DOCTORAL THESYS SUMMARY

entitled

THE USE OF SATELLITE IMAGES TO IDENTIFY AREAS EXPOSED TO DESERTIFICATION

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Land degradation leading to desertification is among the most important concerns of nowadays scientists, despite the constant presence during the last decades, both at global and European level, affecting more than 20% of the global population.

Desertification is considered to be a vulnerability phenomenon, with a step by step instalment and most of the times irremediable. Globally 2/5 of the dry land is affected by desertification causing social, economic and environmental imbalances.

In Romania, the south part of the country has been traditionally agricultural and at the same time has been intensely affected by desertification, due to the natural and anthropic factors. Since 1997, through the approval of Romanian Law 629, ratifying the United Nations Convention to Combat Desertification – UNCCD, national objectives, targets and measures have been adopted and upgraded in order to diminish and minimize the desertification risks.

The main purpose of this study is to contribute to the achievement of the UNCCD Convention objectives, through the identification of the desertification exposed or affected areas, using satellite images. The focus is on Braila County, with second the most extensive land reclamation system in the country. The satellite images were downloaded from free data bases and used to compute 4 vegetation indexes largely used by scientists for desertification evaluation. Braila county selection is based on the high agricultural capacity of this perimeter, mainly for grains and sun flower, intensively and extensively exploited.

Here, due to climatic and edaphic factors, along with human interactions, more than 2000 hectares transformed in desertification sectors and at least another 2000 ha are on the verge of desertification. Despite the research studies since 1975 proving desertification presence in Braila county, from 1990 to 2000 the phenomena grew in intensity along with the undoing of the land reclamation systems, because of to the agricultural holdings fracture, production variations and social and economic transformations.

In chapter I the main approaches to study the desertification phenomenon and the evolution of this issue nationally and internationally were presented. If the evaluation of desertification made sense, traditionally, in the arid and semi-arid areas, due to the UNCCD statistics stating that each year about 40.000 hm^2 are being lost, desertification became the third worldwide environmental issue, after fresh water diminish and climate change.

At the country level, the National Strategy and Action Plan for the Control and Prevention of Desertification in Romania, issued in 2012, confirms that most of the agricultural surfaces are affected by draught, estimating that 1/3 of it is in different stages of soil degradation where the most important factor is water erosion and landslides, affecting over 7 million hectares.

Upshots, 3 areas of draught sensibility have been established in Romania which could cause desertification based on the evaluation of Palfay's aridity index (PAI), namely: Area 1, where annual values of PAI vary between 6 and 12, with the draught years frequency of: 63% in Calafat, 60% in Tulcea, 57% at Adamclisi, 51% at Valu lui Traian, 49% at Grivița and Tecuci, 46% at Craiova and 40% at Galați. Area 2, where annual values of PAI vary from 4 to 6, while the frequency of draught years is between 5% - 34%, at Alexandria for example, and Area 3 where annual values of PAI vary between 2 and 4, with the draught years frequency between 6% at Pitești and 11% at Suceava. Braila County, the subject of this study, has the agricultural landstaf across 2 areas of draught sensibility, varying from moderate drought (where PAI is between 4 and 6) and strong drought (where PAY is between 8 and 10).

In the second chapter of the thesis I have analysed the main characteristics of desertification areas, in order to identify the triggering factors for soil degradation and desertification instalment. Thus, the main processes prior to desertification rely on the

deterioration of the physical, chemical and biological soil components, along with the green cover ravage and important mitigation of soil water reserve.

The National Action Plan for the prevention and control of draught, desertification and land degradation (2001 – 2020) establishes in Romania 4 main climatic areas, classified according to the aridity index R. For Braila county, here analysed, R is between [0, 50 – 0, 65] stating a sub-humid area, where agriculture is based on precipitations. It is important to mention this classification as, during the study, values of aridity index R have been recalculated as fraction between precipitations and potential evapotranspiration extracted from satellite images. The computed values of the aridity index R resulted much lower than the above classification, enclosing Braila County in the arid and semi-arid area rating.

Actually, Braila County has been historically among the hottest and draughtiest areas of the country, as shown by the index for ecosystems sensibility to desertification computed by ICPA, placing to a critic 2 – 3 sensibility level, considering the edaphic fundament and climatic and anthropic factors combined actions.

In chapter three I have presented the natural resources of the study area, starting from the analysis of the meteorological conditions triggering land desertification, from 1894 to 2016, splited in draught intervals and seasons with rain deficit, out of which, 2007 points out with high summer temperatures and the softest winter in the history of meteorological recordings.

Geographically, Braila is situated in the South-Est Region of Romania, with a 4.700 km2 area and little over 300.000 inhabitants, a medium sized county with only 4 towns. It is a component of the Baraganu Plain, with intensive and extended agricultural use, both natural and artificial, due to the land rehabilitation works.

The main physical and geographical units analysed are Braila Plain, as a hole, characteristics of plains, lakes and lacustrian hollows, surface and phreatic waters; main climatic characteristics were interpreted, namely: precipitations, shadow temperatures, soil level temperatures, winds and atmospheric pressure, for the values recorded between 1961 and 2016. Alike, I have presented the main characteristics of the flora and fauna specific to Braila County along with the natural protected areas of national and international interest, as key elements in the land desertification process.

For the same reason, I have reviewed the quality and composition of soils, from the agricultural use suitability, with the predominance of the second class out of five, *good*, defining low limitation fields, brutish texture, salty, ununiformed and near surface phreatic water, as well as the third class, *intermediate*, defining moderate limitation fields, sandy, clay textures and phreatic waters situated at 1-2 m depth.

The transformations in agricultural holdings due to the land reclamation works and social context were analysed from 1990 to 2016. The total of 380.000 hectares of irrigation and drainage systems decreased dramatically, with the dissolving of numerous pumping stations and irrigation systems due to land property defragmentation. For the desertification study purpose, I looked over the forestry areas evolution, which has been growing very little during 1990 – 2016, up to 5% of the county area, one of the smallest percentages in the country and Europe.

In chapter four I have presented the objectives of the study, by designing a working scheme, for:

- Computing the aridity index for the territorial and administrative units of Braila County, through the UNEP formula, adopted in 1992, extracting the potential evapotranspiration values from MODIS satellite images.

- Computing the NDVI, NDWI, VCI and NDDI for each of the territorial units of Braila County, during 2000 – 2016 and analysing the impact of these variations on plants phenology specific to the area.

- Analysing the land usage categories resulted from satellite images, CLC type, for the determination of the land use variation, identification of changes in agricultural areas and correlation with the vegetation indexes values.

In chapter five I presented the materials and methods used for the achievement of the aforementioned objectives Materials were classified in data bases: (1) Climatic, resulted from the recordings at the meteorological station in Braila. (2) Satellite, consisting in MODIS satellite images, 8 days synthesis, for the determination of vegetation indexes, NDVI, NDWI, VCI and NDDI, available and downloaded from http://glovis.usgs.gov/ as well as CLC satellite images, resulted from the CLC Project, namely CLC 1990, CLC 2000, CLC 2006 and CLC 2012, as

reference data for land usage variation at continental level, available and downloaded from land.copernicus.eu/pan-european/corine-land-cover. (3) GIS data base, comprising of maps of the urban and rural land use in Braila County, territorial and administrative organisation and partitioning, hydrographic network, transport network and forests.

Consequently I have presented the methods, step by step satellite images processing, for the determination of the aridity and vegetation indexes, with ArcGIS software, for the interval 2000 – 2016. Similar, I have detailed the CLC data extraction using the same ArcGIS software and the centralisation of the land use variation, by timed category.

In chapter six I have analysed the results computed from the satellite images, in order to determine whether desertification has evolved in Braila County during 2000 – 2016. I have taken into account that the phenological evolution of vegetation in an agricultural area such as, is dependent on the soil capacity to retain and deliver water and nutrients for plants and from this regard, I have evaluated the intensity and extension of desertification through the multidimensional and correlar analysis of the specific vegetation indexes.

The aridity index, as annual and vegetation mean, indicated that Brăila, Vădeni, Cazasu, Grădiștea and Chiscani can be concluded as arid territories, while Mărașu, Galbenu, Movila Miresei, Gropeni, Stăncuța, Frecăței and Ciocile have aridity indexes corresponding to semi-arid areas, along with the rest of the county. Similar results of the computed values of NDVI, with a variation from 0, 01 to 0, 4 the highest values of the multi annual mean between 2000 – 2016, being determined for Berteștii de Jos, of 0,40 which confirms a lack of vegetation cover in the area. General considerations ascribe low values of NDVI, under 0, 14 to lack of vegetation or very dried, while high values of NDVI, above 0, 70 confirm healthy and dense vegetation.

The computed values of NDWI have been analysed along with the VCI. The multi annual means of NDWI indicates a medium towards rare vegetation at Marașu, Frecăței, Chișcani, Gropeni, Stăncuța, Vădeni, Berteștii de Jos, Brăila, Tichilești and Măxineni. The resulted values of VCI state that out of the 44 localities analysed, only 7 can be considered affected by moderate and severe draught while the rest of 38 can be classified as extreme draught affected areas, with unique values of VCI varying from 0, 99 at Cazasu to 0, 43 at Vădeni.

General considerations ascribe high values of NDDI, above 0, 5 as indicators for the constantly draught affected areas and through the analysis of the multi annual means in Braila county, for 31 out of 44 localities the NDDI values were high, from 0, 52 in Romanu to highest of 3, 03 at Măxineni, 3, 1 at Surdila Găiseanca and Traian, 3, 3 at Stăncuța and the maximum of 4, 6 at Zăvoaia. The validation of the desertification affected areas determined through previous vegetation indexes was reconfirmed by the NDDI values, in the study area.

Summarizing, from the vegetation indexes analysis, 30 out of 44 localities in Braila county are affected by severe and extreme draught and out of these, Brăila, Vădeni, Cazasu, Grădiștea and Chiscani have important former agricultural areas turned into arid soil, while at Mărașu, Galbenu, Movila Miresei, Gropeni, Stăncuța, Frecăței and Ciocile more than 50% of the surface is semi-arid.

The comparison between the CLC editions from 1990, 2000, 2006 and 2012, aimed to validate the results computed from MODIS satellite images. Thus, it was confirmed a reduction of the agricultural land use, with more than 16.000 hectares, simultaneously with the spectacular extension of secondary pastures, with over 22.000 hectares. The vineyards are diminishing with over 3.580 hectares while the orchard areas extended with 780 hectares. As far as the forestry areas, in 1990 there were 18.845 hectares accounting for 3, 96% of the county, growing to 4, 35% in 2000, 4, 77% in 2006 and 4, 75% in 2012, representing very little steps in minimising and limiting the desertification areas in Braila County.

The general conclusion of the study is that vegetation indexes computed from satellite images use can be a precise and standardised tool, automatable and updatable with no direct costs, helpful for the authorities, agricultural holdings managers and all other stakeholders, in order to determine the exact position and dimension of desertification affected or exposed to areas, as well as the intensity of the phenomena via the severity levels of these indexes.

The future agricultural sustainable management in Braila will have to integrate reconstruction measures for the desertification affected areas, in order to limit its extension over productive fields, by establishing ameliorative solutions according to the specific soil entities, in order to protect each agricultural sector.