The surface dynamics of ecologically stabilizing land and its actual management problems (case of the Republic of Moldova)

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ABSTRACT: At present, Republic of Moldova is in a difficult process of strengthening ecological network and establishing the necessary functional relations between its main components. Most natural ecosystems, especially forests and natural meadows have been converted to agricultural land which possess a low ecological stability and are massively affected by erosion and landslides. Starting from these premises, this paper aims to research the spatial dynamics of ecological stabilizing land in relation to agricultural, industrial and residential land, with a smaller ecological stability and a greater impact on the natural ecosystems and biodiversity. The main analyzed subjects relates to dynamics and status of forests, pastures, perennial plantations, arable lands and of natural areas protected by state. There are elucidated the causes of reducing of ecological stabilizing land, during the past two centuries, socio-economic and environmental conditions in which respective processes have been manifested. It also proposed some recommendations for expanding and optimizing the various categories of ecologically stabilizing land.

KEY WORDS: forests, pastures and hayfields, perennial plantations, ecological stabilizing.

1. Introduction

Over the past two centuries, the territory between the Prut and Dniester is marked by a multiple and critical reduction in ecologically stabilizing land, especially pastures and hayfields (3.5 times), and river flood plains. However, in the last two decades, there is an increase in the area occupied by pastures and hayfields, which is due both to the promotion of recent public policies to expand stabilizing areas and the abandonment of much arable land by small farms or from reserve fund of LPA. Despite the extension of used areas, the productivity and environmental status of pastures and hayfields continue to worsen or improve very slowly. This situation is conditioned by superficial financial and institutional public support, as well as local population's massive neglect (overgrazing) towards the established land usage regime.

As a result of the Soviet industrialization policies of agriculture, the area and share of perennial plantations recorded a multiple increase during that period. There had also been particularly frequent cases of non-compliance with anti-erosion agro-technical requirements in vineyards and

orchards, which increased the intensity and event area of the erosion and landslides processes. In addition, extensive use of chemicals against agricultural pests has seriously affected the biological diversity of those agrocoenoses.

Table 1 Dynamics of the main categories of land use in Bessarabia and the Republic of Moldova.

Years	Total	Agricultural		Forests		Waters		Buildings and roads		Other land	
	thsd ha	thsd ha	%	thsd ha	%	thsd ha	%	thsd ha	%	thsd ha	%
1812	4511	2762	61	547	12,1	-	-	-	-	1202	26,7
1853	3600	3234	89	276	7,7	-	-	-	-	89	2,4
1900	3449	3118	90	211	6,1	-	-	-	-	121	3,5
1950	3297	2808	85	231	7,0	38,2	1,2	114	3,4	105	3,2
1980	3376	2626	78	382	11,3	65,9	2,0	202	5,9	97,4	2,9
2015	3385	2485	73	471	13,5	99,0	2,8	239	6,9	90	2,6

Sources: tables and figures in this paper are developed by the authors after the: 1) I. Bejan (2008). Land use in Moldova; 2) Land Cadastre of Moldova (1960-2015).

In the period 1812-1940, the forest areas in Bessarabia decreased over 2.5 times (from 500 thsd ha to 200 thsd ha) and later it is attested their steady growth, which allowed doubling the area occupied by forests than that of 1940's. At the same time, forest area expanding was due, mainly, to acacia plantations, which have a reduced ecological significance. Moreover, in the last 2 decades of state independence the forest and fruit tree strips were cleared out on the most agricultural fields. There are also frequent illegal deforestation of communal forests and green spaces, and the current non-transparent transmission process when leasing state forests and timber harvesting works out to private operators has a very serious impact on forest ecosystems.

Expanding land use categories with higher ecological stability is significantly limited by excessive fragmentation of agricultural individual land, by massive pauperization of the rural population and pronounced agrarian character of the rural space. Also, the low efficiency of the national ecological network is not conditioned only by the deficit of natural protected areas, but also by massive failure of the protection regime established for existing categories of natural areas. In a critical situation are protected natural areas and green spaces owned and managed by the local public authorities, especially the communal forests, forest protection belts of agricultural fields and of aquatic objects, the landscape reserves, parks from rural settlements etc.

2. Methodology

We meet the first bibliographical mentions on how to use land at the ancient scholars (Herodotus, "Histories", vol. IV), but they are episodic and superficial. In these works it is shown the distribution of forests and meadows representing the main land categories. This finding is also met in Dimitrie Cantemir's work "Descriptio Moldaviae" (Description of Moldova) [8, p. 14-18].

The first detailed and precise analysis of structure and dynamics of land fund and its usage categories were made in the second half of the XIXth century by the Russian soldiers who were sent to evaluate the economic potential of Bessarabia and component counties. In their reports we find valuable data about the area, dynamics and spatial distribution (by counties) of land usage categories (forests, meadows, perennial plantations). In this context, the Russian officer A. Zaşciuc stresses that at the beginning of the XIXth century Bugeac steppe was poorly used, but by mid-XIXth century this territory was almost entirely upturned and pastures gave way to agicultural land [19]. N. Moghileanskii mentions that in the last decades of the XIXth century, agricultural land had

already been heavily eroded and lakes and rivers had been silted [20, p. 134]. At the beginning of the XXth century precious works of native scholars Zamfir Arbore, Stefan Ciobanu and L. S. Berg appear. In the paper „Geographical dictionary of Bessarabia", Z. Arbore describes the distribution of certain categories of land - arable land, forests, meadows, vineyards, orchards by counties [1, p. 117-118]. In the „Statistical Dictionary of Bessarabia" [9] is offered a deep analysis of spatial dynamics of forests and arable land, are identified the problems of deforestation and soil erosion and their causes. The period of Russian colonization (1812-1918) is described the best in Stefan Ciobanu's work „Bessarabia". The author describes in detail each land category and enumerates a number of causes that had influenced their evolution [7, p. 317-341]. L. Berg analyses the land structure by counties, land occupied by roads and buildings, conversion of pastures and forests into arable land, distribution of perennial plantations according to climatic conditions and relief [17].

In the interwar period, the number of works approaching the issue of land usage was reducing, but the veracity of presented statistical data was increasing. There was also analysed the degree of population's assurance with main land categories. In the post-war period appeared valuable works where it was analyzed the structure and dynamics of land fund according to usage categories; there was delimited land for nature protection and health; there were identified the economic and environmental problems when utilizing various usage categories. A major study contribution to the dynamics, structure and problems of land usage categories including environmentally stable land has been brought by the works done by V. Proca [22], D. Nour and M. Voloşciuc [21]. A comprehensive analysis of the structure and dynamics of agricultural land in the period 1940-1998 was carried out by V. Sochircă [16]. Also, this author analyses the influence of the agrarian reform on land usage.

An important role in systematizing land usage studies has also been owned by the Romania's geographers - V. Nimigeanu [14] - the methodology of studying land use; I. Iordan [12] - methodology of land usage and regions of use; Al. Ungureanu- dynamics of geographical landscapes, I. Muntele [13] - the types of land usage, structure and spatial distribution of farmland.

The main methods used in this study elaboration are statistical, cartographic, comparative, historical, remote sensing, analysis and synthesis. Statistical methods was used in the collection, processing and mathematical analysis of data on dynamic land usage categories, even using special computer programs. Cartographic methods was used in map drawing regarding the spatial distribution of land usage categories in Bessarabia and the Republic of Moldova, as well as to identify spatial (regional) typology of land usage according to the dominant usage categories.

The comparative method has focused on comparing the shares of different land categories and their dynamics. The historical method was used to analyse the dynamics of land fund structure as a whole and as geographical and administrative units. Remote sensing method was used to process spatial data on land usage, on the basis of the universal system of land usage classification Corine Land Covery.

In this study, as ***main source of information*** was used the statistical material extracted from the Land Cadastre of the Republic of Moldova [6], including centralizing land cadastral sheet (the years 1962-2014) and the commune cadastral sheets (the years 2005 and 2014). The statistical data for prior periods (1812-1962) were taken from the bibliographic sources mentioned above where land usage categories and their dynamics were analysed. In some cases (delimitation of city real estate etc.) were used other sources - topographic maps from different periods, cadastral plans, satellite images etc. Studies were conducted for the territory of Bessarabia (1812-1940) which limits were

Moldova's ones in different periods (1940-2008), and include the territory on the left of the Dniester River.

3. Results and discussions

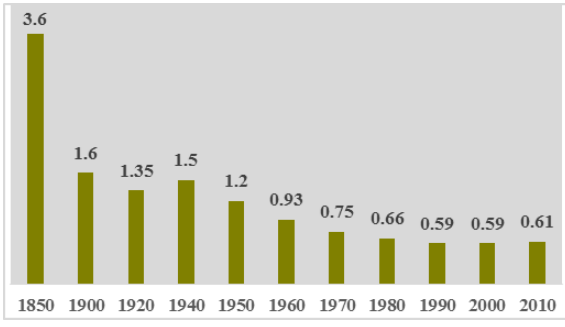
3.1. Providing degree with agriculture land, including ecologically stabilizing one

The geographical location and existing natural conditions led, since ancient times, to a predominantly agrarian character of land fund structure and the traditional crafts of indigenous people. At the same time, population density and degree of agricultural land usage was quite low and the providing degree with agricultural land was quite high if compared to other European countries due to the remoteness from the main European and Asian markets, the economic underdevelopment and frequent social cataclysms (nomadic invasions and wars) and the natural ones (drought, invasions of locusts, pests etc). Thus, at the time of annexation to the Russian Empire, there was an amount of more than 10 ha of agricultural land and more than 2 ha of arable land per capita. The maximum decrease is specific for the years 1812-1880 being conditioned by zootechny yielding its leading position to phytotechny (cereals); population increase (5 times); domestic and imperial demand; application of technological and commercial innovations. Later, until the 30s of the XXth century, there is a multiple reduction in these indicators (fig. 1, 2) and Bessarabia becomes a poor region in agricultural land despite its permanent agricultural character.

The decrease in the providing degree of arable and agricultural land in that period is due, mainly, to the multiple population increase (nearly 10 times) and insignificantly to the increase in the area and share of occupied land by other sectors of the economy. Moreover, during that period there has been a multiple and critical decrease of ecologically stabilizing land, particularly forests, pastures and hayfields (3.5 times), which previously significantly exceeded the arable land.

Table 2 Area dynamics of agricultural land on the territory of Bessarabia and the Republic of Moldova.

	1812	1850	1880	1900	1920	1940	1950	1960	1970	1980	1990	2000	2015
Total	4511	3600	4442	3449	4442	4442	3376	3376	3376	3376	3376	3385	3385
agricultural land	2762	3232	3889	3118	3489	3672	2843	2764	2694	2604	2566	2541	2485
%	61	90	88	90	79	83	84	82	80	77	76	75	73
arable land	516	1210	2378	2320	2887	3163	2124	1940	1911	1835	1739	1813	1830
%	11	34	54	67	65	71	63	57	57	54	52	54	54



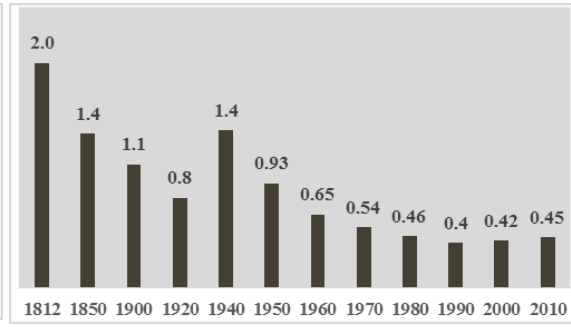


Figure 1 and 2 Dynamics of providing with agricultural land and arable one, ha per capita Sources: adapted according to: I. Bejan. Utilizarea terenurilor în Republica Moldova, Chișinău, 2008, p. 60-71; State Land Cadastre for the years 1990-2010.

Agrarian reforms in the 20-30s of the XXth century have considerably increased the area and share of agricultural land and in particular the arable one [7, p. 317-346], but this was achieved largely on the account of deforestation. The territorial annexation of the southern Bessarabia and its rapid

annual population growth (2-3%) in the immediate post-war period has conditioned a multiplication (about three times) of the level of providing arable and agricultural land. In addition, there decreased significantly the stabilizing agricultural land, such as pastures, hayfields and river flood plains. They were subjected to an intense process of draining and upturning, being transformed heavily in saline and poorly productive land and their previously rich biocoenosis were massively destroyed. Area and share reduction of the arable and agricultural land was conditioned, to a large extent, by removing degraded land aside the agricultural circuit and its conversion into forest plantations. Also, due to land improvement that had been made, a large part of the arable land on the slopes with medium and large inclination was transformed into vineyards and orchards.

The profound social and economic crisis of the 90s of the last century has conditioned a marked depopulation, especially of rural area, so that in the last 10-15 years it was attested an increase in the providing degree with agricultural land, particularly arable. Moreover, a more rapid increase in the providing degree with arable land was not conditioned only by the demographic decline, but also by the rapid decrease of land occupied with vineyards and orchards which has an ecological stability coefficient far higher than arable land and a commercial and industrial character more pronounced than the cereals do. Unlike the Soviet period, the land improvement works had a chaotic and fragmented character, and the private landowners were involved very little into such measures.

As a result of the economic underdevelopment and exclusive character of the local agricultural market, at the study beginning the ***perennial plantations*** had a very small share in the structure of land fund as well as agricultural land. Thus, in the early XIXth century, perennial plantations made up about 1% of the land fund area, of which about ¾ belong to orchard plantations. Increased imperial demand for Bessarabian fruit tree and wine products and transport development have contributed to the gradual increase of perennial plantations, so that at the end of the XIXth century the share of this land was ≈4%. This increase is solely due to vineyards, while orchard plantations show a decrease in cultivated land, most of which are concentrated in the Lower Dniester Valley and the suburbs of Chisinau and other large cities. Area decrease of orchards has been conditioned, mainly, by their transformation into arable land. The decrease of perennial plantations in the last decade of the XIXth century is due to phylloxera spread which has seriously affected the vineyards. In the first 4 decades of the XXth century, there is stated a fluctuated evolution, the share of perennial plantations ranging between 3-4%.

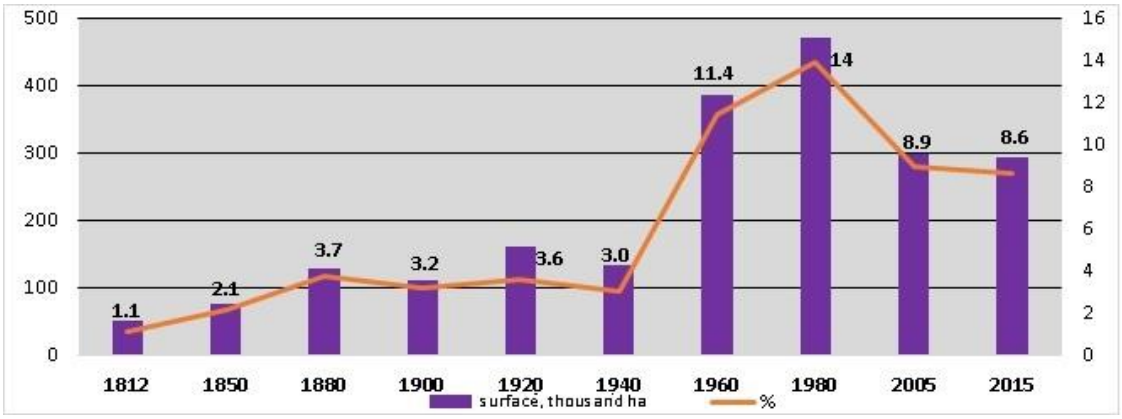


Figure 3 Dynamics of perennial plantations.

In the years 1940-1980, the area of perennial plantations increased about 5 times. Unlike previous periods, there was a much higher increase in orchards, particularly in the northern districts of the republic. Multiple increases in perennial plantations during the Soviet period was conditioned by the very high demand in orchard and vineyard products on the USSR market and the building of over 100 wineries and several dozens of processing fruit factories, especially in the central region. Meanwhile, non-compliance with anti-erosion agro-technical requirements in vineyards and orchards has increased the process intensity and manifestation area of erosion and landslides as well as extensive use of chemicals against agricultural pests has seriously affected the biological diversity of the agrocoenoses.

As a result of the promotion of reckless struggle with alcoholism, in the late 80s, there were destroyed over 20% (50 thsd ha) of vineyards, which conditioned the significant area reduction in perennial plantations. After 1990, the area decreasing trend in perennial plantations is kept on, especially due to the destruction of large collective farms, land fund fragmentation, abandonment of orchards and the high costs of their restoring, massive depopulation and impoverishment of rural areas, more and more arid climate etc. In addition, there are deforested a great part of mulberry and walnut tree plantations. Recently, due to preferential credits, there is a slow increase in walnut plantations, especially those of private agricultural beneficiaries. The actual Russian embargo on agricultural and agro-food products imported from Moldova has a significant negative impact on perennial plantations and manufacturers.

Until the mid-XIXth century, ***the natural pastures and hayfields*** were the main category of land usage. Subsequently, as a result of phytotechny development, rapid population growth, massive upturning and conversion of grassland into arable one, there is stated a multiple decrease (about 5 times) in the area and share of pastures and hayfields [3]. After World War II agricultural workforce resources diminished substantially as a result of massive casualties from war, hunger and Stalinist deportations. This conditioned the abandonment of much arable land and its transformation into fallow. Also, pasture area increase in the immediate post-war period was due to the degradation of arable land and its turning into pasture and forest plantations.

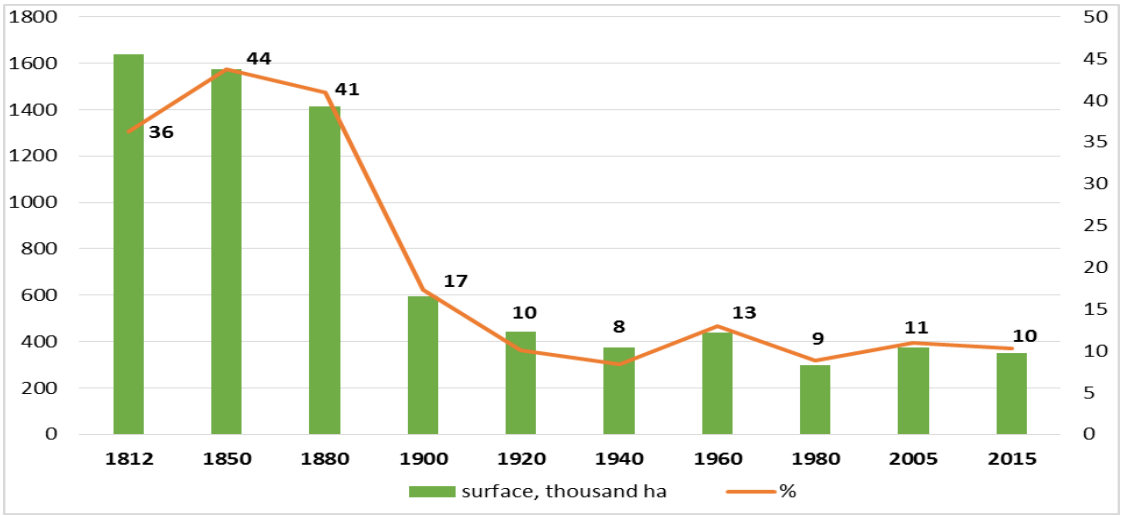


Figure 4 Dynamics of pastures and hayfields.

In the years 1960-1980, the area and share of grassland recorded a negative dynamics being conditioned by the afforestation of degraded pastures and hayfields, as well as the transformation

of grassland, especially that from river meadows into arable one. In the 1990s, there was a slow increase in the area of pastures and hayfields due both to the promotion of the extension policies of stabilizing areas on the account of arable land in the river meadows and slope land previously massively subjected to erosional and landslides processes, and to the abandonment of much arable land of small farms or from the reserve fund or the LPA. In the last decade (2005-2015) there is an oscillating dynamics of grassland occupied area, conditioned by similar dynamics of degraded pastures subjected to reforestation. Also, official statistics does not reflect appropriately the actual structure of the land fund, because the most abandoned and unworked arable land is not assigned to pastures and hayfields, but to arable land.

Despite the extension of used areas, productivity and environmental status of pastures and hayfields continues to worsen or improves very slowly. This situation is conditioned by superficial financial and institutional public support as well as massive local population neglect (overgrazing) towards the established land use regime. Also, there is not a system of evaluation and monitoring pastures and hayfields, especially those privately owned or leased, or expanded programs of grassland monitoring and restoration. Conditions and terms of pastures and hayfields exploitation are respected superficially. Among some other management shortcomings of pastures and hayfields we can mention: the formal involvement of land beneficiaries, very low land tax rates for pasture and hayfields beneficiaries (0.75 MDL for degree/ha or only 55 MDL/ha); superficial application of administrative sanctions for ecological damage. However, there have been initiated programs to rehabilitate the pastures in the National Park Orhei, riparian wetlands etc.

3.2. Forest area

The territory between the Prut and Dniester was marked permanently by a forest area deficiency, a fact which was conditioned both by physical and geographical specific conditions and administrative and territorial composition change and by increasing human pressure on forests.

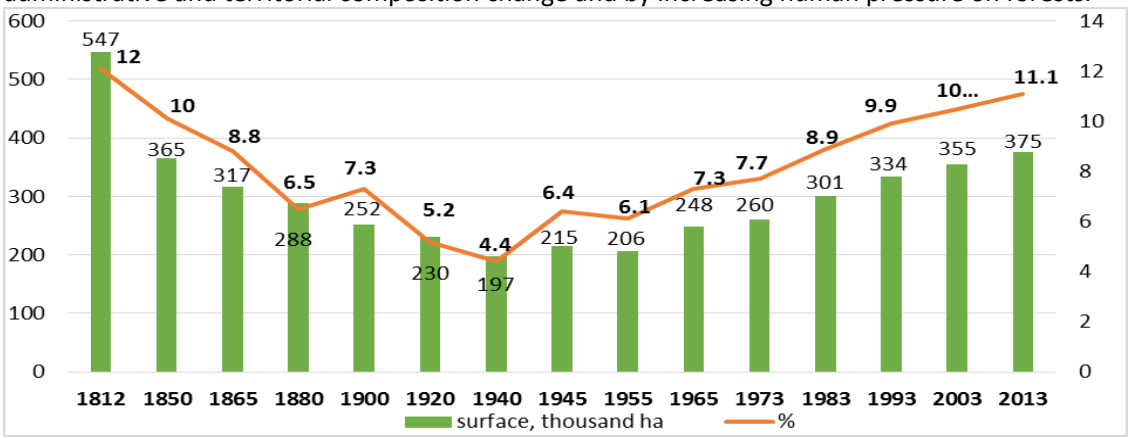


Figure 5 Area and share dynamics of forest fund. *(Sources: Bejan I. Utilizarea terenurilor în Republica Moldova. Chişinău: ASEM, 2010, p. 89 and the data of the Agency Moldsilva)*

Over the last two centuries, the forests and their share in the land fund structure record a fluctuated evolution (fig. 5). In the years 1812-1940, forest area has decreased by over 2.5 times. During the XIXth century, as a result of the expansion of agricultural land and intravilan [1, p. 88-95], there is a substantial decrease in forest area, with over 300 thsd hectares. Thus, by 1900, the forest fund was estimated at just 250 thsd ha or 7.3% of the territory.

In the first decades of last century, the decreasing process of forest area continued at a high rate being conditioned by the implementation of the agrarian reform initiated in the 1920s. The deforestration process contributed to the dismantling of forest bodies. This phenomenon has seriously affected the ecological state of forest landscapes. Meanwhile that period it was initiated the engineering planning of forest area and forestry logging connection with the needs of local population. Despite the initiating afforestation work, the total forest area continued to decrease, reaching in 1940 only 197 thsd ha or 4.4% of the territory.

As a result of territorial changes in the immediate post-war period, there is stated a sudden increase in wooded areas (18 thsd ha) followed in the 1950s by a slow decrease. In the 60s, a massive campaign launched the extension of the state forestry fund and the communal forests. The scientific criteria, social and environmental utility, comprehensive and efficient exploitation of forests have been put at the basis of the operation and management of forest area. Meanwhile, indigenous species of high economic and ecological importance (e.g. Oak) were massively replaced by scattered and fragmented acacia plantations with a small reliability and insignificant ecological importance.

The substantial reduction of forest area was accompanied simultaneously by significant population increase and human pressure on forest landscapes. At the same time, as a result of solving the local population's energy problems on the basis of alternative sources and the wood brought from other parts of the USSR as well as multiple decrease of livestock in the households, the anthropic pressure did not exceed the reproductive capacity of wood mass and accessory products and the ecological and recreational functions became a priority.

In the 1990s, there was stated a slowdown and a stopping in the growth rhythm of forest area followed by an intensification of its growth in the 2000s. At the same time, the anthropic pressure became alarming and the destructive effects were intensifying rapidly, especially in the area of communal forests, protection strips and green spaces, due to massive impoverishment of the rural population and deepening of problems of providing energy sources and pastures. The ability to fulfill eco-productive and ecological functions was considerably decreasing. Besides, the processes of climate aridization manifested actively, and the frequency and intensity of weather-related disasters increased considerably [5] .To improve the situation in this area, in the 2000s, there have been started a number of programs and strategies, among which the Program on the Restoration of Degraded Land [10], The Sustainable Development Strategy of Forest Fund [6], Strategy and Action Plan on Biodiversity Conservation [11]. According to these strategic documents, to provide adequate forest productive and ecological functions in the physical, geographical and ecological characteristics of the Republic, the area of forest land must exceed 15% (500 thsd ha) of the territory, which would mean an increase of more than 100 thsd ha of the actual area.

In the years 2010-2015 as a result of multiple reductions (about 5 times) in the budget allocations from the part of central forestry authority, there is a similar decrease in new wooded areas as well as an increase in deforestation. Besides this, semi-legal transmission of wood harvesting works from the State Forest Fund to private operators has generated a serious situation in many forest districts. More than that, the species with high ecological value such as oak, sessile, beech, alder, etc are extracted massively, even inside the perimeter of scientific reserves.

3.3. State Protected Natural Areas

A key role in the formation of the national ecological network, carrying out the eco-productive functions and biodiversity conservation is played out by the **state protected natural areas**. The

first natural areas taken under state protection since the early XXth century were the natural monuments with high scientific and historic value. In the years 1960-1980 the most protected natural areas, including geological and botanical natural monuments, landscape reserves, nature reserves and resource reserves, landscape architecture monuments, botanical and zoological gardens were identified and inventoried. In the early 90s the list of scientific reserves, natural monuments, especially hydrological ones is extended. It is also carried out an inventory of all objects and natural complexes protected by the state, and were subsequently included in Law no. 1538 on State Protected Natural Areas in 25.02. 1998. At the time the law was aproved the total area of State Protected Natural Areas Fund (SPNAF) was 66.4 thsd ha or 2% of the national territory. In the years 2000-2006, under SPNAF there were included three wetlands of international importance, including the Lower Prut Lakes, the Lower Dniester and Unguri-Holoşniţa with a total area of 95 thsd ha. As a result, SPNAF area has increased 1.4 times and reached 161 thsd ha or 4.8% of the national territory.

SPNAF's last significant increase occurred in July 2013 by founding the National Park Orhei with an area of 33.8 thsd ha. So far, actual surface of state-protected natural areas is 195 thsd ha or 6% of the national territory, including 1 national park (Orhei); 5 scientific reserves ("Codrii", "Plaiul Fagului" " Pădurea Domnească", " Iagorlâc " and " Prutul de Jos"), with a total area of 19.4 thsd ha or 10% of the SPNAF (fig. 6); 3 wetlands of international importance with an area of 95 thsd ha or 49% of SPNAF; 41 landscape reserves with an area of 34.2 thsd ha or 18%; 63 nature reserves, including 51 forest reserves, 9 medicinal plant reserves and 3 mixed ones with a total area of 8009 ha or 4%; about 500 natural monuments, including 86 geological and paleontological objects and complexes, 31 hydrological, botanical and mixed on a total area of 3 thsd ha; 13 resource reserves, with an area of 523 ha; 32 multifunctional management natural areas; 20 monuments landscape architecture (parks and alleys); 2 dendrological gardens and 1 zoo.

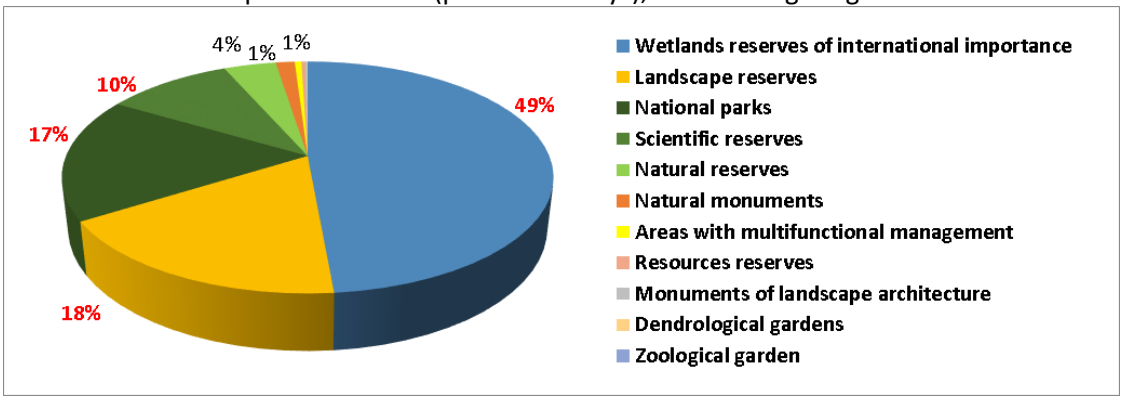


Figure 6 Area and share of the categories of natural protected areas *(Sources: elaborated by the author according to the annexes to the RM's Law on SPNAF)*

Despite the rapid expansion of SPNAF, if compared to most European countries, Moldova has a low percentage of protected natural areas (Fig. 7). In addition, most SPNAF categories and objects do not match the status and the established usage and protection regime, it having only a formal character. The connection between protected natural areas included in the national ecological network is not sufficiently provided. Most geological and paleontological monuments, landscape reserves and monuments managed by local authorities are in an advanced state of decay.

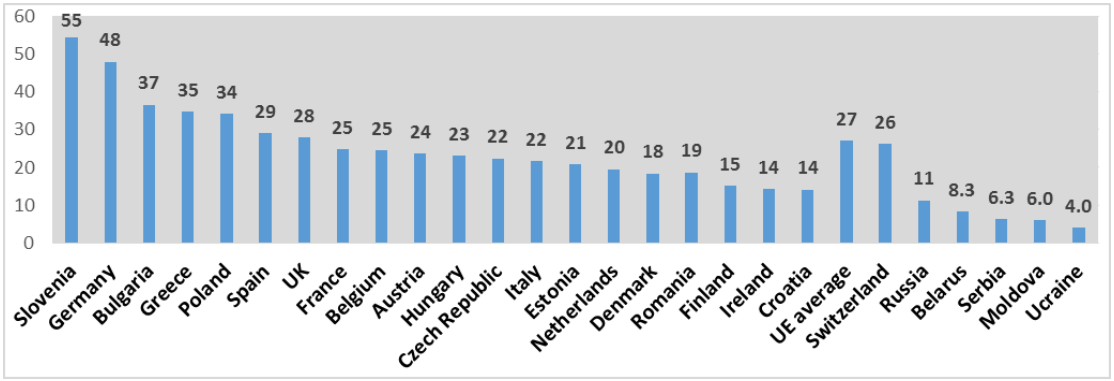


Figure 7 Share of protected natural areas of the total area of the European states *(Source: World Development Indicators, 2015. Environment. In: http://wdi.worldbank.org/table/3.4).*

Conclusions

1. Over the last 2 centuries, the territory between the Prut and Dniester is marked by a multiple and critical reduction in ecologically stabilizing land. The main causes of this alarming trend are: multiple increasing of population and demographic pressure; expansion of arable land and built-up one; massive industrialization of agriculture and non-compliance with agro-technical and environmental requirements;

2. During the XIXth century and the first decades of the XXth century it is noticed a very strong permanent decreasing tendency in ecologically stable area. The maximum reduction is observed in the years 1812-1850 being conditioned by the sharp reduction of forest area and in the period 1850-1920 it happened due to multiple area decrease of pastures and hayfields;

3. The Soviet period is marked by the expansion of agricultural land at the expense of grasslands, especially in river flood plains, as well as the significant expansion of forests and perennial plantations. Meanwhile, the majority of new forestry areas, particularly in the communal forests were constituted of acacia plantations of a low ecological productivity. The agro-technical and ecological requirements were respected superficially for vineyards and orchards, thus being heavily affected by great erosion and landslides;

4. The recent period (1992-2015) is marked by a slow increase in the area of ecologically stabilizing land, especially due to the expansion of the state forest fund, protected natural areas and grassland in the river meadows set aside the agricultural circuit as well as abandoned agricultural land. During that period it has been attested a massive destruction of ecologically stabilizing land under the management of APL and private land beneficiaries, particularly forest belts to protect agricultural fields, communal forests and green areas etc;

5. Despite the existence of the necessary legal framework, strategic documents for expansion and improvement of the ecologically stabilizing land, especially of river meadows, pastures and hayfields, and various categories of protected areas, their ecological condition does not improve and one of the main causes of this unfavourable situation is the lack of funds, especially from the tax receipts for the usage of natural resources, to perform public and private measures to restore these land.

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