882, reached at Drobeta-Turnu Severin, and a minimum of 1,465 – Măceşu de Jos. The human stress expressed through the general population density registers a maximum of 1,971 persons/ha – Drobeta-Turnu Severin and a minimum of 18 persons/ha – Burila Mare.

We shall further analyse the nature and intensity of the human influence in the landscape changes, starting from the basic transformations occurred during the last two centuries and emphasizing those that took place during the second part of the 20th

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century, as well as the change of the tendency in the transition period. Furthermore, we shall underline the necessity to avoid the degradation of the floodplain under the human impact and to favour the sustainable use of its support capacity, as well as the uncertainties connected to the restoration of the Danube Floodplain.

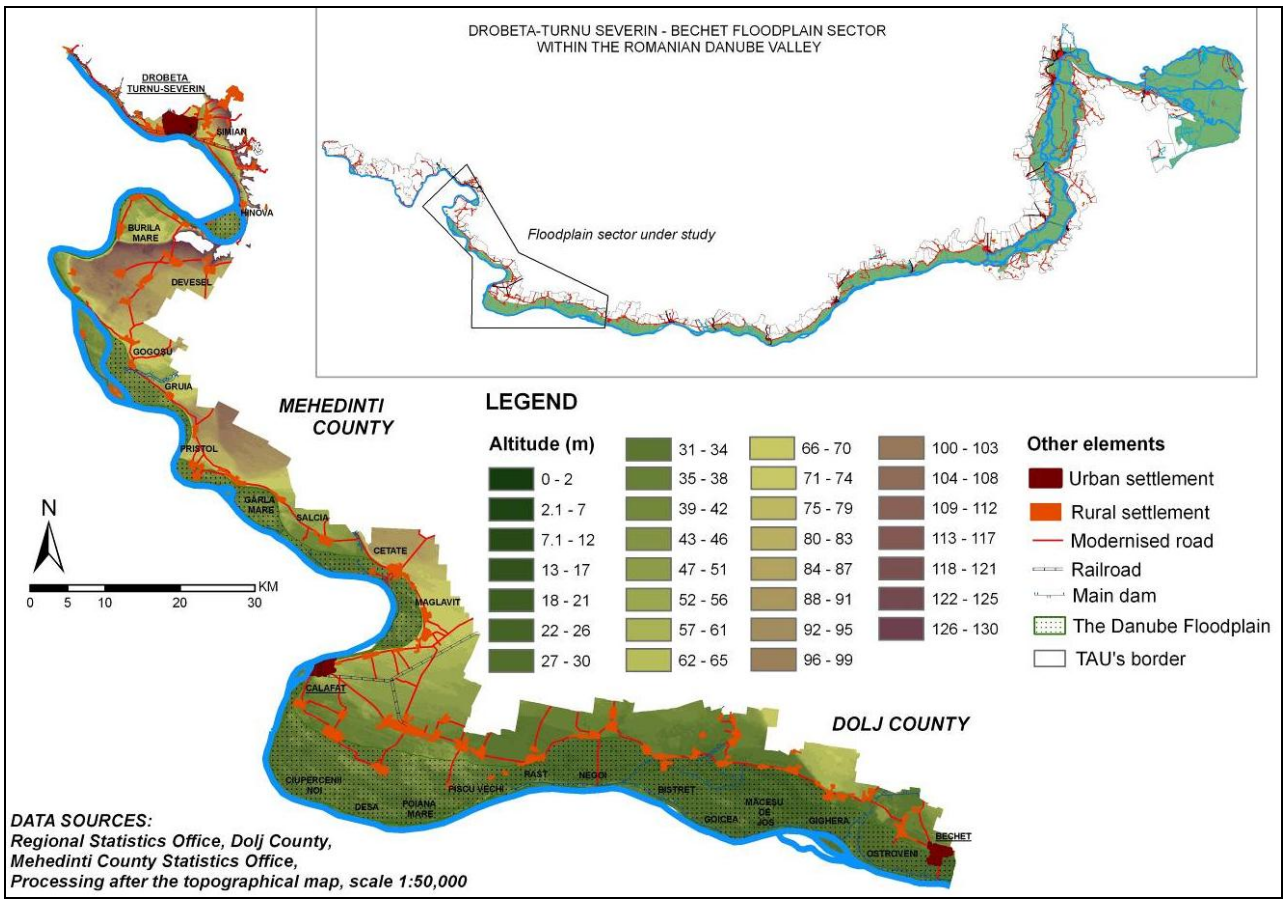

Fig. 2. Location and main characteristics of the Danube Floodplain, Drobeta-Turnu Severin - Bechet sector

2. DATA AND METHODS

For the analysis of the main environmental transformations within the Danube Floodplain, a database was realized (ArcGIS 9.x), starting from cartographic materials of the 18th and the 19th centuries (Specht - 1790, Szatmari - 1864). The research continued with various generations of topographical maps (1912, 1955-1960, 1975-1985) at different scales, forest distribution maps and with the 21st century orthophotos (Shamsi Uzair M. U., 2008). The database was populated with digitised elements of interest (forest and aquatic surfaces, pastures and meadows, built-up areas, communication network, agricultural spaces etc.), the attributes of which were subsequently assessed.

The comparative analysis of the various cartographical materials and the resulting database were updated with field observations and measurements. The field campaigns conducted between 2007 and 2010 enabled the determination of the elements that are not (clearly) noticeable on the maps, of the dynamic elements, as well as the correction of certain errors appeared on the cartographic material and in the statistical data.

The effects of the human geomorphic activity are analysed in relation with the land use within this unit, given the fact that the latter element represents the concrete modality of expressing the integration of human life and activity in the landscape (Dumitraşcu Monica, 2006). For the post-communist period, the valorisation of the Corine Land Cover database allowed for a more detailed analysis of the land use dynamics.

The statistical analysis and the computed landscape indicators allowed for the highlighting of the human intervention dimensions at the level of the TAUs within the Danube Floodplain (Gergel Sarah E. et al, 2002).

In accordance with the formula used by Marusycyak – Poland, in 1988 and retaken by Malgorzata Pietrzak in 1998, for the assessment of the human impact on the Polish landscape, we computed the environmental change index for the case study area, mirroring the report between the

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surface occupied by forests, pastures and meadows and the built-up surface. For the Danube Floodplain, the report between the forested and aquatic surfaces, on the one hand, and the agricultural and built-up surfaces, on the other hand, becomes more relevant. The amendment brought to the initial formula relies on the fact that the agricultural ecosystems represent artificialized entities of the environment, they are not capable of self-regulation and they are subordinated to the interests of the human communities. In this case, the computation formula becomes:

Adapted E. Ch. I.=(ForestS.+MeadowS.+AquaticS.) /(Built-upS.+ArableS.+VineyardsS.+OrchardsS.).

This adapted formula includes the surfaces occupied by the transportation network and it was used by Dumitraşcu Monica (2006) in the assessment of environmental transformations within the Oltenian Plain.

In accordance with the state of the relations among the systemic components, at the level of the case study area, there were delineated three natural units, i.e.: Natural unit I - Drobeta-Turnu Severin - Gruia, Natural unit II - Gruia - Calafat, Natural unit III - Calafat - the Jiu (***, *Redimensionarea ecologică şi economică pe sectorul românesc al Luncii Dunări, 2008*). There were identified the areas in biostasy (the stability stage in the evolution of the relief because of the absence of erosion, in the framework of a permanent vegetation cover) that are present on the entire non-systematised surface of the floodplain; the areas in rhexistasy, which comprise the urban and rural settlements; the areas in parastasy (the instability stage in the evolution of the relief because of the erosion, given the absence of a permanent vegetation cover), which are characteristic to the surfaces with agricultural functions. Starting from the CLC2000 database realised by the European Environmental Agency with regard to the land cover, there were determined the areas being in the three stages mentioned, thus: the artificial surfaces are territories in rhexistasy; the surfaces with agricultural use are in parastasy; the terrains covered with forests and the semi-natural areas, the wetlands, the water surfaces are considered in biostasy.

3. RESULTS AND DISCUSSIONS

3.1. The most important human-induced changes within the floodplain

The interaction of the natural processes within the floodplain environment leads to its evolution, but the intensity and manifestation forms of the human activity generates a strong footprint. Among the environmental changes that marked the Danube Floodplain, special attention has been paid to the morphological and hydrological transformations occurred as result of the human geomorphic activity.

The archaeological vestiges, the historic documents and the local toponymy confirm that human settlements were organised early along the Danube and some of them became important commercial centres where intense trade was realised between the local population and the merchants who sailed upstream the Danube. The riverside residents used to say: *if dug on, every sandbank within the Danube Valley shall reveal human bones and…crocks* (Conea, 1956, quoted in ***, *Geografia României*, 2005). In fact, the numerous old tumuli existing in the Oltenian Plain, as well as in the Danube Floodplain represent some of the first forms of man-induced relief in the area (Fig. 3).

Fig. 3. Tumuli in the floodplain area, near the settlement of Negoi, Dolj County

The local population had to intervene and to defend the crops, houses or any other kind of infrastructure from the high waters. If a few centuries back, the man-induced changes within the Danube valley were insignificant, during the last hundred years, the effects of these types of environmental transformations became alarming.

At the end of the 18th century, the natural pastures and meadows dominated the flood-prone Danube area (Toşa-Turdeanu Ana, 1975). The husbandry, the fishery and the cultivation of cereals were in full progress at the time. The poor access roads towards the Danube or the reed hedges - empiric fishery constructions as compared to the present ones – represented the only development works realised in the fluvial corridor. The sheepherding, one of the oldest traditions of the Danube Floodplain inhabitants, reached its peak in the 18th century and at the beginning of the following one, but its decline started during the second half of the 19th century, as the terrains cultivated with cereals extended. The Adrianople Peace (1829) represented a crucial moment in the economy of the Danube valley. This treaty impelled the naval and terrestrial traffic and, implicitly, the development of the port-settlements, which became important trade centres. All these elements

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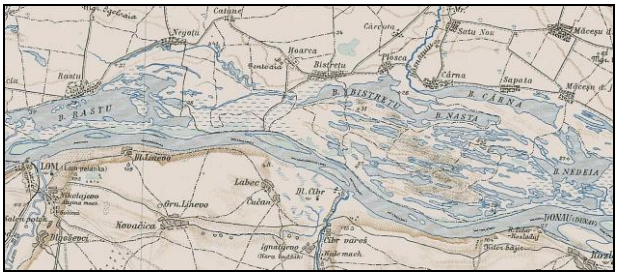
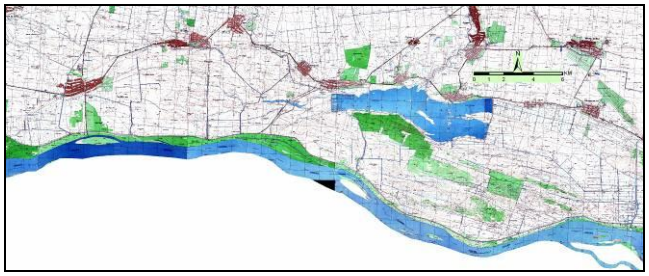
gradually led to significant human-induced changes: the agricultural fields expanded in the detriment of the floodplain coppice, ports and roads were constructed, channels were cut etc. The most important regulation works began after the Second World War and they included drainage works, building of flood-control dykes and irrigation networks, actions for the prevention of soil degradation etc. The passage from the co-operative system to the capitalist one, after 1989, imposed new, sometimes paradoxical trends, which are connected to two important elements: the changing of the property type, accompanied by the abandonment and the depreciation of the agricultural and industrial systems and the increased incidence of the natural phenomena of risk. To these elements there is to be added an accentuated theoretical legislative preoccupation concerning the protection of the natural capital of the region (Schneider E. & Drăgulescu C., 2005).

The various types of human interventions in the Danube Floodplain affected the balance and the metabolism of the natural ecosystems. In numerous instances, these intrusions, under their multiple forms, led to irreversible changes of the natural environmental characteristics (Fig. 4). The most important human-induced transformations within the case study area of the Danube Floodplain fall into three major categories - topographical and hydrographical changes, edaphic and microclimatic changes and changes of the fauna and flora elements - and they will be further analysed.

A. Szatmari Map, Scale 1:57,600 (1864)

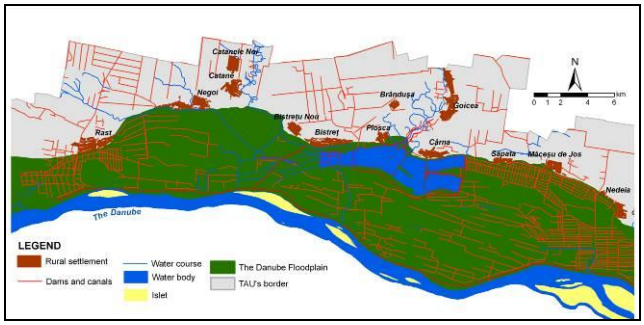


B. General Austrian Map of the Central Europe, Scale 1:200,000 (1912)



C. Topographical Map, Scale 1:25,000 (1975 – 1985)

D. Ortophotograph, after the 2006 spring flood



E. Topographical and hydrographical changes induced through regulation works

F. Dams (Bistreţ) and canals (Rast) abandoned after 1989

Fig. 4. Rast - Bistreţ - Nedeia area. Landscape changes mirrored in the cartographic and photographic documents from the last two centuries

3.1.1. Topographical and hydrographical changes

The transformations induced through hydrological regulation works firstly concern the building of longitudinal and partitioning flood-control dykes, of irrigation or drainage channels, the appearance of rice paddies, the planning of sand dunes and depressions, which led to the change of certain relief parameters through levelling, compression, cut and fill works etc. with direct impact on the landscape and with indirect influences

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on the soil cover, fauna, flora, certain hydrological parameters, and the specific topoclimates. Thus, the direct effects of these regulation works are mirrored by the quality and quantity of drinkable water, of that used for irrigations, by the change of the piezometric level, by the changed characteristics of the soils (salinization, gleization and pseudogleization). Furthermore, they led to the disappearance of certain ecosystems (such as the Nedeia and Rast Lakes, the extended ponds located south of Ciupercenii Noi - Desa - Pisculeţ settlements) or to their severe degradation.

The human-induced changes within the Danube Floodplain, and, in a wider context, those occurred in the entire river valley, mostly followed the exclusive economic interest. The authorities of the time sustained that, along with the economic advantages, the damming also offered social advantages translated in the protection of the floodplain settlements from spring flash floods (Pătroescu Maria et al, 2000).

In 1910, Grigore Antipa considered the Danube Floodplain and ponds as *safety valves* playing a regulating part in the establishment of the dynamic balance of the great river and of the biotic elements. Antipa judged the nonsubmersible dams efficient only on limited surfaces, so that their building would not lead to the increase of the water level. His vision concerned *an economic use of the floodplain through the exclusive protection offered by the high grounds against the floods and the keeping of the low areas in natural regime.* Nevertheless, the works conducted five decades later were the opposite of the scholar's recommendations (Mihnea I. et al, 2007).

Mostly realised after 1959, the complex system of flood-control dykes protected more than 70 percent of the floodplain sector from overflowing. The complex irrigation and drainage systems developed within the Danube Floodplain, downstream of Calafat comprise the following sectors: Calafat - Ciuperceni (6.5 thou. ha), Ghidici - Rast - Bistreţ (8.5 thou. ha), Bistreţ - Nedeia - Jiu (14.0 thou. ha).

The damming led to increased levels during the high waters, the reduction of the total travelling time of the flash flood waves, the limitation of fish reproduction surfaces and of the biological filter effect ensured by the floodplain. Other consequences of the damming works concerned the appearance of salinization phenomena, as the appropriate drainage was missing and the moisture excess prevailed (it can be noticed south of Gighera settlement), the erosion in the dam-bank areas that are not appropriately protected through tree screens and are exposed to waves generated by the naval traffic. Since the damming works were doubled by lake drainage actions, numerous lacustrine and pond ecosystems were transformed into agroecosystems.

After 1989, most of the irrigation systems within the Danube Floodplain underwent severely diminished activity or they were abandoned, situation that led to the reduction of the water volume collected from the Danube, as well as to the clogging of certain unused channels with alluvia or waste materials (Fig. 5).

The changes induced through the intensive and systematic fisheries predominantly affected the Cetate - Basarabi, Salcia, and Bistreţ - Cârna sectors. The earliest systematic fishery that offered its first production in 1971 was that located near Cetate - Basarabi settlements, among its initial functions being that of fish nursery for *Porţile de Fier II* Reservoir. The nursery required a water surface of ca 160 ha, but the natural conditions also allowed for the extension of the fishery developments downstream, on a surface of 420 ha. The systematization of the Hunia, Maglavit and Golenţi ponds served this purpose. The second and most extended pond farm was the Bistreţ - Cârna fishery (with a surface of ca 1,800 ha, among the biggest in Romania). The floodplain environment was strongly modified, as the extensive lacustrine depressions Bistreţ, Cârna, Nasta, Nedeia etc. were reduced at the fish nursery located south of Bistreţ settlement and continued westwards with four fish basins. The Salcia fishery entered the production in 1976, with a systematised surface of 350 ha, and it was placed on the Balta Mare and Băltica water bodies. Other less extended fishery developments were located in the floodplain south of Ciuperceni - Desa - Pisculeţ settlements. The systematised fisheries were provided with precincts and partitioning dams, installations and works for water supply and evacuation, nurseries and fishing points, as well as with a series of exploitation annexes. After 1989, these arrangements were strongly degraded and the operating equipments were mostly stolen or destroyed (Fig. 6). The floodplain terrains granting allowed for new private fisheries to be realised (such as the one located on the west of Călugăreni Pond) (Fig. 7) or for old precincts and degraded channels to be exploited for fishing (Salcia).

The changes induced by the new types of land use were among the most severe within the region, the Danube Floodplain registering radical transformations from the viewpoint of the agricultural use. As the water covered important surfaces, the local inhabitants used to refer to the floodplain as *the marsh* (Rom. *balta*). The Szatmari Map (1864), the General Austrian Map (1912), and the Lambert Maps (1900, 1920) record the prevalence of the terrains

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covered by lakes and marshes, i.e. with moisture excess, with natural pastures and meadows, forests, as well as the insular presence of the arable fields that were often subject to devastating flooding.

Fig. 5. Out-of-use irrigation channel in the Calafat – Ciuperceni system

Fig. 6. Partitioning dam and equipments formerly used in the Bistreţ fishery

Fig. 7. New private fishery located on the west of Călugăreni Pond

Although started at the end of the 19th century, the regulation works became especially extended after 1960, also marking the severe reorganization of the land use and land cover within the Danube Floodplain, with significant extension of the agroecosystems and the related biodiversity losses. Meadows, forests and water bodies regressed to the profit of ploughed lands. Spring cultures surfaces increased and left the ground naked in winter. Higher or sloping grounds were gradually colonized by vine or other cultures. The use of herbicides left the ground naked between each crop. New cultural practices, such as mechanization also increased the risks of erosion.

After 1990, because of the general economic decline and of the uncertain situation concerning the property over terrains and equipments, most of the irrigation systems were put out of use and drought destroyed periodically the crops. Nevertheless, the arable fields register a high part in the case study area, accounting for about 40 percent of the total surface (even more important values at the level of Gogoşu, Rast, Negoi, Măceşu de Jos, Gighera, Ostroveni and Bechet settlements. The surfaces occupied by vineyards (2.8 percent) and orchards (0.05 percent) have only an insular distribution, especially in the floodplain-terrace contact sectors. In the transition period there is to be noticed the reduction of the human stress through this type of cultures. The explanation lies in the difficulties appeared after 1989 at the level of the administration, the production cost and in the product marketing, all determining the small farmers to abandon the more extended plantations and to maintain only those necessary for their own consumption. The pastures and hay fields occupy more extended surfaces in the Calafat – Piscu Vechi sector, while the forests cover small areas disseminated on the entire floodplain, especially along the dams, accounting for 18.7 percent of the area. The surfaces occupied by civil constructions, industrial or trade units, transportation infrastructure etc. account for about 2 percent of the floodplain sector under analysis (Fig. 8)

The development works connected to the communication infrastructure paralleled the progress of the hydrographical regulation works, industrial or trade units, and settlements located in the Danube Floodplain or at the geomorphologic contact. The easy access to the various objectives required a modernised road network supplemented by numerous lower-quality segments, as well as by bridges that pass over the Danube or its branches (the Calafat bridge – under construction – Fig. 9, the bridges that connect *Ostrovul Mare* with the rest of the country). In close connection with the harbour facilities there developed the railways, on which raw materials or processed products were transported. Through the cut-and-fill and compaction works that they required, the communication axes led to changes in the underground water circulation, increased the impermeable surfaces and lead to streaming and ground loss (Dale V. H. et al, 2000).

The changes induced by the construction of hydroelectric dams concern the building of *Porţile de Fier II* (*The Iron Gates II*) hydroelectric and navigation system on the Danube (at the fluvial kilometre 863 – Fig. 10), which involved the appearance of an important water accumulation. It changed the base level of the tributaries (consequently leading to transformations in the slope and bank modelling), the Danube flowing regime and current velocity, the structure of the aquatic ecosystems, and, directly or indirectly, the habitation conditions within the Danube Floodplain.

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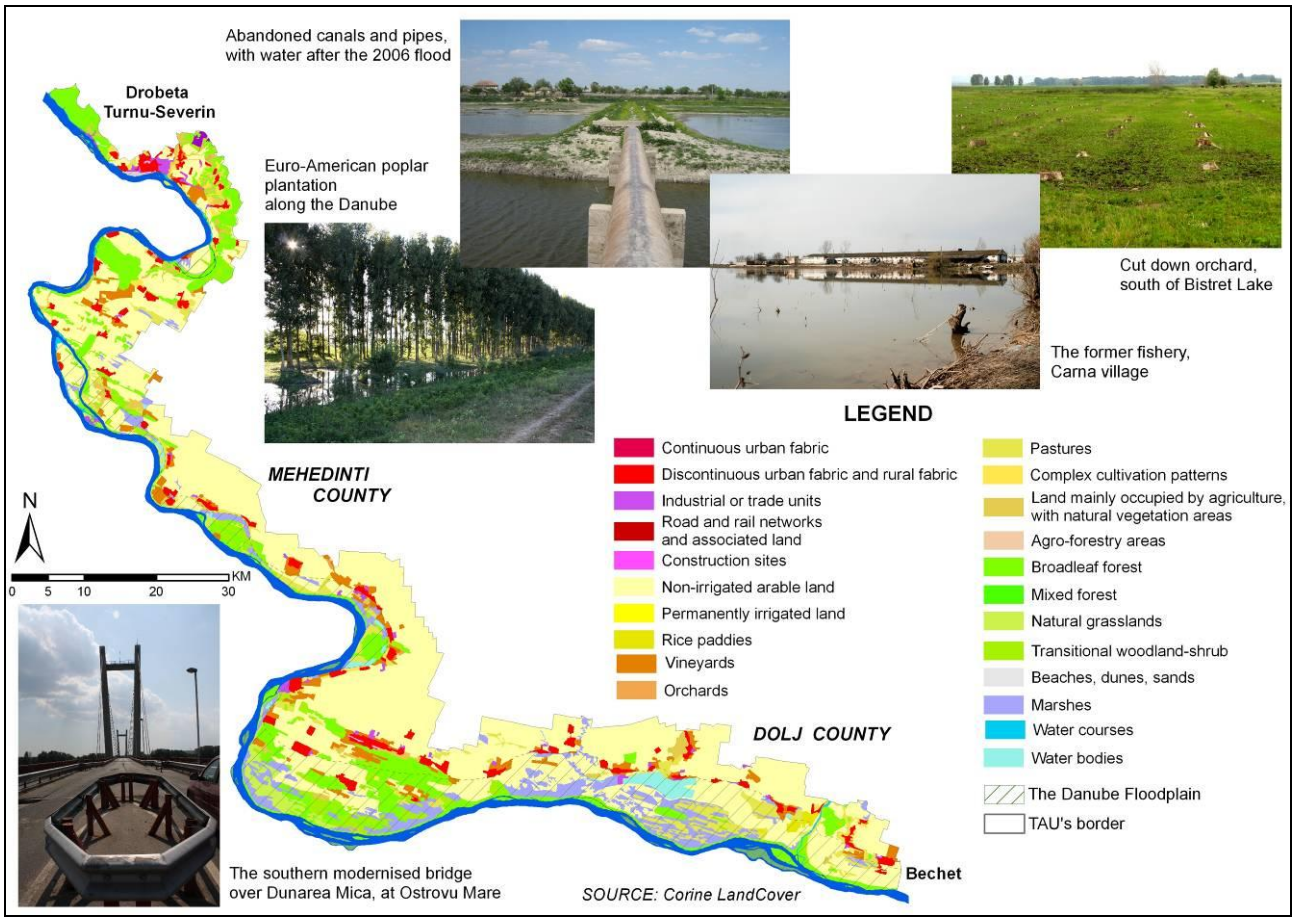

Fig. 8. The Danube Floodplain, Drobeta-Turnu Severin - Bechet sector. Land use and land cover

Fig. 9. The bridge over the Danube, at Calafat - under construction

Fig. 10. The *Portile de Fier II* hydroelectric and navigation system

3.1.2. Edaphic and microclimatic changes

The minor landforms within the floodplain, be them flood-prone or flood-safe in natural conditions, represent different situations in soil formation, but, on most part of the surface, the pedogenesis was complicated by the human intervention. The former pond or lake depressions are characterised by the presence of gleyc alluviosols or gleysols, as it can be locally noticed within the Cetate - Maglavit - Basarabi, Ciuperceni - Desa - Piscu Vechi and Negoi - Bistreţ - Cârna sectors (Fig. 11). The higher parts of the sand dunes relief display the presence of sandy soils that are in a poor or average state of evolution and of psamosols (the units located near Calafat - Ciuperceni - Ghidici, Ostrovul Corbului, Ostrovul Mare, as well as the narrow floodplain situated south of Gârla Mare - Vrata. Depending on the deflation intensity, there appeared wind-blown sands, semi-fixed sands and sands that are in an incipient state of soil formation with transition towards the humiferous solified sands. Pastures and meadows developed on them, especially in the broad depressions situated between dunes, in the floodplain areas that were not systematised (in the south of

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Ciuperceni, Desa, Pisculeț, Cetate, Basarabi, Gârla Mare, Vrata, and Salcia settlements). In the floodplain area located under the scarp of the lower terrace, at Gighera, where the underground layer is close to the surface, there have developed soils with different salinization degrees, as indicated also by the specific vegetation appeared there; the situation is similar south-westwards of Desa settlement.

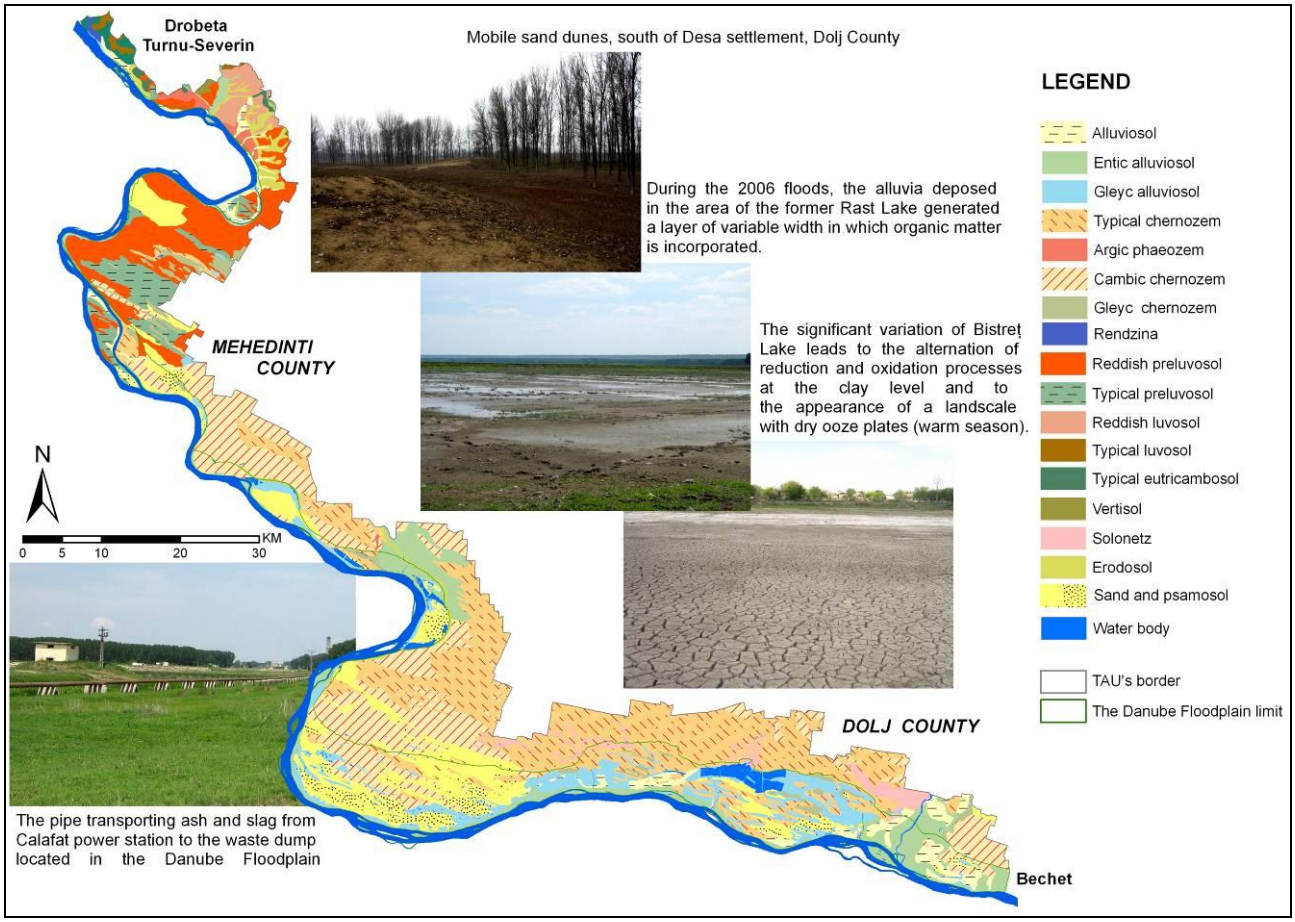

Fig. 11. The Danube Floodplain, Drobeta-Turnu Severin – Bechet sector. The soils

All man-made regulation works conducted in the Danube Floodplain led to changes in the active biological horizon of the soils. The drainage, the damming, the irrigation systems and methods, the agricultural-industrial units changed completely the natural regime of the floodplain soils and led to the appearance of more pollution types. Soil degradation through salinization was an effect of the intensive irrigations. The secondary soil salinization was generated by the changes occurred in the periodical percolative hydric regime of salinization-desalinisation under the influence of flooding with non-reversible hydro-saline regime (the dammed floodplain areas located under the terrace, undergoing phreatic-saline water contribution), but also by the irrigations with poor-quality water.

Fertilization by mineral manures rather than organic manure gradually destructs the soil, contributing to the decrease of its organic matter content and of its biological activity (in particular, in relation to chemical uses). Because organic matter enhances water and nutrient holding capacity and improves soil structure, managing for soil carbon can enhance productivity and the environmental quality, and can reduce the severity and costs of natural phenomena, such as drought and flood (***, *Human induced land degradation is preventable through understanding and remediation of the underlying causes; Soil organic matter*, 2011).

The soil covered with ash and slag heaps (near Calafat town, in the depression of Ciuperceni Pond, where there is located one of the most important industrial heaps in all Oltenian Plain, which receives the waste material from the Calafat power station) or with domestic and industrial waste platforms is driven out of the natural circuit.

Lastly, clearings are responsible for forest soils degradation and for sand reactivation in the area.

The local influences of the active surface structure (the different types of water surfaces, the morphohydrography specific to the Danube ponds and swamps, the drained or irrigated areas, the dams,

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the sand dunes, the terrace levels and the scarp of the neighbouring plain, mostly with southern orientation, the diverse vegetal cover, including the mosaic of agricultural crops, the soil types) induce different topoclimate nuances on the framework of the Danubian climate. For example, if on the dry sand dunes located on the Manginiţa - Poiana Mare floodplain sectors the maximum temperature can rise up to 65 - >70°C at their surface, in the wetlands it can hardly surpass 40°C, while the water temperature near the riverbank is of 25 - 26°C.

The human-induced changes of the land cover led to transformations in the topoclimate of the Danube Floodplain. In the absence of the natural moderator elements specific to this unit, topoclimate nuances fade and the floodplain is subject to antagonistic phenomena like severe droughts and periods with important moisture excess.

3.1.3. Vegetation and fauna changes

The biological fertility of the Danube depends on its interdependency with the flood-prone area. In their turn, the evolution and the dynamics of the ecosystems within this area depend on the water and fertilizing substances supply, as well as on the timing, intensity and duration of the floods generated by the great river.

In time, the human interventions led to important transformations of the initial specific vegetation and fauna. Numerous lake ecosystems disappeared (Rast, part of Bistreţ etc.) and so did extended coppice within the Danube Floodplain, while the mezohigrophile and higrophile vegetation suffered important losses and limitations. During the last decades, allochthonous species (acacia, Euro-American poplar, pine tree, Douglas fir etc.) and agricultural ecosystems (cereals, vegetables, technical plants etc.) replaced the natural vegetation specific to the floodplain. The changes occurred in the hydrological regime of the Danube and the succession of droughty years (1988 - 1995, post-2000) generated unbalances in the vegetative state of poplar and willow forests. Thus, hard broadleaf species were introduced on extensive surfaces so that they can resist to the meteorological-hydrological risk phenomena. In the systematised floodplain located between Ghidici and Bechet, the human influence upon the natural vegetation translates in the change of forest fund area and structure, while the natural pastures and meadows were mostly transformed into arable lands. On most of the floodplain surface the old specific forest was cut and, where the terrain was not favourable to agriculture, fast growing species were planted. The vegetation of the Danube islets is characterised by the same natural forests of poplar and willow, with the exception of Gâtanul, Ţigănaşi, and Kozloduy islets, where Euro-American poplar plantations were realised. On the more extended such units - *Ostrovul Corbului* (dammed), *Ostrovul Mare*, where the terrain is mostly used for agriculture - the natural vegetation remained on small surfaces (Tomescu Viorica, 1998).

The recent evolution of the vegetal cover within the Danube Floodplain was mostly determined by the human activity. The reorganization of the terrestrial and aquatic biocenoses changed the ecological balance of the aquatic ecosystems within the space of the floodplain. The massive damming and drainage regulation works modified severely the aquatic fauna of the Danube and of the floodplain lakes that underwent significant surface cuts. There are to be added the great hydroelectric and navigation constructions on the Danube, the increased water eutrophication and pollution degree, as well as the intensive fishing and certain types of poaching, all these leading to the drop of the ichthyofauna. The mineral and organic input promotes the proliferation of plant life, especially algae, which reduces the dissolved oxygen content and, implicitly, the development of zoocenoses and it can be mostly noticed near the settlements, at the aquatic - land interface. Consequently, the species with high economic value, such as *Cyprinus carpio, Silurus glanis***,** *Esox lucius* etc. and especially the sturgeons gradually began to be replaced by fish species with lower economic value, among which there are to be mentioned *Abramis brama, Scardinius erythrophthalmus, Carassius Auratus Gibelio, Perca fluviatilis* etc. (***, *Geografia României*, 2005). The inorganic and organic substances discharged into the Danube (suspensions, acid or alkaline substances etc.) modified the chemism of the water and the metabolism of the aquatic biocenoses.

3.2. Necessity and uncertainty in the restoration of the Danube Floodplain

The human stress upon the Danube Floodplain, very diverse through its manifestation forms, represents the main responsible for the present state of the environment. The human settlements and the economic units led to increased water demands for different uses and these were mostly satisfied from the Danube. Subsequently, the loading of the waters with chemical substances through discharging became harmful for the aquatic flora and fauna. The population growth and the permanent development of the human habitat, both urban and rural, intervened in the physiognomy and functionality of the ecosystems along the Danube Floodplain. Thus, the extension of the agricultural fields, the development of the transportation network, and the

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spreading of the built-up area led to the fragmentation of the biogeographic domains, most frequently the initial vegetation being totally removed. The agriculture realised on the drained surfaces had good results initially, the value of the crops surpassing that of the fish. Nevertheless, from the ecological viewpoint, this represented a genuine disaster, especially in the area of the ponds and swamps. The agricultural crops diminished in the framework of the unevolved soils with decreasing fertility, of the shallow phreatic table and of the general environmental fragility. The regulation works often led to the transformation of the aquatic ecosystems in agricultural ecosystems, to the drop of fish population, while in the dammed precincts they raised the piezometric level and they changed the evolution characteristics of the soil horizons through the appearance of gleization, pseudogleization and salinization phenomena. In certain instances, these works generated functional changes of the terrestrial and aquatic ecosystems, a poor water circulation and the reduction of the oxygen level in the water. The disappearance of extended wetlands directly affected the topoclimates within the Danube Floodplain and the migration of the specific avifauna.

The environmental change index was computed for the assessment of the human impact on the Danube Floodplain landscape. To reflect better the floodplain conditions, the initial formula was adapted to show the report between the forested, grassland and aquatic surfaces, on the one hand, and the agricultural and built-up surfaces, on the other hand. In 2007, the riverside TAUs within the case study area registered values comprised in the following characteristic classes: 1.68-1.12 - landscape with relatively stable ecological balance (Drobeta-Turnu Severin, Hinova); 1.11-0.65 - landscape with slightly affected ecological balance (Burila Mare, Gogoşu, Şimian, Desa, Ciupercenii Noi, Piscu Vechi); 0.64-0.41 - landscape at the limit of the ecological balance (Salcia, Griua, Gighera, Gârla Mare, Calafat, Poiana Mare); 0.40-0.29 - landscape with seriously altered ecological balance (Bechet, Devesel, Ostroveni, Goicea, Bistreţ); 0.28-0.20 - very strongly altered landscape (Măceşul de Jos, Cetate, Negoi, Pristol, Rast, Maglavit) (Licurici Mihaela, 2010a).

The landscape is defined as *a spatial segment characterised by a type of dynamic, hence unstable combination of physical, biotic and human elements that, dialectically reacting among them, form territorial units – landscapes – that display a unitary evolution, both under the effect of the components and under that of the separate dynamics shown bythese constituents* (G. Bertrand, 1968, quoted in *Redimensionarea ecologică şi economică pe sectorul românesc al Luncii Dunării, 2008*). The same author specifies that the individuality of the landscape is based on the interactions established among three main components: *the ecologic potential* (the ecologic support), *the biologic exploitation* (the communities of living organisms) and *the human actions* (the social activity). They ensure the common dynamics of the geosystem, physiognomically expressed through a certain type of landscape.

Often, the dynamics of one element can differ from the dynamics of the ensemble and then the changing of the reports among the components imposes a new dynamic trend expressed through the transformation of the landscape. The geosystems can evolve in three defining states: *rhexistasy* (unbalanced relations among the components, determined by natural or man-induced causes), *parastasy* (unbalanced relations among the constitutive elements, their connections being modified because of the human impact) and *biostasy* (balanced relations between the ecologic support and the biological exploitation, morpho-structural stability of the components). The effects of these relations mark, in their turn, the ecologic support and/or the biological exploitation and they are mutually transmitted among all components.

Between Drobeta-Turnu Severin and Gruia, the units in rhexistasy are represented by the settlements of Hinova, Ostrovul Corbului, Vrancea, Burila Mare, Izvorul Frumos, Ostrovul Mare, Gogoşu, Izvoarele etc. and they cover a surface of 790.297 hectares (6 percent). The units in parastasy account for 62 percent, with a total surface of 8,002.597 hectares. The units in biostasy are represented through forests (Stârminei, Vrancea, Călugarească, Braniştei), inland wet areas (Rotunda Pond, Jiana Pond, Balta Verde) and cover a surface of about 4,215.886 hectares (32 percent, among which forests - 23 percent, wet areas - 8 percent and water surfaces - 1 percent) (Fig. 12).

In the floodplain extending between Gruia and Calafat, the units in rhexistasy are represented by the settlements of Pristol, Gârla Mare, Salcia, Cetate, Maglavit, Calafat, covering a surface of almost 421.290 hectares (3 percent). The units in parastasy account for 51 percent, corresponding to a surface of 6,968.819 hectares. The units in biostasy are represented through forests (Vrata, Maglavit etc.), inland wet areas (Vrata Pond, Balta Mare, Golenţi Lake) and cover a surface of ca 6,090.878 hectares (46 percent, among which forests - 30 percent, wet areas - 10 percent and water surfaces - 6 percent) (Fig. 12).

In the eastern Calafat - the Jiu sub-sector, the units in rhexistasy are represented by the following settlements: Ciupercenii Noi, Desa, Smârdan, Poiana

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Mare, Piscu Vechi, Rast, Bistreţ, Gighera, Ostroveni. This type of areas covers a surface of almost 2,703.331 hectares and account for 3 percent of the entire area. The parastasy areas are represented by the arable fields, vineyards, orchards, pastures and hold a surface of 37,907.002 hectares (49 percent). The areas in biostasy are represented by forests (Ciupercenii Vechi, Drăcila, Catrana, Purcarului, La Grinduri, Braniştea - Bistreţ, Zăval), accounting for 28 percent and an occupied surface of 22,189.780 hectares, by wetlands (Ciuperceni, Măgura Mare, Coldova, Renca, Strâmba Ponds etc.), with a part of 17 percent and a surface of 13,067.051 hectares, as well as by the water surfaces (Bistreţ, Cârna, Nasta, Cîlnişteа, and Lipanul Lakes), with a surface of 2,117.777 hectares (3 percent). The biostasy areas within this unit cover a total surface of 37,374.608 hectares and account for 48 percent (Fig. 12).

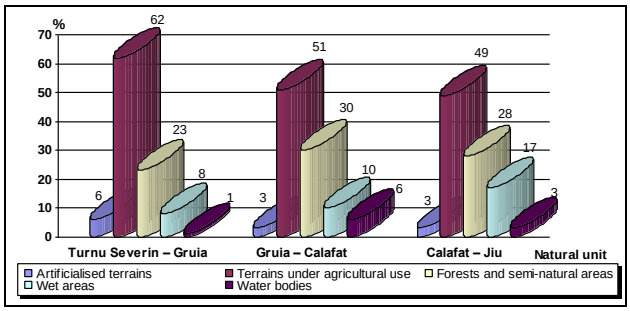

Fig. 12. The part of the equipotential areas within the Drobeta-Turnu Severin Bechet sector of the Danube Floodplain

The research on the situation within the Danube Floodplain recorded the environmental unbalances caused by the human interventions from the last half century and by their harmful consequences. The severe limitation of the flora and fauna diversity, the qualitative and quantitative pauperization of the natural landscape, the amplitude of erosion processes, with significant effects of the riverside settlements and economic activities, the more severe manifestation of the global climatic influences require an improvement of the equipotential report by means of ecological renaturation, restoration and rehabilitation works (Darby S. & Sear D., 2008). The first requirement concerns the preservation of the specific natural capital through the protection of the biological elements and of the habitats less affected by regulation works.

Given the present behaviour of the terrains, after the entire series of regulation works, there must be stated that the present land structure is not appropriate for the local natural conditions. On numerous surfaces, it does not represent the optimal category. Thus, in many areas, generally depression ones, former lakes or ponds, despite the drainage, there is registered moisture excess (originating in the underground infiltrations, in certain springs or in the precipitation), which affects the agricultural production on the surfaces turned to arable lands. Therefore, taking into account the geographic particularities, it is necessary to re-evaluate these structures for their possible reversion to the traditional functions of piscicultural areas or land covered with natural pastures, which better correspond to the local environmental conditions and satisfy to a significant extent the consumption needs of the local population.

Between the visions that support the return to wilderness and those that propose the intensive regulation of the floodplain, the aspects of the sustainable development must be closely analysed in order to solve in the best manner the contradiction between the necessities of the human communities and the protection of landscape and biological diversity (Freeman R. E. et al, 2003; O'Neill R. V. et al, 1997). The efforts to reach the balance between the two elements are based on the initiatives of the local communities, of the conservational organisations and of the government, initiatives that sometimes end by being transposed into environmental laws or regulations. These efforts can take multiple forms, but they would have to begin with individual or collective commitments concerning the prevention of the destruction of habitats and species, the aim being that of preserving valuable specific natural elements (Turner M. G. et al, 2001).

The environmental protection within the Danube Floodplain implies the maintenance of all natural processes in a state of balance that would allow the development of life in all its complexity. Its achievement requires the rational use of natural resources, the prevention and the fighting of environmental pollution and of the harmful effects of the natural phenomena of risk (***, *Geografia României*, 1983).

4. CONCLUSIONS

The natural capital of the Danube Floodplain holds a productive capability that must be known through its functional cells in order to avoid the degradation under the human impact and to favour the sustainable use of its support capacity. The guarantee of the sustainable social-economic development in the Danube Floodplain space is based on accurate knowledge concerning the ecological sustainability, the integrity of ecosystems, the support capacity of the environment, the regional and local ecologic balance of the ecosystems (***, *Redimensionarea ecologică şi economică pe sectorul românesc al Luncii Dunării*, 2008).

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The sustainable development requires a multidisciplinary approach, which underlines the need to protect the biodiversity and, at the same time, supports the economic development and the improvement of the human communities' living conditions, although the efforts made to preserve the natural capital sometimes seem in conflict with the human needs (Vădineanu A., 1998).

The man-induced changes, initially destined to increase the economic value of the region and to reduce the flood danger, proved to have negative impact. The old floodplain landscape remains visible in few natural units, but is starts to take shape once again in the conditions offered by the abandonment and by the protectionist measures that characterize the post-revolutionary period. The local restoration and functioning of the landscape that is characteristic to this unit must be related with a series of measures that concern the bettering of all environmental components, from the ecologic support and the biotic sub-system to the demographic component and the related activities, with a strong emphasis on the educational and awareness actions for the population (Licurici Mihaela, 2010a,b, Licurici Mihaela et al. 2011).

One of the key elements of sustainable development within the region on focus is raising the community awareness concerning the impact it has upon the environment and the value of the natural potential of the Danube Floodplain. It is necessary to bring methods and examples of good practices in order to prevent future biodiversity loss and damages at the level of the authentic landscape elements, in order to reduce the vulnerability to the risk phenomena that are specific to the southern Romania and in view of the sustainable development of the region (Bălteanu D. & Urdea I., 2003).

In the light of the hydro-meteorological dangerous phenomena that took place during the last decade, there can be stated that the results of such a research could be more easily integrated within the environmental politics and put into practice, because the affected communities are more likely to understand the impact of the dramatic landscape transformations (the intensification of soil degradation, the decrease of the resilience to risk phenomena etc.).

The agricultural practices at the level of the '70s are not an option any more and we consider that the revitalization of this sector of the Danube Floodplain can be also achieved through certain tourism forms that would meet the following requirements: nature protection and preservation, valorisation of the local human resources, educational character, respect for nature – raising the awareness of the tourists and of the local communities, minimum negative impact on the natural environment and on the social-cultural elements.

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