PLANNING THE ECOLOGICAL RESTORATION WORKS OF LANDS AFFECTED BY THE DESERTIFICATION FENOMENON - CASE STUDY OSTROVENI COMMUNE, DOLJ COUNTY

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Abstract: *Desertification is a complex economic hazard defined by the UN Convention to Combat Desertification (Paris 1994) as "the degradation of land in arid, semi-arid and sub-dry areas as a result of the action of various factors, including climate change as well as human activities". Soil degradation in areas subjected to desertification is identified as a reduction of biological or economic productivity. Romania is not at all strange to this phenomenon, significant surfaces of land being affected to a smaller or larger extent (especially in the southern part of the country). Thus, according to official figures, in Dolj County about 6% (over 450 km^2) of its total area is considered to be a desert and in the absence of measures to stop the phenomenon and to ecologically restore the already affected land, this surface will become increasingly larger in the future. Starting from this reality, in the first part of the present paper, the current physical, chemical and pedological conditions of a 375 hectares area located in the southern part of Dolj County (namely on the territory of Ostroveni commune, Lişteava village) were analyzed and the necessary steps were identified for the purpose of ecological restoration of the affected land. In the second part of the paper, while establishing the type of ecological restoration of the land, taken into study, namely its return to the productive agricultural land status (through the 7 well-individualized steps), we took into account the fundamental principles of ecological planning, especially the one referring to the globality or inter-causality, pointing out that the territory subjected to ecological restoration must be viewed as a whole. Beyond the productive function (the agricultural crops will produce substantial incomes for the local community), the ecological restoration also aims at the reintegration of the 375 hectares of land heavily affected by the desertification phenomenon in the context of the surrounding landscape (specific to the anthropic - agricultural ecosystems).*

Key words: *agricultural land, desertification, ecological restoration, productive function*

INTRODUCTION

Desertification is a complex phenomenon linked to the combination of natural causes and anthropogenic pressure on vulnerable ecosystems in arid, semiarid and sub-dry lands. Among the natural factors are the climatic conditions, which include the reduction of rainfall, changes in their regime, climate warming and wind intensification, the latest increasing the evaporation and drying the vegetation. The human factor intervenes through poor management of agricultural land, the destruction of forest protection screens, the destruction of irrigation systems, overgrazing, etc.

The main phenomena that highlight desertification are: soil destruction by surface erosion, deflation, crust formation, aridisation, salinisation and alkalinisation. In these conditions the quantity of water that infiltrates into the soil is reduced, its flow on the ground generates an increase of the surface erosion and occurrence of gullies and ravines (in the case of inclined lands) (LAZĂR, 2010). The accelerated erosion of soils generates, in turn, more severe destruction of vegetation and the transformation of stable sand dunes into mobile ones and their advancement.

Reclaiming degraded land is a very slow process. It takes between 100 and 500 years to restore 2.5 cm of soil (depending mainly on local geological and climate conditions) (LAZĂR, 2001).

Dust storms are an increasing problem in many areas affecting people's health as well as local and distant ecosystems.

The consequences of desertification are: diminishing food production, reducing soil productivity and decreasing land regeneration capacity; increased floods in downstream areas, water quality reduction, sedimentation in rivers and lakes, and clogging of reservoir lakes and waterways; aggravation of health problems due to sand and dust storms, especially eye infections, respiratory difficulties, allergies and stress; reducing livelihoods, forcing the affected population to migrate (HELMUT, 2013).

Desertification is obvious on almost 25% (39.4 million kilometers^2) of dry land surface and affects over 110 countries with nearly one billion inhabitants on all continents, with annual damages estimated at 42 billion dollars, this phenomenon being called "Earth's cancer". The territories affected by desertification occupy 36% in Africa, 25.4% in Central and North America, the rest being distributed in Europe and Australia (UN, 1994).

The UN Convention to Combat Desertification was signed by 191 countries, (all UN members). The UN Global Ecosystem Agreement states that it is easier to prevent desertification (through better crop management and more attention to irrigation) rather than combat it (UN, 1994).

MATERIALS AND METHODES

In this paper, an agricultural land located in the SE of the Dolj County, seriously affected by this phenomenon, was considered. Currently, land productivity is estimated to be fewer than 10% of the potential, which has serious consequences for the local community that relies almost entirely on farming to ensure the needs of everyday life.

Location of the studied land

The land affected by the desertification phenomenon, for which ecological restoration works are designed, is located in Ostroveni commune (Lişteava village) and occupies a total area of 375 ha (Figure 1). Access to the area is done on the county road DJ 742, to the village Lişteava, and from there on the existing agricultural exploitation roads.

Figure 1. Location of the degraded land

It is located in a plain area, with a slight slope to the south (towards the Danube) and for a good period of time (until the early 90's) was considered to be a field with increased productivity, part of one of the more fertile areas of Romania (Romanian Plain). The land in question is located at approx. 4 km away from the Jiu River, on the left bank towards its flow direction and approx. 6 km north of the Danube River.

It should be noted that originally the land was not an agricultural one, being largely occupied by deciduous forests, but as a result of the expansion of the arable land that began around 1950, it was transformed and its destination changed.

The studied area is actually part of a much wider area located in the southern and southeastern part of Dolj County heavily affected by the phenomenon of desertification. The land transformed into a desert also extends to the neighboring communes Sadova, Călăraşi, Dăneşti and Dobreşti, as well as to the agricultural areas belonging to the towns of Bechet and Dăbuleni, the degree of desertification being variable, ranging from incipient to areas that look like a true desert (including sand dunes).

The need for ecological restoration

The ecological restoration of any degraded land (for all types of degradation) requires special attention from the point of view of the legislative and normative framework, which allows a greater flexibility of the forecasts and the possibility to change the destination of the land areas and which takes into account the landmarks and the characteristics of the territory based on a complex process of analysis of the built landscape, using the most modern methods of work (LAZĂR, 2010, LAZĂR ET AL., 2017).

The predominant character of the relief in the studied area is that of a plain, falling within the category of the Danube areas (the Danube being the main agent that generated the relief). In more detail, the relief includes the Danube meadow and the plain, the altitude rising from 42 to 55 m above sea level, from south to the north (JURJ, 2018).

As stated before, around 1950, the area was largely covered by deciduous forests. Starting from that moment on it undergone a radical transformation, in the sense that the forests were cut down in order to increase the surfaces of arable land and extend agriculture. From that time until the 90s, the land was part of an extensive area of Dolj County where intensive farming was practiced.

It should be noted that irrigation systems have been built in the area to supplement the amount of rainwater (which has always been insufficient) so as to provide the water required by agricultural crops. After 1989, gradually, these irrigation systems were either abandoned or destroyed, so land productivity began to decline from year to year.

Of course, in these conditions, i.e. in the absence of irrigation systems, given the intensive practice of agriculture, climatic changes that have become even more extreme in recent years (decreasing rainfall or passing through periods of extreme drought, rising temperatures, increasing winds etc.) or, in other words, of a faulty way of land management, they have lost the ability to sustain the vegetation (crops, fruits or vineyards) and gradually have turned into a desert (Figure 2).

Figure 2. Land near Lișteava village (JURJ, 2018)

Geology consists of soft, young, partly unconsolidated rocks: reddish clay, sands, gravel and loessoid deposits, arranged in relatively homogeneous horizons and with poor or moderate geodeclivity (JURJ, 2018).

The clay (clays with sand) predominates on approx. 200 ha (53%) of the area. On approximately 100 ha (26.6%) there are medium - fine clays interposed with medium coarse materials (coarse sands). The remaining 75 hectares (20.4%) consists of coarse medium sized materials (sands with clay and sands), somewhere interspersed with medium materials (clays and clayey sands) (JURJ, 2018).

Morphological transformations occur due to water and wind erosion, and consequently the factor "vegetal (fertile) soil" has disappeared.

In this context, it is self-obvious that few plant species, rare as a number of individuals, have been spontaneously installed on the ground (eg *Cyperus arvensis*, *Apera spica venti*, *Setaria sp*., *Galium sp*., etc.).

The situation is very different from the original one, when these lands were covered with forests, but also from the one over 25 years ago when these lands were cultivated and farmed. The disappearance of vegetation leads to the formation of dust clouds that affect the health of the local inhabitants during periods affected by droughts, accompanied by winds.

The need for ecological restoration of the 375 hectares of land is not necessarily linked to the restoration of the original ecosystem (the one before intensive farming) but rather to the restoration of its quality and its reintroduction into the agricultural circuit.

All planned ecological restoration works contribute to the remediation of the environmental components affected by the desertification phenomenon, with the most important positive effects on soil, local hydrogeology and vegetation.

The restoration of the land to a productive status will play an important role in improving air quality (diminishing sediments and suspension particles, diminishing thermal amplitudes, increasing atmospheric humidity, increasing the amount of oxygen produced, etc.) in the area. Of course, improving air quality has positive effects on the health and mental state of the population.

The restoration of the landscape, specific to the anthropic - agricultural ecosystems also interferes with the mental state of the population, also increasing the attractiveness of the area.

Characteristics of the restored ecosystem

Hydrography - the main valleys that are distinctly identified by morphometric elements are Jiu to the west and the Danube to the south. In the studied territory, the Jiu has a N-S flow direction, passing a distance of about 6 km to the confluence with the Danube. The average slope of the river in this sector is 1.9%.

The underground deepwaters of the perimeter under investigation are located in deposits of different age. The most important aquifer accumulations in the permeable deposits belong to the Lower Pleistocene (Cândeşti strata), Levantin and Dacian.

Climate - global solar radiation has high annual average values of about 125-127 kcal/cm^2 (90-92 kcal/cm^2 in the warm semester and 35 kcal / cm^2 in the cold one).

The average annual temperature at Bechet Meteorological Station is 10.8ºC, over the years the values varying between 9.1ºC (in 1933) and 13.5ºC (in 2017) with average annual amplitude of 24.9ºC. The absolute maximum monthly temperatures vary between 19.5ºC in December and 43.5ºC in July, and the absolute negative temperatures drop below -25.0ºC, the lowest value being in January (-35.5ºC). In percentage, from the total number of days of the year, 28.7% (104.8 days) are typical summer days, 9.5% (34.7 days) are tropical days and 1.3% (4.9 days) have tropical nights (***, 2008).

The average multiannual quantity of rain is 520.9 mm (or l/m^2), but it should be noted that if we analyze the total amount of rainfall only in the last 20 years, it has a much lower average value of just 470.1 mm. Also during this period there is a growing occurrence of prolonged and extreme drought episodes.

The wind blows most frequently from the West and East, these two directions having an almost equal frequency and accounting for about 44% of the observations. The highest average speeds belong to the same directions (4.3 m/s for E, 4.2 m/s for V) and the average annual speed is about 3 m/s (***, 2008).

Soil - soil quality studies, or more accurately said what has been left of the fertile soil of the past, have highlighted the fact that at present the land is characterized by: coarse texture (NL - L) or fine (AL - A); presence of the mineral skeleton on the surface and on the profile; low alkaline reaction (pH) (7.5 - 8.5); nutrients (NPK complex) are almost lacking, and humus is absent.

Vegetation - the afforestation coefficient of the Danube basin (in the studied area) is 4.4%. The initial vegetation of the area consisted of Quercinee forests: *Quercus polycarpa, Quercus frainetto, Quercus cerris*. These forests have been grubbed up to expand the agricultural land in the area, but there still can be found pliers west of Lişteava, in the Jiu meadow, and small remains from what once were the protection screens of the agricultural area against wind erosion (these were grubbed after 90s by the locals, the wood being used for heating the dwellings). After deforestation and the start of agricultural activities, the place of the natural species was taken by the cultivated plant species (cereals, maize and legumes) (***, 2008).

Pomacey are represented by: *Prunus cerasifera*, *Prunus armenica*, *Prunus nigra*, *Prunus avium*, *Juglans regia*, *Malus sp*.

The herbaceous species presented are those from the families of *Agrostis, Cynosurus, Deschampsia, Festuca, Lolium, Poa* and *Agropyron sp*.

The fauna - the specific fauna changed as the land use was modified. However, it should be noted that the fauna that adapted to the new conditions has prospered to some extent precisely because of the agricultural crops that have become an easily accessible source of feed for birds and rodents, and the growth of these populations has also attracted an increase of predator populations.

With the widespread increase in desertification, these species have migrated massively to other areas. However, specimens of rabbits (*Lepus europaeus*), foxes (*Vulpes vulpes*) and jackals (*Canis aureus*) can be found in the area.

The avifauna is the common one: *Passer domesticus, Sturnus vulgaris, Dendrocopos syriacus*, and rare specimens of *Cuculus canorus* and *Upupa epops.*

The waters of Jiu and the Danube are populated by a rich and diverse aquifauna, even though official estimates place it under normal potential.

Different species of lizards and snakes are found in the area, especially in the meadow as well as invertebrates: lumbricides, enchytraeids, colemboles, nematodes, mites, annelids.

RESULTS AND DISCUTIONS

In order to achieve the proposed objective, namely the ecological restoration of the land from the village of Lişteava through restoration of its productive capacity, it is necessary to go through several stages: 1. Construct the water supply system from Jiu River and the channel system needed to restore the hydrostatic level in the region; 2. Field preparation by deep scarification (60 cm); 3. Transport and deposition of the fermented sludge from the waste water treatment plants in order to fertilize the soil and achieve the mixture with the scarified soil; 4. Filling the hydrotechnical channel system with water; 5. Planting trees on the anti-erosion protection screens alignments; 6. Reducing the content of heavy metals in the newly formed soil by means of technical plants (tobacco); 7. Establishment of the planned crops.

1. Construction of the water supply system and the channel system necessary to restore the hydrostatic level in the region - it was chosen to construct an 800 mm diameter pipe, ensuring the necessary flow rate for the initial filling of the hydrotechnical channels and maintenance of the water level in them. In this way a more efficient control of the quality and quantity of water that can be used to create the artificial underground horizon in the area can be achieved. The total length of the pipeline will be 4.3 km and requires a single pumping station (at Jiu River intake), the rest of the water circulating gravitationally.

The hydrotechnical channels, that will ensure the creation of a new groundwater horizon in the project area, will have a depth of 1.5 m the transversal ones, respectively 1.8 m the longitudinal ones. The opening at the top will be 2 m for the transversal ones, respectively 2.5 m for the longitudinal ones and 1 m at the base. The part at the base of the channels will be paved with concrete slabs, while for the protection of the side walls natural rocks shall be used so as to allow the infiltration of water into the land undergoing restoration (Figure 3 a and b).

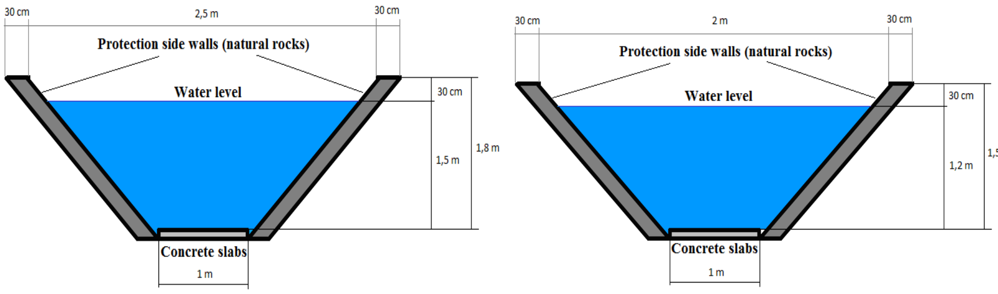

Figure 3. a) longitudinal hydrotechnical channels; b) transversal hydrotechnical channels

The total length of the hydrotechnical channels is 18 km and the permanently stored volume of water will be 39,150 m^3. The permanent water level in the two channel types will be 1.2 m in the transversal ones and 1.5 m in the longitudinal ones, ensuring a protection distance (in depth) of 30 cm from the ground level.

The distance between the two transversal channels is 300 m and the distance between the longitudinal channels is 1000 m. Adopting this way of laying the hydrotechnical channels the land is divided into 11 equal plots of 32.7 ha and a smaller one, of 15 ha (Figure 5).

Any surplus water (in times of extraordinary rainfall) will be evacuated to the southern side to a former irrigation channel.

2. Ground preparation by depth scarification (minimum 60 cm) - can be overlapped as a period of execution with the first stage. The degraded land will be scarified and eventually disked on a depth of at least 60 cm. This option is required for the soil blocks to be disaggregated so that in the next step, when the fermented sludge from the waste water treatment plants is added, a more compact and uniform mixture of the two types of material can be achieved. These disaggregation and grinding operations of the soil blocks must be carried out over a period of time in which the humidity of the material does not exceed 30%, otherwise it behaves as a clayey material and necessary fragmentation is not obtained.

3. Transport and deposition of the fermented sludge from the waste water treatment plants in order to fertilize the soil and achievement of the mixture with the scarified soil - the fermented sludge from the domestic waste water treatment plants from Dolj County will be transported and deposited on the previously prepared land surface (in stage 2). It will have to be equivalent to a uniform layer of 40 cm in thickness. The total volume of sludge required at this stage will be 1,500,000 m^3. After the fermented sludge has been deposited on the 12 plots is necessary to mix it with the fragmented and loosen material. This operation will be done using plough machines.

The major disadvantage resulting from the use of sludge from sewage treatment plants is related to the relatively high content of heavy metals (Table 1).

Table 1

Concentrations of elements in the sewage sludge from Craiova Waste Water Treatment Plant

Parameter	MAC cf. Order 344/2004	MAC cf. Order 756/1997 (warning threshold for sensitive uses)	Month	09.2017	10.2017	11.2017	12.2017
			MU	Determined values			
pH	-	-	pH unit	7.68	7.53	7.74	7.33
Moisture	-	-	%	80.98	82.8	79	81.2
Calcination loss	-	-	%	58.77	61.8	65.15	65.5
Total N	-	-	mg/kg ds	432	905.95	924	542.76
Total P	-	-	mg/kg ds	9,226	10,373	17,464	11,146
K	-	-	mg/kg ds	2,691	3,864	4,800	5,237
As	10	15	mg/kg ds	5.7	5.1	4.91	5.4
Cd	10	3	mg/kg ds	4.55	3.04	2.42	2.98
Total CN	-	5	mg/kg ds	<1	<1	1.14	<1
Co	50	30	mg/kg ds	10.2	8.36	8.99	7.88
Total Cr	500	100	mg/kg ds	97.7	95.2	94.6	99.6
Cu	500	100	mg/kg ds	420	250	482	319
Hg	5	1	mg/kg ds	0.89	0.9	0.24	0.28
Ni	100	75	mg/kg ds	68	65.2	67.4	68.5
Pb	300	50	mg/kg ds	80.4	66.7	71.7	73
Zn	2000	300	mg/kg ds	131,7	108,3	167	104.8
Total PAH	5	7.5	mg/kg ds	2.26	3.08	2.35	3.58

Due to the heavy metal content, the land can not be used directly for agricultural purposes. There is a real possibility that the harvested crops, due to the migration and accumulation of heavy metals into the plant body, to be compromised (DAMIAN ET AL., 2008; BIG ET AL., 2012; LASSOUED ET AL., 2013).

As can be seen from Table 1, the concentration of heavy metals in the sludge falls within the limits allowed by the legislation in force (Order 344/2004), but the values are above or close to the limits allowed by the Order 756/1997 on heavy metal concentration (the warning threshold) in soils with sensitive uses (in this category being included any agricultural activities).

From the point of view of the concentration of macronutrients, the fermented sludge can be regarded as an excellent fertilizer for the land depleted or deficient of these elements (GDAPM, 2011).

The method for reducing the heavy metal content of the anthropic soil obtained on the 375 ha of land undergoing ecological restoration will be presented in stage 6.

4. Filling of the hydrotechnical channels with water - the initial transfer of water from the Jiu River into the hydrotechnical channels will be made through the pipeline and by means of the pump station. The water level needs to be monitored permanently in the channels, to ensure the required optimal groundwater conditions near the land surface, as well as the water quality of Jiu River in the area of the intake.

5. Planting the trees on new anti-erosion protection screen alignments - as we have shown in the previous chapters, the land in the studied area has been heavily affected by erosion, especially by wind, due to the fact that the inhabitants of the area have cleared the forest protection screens.

For this reason, the first category of biotic interventions refers to the restoration of forest protection screens in the area of the ecological restoration works. For this purpose, mesohydrophylus ash trees (*Fraxinus pallisae*) will be used along the perimeter of the ecologically restored land on the exterior side. Ash trees will also be planted along the longitudinal middle channel on either side of it. The location of anti-erosion protection screens is presented on the situation plane from Figure 5.

On the new alignments set for tree planting, a four-row alternating planting scheme will be used. Total protection screen lengths will be 6.5 km (requiring a total area of 4 ha).

Under the new conditions offered by the land, the recommended species is ash tree (*Fraxinus pallisae*), and the planting scheme applied will be 2/1 - 5,000 seedlings/ha. According to this scheme, there will be necessary: in year I - 4 ha x 5000 seedlings/ha = 20,000 seedlings; a total of 40% is foreseen for completion works (in year II - 30% = 6,000 seedlings, in year III - 10% = 2,000 seedlings). The total number of seedlings from year I to III = 28,000.

Planting will take place in the autumn (October - November), the biotic material will be accompanied by health certificates and will comply with SR 1347/2004 for ash tree. The seedlings will be planted in holes of 30/30/30 cm, with root borrowing soil.

6. Reducing the content of heavy metals in the newly formed soil by means of technical plants (tobacco) - the disadvantage of the use of sludge from sewage treatment plants is the relatively high content of heavy metals (NYAMANGARA AND MZEZEWA, 1999; USMAN, 2012; FAUR ET AL., 2016).

In order to reduce this heavy metal content from the anthropic soil obtained on the land surface undergoing ecological restoration so that it will be appropriate to the practice of agriculture, it was chosen to practice a crop of technical plants, in this case tobacco, for two years from the completion of the previously presented works.

Why tobacco?

Because studies conducted by specialists have highlighted the high ability of this species to assimilate and fix heavy metals from soil in different tissues.

Heavy metals present in soil and plants can manifest themselves as microelements, some of which have a positive effect on the development of tobacco, sometimes they may be phytotoxic depending on their level of presence or may have a negative influence on the smoking taste. The main heavy metals important for tobacco are: Cu, Zn, Co, Pb, Mn, As, Hg, Cs, Li, Fe, Cd, Ni, Cr (PĂTRAȘCU, 2006).

From a series of experiments, it was confirmed that tobacco (Figure 4) absorbs heavy metals easily and translocate them into the leaves. The content of heavy metals (Cd, Cr, Co, Cu, Ni, Pb) was determined in some tobacco varieties (Table 2) (ZDREMȚAN ET AL., 2010).

Figure 4. Species of tobacco: Virginia, Burley and Oriental (PĂTRAȘCU, 2006)

Variations in the content of heavy metals depend on the type of tobacco, the stage of plant development, foliar floor, crop technology, crop area, soil type, etc. (ZDREMȚAN ET AL., 2010).

Table 2

Absorption of heavy metals (mg/kg tobacco) for standard crops (ZDREMȚAN ET AL., 2010)

Crt. No.	Heavy metal	Tobacco species		
		Virginia	Burley	Oriental
1	Cd	1.00 – 3.00	5.10 – 7.00	0.10 – 0.70
2	Co	0.90 – 1.54	0.00 – 0.55	NA
3	Cr	0.89 – 1.55	0.90 – 1.54	NA
4	Cu	14.00 – 21.00	14.01 – 21.20	NA
5	Ni	3.89 – 4.52	3.78 – 7.83	NA
6	Pb	11.8 – 16.20	12.8 – 17.12	NA

It is worth mentioning that tobacco, generally is cultivated on basic soils (pH = 7.5-8.5), which facilitates the solubilization of heavy metals and thus improves absorption.

Obviously, these cultures, from the first two years, can not be economically exploited, and they are more like waste. For this purpose, for weight and volume reduction, it is recommended that these crops be dried and chopped, and then sent either to special waste storage facilities or to incineration plants. Planting the tobacco on the land for which the reduction of the heavy metal concentration is intended is carried out conventionally, by sowing, the amount of seed per hectare being 200 kg.

7. Establishment of the planned crops - after the reduction of the heavy metals content of the newly created soil on the land surface of 375 ha under ecological restoration (after the two years of tobacco cultivation) the land can take over the agricultural function. Thus, the final objective of the ecological restoration works, namely the reintroduction of the land affected by desertification into the productive circuit is achieved (the cultivated species being chosen according to the pedo-climatic conditions).

Figure 5 shows the final situation plan of the land subjected to ecological restoration.

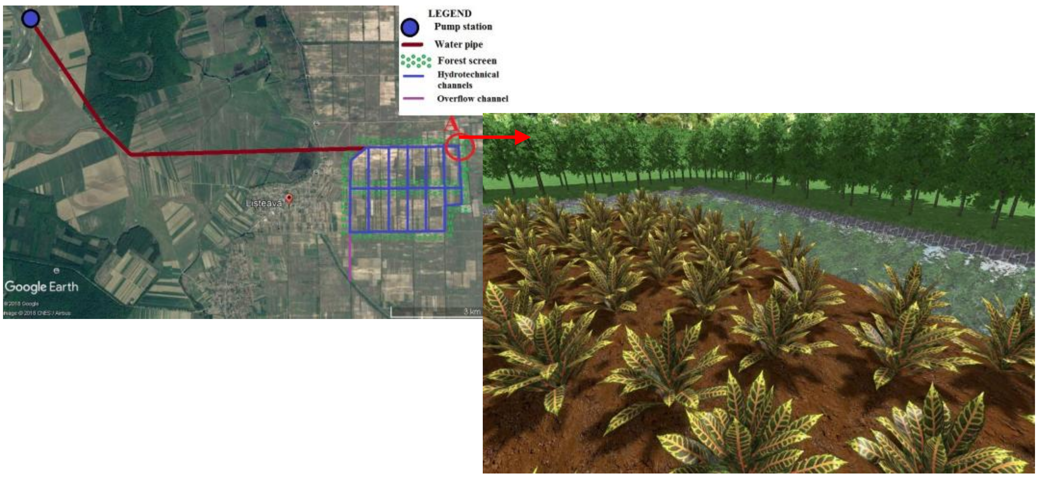

Figure 5. Final situation plan

CONCLUSIONS

For the design of the ecological restoration works of the land in question, the existing physical, chemical and pedological conditions were analyzed and solutions for their restoration were identified by establishing the necessary works. It was started with the needs of local communities, taking into account the plans to combat desertification developed by the UN, the European Union and the central authorities in Romania and the extent to which these plans were already included in the landscaping plans developed by the local authorities.

One of the most important works, namely the restoration of the hydrostatic level in the region, involves the creation of an artificially phreatic layer through channels. This method has been successfully tested on land affected by desertification in the US and Central America.

In order to restore the fertility conditions (nutrients and organic matter) it was chosen to use fermented sludge from domestic sewage treatment plants at the expense of the use of artificial fertilizers. This option was chosen in accordance with the national strategy for sludge management. The disadvantage of using sewage sludge consists in the relatively high concentrations of heavy metals in the sludge, but this disadvantage can be relatively easily exceeded.

The proposed model can be taken over and implemented for other land areas affected by the desertification phenomenon.

However, it should be clear that such a project can not be implemented by resorting only to local or county resources, in this sense it is necessary to find financing sources at central or EU level.

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