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Ecological reconstruction of the plain areas prone to climate aridity through forest protection belts. Case study: Dăbuleni town, Oltenia Plain, Romania

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Abstract

The paper aims to make an overall assessment of drought related problems, and to shed some light on land degradation and aridity in Romania, with particular emphasis on Dăbuleni Town belonging to the Dolj County. The main research methods employed for this study were observation, survey and cartographic method, which made use of GIS techniques. A map with the current spatial distribution of the forest belt fragments overlapping the initial vegetation was accomplished. The investigation has found that these patches cover small areas lying in the immediate vicinity of the Dăbuleni town.

We suggest that in order to mitigate the impact of climatic modifications and to prevent land degradation the reconstruction of forest protection belts created between 1970 and 1980 is a must, in as much as in their present condition they can no longer protect the hydrotechnical improvements and the lands. However, project implementation is hindered by the lack of cadastre and funds. At the same time, the population and the landowners in the area need to be explained the importance of forest protection belts for the improvement of environment and living conditions, for the gradual diminishing of drought effects and for the enhancement of agricultural production. Another problem that must necessarily be settled is the development of a methodology for granting compensations to those landowners who agree to change the use of their agricultural lands so as to allow the creation of forest protection belts.

Keywords: drought; aridity; land degradation; forest protection belts; Romania.

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1. Introduction

Climate changes at global level, associated with pollution, deforestation and landscape degradation make some areas experience aridity phenomena (vegetal cover disappears and the soil is heavily degraded). In Romania, such areas are extensively found in Dobrogea and the southern part of the Romanian Plain (Fig.1) [1, 2]. In southern Oltenia, the Thornthwaite aridity index values (I ar-TH) (%) define a realm that becomes increasingly dry from north (40%) to south (45%) and southwest (50%). The highest values, which express a pronounced aridity (Iar-TH ≥ 50%), characterize most of the Blahnița and Desnățui plains, the southern part of the Romanați Plain (Dăbuleni flatlands), the Jiu and Olt floodplains and the adjacent Danube floodplain (about 65%) [3].

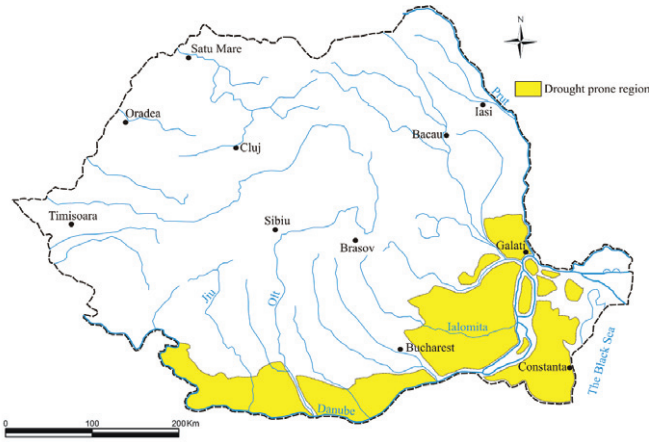

Fig. 1. Drought prone regions in Romania. Map adapted after [2].

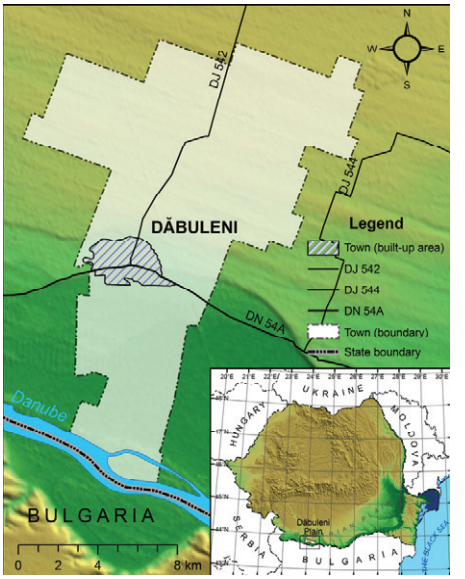

Fig. 2. The location of Dăbuleni town

During the period 1937 – 1961, many scientific studies and researches deal with the need of creating forest protection belts. At the same time, they assess the working procedures, the methods of caring the trees, the structure and composition of forest belts, and the influence they bear on prevailing winds, soil cover, fauna, crops and agricultural yield [4]. Between 1947 and 1960, more than 5000 ha were planted in Dobrogea, Bărăgan and southern Oltenia [4]. In 1958, the first hostile actions against the forest protection belts in Romania began. Thus, the decisions of the Council of Ministers no. 273 and 385 of 1962 paved the way for the clearance of the existing protection belts, as well as for the cessation of scientific research activities in this respect [5]. Until 1970, more than 9000 ha of forest and acacia belts were cleared in the Oltenia Plain in order to allow the building of the Sadova – Corabia irrigation system. Following the deforestations, the formerly stabilized sand dunes became mobile, which created imbalances in the local environment, inasmuch as deflation processes were reactivated [6]. The replanting of forest protection belts was resumed after 1970 with the designing and creation of the Sadova – Bechet defense network, which covered 1600 ha [4]. After 1989, however, many belts aimed at protecting the soil and transportation routes in southern Oltenia were illegally cut down. Under the circumstances, it was felt the need to reestablish them as soon as possible [4].

The rationale behind this study is twofold: (1) the sandy area lying on the left bank of the Jiu River is one of the most arid in the country and has a low share of afforestation, and (2) water deficit and the mobile character of the lithological substratum have long been a problem for the region (the creation of forest protection belts in southern Oltenia in the second half of the 20th century stands as evidence).

The increase of the area covered by forest vegetation and the necessity to take actions against drought, aridityand land degradation is a priority of the national strategy for the prevention and control of such processes [7]. These lands have a low crop production capacity (as irrigation systems are missing) and, under the present use they are subjected to continuous erosion (e.g., aeolian) [8].

The reforestation of the lands in the Dăbuleni area target the following ecological and socio-economic objectives: restoring the ecological balance by gradually stabilizing and improving the soil by means of forest plantations; preventing the aridityof the region; and improving and turning to account the local landscape, which at present is dull and exposed to natural and anthropogenic degradation. Using more efficiently the lands and even creating the conditions for wood extraction in an area where such resource is lacking will be in the benefit of the entire community.

The paper intends to debate the problems regarding drought, land degradation and aridityin Romania, with particular emphasis to the Dăbuleni town, belonging to the Dolj County.

2. Methods

The main research methods employed during the study were observation, numerical methods of assessing the ecological potential of the territory and cartographic method, which relied on GIS techniques. Investigations in the field consisted in a number of visits to the study area undertaken during the years 2010 and 2011, in order to visually assess the forest belt condition and the state of soil cohesion.

The assessment of the ecological potential of Dăbuleni town, as a premise of designing a scenario for the creation of forest protection belts, relied on the computation of representative climatic indices, which are used in many studies accomplished in Romania dealing with the bioclimatic potential of various regions. We are referring here to the hydric compensation index, the sum of precipitation for the period of maximum biological activity, the sum of precipitation for the period of moisture accumulation in the biologically active soil horizon and the De Martonne aridity index [9, 10, 11, 12, 13, 14, 15, 16, 17]. The hydric compensation index ($I_{ch}= \Sigma\Delta P^{+}/ \Sigma\Delta P^{-}$, where $\Delta P = P – ETP$) highlights to what extent the water deficit in the soil can be compensated by precipitation [9, 10, 16. As far as the sum of precipitation for the months with maximum evapotranspiration ($\Sigma P_{VII -VIII}$) and the sum of precipitation for the period of moisture accumulation in the biologically active soil horizon ($\sum P_{IX-III}$) are concerned, these are very helpful for the assessment of climatic favorability for the development of tree species [16]. The values of the yearly De Martonne aridity index ($I_{ar} = P/T+10$, where P = yearly precipitation, T = mean annual temperatures) may explain the presence over a territory of some vegetal species having certain hydric requirements. Thus, the values less than 20 highlight the areas with significant water deficit, while those between 20 and 25 characterize the areas with mean water deficit [9, 10, 11, 12, 13, 14, 15, 16].

In order to develop the cartographic materials, we used the second edition (1977 – 1979) of the topographic maps of scale 1:25000 and the ortophotoplans provided by the National Agency for Cadastre and Real Estate Publicity. The latter are based on the aerial photographs of 2005, with a resolution of 0.5 m, and they were georeferenced in the Stereographic Projection 1970 on the Krasovski ellipsoid, map datum Dealul Pisculi. The topographic maps produced by the Military Survey were scanned and afterwards were georeferenced and digitized in order to identify the current forest protection belts by using the ArcGIS 9x (ESRI, Redlands, CA).

From the administrative point of view, Dăbuleni settlement is situated in the Dolj County and since 2004 it has been a town [19]. From the geomorphological standpoint, it overlaps the Dăbuleni plain, a

sub-unit of the Oltenia Plain (see Fig. 2), which stretches out as far as the Danube's floodplain and terraces [20], thus accounting for 103 000 ha of agricultural land developing on sands [21].

Dăbuleni town lies in one of a area prone to drought and aridityin Romania [18] and in addition, it has one of the lowest shares of afforestation.

3. Results and discussion

3.1. Environment controls in developing the improvement scenario

The establishment of forest belts must take into account several important ecological and anthropogenic factors such as lithology, topography, climatic conditions, soil, hydrological potential, natural and cultivated tree vegetation, the performed works and the employed machinery, as well as the network of transportation routes [22, 23, 18].

In the administrative area of the Dăbuleni town, the surface deposits that are of interest from the standpoint of soil formation and evolution are as old as the Quaternary. The sand deposits are sometimes a few meters thick. The rolling topography is due to the presence of longitudinal sand dunes, of variable length (from several hundred meters to 1 or 2 kilometers), which generally trend from west to east [24]. Mean altitude of the area is 95 m, but the relative heights between the dune crests (103 – 104 m) and the bottom of the interdunes (83 m) range between 3 and 18 m.

On rather small areas, in interdunes or within the microdepressions one can see hydromorphic traces and/or sapropelic muds that have developed on the bottom of the pools in the area. The soil cover is mostly represented by sandy soils and loose sands, which have a low fertility because of their low capacity of retaining water and nutrients [25].

From the hydrological point of view, except for the interdunes acting as torrential valleys, there are no permanent streams (semi-endorheic region). On the dunes, water table sinks to 2 or 3 m and sometimes even to 5 m, while in interdunes it is found at 0.80 to 1.20 m; locally, but on small areas, it can rise even higher.

Climatic conditions of a region are decisive for the nature of its forest vegetation (tree composition), and along with soil cover, they influence the economic productivity of wooded areas. Thus, according to the values of climatic parameters, Dăbuleni flatlands correspond to the forest steppe area, which in this region bears some influence from the sand dunes, which are the prevailing landform. T

he mean monthly temperatures and the considerable length of the interval with mean monthly temperatures higher than 20^0C reveal a thermal potential that encourages the development of more termophilous vegetal species. The specific features of the pluviometric regime are highlighted by the values of some representative ecometric indexes (Table 1) that are useful in appreciating thearidity degree of a territory. In addition to that, they have helped us in identifying the tree species that can thrive under such climatic conditions. The values of the aridity indices show that the study area fits the semi-arid and excessively dry climate.

One of the factors that accelerate the transpiration process is the wind (Table 2). Once its speed increases, the water in the soil evaporates at a higher rate, even ten times faster than during calm periods.

By the mean multiannual temperature (11^0C), bioactive period (310 days), the length of vegetal season (202 days) and the sum of mean daily temperatures exceeding 0^0C (4062), we could state that the study area offers good conditions for acacia, hybrid poplar trees, white and black poplars, mulberry trees, honey locust, sub-mesophilous and termophilous oaks, etc.

The multiannual precipitation and the aridity indices highlight favorable conditions for species like acacia and sub-mesophilous and termophilous oaks.

Table 1. Ecometric indexes for the interval 1896 – 2005 (Craiova and Calafat wheather stations)

Wheather site/month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Craiova												
P	37.6	28.2	29.3	44.0	59.6	71.3	51.2	42.2	35.1	43.3	42.4	38.8
ETP	0	0	17	52	95	125	146	127	85	46	14	0
ΔP^{*}	37.6	28.2	12.3	- 8	-35.4	-53.7	-94.8	-84.8	-49.9	-2.7	28.4	38.8
$\sum\Delta P^{+}$ = 145.3; $\sum\Delta P^{-}$ = 329.3; Ich^{**} = 0.441; $\sum P(VII\text{-}VIII)^{***}$ = 93.4; $\sum P(XI\text{-}III)^{****}$ = 159.3; I_{ar} = 25.14												
Calafat												
P	38.2	30.7	36.9	52.4	66.3	63.4	48.4	31.2	44.9	54.4	36.4	46.8
ETP	0	1	18	52	98	129	148	133	86	47	14	2
ΔP	38.2	29.7	18.9	0.4	-31.7	-65.6	-99.6	-101.8	-41.1	7.4	22.4	44.8
$\sum\Delta P^{+}$ = 161.8; $\sum\Delta P^{-}$ = 339.8; Ich^{**} = 0.476; $\sum P(VII\text{-}VIII)$ = 79.6; $\sum P$ (XI-III) = 189; I_{ar} = 26.51												

Source: National Agency for Meteorology (ANM), 2011 [26]. *$\Delta P = P - ETP$; **$Ich = \sum\Delta P^{+}/\sum\Delta P^{-}$; ***$\sum P$ (VII- VIII) = Sum of precipitation in the period of maximum biological activity; ****$\sum P$ (XI - III) = Sum of precipitation in the period of moisture accumulation inside the soil

Table 2 The average wind frequency and speed on prevailing directions

Wind direction	N	NE	E	SE	S	SV	V	NV	Calm
Mean wind frequency (%)	3,8	11,4	5,1	6,2	3,9	5,6	12,4	13,3	38,3
Mean wind speed (Bf)	1,4	1,8	1,5	1,3	1,0	1,3	3,2	3,8	-

Source: Forest Research and Management Institute (ICAS), 2008 [27].

Sandy soils, which are dominant in the area, offer good substratum conditions for oak, Turkey oak, Italian oak, lime, Field maple, acacia, etc. From a biogeographical standpoint, on a European scale Dabuleni settlement lies in the continental region where natural vegetation belongs to the southern forest steppe characterized by Pedunculate oak *(Quercus pedunculiflora)* and Pubescent oak *(Quercus pubescens)* forests mixed with Turkey oak *(Quercus cerri*s), Italian oak *(Quercus frainetto)* and, occasionally, even Pedunculate oak *(Quercus robur)*. In the area of the Dăbuleni town, the natural wood vegetation is limited only to isolated specimens of oak, elm and ash, which are the relics of the former forests that have been replaced by agricultural lands. The planted vegetation is represented by various tree species, like acacia, hybrid poplars and tree poplars, as well as by shrubs (hawthorn and Russian olive), all representing the remnants of the former forest belts.

3.2. The theoretical model of forest protection belts

According to the role they play and the importance they have in the protection belt the tree species can be grouped in several categories: main or basic species; secondary or mixed species; shrubs for soil protection; and marginal protection species (with thorns) (Fig. 3; Fig. 4).

3.3. Scenario for establishing a network of forest protection belts at Dăbuleni

According to the map of the spatial distribution of the current forest protection belts (Fig. 5) it is clear that these are found on small areas (137 ha). They are either highly fragmented (Fig. 6) or are lacking completely in comparison with the initial belts (1125 ha) created between 1970 and 1980. The distance between the main forest belts has roughly been established at 250 m.

The secondary belts make the connection with the main ones, forming together more or less regular geometric shapes (usually rectangles and trapezes) (Table 3). The distance between the secondary belts has been established at 500 m, as it happened in the case of the Sadova-Bechet network of forest protection belts.

Main tree (height =15–20 m)
-ensures the best protection
-produces quality wood

Secondary tree cut for sprigs (height = 6–10 m)
-ensures medium protection
-produces firewood and poles

Shrub (height = 1–5 m)
-ensures lateral protection
-ensures shelter and food for animal species

Fig. 3. The constituents of a forest belt [18]

Fig. 4. The structure of a forest protection belt [18]

The fragments of the present belts are located especially near the outskirts of the built-up area of the town. According to the data provided by the Craiova and Calafat weather stations, the Dăbuleni area experiences prevailing winds blowing from west, northwest and northeast. Under these circumstances, the best orientation for the main belts would be on a north-south direction. In general, the secondary belts should be oriented perpendicular to the main ones.

Besides the orientation imposed by the prevailing winds, the location of the forest belts must take into account the shape of protected areas, their division into exploitation plots and the position of the roads,

irrigation canals, electric wires and so on. The fragmentation of agricultural lands should be avoided as much as possible, even if the distance between the belts will have to be altered.

The most important factor that defines the size of protected area is the height of the belt. The extension of this area oscillates from belt to belt and increases according as the belt develops.

The density of the forest belt is the ratio between the compact area of the longitudinal section and its total area. As a rule, speed decreases when the wind passes through the open areas of the belt, which means that if the belt was compact the wind will be hindered or even completely stopped. The correlation between the height and the density of forest belt influences the reduction of wind speed and the length of protected area.

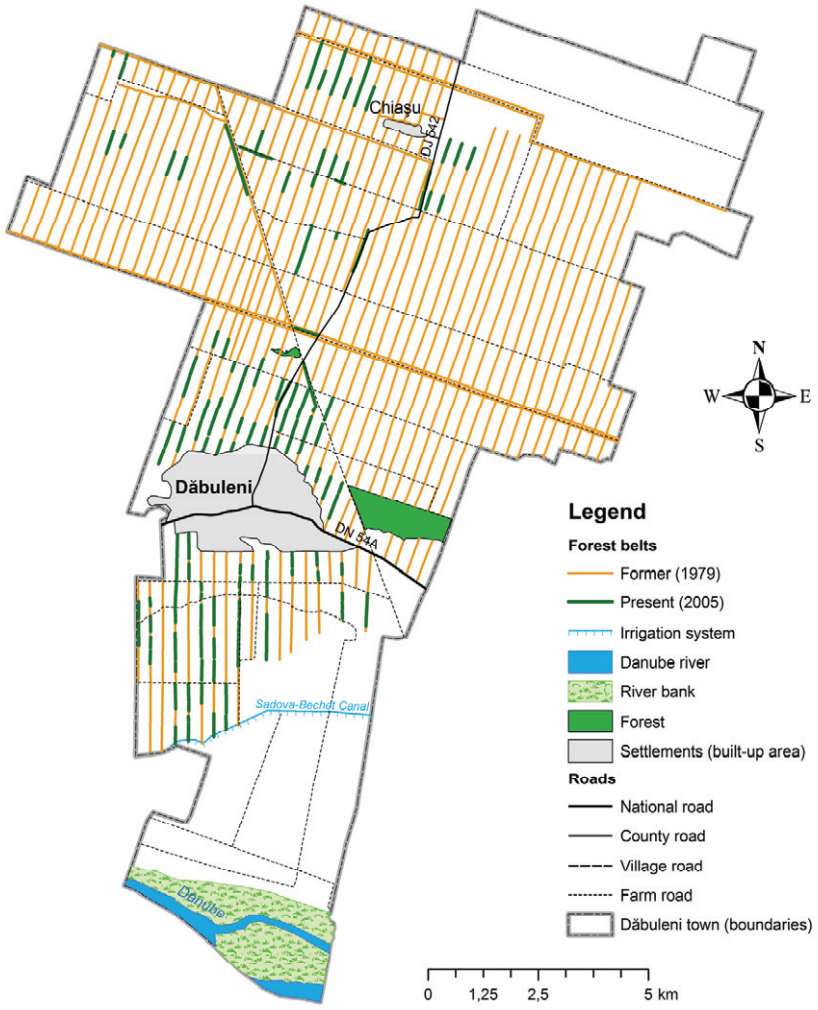

Fig. 5. The spatial distribution of the forest protection belts in the Dabuleni area (Oltenia Plain)

Table 3 The proposed forest structure of the protection belts at Dăbuleni [18].

Composition and scheme	Main belt					Secondary belt			
Forest steppe area	a	Stb	a	Stb	a	a	Stb	a	Te
Main belt	Te	a	Te	a	Te	Te	a	Stb	a
20Stb(Ce, Gî) 30Te(Fr,Ju,Mj) 50 Arb	a	Stb	a	Stb	a	a	Stb	a	Fr
Secondary belt	Te	a	Te	a	Te	Te	a	Stb	a
25Stb(Ce,Gî) 25Te (Fr, Ju, Mj) 50 Arb									

Arb (a) – shrubs; St, Stb – oak, pedunculate oak; Ce – Turkey oak; Gî – Italian oak; Fr – ash; Te – lime; Ju – field maple; Mj – Manna Ash .

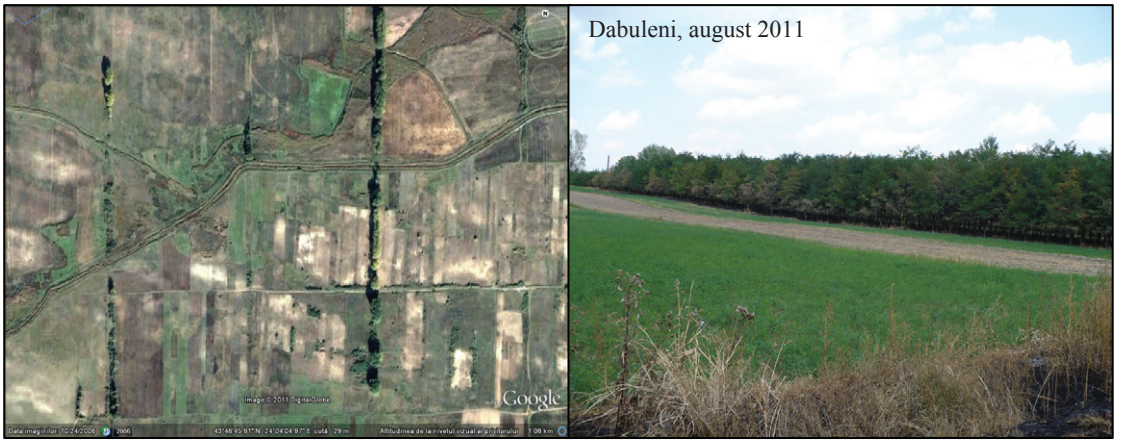

Fig. 6. Highly fragmented forest belts in Dabuleni area

Table 4 Compositions and afforestation schemes [18].

Composition and scheme	Main belt					Secondary belt			
The forest area in the plain	a	St	a	St	a	a	St	a	Fr
Main belt	Fr	a	Fr	a	Fr	Fr	a	St	a
20St (Ce, Gî) 30Fr (Te, Ju) 50Arb	a	St	a	St	a	a	St	a	Fr
Secondary belt	Fr	a	Fr	a	Fr	Fr	a	St	a
25St (Ce, Gî) 25Fr (Te, Ju) 50 Arb									
	Main belt					Secondary belt			
The forest steppe area	a	Stb	a	Stb	a	a	Stb	a	Te
Main belt	Te	a	Te	a	Te	Te	a	Stb	a
20Stb (Ce, Gî) 30Te (Fr, Ju, Mj) 50 Arb	a	Stb	a	Stb	a	a	Stb	a	Fr
Secondary belt	Te	a	Te	a	Te	Te	a	Stb	a
25Stb (Ce, Gî) 25Te (Fr, Ju, Mj) 50 Arb									

Arb (a) – shrubs; St, Stb – oak, pedunculate oak; Ce – Turkey oak; Gî – Italian oak; Fr – ash; Te – lime; Ju – field maple; Mj – Manna Ash

The composition of forest protection belts is established based on the local conditions and on the species capacity to comply with these (Table 4). The shrub species (a) that can be used are the following: common hawthorn, dog rose, smoke tree, elder, privet, spindle, salt cedar and caragana. The dog rose will be introduced only on the side rows, while the privet and the spindle will be put especially on the inside.

These species are not only extremely important for soil protection, but they also make the belts impenetrable, which is the ultimate purpose of the improvement works. The need of saplings will be established by taking into account the areas that have to be reforested, the plantation schemes and the percentage required for every afforestation composition.

Land preparation is one of the basic operations that warrant success in the development of forest protection belts. The technique of land preparation depends on land configuration, its present state and the previous land use. The preparation works that will be accomplished consist of grubbing and the cleaning of the entire land of herbaceous and wood species, according to the rules in force. The tree saplings that will be planted will have the required size in conformity with the present regulations. The planting will be done automatically. The annual control works will be undertaken according to the specific instructions and regulations. Until the saplings will grow to form a forest belt, a series of maintenance measures are to be taken, which consist of revisions and pest control works.

3.4. Restrictive factors for implementing the development project

Project implementation is hindered by the lack of cadastre plans and money. Likewise, it would be necessary to make the people and the landowners in the area aware of the importance of the forest protection belts for the improvement of the environment and the living conditions, for the gradual reduction of drought effects and for the increase of agricultural yield. On the other hand, however, the stakeholders should be allowed to state their objectives clearly from the very beginning and to have their say in the decision-making process [28].

Another problem to be solved is to develop a methodology for offering compensations to those landowners that at present refuse to change the use of parts of their farmlands to allow the creation of forest belts.

3.5. The consequences of the creation of forest protection belts

The consequences of such undertakings would be the following: the improvement of microclimate conditions; the improvement of growing and development conditions of the adjacent crops; the increase of soil fertility and stability; the diminishing of erosion and sheet wash along the slopes; the reduction and even the complete curbing of deflation; the increase of soil moisture; the enrichment of soil in humus and other nutrients and the changing of pH values due to the organic substances resulting from decaying leaves and roots; the increase of wood production; the extension of forest areas; the protection of socio-economic units and transportation routes; the creation of favorable conditions for the development of local fauna; the improvement and reconstruction of the landscape [18].

4. Conclusions

The present study has developed a map of the current spatial distribution of the left over forest patches belonging to the initial network. It has been noted that they cover small areas, which lie especially in the immediate vicinity of the Dăbuleni built-up perimeter. In order to mitigate the impact of climatic changes and to prevent land degradation we strongly recommend the reconstruction of the forest protection belts created between 1970 and 1980, which at present, because of their deterioration, cannot fulfill any longer the functions for which they were created. The project implementation is hindered by the lack of cadastre plans and funding. Likewise, it is necessary that measures be taken in order to raise people's and local landowners' awareness of the importance of forest protection belts. Another problem that has to be settled

is the designing of a methodology for giving compensations to the landowners who presently are reluctant to change the destination of some of their lands, in order to allow the creation of forest protection belts.

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