LAND USE RECONVERSION IN THE DROUGHT – AND ARIDITY –AFFECTED AREAS IN SW ROMANIA (BECHET, DOLJ COUNTY)

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Abstract

In the terms of current climate change, reconversion of land use in the drought-and aridity-affected south-western Romania, is an issue of utmost priority. Thus, the present study aim represents a diachronic analysis of the land use within the Bechet town area and proposes viable solutions for soil drought and aridity mitigation. Since 1989, uncontrolled and abusive logging affected the black locust forest areas, enabling the sand dunes expansion and causing ecological disturbance. The main research methods were: field observation, statistical-mathematical methods and GIS mapping. The analysis of topographic maps and orthophotographs in 1970 to 2008 revealed a very low spatial distribution of both the forest shelterbelts and shelterwoods. We proposed a reconstruction of these forest areas, which today can no longer perform their fundamental function of land protection, because of intensive degradation. The positive consequences on long term would be the mitigation of climate change impact and prevention of further land degradation.

Key-words: land use, dune, aridity, land degradation, shelterbelt, restoration.

Introduction

Romania is one of the countries having a number of regions prone to edaphic drought and aridity (south and south-east of the Wallachian Plain, south of Moldavian Plateau and Dobrudja). These phenomena were caused by the summer droughts triggered both by some climatic disturbances, and the decrease of forested areas and forest belts in the lowlands (Costăchescu *et al*., 2010; Achim *et al*., 2012; Vijulie *et al*., 2013).

In the context of climate change, land use conversion in the southern regions of Romania, affected by drought and aridity, is a priority.

Thus, the present study concerned on a diachronic analysis of the land use in Bechet town and proposed a set of solutions for combating edaphic drought and aridity, by planting new forest shelterbelts and restorating the old ones on the croplands.

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The objectives of the study were the following: i). to perform a diachronic analysis of the land use within the study area, by using GIS techniques; ii). to assess the aridity degree, and the favourability of climatic potential of the study area for the optimum growing of forest species and crops, by calculating a set of climatic indices; iii). to propose viable solutions for mitigating the effects of drought and aridity, by restorating the old network of forest shelterbelts and planting new ones.

The physical landscape. Bechet town is located in the Oltenia Plain (the Romanaţi sub-unit), on the alluvial terraces and floodplains of the Danube and Jiu rivers (Fig. 1).

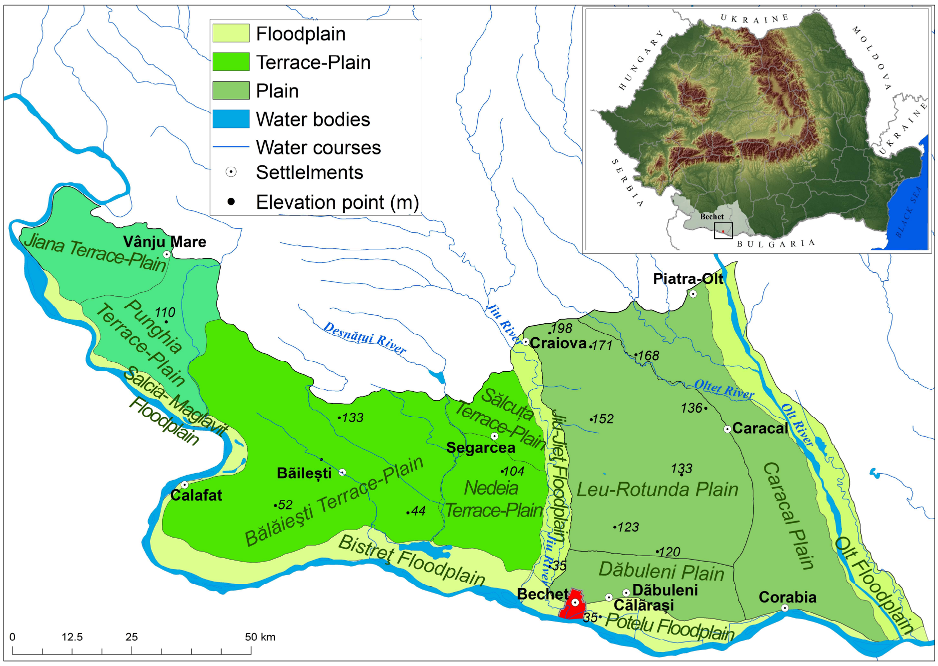

Figure 1. Geographic position of the Bechet town in Romania

In Bechet, a considerable area is covered by mobile aeolian dunes (Coteț, 1957; Prăvălie, 2013). It is part of the so-called ”Oltenia Desert” or the ”Sand Triangle”, enclosed by the urban localities Craiova, Bechet, and Corabia (Fig. 2). Thus, the wind-blown particles have continuously been moving eastwards under the control of the westerly’s and south-western winds (*e.g.* ”Austrul”), and deposited, forming longitudinal dunes on a west-east direction. These sandy dunes have about 3-4 km in length and 600-800 m in width; they cover the loess and loess-like deposits on the Danube terraces, the left-sided terraces of the Jiu

River and a considerable area of the Leu-Rotunda Plain, located northwards from the study area (Popescu & Bugă, 2005).

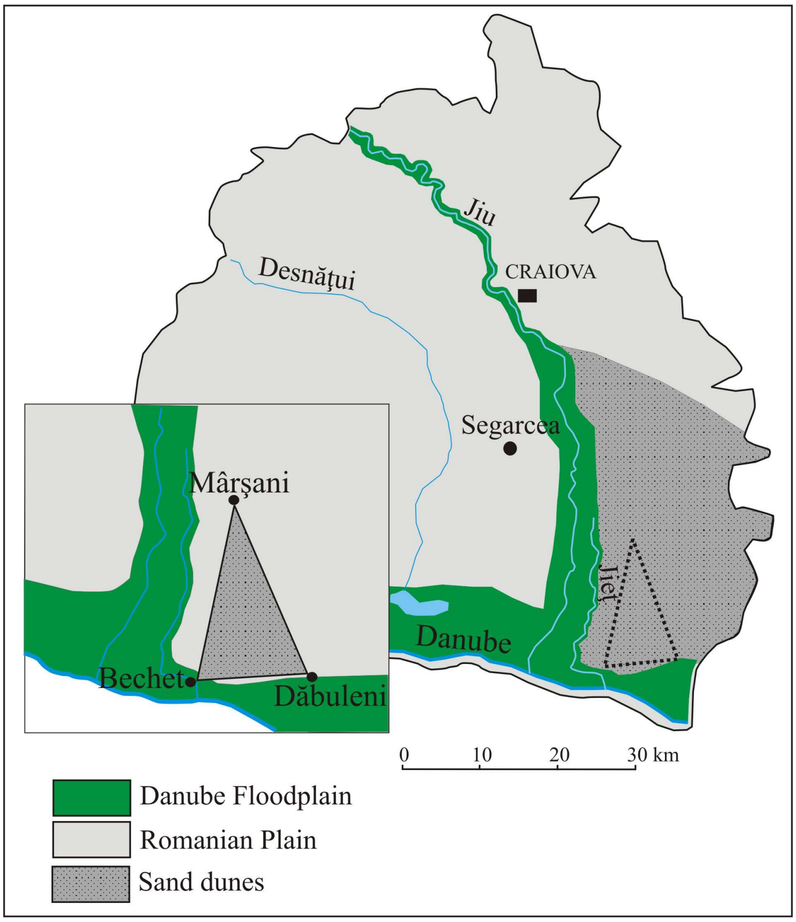

Figure 2. The "Oltenia Desert"

The altitude between the dunes and the inter-dunar areas varies between 5-6 m and 8-10 m. The widely open landform, exposed to permanent winds and strong insulation during summer, is becoming a semi-arid landscape.

The climate is moderate-continental, with the highest mean annual temperature in Romania (11.5°C) and mean annual precipitation of 500 mm/year. The periodic winds are very important as they sweep the uncohesive sands. The ”Austrul” blows during spring and summer on a WNW-SSE direction, sweeping strongly the sand and shaping the dunes on the W-E direction.

The ”Crivăț” acts only during winter from NE and E, with a minor role in sweeping the sands in the area.

During the summer, the sand gets very hot and reaches over 60-70°C at the surface. Although the precipitation amount is not typical for a dry climate, the sandy landscape sometimes have a desert-like form, because of these very high termperatures and the action of ”Austrul”, a hot and dry wind (Năstase & Boaghe, 2011).

The drainage network in the study area is extremely poor, represented only by the Danube to the south and Jieț to the south-west. The Jieț is a former course of the Jiu river, which shapes large meanders through its floodplain before flowing into the Danube. A number of ponds have occurred in the Danube floodplain: Arădan, Luminoasa, Aradănuş, Balta Mare, Balta lui Pică, etc.

The associations are typical to the silvosteppe biome and floodplain ecosystems (Pătroescu, 2005). Natural vegetation of the sandy lands has been replaced by crops or plantations of Black locust *(Robinia pseudoacacia)*. The dominant soils are the chernozems, alluvial soils and sandy soils (Geanana, 2005).

The physical patterns of the area reflect a natural vulnerability to aridization caused by several factors: the presence of sandy soils, which cannot retain the precipitation water; the geographical setting towards the Carpathian arch, involving the influence of hot winds (the ”Austrul”), which in turn inhibit precipitation; extensive deforestation and removal of the former forest shelterbelts; drainage works performed during the Communism, and global warming.

Methodology

The main research methods applied were: direct field survey; diachronic analysis using GIS techniques; numerical analysis methods for calculating the climatic water deficit, in order to assess the aridity degree and the favorability of climatic potential for the growing of forest species and types of crops in the study area.

The field survey consisted in successive campaigns during November 2015 to August 2016, when the following components were visually assessed: degraded croplands, the sand dunes continuously moving eastwards, and the massive fragmentation (to total removal) of the forest shelterbelts planted in 1970-1980.

The land vulnerability to climatic water deficiency was assessed by the following numerical analysis methods:

- *The hydric compensation index* ($I_{ch} = \Sigma\Delta P+ / \Sigma\Delta P–$, where $\Delta P = P – ETP$) emphasized the degree by which the soil humidity deficit could be compensated by precipitation (Pătroescu, 1987; Dumitraşcu *et al*., 2004; Manea, 2009; Achim *et al*., 2012).The calculation of this index required another two indices: *the sum of precipitation in the months with moisture accumulation within the* *biologically active soil layer* (ΣP_{XI-III}), and *the sum of precipitation in the months with maximum evapotranspiration* ($\Sigma P_{VII-VIII}$).

- *The De Martonne aridity index* was calculated by the formula: $Ia_{DM} = P/T+10$, where P = mean annual precipitation and T = mean annual temperature.

It justifies the presence on a territory of the associations with specific hydric requirements: $Ia_{DM} < 20$ emphasizes an area with high water deficit; $Ia_{DM} = 20\text{-}25$ reveal an area with medium water deficit (Ozenda,1994; Iojă, 2006; Păltineanu *et al*., 2007; Costăchescu *et al*., 2010; Achim *et al*., 2012; Vijulie *et al*., 2013; Mavrakisa & Papavasileiou, 2013; Prăvălie *et al*., 2014). These indices are very useful for the selection of those forest species and crops which are suitable for growing on the study area. They were calculated based on the meteorological data provided by the weather stations located around our study area: Calafat and Caracal (Table 1).

Table 1

Mean annual temperature and precipitation (1961-2007)

Weather station	**Climatic parameter**	**Month**												
		I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Total**
Caracal														
	T	– 1.8	0.4	5.4	11.6	17.3	21	23	22.2	17.7	11.5	5.2	0	11.1
	P	34.4	33	38.3	46.6	58.9	68.1	62.8	52.2	38.9	36.3	45	41.7	555.1
	ETP	0	0	16.9	51.7	95.8	129.4	142.9	126.2	84	42	13.1	0	–
Calafat														
	T	– 0.7	1.3	6.1	12.2	17.7	21.3	23.3	22.6	18	11.9	5.7	0.8	11.7
	P	33.5	34	37.4	48.9	58.3	56.3	49.7	39.3	39.9	39.1	47.4	45.1	529
	ETP	0	2.1	19	53.7	96.8	129.8	143.6	127.8	84.6	43	14.2	0	–

Data source: Caracal and Calafat weather stations. ETP (evapotranspiration) was calculated using the *Thornthwaite* online application (Ponce, 2015).

Results and discussion

The analysis of land use map for the 1970-2008 period has shown that significant changes had occurred in the land structure of Bechet town (Table 2). Thus, the arable land extended from 1555.01 hectares in 1970 to 1727.23 ha in 2008, given that a considerable area of the vineyards and orchards had been turned into arable. Likewise, the degraded lands have expanded after 1990, because of the areal decrease of forests, shelterbelts, pasturelands, etc.

Spatial-temporal dynamics of the forest shelterbelts

In 1947 to 1960, acacia *(Robinia pseudoacacia)* forests and shelterbelts were extensively planted in Bechet, but in 1962 the authorities proceeded to deforestations in order to increase agricultural areas. They were removed at the end of the 60s (1969-1970) for the arrangement of the Sadova-Corabia irrigation system, despite their protective role in stabilizing the mobile sand dunes. Therefore, deforestation has triggered the deflation phenomenon. Afterwards, during the 70s and 80s, the plantations were restored (*e.g.* the Sadova-Bechet protective shelterbelts system), but only on the mobile sands, in order to protect the soil and crops (Fig. 3, 5).

Table 2

Land use change data (1970-2008)

Land use/Year	1970	1990	2008
Arable land	1555.01	1740.83	1727.23
Degraded land	0.00	3.94	297.42
Built-up areas	385.40	386.37	368.65
Water bodies	208.58	248.13	214.36
Forest	182.90	193.09	169.99
Deforested areas	0.00	34.30	27.90
Vineyards	326.87	206.51	56.02
Orchards	8.73	35.12	0.00
Pasturelands	139.63	0.00	0.00
Wetlands	111.23	70.06	56.54
Total area	2918.35	2918.35	2918.10

Source: The attributes table of shape file layers in *Figures 3* and *4*.

After 1989, once the croplands were restituted, most shelterbelts were destroyed by illegal logging (Fig. 4, 5, 6). Currently, the main measures to limit the aridity phenomenon consist in reintroduction of protective forest systems. The law 289/2005 on the restoration of national shelterbelts system has not been yet applied because of lack of funding and refusal of the local landowners, who do not agree on the land use change after the future shelterbelts, would be set.

The analysis of climatic indices shows a humidity deficit in the study area, which is therefore more vulnerable to drought and aridity comparing to other regions in Romania (Table 3). The hydric compensation index reveals a high humidity deficit during summer (the period with maximum biological activity). The values of De Martonne aridity index at Calafat (23.96) and Caracal (26.3) weather stations indicate a medium humidity deficit during the entire year.

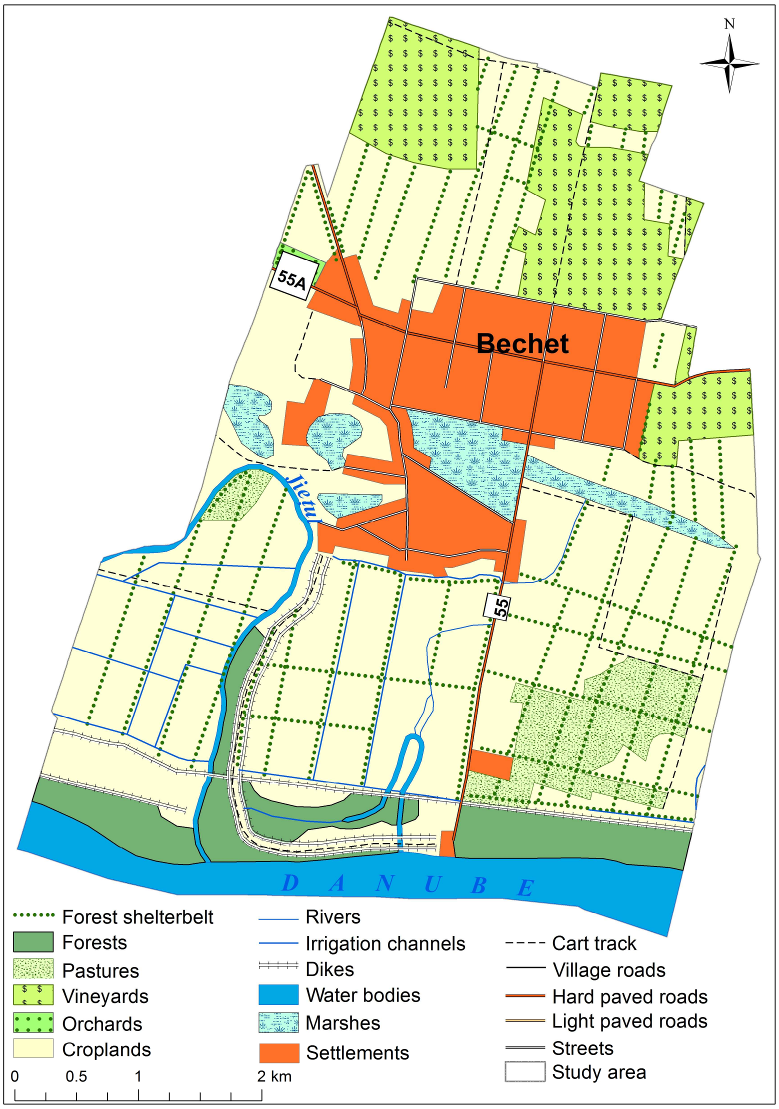

Figure 3. Land use in Bechet (1970).
Source of data: topographic map at the scale of 1: 50.000 (Military Topographic Survey, 1970)

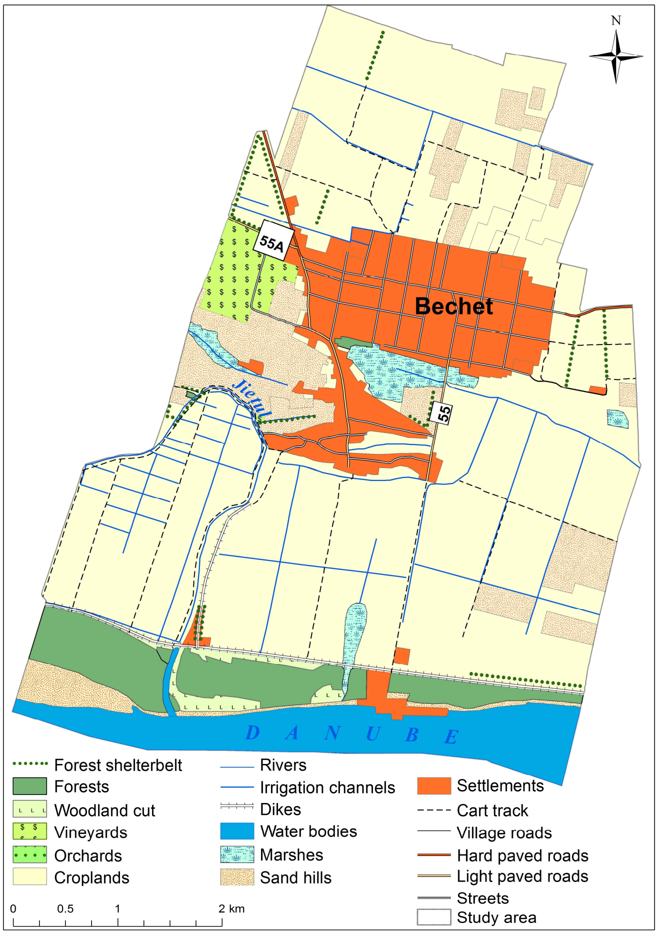

Figure 4. Land use in Bechet (2008)
Source: topographyc map at the scale of 1:50.000 (Military Topographic Survey, 2008)

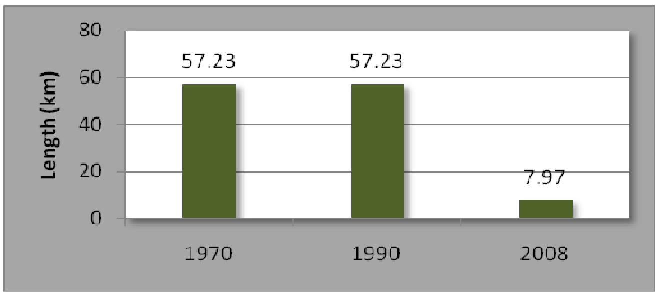

Figure 5. Evolution of the protective shelterbelts in Bechet (1970-2008).
Source: The attributes table of shape file layers in *Figures 3* and *4*

Figure 6. Shelterbelt phragments in Bechet
(November 2015, and August 2016). Photos by I. Vijulie

To mitigate the impact of climate change and prevent land degradation, the restoration of forests and shelterbelts in the study region is a priority. According to climatic indices, forestry species that can adapt better to climate change are indigenous (*e.g*. Turkey oak, Hungarian oak, ash, hawthorn, rose hips) along with acacia and agricultural crops resistant to drought: grape-vines, trees (*e.g*. apricot), watermelon, pumpkin, beans, tobacco, etc. Currently, windbreaks cannot perform their protective function anymore, as they were strongly degraded.

The values of representative climatic indices for assessing the water balance in the study area, and for selecting tree and shrub species used in the restoration of suitable shelterbelts and crops were calculated in Table 3.

Once reset, the forest shelterbelts have favorable effects on local microclimate, crops, soil, biodiversity, etc. They contribute to retaining and uniformly distributing the snow on lands, thus increasing the water reserve in soil; balance the air temperature during summer; protect the settlements, the communication lines and crops against snow cover. When mature, they can be used as wood by the landowners (Costăchescu *et al*., 2010).

Table 3

Climatic indices at the Caracal and Calafat weather stations (1961-2007)

	CARACAL											
Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
ΔP	34.4	33	21.4	– 5.1	– 36.9	– 61.3	– 80.1	– 74	– 45.1	– 5.7	31.9	41.7
$\sum\Delta P^{+}$	162.4											
$\sum\Delta P^{-}$	308.2											
I_{ch}^{**}	0.52											
$\sum$P (XI-III)	192.4											
$\sum$P (VII-VIII)	115											
I_{aDM}	26.3											
CALAFAT												
ΔP	33.5	31.9	18.4	– 4.8	– 38.5	– 73.5	– 93.9	– 88.5	– 44.7	– 3.9	33.2	45.1
$\sum\Delta P^{+}$	162.1											
$\sum\Delta P^{-}$	347.8											
Ich^{**}	0.46											
$\sum$P (XI-III)	197.4											
$\sum$P (VII-VIII)	89											
I_{aDM}	23.96											

where: $\Delta P = P - ETP$; $I_{ch} = \sum\Delta P^{+}/\sum\Delta P^{-}$;$\sum$P (VII-VIII) = the sum of precipitation in the period of maximum biological activity; $\sum$P (XI-III) = the sum of precipitation in the period of moisture accumulation inside the soil; I_{aDM} = De Martonne aridity index ($P_{annual}/T_{annual}+10$).

Conclusions

Between 1970-2008 there have been a number of changes in the land use, in the sense that the land areas occupied by vineyards, pastures, orchards, forests and shelterbelts were reduced. Instead, the areas occupied by degraded land have increased due to the fact that on those reconverted lands they have not obtained the expected crop yields and thus were left fallow (uncultivated).

Changes in the structure of agricultural land have occurred mainly due to the change of the type of land ownership after 1989. Thus, allotment citizens wanted to expand the arable land areas occupied by the expense of others, and the end result was that the surface occupied by degraded lands increased.

Reducing the effects of aridization within this perimeter would be possible both by planting new shelterbelts, and restoring the former ones. To this end it is necessary to sensitize the local population about the importance of forest shelterbelts for improving the environment, for the gradual reduction of the effects of droughts and increasing agricultural production.

Not only the global climate change are the cause of aridization in this area, but *a natural vulnerability to this phenomenon* was found because of the sandy soil, geographic position towards the Carpathian arch, which predisposes to hot winds, along with deforestation and drainage of the Danube Valley made under the communist regime.

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