INFLUENCE OF SURFACE AND SUBSURFACE DRAINAGE SYSTEMS ON THE SUSTAINABLE DEVELOPMENT OF THE RURAL ENVIRONMENT IN THE MOLDOVA RIVER WATERSHED

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Abstract

Agriculture plays a strategic role worldwide, as it is the main sector responsible for population food security and has, at the same time, a special contribution to the general sustainable economic development and environmental protection process. In order to regulate the water regime on the surface and on the profile of the soils in the hydrographic basin of the River Moldova, four surface and subsurface drainage systems with an area of 8761 ha of which 3059 ha with works underground drainage were arranged from 1978 to 1980. The improvement of the physical, physicochemical and biological properties of the soil as a result of the hydro and agropedoameliorative works allowed the cultivation of large areas of land previously used as grazing and hay land, as well as the cultivation of a wide range of agricultural plants. The drying-drainage works performed have resulted in high yields in both normal and heavy rainfall years. The constant high yields have resulted in higher income per area unit and, implicitly, in the improvement of the standard of living of the rural population. The 40-year life of the surface and subsurface drainage systems, and the poor management and lack of maintenance works, especially after 1990, require rehabilitation and sustainable exploitation measures, given the major importance of agriculture in the life and development of rural areas.

Key words: sustainable exploitation, drying-drainage, soil productivity

The agricultural landscape has been continuously shaped and reshaped since the early Holocene. Throughout human history, societies have left traces of agricultural activities in the entire world. Moreover, studies have shown that the collapse of many civilizations was linked to accelerated soil degradation caused by agricultural practices (Denevan W. M., 2001; McNeill J.R. and Winiwarter V., 2010; Montgomery D.R., 2012).

The management of soil systems influences soil productivity and food security. Adeel Z. et al., 2005, define land degradation as a persistent deterioration of its productivity, in which soil plays a major role. Land degradation is caused by several factors, both biophysical (climate, topography, hydrology and soil characteristics) and human (land use and management, policies and governance, migration, poverty and exploitation of natural resources). Land degradation processes have been noticed worldwide (Torres L. et al., 2015, Xie L. W. et al., 2015, Obalum S. E. et al., 2012; Reed M. S. and Stringer L. C., 2016).

The fate of contemporary civilization depends on the soil as a source of resources, goods and services (Keesstra S. D. et al., 2012).

For a better use of soil resources, drying-drainage works were carried out in many parts of the globe with land affected by excess humidity. Agricultural drainage protects the basic resources that contribute to food production, supports and contributes to increasing agricultural output and better rural products, protects investments in the irrigation sector and increases the value of land. However, the main goal of agricultural drainage is to create in the roots area an environment that supports plant development and optimizes agricultural production. Drainage should be seen as an indispensable part of sustainable land management, although further research is still needed in this direction (Halbac R., 2014).

MATERIAL AND METHOD

The Moldova river basin is located in the NE part of the Eastern Carpathians and in the NW of the Plateau of Moldova (*figure 1*). The basin is bounded by $25^0$08'37″ - $26^0$58'35″ meridians east longitude and $46^0$55'37″ - $47^0$43'38″ parallels north latitude.

Many geographers (Coteţ P., 1973, Posea G., 1974) include this area in the Subcarpathia region, as an external hilly piedmont plateau unit.

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Figure 1 **Localization of the Moldova river basin in Romania**

The natural conditions of the Baia piedmont plain favor the occurrence and maintenance of excessive humidity both on the surface and underground. The flood plain of Moldova River and the strip-shaped 1.5 km wide terraces, which are almost parallel to the Moldova riverbed, running from NW to SE, with mild 1-5% slopes, with flat areas and many small depressions, allow the water to stagnate.

The wet climate specific to the Moldova River watershed area, the heavy rainfalls of 1-5 consecutive days and the low evaporation and perspiration rates are the main cause of excessive humidity in hardly permeable soils (Nitu T. et al., 1985).

Four surface and subsurface drainage systems (Rotopăneşti-Rădăşeni-Fântâna Mare, Drăgoieşti-Berchişeşti, Bogdăneşti-Baia, and Băişeşti-Dumbrava), consisting of 8761 ha of dried-drained land, of which 3059 ha with underground drainage works, were developed between 1978 and 1980 in order to remove excessive water from the Moldova River valley and terraces in Suceava county (*figure 2*).

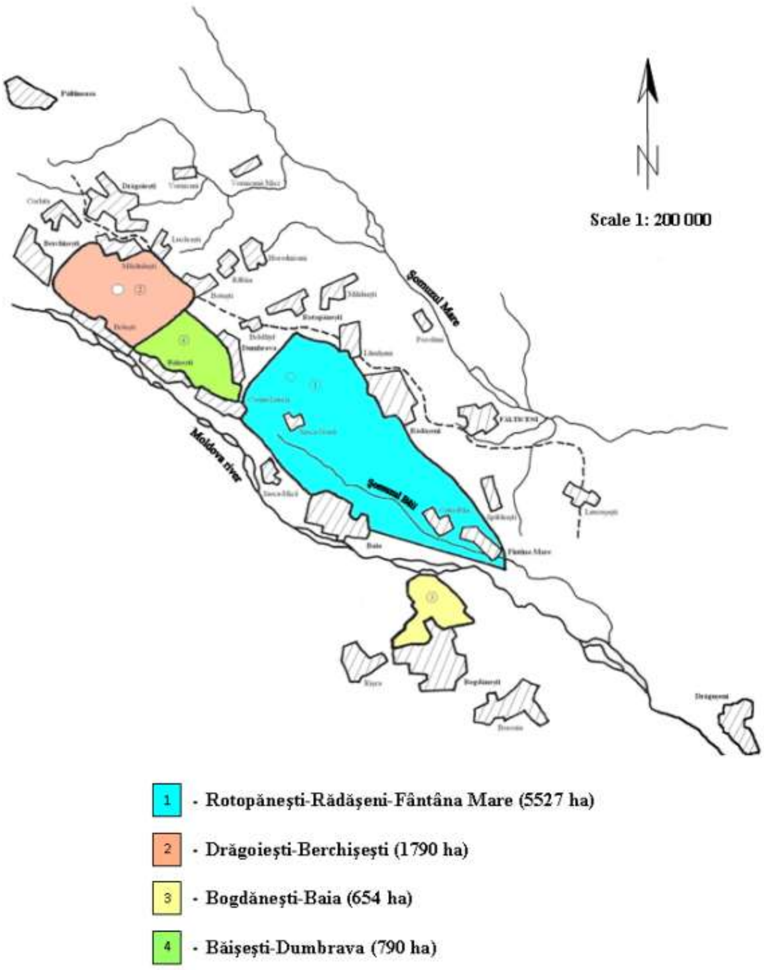

Figure 1 **Surface and subsurface drainage systems of the Moldova River flood plain in the County of Suceava**

In order to highlight the influence of the surface and subsurface drying-drainage works carried out in the Moldova River watershed, Suceava County, we conducted field observations, read the ANIF Territorial Branch for Land Improvements Suceava archives and collected data from the local halls of the administrative-territorial units in the area, as well as from the Statistical Yearbook of Romania.

RESULTS AND DISCUSSIONS

The drying-drainage works have contributed to the overall improvement of the agrophysical condition and to the optimization of the aerohydric regime of the soil. In the conditions of the underground drainage associated with the modeling of the terrain in ridges, the about 43-56% of the stagnant water from precipitations fallen throughout 1-5 consecutive days was removed due to underground drainage works and land shaping in the bedding with ridges and furrows (Moca V. et al., 1996).

The improvement of the physical, physico-chemical and biological properties of the soil determined the increase of the arable area by 1846 ha, in general, at the expense of pastures and meadows, whereas the agricultural area decreased by approximately 108 ha due to drainage ditches and operating roads (*table 1*). Prior to development, pasture and meadow land was frequently affected by excessive water from the melting of snow and/or rainfall. Also, due to the stagnation of water for a long time, the pastures and meadows had a poor-quality flower composition, as hygrophilous plants predominated. After its development, this land was replanted with valuable fodder plant species and the percentage of hygrophilous plants was considerably lower.

Table 1

Evolution of the Destination Classes of the Drying-Draining Systems in the Moldova River Basin (according to the A.N.I.F. – Suceava Branch documentation)

Category of use	Surface (ha)				Differences
	Before fitting		After fitting - 1990		
	ha	%	ha	%	ha
Arable	5610.97	64.04	7456.97	85.11	1846.00
Pastures	1168.51	13.34	427.48	4.88	-741.03
Rough	1344.09	15.34	131.42	1.50	-1212.67
Orchards	7.86	0.09	7.86	0.09	0
Total agricultural	**8131.43**	**92.81**	**8023.73**	**91.58**	**-107.70**
Forestry	255.15	2.91	216.83	2.47	-38.32
Waters	28.92	0.33	20.30	0.23	-8.62
Channels	10.59	0.12	140.03	1.60	129.44
Exploitation roads	88.99	1.02	125.40	1.43	36.41
Court-construction	230.91	2.63	234.15	2.68	3.24
Non-productive	15.45	0.18	1.00	0.01	-14.45
Total non-agricultural	**630.01**	**7.19**	**737.71**	**8.42**	**107.70**
Total area	**8761.44**	**100.00**	**8761.44**	**100.00**	-

Prior to its development, due to the excess water, the arable land had a very low productivity, the average yields in rainy years being reduced by about 25-50% compared to those obtained in normal precipitations years (*table 2*).

The development of systematic underground drainage systems together with the conduct of agricultural land improvement works have enhanced soil fertility, both by increasing the pH values and by increasing the content of nutrients (Moca V. et al., 1998).

The decrease of the agricultural area by 108 ha (*table 1*) was compensated by the increase of higher use categories of land and by constant high yields per hectare, due to the provision of adequate agricultural plant growth and development conditions.

Table 2

Mean Yields in Agricultural Crops before and after Development
(according to the A.N.I.F. – Suceava Branch documentation)

No.	Culture	Average production (kg/ha)		
		Before fitting		After fitting
		Years normal	Years with excess	
1.	Wheat-rye	1440	640	2000
2.	Barley	1400	570	2200
3.	Corn	2250	1000	2300
4.	Potatoes	11000	6000	20000
5.	In the throat	3750	2250	4000
6.	Clover	3500	2000	4000
7.	Fodder plants	5000	3500	5500

Between 1980 and 1990, the improvement of soil characteristics as a result of the drying-draining works and of the use of modern agricultural technology has brought about a substantial increase in agricultural production and higher quality produce. Thus, according to the data recorded in the accounting books, yields of about 7-8 t/ha of maize grain, 30-40 t/ha of potato, 5-6 t/ha of fiber flax, 4-5 t/ha of wheat, 50-60 t/ha of fodder kohlrabi and 90-100 t/ha of fodder beet were obtained.

The increase in yield per hectare on dried-drained land is also reflected by the yields obtained under experimental conditions on a glossic albic pseudogley luvisol in the Baia Field. The yields obtained within the experimental field have frequently reached 5-7 t/ha in grain maize, 35-45 t/ha in autumn potatoes, 7-8 t/ha in fiber flax and 4-5 t/ha in wheat (Nitu T. et al., 1985).

Agricultural policies and land laws adopted after 1990 have had a major impact on sustainable land management, in particular on the management of improved land. The small arable surface per capita in the studied area has led to the fragmentation of the land into strip-like plots. For a long time (1990-2015), land works were carried out on individual plots, which resulted in the occurrence of furrows in the border line area and a ridge in the middle of the plot. Thus, rainfall water would stagnate for a long time with negative effects on the plants in the furrow area. Year in, year out, these furrows have led to significant harvest losses caused on the one hand by the delays in the sowing and harvesting works, and on the other hand by the use of inadequate agricultural machinery and equipment. Land use on individual plots, the lack of adequate agricultural machinery, the absence of new varieties and hybrids, the application of an irrational crop rotation and, sometimes, the preference for single-crop farming have led to the turning of many arable plots into hay land.

Some land areas, which underwent drying-drainage works, have been ploughed together, on drying sectors, since 2016. Land reparcelling, the use of modern agricultural equipment, and of the newest varieties and hybrids, and the use of agricultural technologies specific to improved land have led to constant high yields (*table 3*).

From the analysis of table 3 we can observe large differences of production obtained in the cultivation of potato, maize and wheat on the plots individually worked and the surfaces worked together. Also, by comparing the productions obtained in the studied area with those obtained at Suceava county level and at national level, it is ascertained the high productivity of soils in this area.

According to the data in table 3, there are significant yield differences between potato, maize and wheat crops on individual plots as compared to larger land areas. Also, comparisons between yields in the studied area and yields in both Suceava country and the entire country have enabled us to notice the high soil productivity in this area.

The regulation of the aerohydric regime in the soil, and also the climate changes allowed the diversification of the structure of the agricultural crops by introducing new crops, such as: sunflower, rapeseed, buckwheat, beans and even medicinal plants, on small surfaces.

Soil productivity influences the standard of living of the rural population, as, for most of these inhabitants, agriculture is the only occupation that generates income and, hence, welfare.

Table 3

Mean Yields for the Main Agricultural Crops in 2016
(according to local data and Statistical Yearbook)

No.	Culture	Average production (kg/ha)			
		Study area		Suceava county	Nationally
		individual plots	fused area		
1.	Wheat-rye	2800	5200	4000	3900
2.	Corn	4000	8500	5400	4600
3.	Sunflower	1200	2900	2400	2000
4.	Potatoes	14000	24500	18800	14500
5.	Clover (green table)	12000	18000	13000	14000

Despite the high agricultural potential of the studied area, the poor organization of this sector due to the fact that there are no large farms, but rather small individual plots, prevents the use of new technologies, which makes rural development dependent on the weather conditions. If it is properly exploited, the existing agricultural potential allows a more efficient employment of the work force, thus contributing to making real progress in reducing rural poverty and income disparities between the rural and urban population. However, the competitiveness of agri-food products must be associated with the sustainability of their production.

The use of improved land requires adequate agricultural policies designed to facilitate agricultural production, sustainable livelihoods and sustainable land management.

Rural development issues are diverse and they are addressed by different governmental structures, which due, on the one hand, to the lack of precisely formulated and coherent rural environment objectives and, on the other hand, to poor communication, fail to have the expected outcomes.

After 40 years of operation, over 50% of the drying-draining works carried out in the Moldova River basin require some rehabilitation works. The trend is to rehabilitate, modernize and sustainably use existing systems rather than to implement new systems. Efficient drainage water management can help both avoid water stagnation and minimize soil degradation.

CONCLUSIONS

Due to the drying -drainage works carried out in the Moldova River watershed, the arable area increased by about 1850 ha, increasing its share on the total improved land area from 64% to 85%. The increase of the arable area was made possible by the cultivation of land with lower uses, especially hay land, the percentage of which decreased from 15% to 1.5%, whereas the pastures dropped from 13% to 5%.

The improvement of the physical, physico-chemical and biological properties of the soil, as a result of the application of hydro and agropedoameliorative works, allowed the cultivation of a varied assortment of agricultural plants and the obtaining of high constant yields.

Due to the fragmentation of improved dried-drained land in numerous plots of different sizes and orientations, drainage is reduced and water collection and evacuation is diminished in the drained section, which particularly affects the plants growing near the furrows formed between the plots.

The need to ensure the maintenance of a high productive potential of the soil requires, as a matter of urgency, the implementation of local measures consisting of informing and educating people in order to raise awareness on the role of drying-drainage works, of stimulating the use of dried land plots by exempting the users of charges and taxes, and, last but not least, of the organization of a rational grazing practices.

The process of land reparcelling in the area seems to be long lasting and not at all simple, due to a number of reasons: the high number of the strip-like plots, unclear property relationships, aged owners more reluctant to the association and roads offering poor access to the agricultural land.

The 40-year life of the surface and subsurface drainage systems, and the poor management and lack of maintenance works, especially after 1990, require rehabilitation works. The global trend is to rehabilitate, modernize and sustainably use existing systems and not to implement new surface and subsurface drainage systems. Efficient drainage water management can help both avoid water stagnation and minimize soil degradation.

REFERENCES

Adeel Z., Safriel U., Niemeijer D., White R., 2005 - *Ecosystems and human well-being: desertification synthesis*. Washington, D.C.: World Resource Institute.

Coteţ P., 1973 - *Piemonturile de acumulări şi importanţa lor. Probleme de geografie*, vol. II. Editura Academiei Bucureşti.

Denevan W. M., 2001 - *Cultivated landscapes of native Amazonia and the Andes*. Oxford University Press, New York. Google Scholar

Halbac R., 2014 - *A view on land degradation and desertification issue*. 42nd International Symposium on Agricultural Engineering, 25-28 February, Opatija, Croatia, ISSN 1848-4425, pp 25-34, WOS: 000340762800002.

Keesstra S. D., Geissen V., Mosse K., 2012 - *Soil as a filter for groundwater quality*. Current Opinion in Environmental Sustainability 4 (5), 507– 16. Web of Science®Google Scholar

McNeill J.R., Winiwarter V., 2010 - *Soils and societies: perspectives from environmental history*. White Horse Press, Isle of Harris. Google Scholar

Moca V., Filipov F., Călin M., Radu O., 1998 - *Efectul drenajului subteran şi al modelării repetate asupra unor însuşiri ale luvisolului albic pseudogleic din Depresiunea Baia-Moldova*. Simpozionul Ştiinţific Internaţional al Facultăţii de Agricultură Iaşi, vol. 41, p. 121-130, seria Agronomie, U.Ş.A.M.V., Iaşi, ISSN 1454-7414.

Moca V., Radu O., Filipov F., Călin M., 1996 - *Comportarea în exploatare a solurilor cu exces de umiditatedrenate şi modelate în benzi cu coame, din depresiunea Baia-Moldova*. Lucrări Ştiinţifice, seria Agronomie, vol. 39, p. 42-48, Universitatea Agronomică Iaşi, ISSN 0379-8364.

Montgomery D.R., 2007 - *Soil erosion and agricultural sustainability*. Proceedings of the National Academy of Sciences of the Untied States of America 104, 13268 – 72. Google Scholar

Nitu T.I., 1977 - *Desecarea şi drenarea solurilor cu exces de umiditate, mijloc de creştere a producţiei agricole*. D.G.A.I.A. Suceava.

Obalum S. E., Buri M. M., Nwite J. C., Hermansah W. Y., Igwe C. A., Wakatsuki T., 2012 - *Soil degradation-induced decline in productivity of sub-Saharan African soils: the prospects of looking downwards the lowlands wit the Sawah Ecotechnology*. Applied and Environmental Soil Science Article ID 673926. DOI:10.1155/2012/673926.

Posea Gr., 1964 - *Harta geomorfologică generală.* Analele Universităţii Bucureşti, nr. 1.

Radu O., Cîmpeanu S.M., Teodorescu R.I., Bucur D., 2017 - *Technical Efficiency of the Subsurface Drainage on Agricultural Lands in the Moldova River Meadow*, In: Current Perspective on Irrigation and Drainage, Kulshreshtha S. and Elshorbagy A. ed., ISBN 978-953-51-2951-6, 69-81 pp. - DOI: 10.5772/67258, WOS:

Reed M. S., Stringer L. C., 2016 - *Land degradation, desertification and climate change: anticipating, assessing and adapting to future change*. Oxon: Routledge, UK; 184.

Torres L., Abraham E.M., Rubio C., Barbero-Sierra C., Ruiz-Perez M., 2015 - *Desertification research in Argentina*. Land Degradation & Development 26 (5): 433–440. DOI:10.1002/ldr.2392.

Xie L. W., Zhong J., Chen F. F., Cao F. X., Li J. J., Wu L. C., 2015 - *Evaluation of soil fertility in the succession of karst rocky desertification using principal component analysis*. Solid Earth 6(2): 515–524. DOI:10.5194/se-6-515-2015.

*****, 1971-1978** - Proiecte de execuţie a amenajărilor de desecare-drenaj din lunca râului Moldova, judeţul Suceava.