ANALYSIS ON THE DYNAMICS AND VULNERABILITY OF THE AREAS COVERED BY FORESTS, HARGHITA COUNTY

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***Abstract**: In this article the main topic of interest is to explore the analyzing possibilities of exploiting data available from multiple sources. We chose to use several methods of data investigation, as follows: in the GFW (GlobalForestWatch) geoportal; in the ArcGIS Online application created based on MapBuilder; in ArcGIS Pro.*

The results and conclusions were extracted based on charts and model elements, offered by the latest version of ArcGIS Pro.

The purpose of this work consisted in integrating different sources of data regarding forested areas. Thus, it is revealed the importance of integrating the information that can be obtained in GIS with those from the geoportals of spatial data, all of which can bring benefits to the local administration for creating strategies. The obtained result draws attention to protected areas vulnerable to change by 2050, and also present in loss areas, constituting a starting point for the thorough monitoring of these areas.

***Keywords:** GFW, ArcGIS Online, MapBuilder, ArcGIS Pro, forest loss, forest gain, GHG (greenhouse gas), LULUCF (Land Use, Land-Use Change and Forestry)*

1. Introduction

A real problem is represented by multiple land use practices in forests lead to loss of carbon stocks and emissions of carbon dioxide and, if the biomass is burned during the clearing process, additional non-CO2 gases are emitted [1] There is a correlation regarding deforestation and GHG emissions, according to [2], though emissions from deforestation and forest degradation account for 11% of greenhouse gas (GHG) emissions. At the same time nearly 1.6 billion people depend on these forests for food, water, shelter and energy.

On 14 July 2021, the European Commission adopted a series of legislative proposals. There was setting out how EC intends to achieve climate neutrality in the EU by 2050. It exists an intermediate target of an at least 55% net reduction in greenhouse gas emissions by 2030, compared to 1990. The legislative proposal package is focused on revising several pieces of EU climate legislation, including the EU ETS, Effort Sharing Regulation, transport and land use legislation, setting out in real terms the ways in which the Commission intends to reach EU climate targets under the European Green Deal. [3]

Efforts are being made to consider keeping them intact, more sustainable management of forest-covered areas, and reforestation of lost forest areas. [4] It is a fact that forests provide healthy ecosystems, including by protecting biodiversity, and help in sustainable development. One of the major topics of UNCC (United Nations Climate Change) [5] is Land Use, Land-Use Change and Forestry (LULUCF), land being a source and also a sink of GHGs, playing a key role in the exchange of energy, water and aerosols between the land surface and atmosphere. It is stipulated in [6] that among the measures related to forest management, reduced deforestation and degradation, reforestation and forest restoration, afforestation, are worth mentioning

REDD+, forest conservation regulations, recognition of forest rights and land tenure, adaptive management of forests, land-use moratoriums, reforestation programmes and investment.

One of the dangers affecting Romania is the desertification phenomenon [7], being developed in this respect of the Desertification Indicator System for Mediterranean Europe [8]. There were investigated deforestation issues in [9], by using a model that had been created from a layer containing information on the forests of Romania and a layer on forests which are considered to have a risk of deforestation, being extracted information on different types of surfaces covered with forest in Dambovita county - deciduous, coniferous and mixed, using specific functions.

An aspect of interest is the assessment of the degree of desertification (figure 1), sensitivity to the desertification of the different spatial homogeneous units being defined by an index (FDI: index of sensitivity to the Desertification) obtained from the geometrical average of three indexes of the soil quality, climate and vegetation [10].

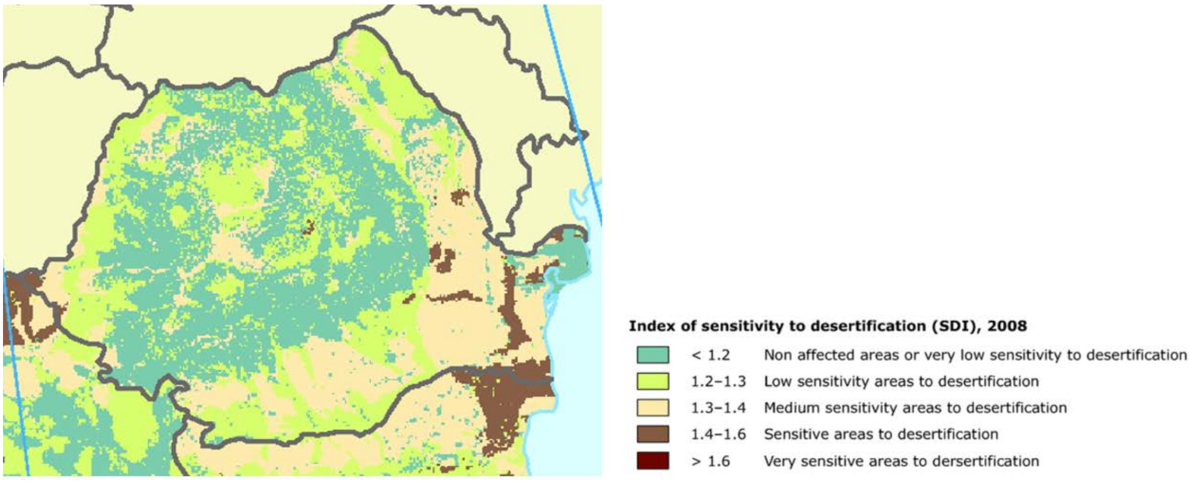

Figure 1 – Highlighting Desertification using Index of Sensitivity [10]

Currently there are a multitude of open datasets that can be used when one wants to analyze the analysis of the land cover and especially the analysis of the dynamics of the areas covered with forests. In this paper we want to emphasize the possibility of analyzing these open data using GIS tools.

2. Materials and Methods

To carry out this study, multiple source open data was used, which was integrated and analyzed using ArcGIS Pro. The study area was chosen in Romania, in Harghita County.

The input data are annual forest loss data and annual forest gain data [14], in raster format, at 30 m spatial resolution, produces as a collaboration between the GLAD (Global Land Analysis & Discovery) lab at the University of Maryland, Google, USGS, and NASA. In this dataset tree cover is defined as all vegetation greater than 5 meters in height, and may take the form of natural forests or plantations across a range of canopy densities. Loss indicates the removal or mortality of tree cover and can be due to a variety of factors, including mechanical harvesting, fire, disease, or storm damage, so this term does not equate to deforestation [14].

It was used ArcGIS - Land Cover Vulnerability Change 2050 - regional model layer useful for performing analysis within a single continent. The predictions are integrated in this layer, within each continent of relative vulnerability to modification by humans by the year 2050, being based on ESA CCI land cover maps from the years 2010 and 2018. As variable mapped is vulnerability of land cover to anthropogenic change by 2050, global extent, cell size has 300m, the visible scale: 1:50,000 and smaller, being developed by Clark University, in April 2021. The model predicts land cover changes based upon patterns it found in the period 2010-2018, but it cannot predict future land use [17].

A vector shapefile containing the area of Harghita county was used for analysis (online analysis and ArcGIS Pro). It was downloaded Hansen_GFC-2020-v1.8_lossyear_50N_020E [14], [16].

The WDPA (World Database on Protected Areas) is a joint project of UNEP (United Nations Environment Programme) and IUCN (International Union for Conservation of Nature), produced by UNEP-WCMC (World Conservation Monitoring Centre) and the IUCN World Commission on Protected Areas working with governments and collaborating NGOs. The World Database on Protected Areas (WDPA) is a global database including terrestrial protected areas, internationally recognised in conserving species and ecosystems. UNEP-WCMC has been processed the data and making the information available to the global community, through its Protected Areas Programme [15].

The forest base map includes both ‘natural’ forests and planted trees, using 20% canopy cover threshold and resampled to 300 m. Online tools are being developed to enable users to tailor the global assumptions, weights, and criteria. [18].

Application development was made using an ArcGIS Online account by the organization. Layers from GFW loss, gain, nature reserves, LULC (Copernicus), LivingAtlas2050 data were used.

There were performed analyzes using three possibilities in this article:

1. in the GFW geoportal;
2. in the application created in ArcGIS Online based on MapBuilder;
3. in ArcGIS Pro

In fact, GFW is an online platform that provides data and tools for monitoring forests, being used especially for manage forests, stop illegal deforestation and fires, call out unsustainable activities, defend their land and resources, sustainably source commodities, and conduct research at the forefront of conservation [16].

MapBuilder, as a GFW tempate, offers the possibility to create a customized monitoring application by combining the spatial data on GFW with the own data.

It was used a paid-for ArcGIS Online organizational account in order to use MapBuilder. Organizational accounts provide advanced web-mapping features designed for users that work within a group, team or organization. In addition to the public account features, organizational account users have private data and map sharing capabilities. Areas created on a MapBuilder App are synced with MyGFW area subscriptions and dashboards on the main GFW platform – in this case for Harghita County area.

The geospatial data can be visualized and overlayed to better understand what’s happening in a particular place, identify information on map features – data, analyze features, satellite imagery and basemaps, by performing on-the-fly analyses to see statistics on how the data has changed over time [16].

It was used ArcGIS Pro to analyze data in depth, by integrating the geoprocessing tools in Model Builder. [12]

3. Case Study Results

Harghita County was chosen for the case study. In figure 2 is highlighted tree cover loss between 2001 and 2020. In figure 3 is emphasized the forest loss analysis between 2001 – 2021 using canopy density greater than 20% and greater than 75% using GFW.

From 2001 to 2020, Harghita, Romania lost 38.8kha of tree cover, equivalent to a 12% decrease in tree cover since 2000. [14]

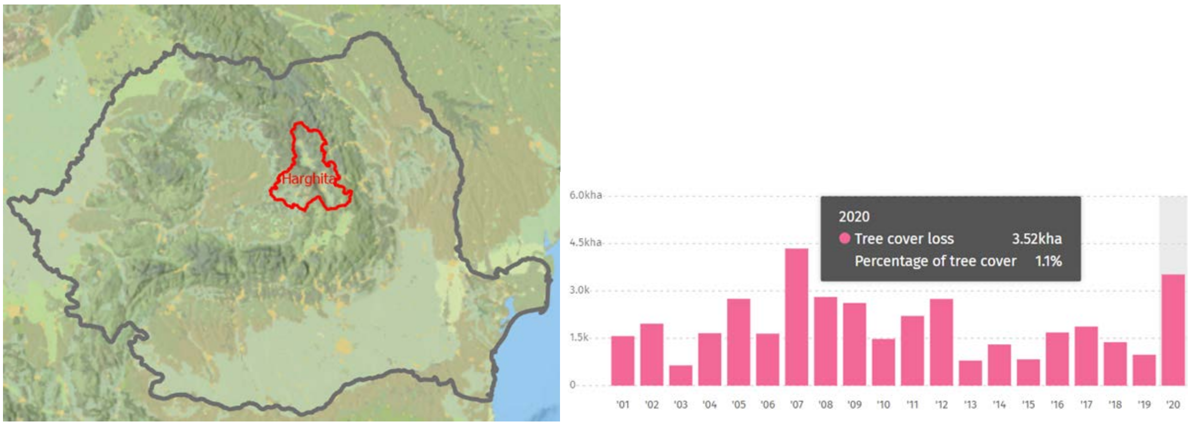

Figure 2 – Tree cover loss in Harghita County between 2001 and 2020 (analyzed using [16])

We analyzed the fire alerts using GFW. In Harghita the peak fire season typically begins in late February and lasts around 11 weeks. There were 3 VIIRS fire alerts reported between 19th of April 2021 and 11th of April 2022 considering high confidence alerts only. This is normal compared to previous years going back to 2012. (figure 4)

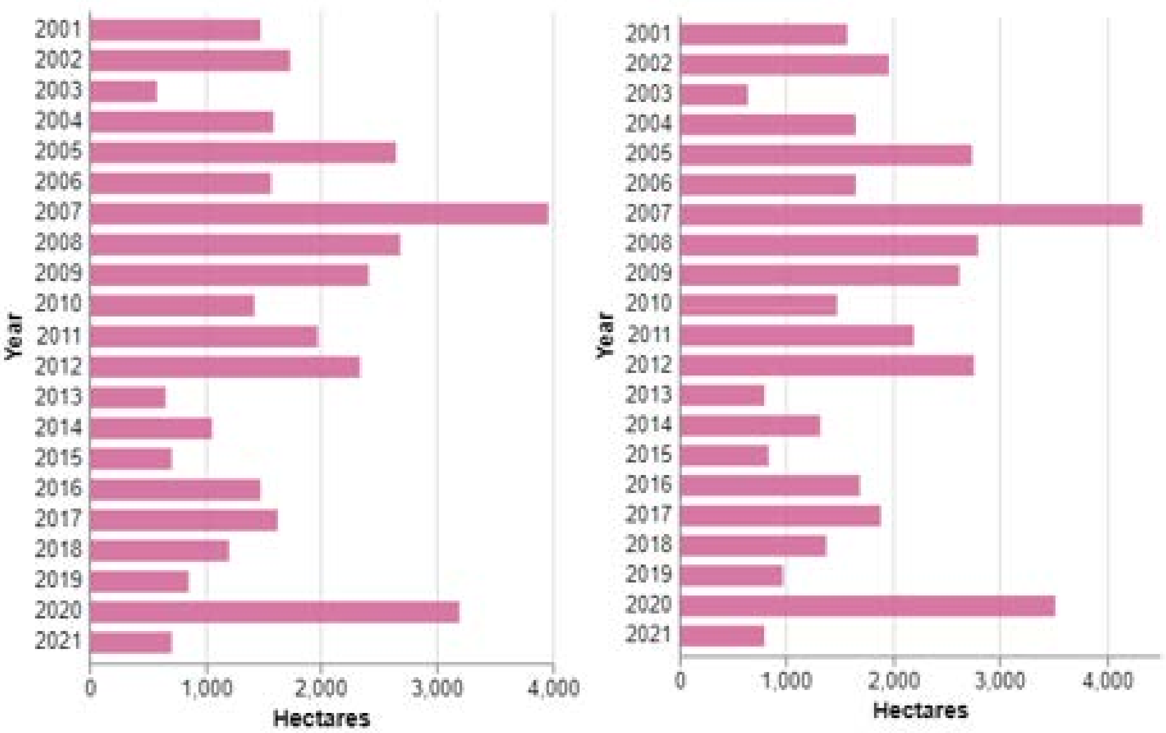

Figure 3 - Analysis comparing Forest Loss between 2001 – 2021 using Canopy Density >20%, >75% (analyzed in ArcGIS Online based on MapBuilder App)

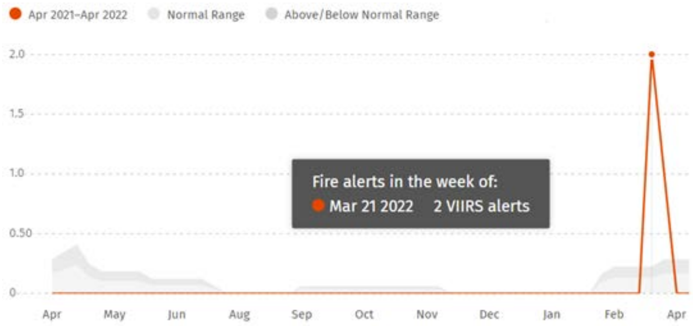

Figure 4 - Fire Alerts in the last year (analyzed using [16])

Between 15th of April 2019 and 11th of April 2022 Harghita experienced a total of 107 VIIRS Alerts fire alerts, with a peak of 23 alerts on March 10, 2014. Between 2nd of January 2012 and 11th of April 2022 Harghita experienced a total of 454 VIIRS Alerts fire alerts, with a peak of 55 alerts on March 10, 2014.

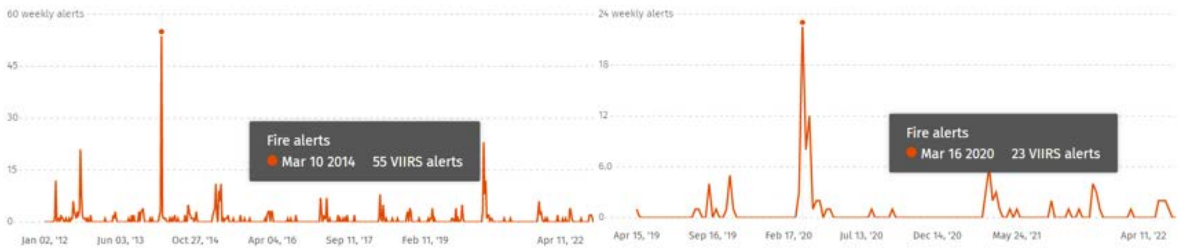

Figure 5 – Comparison between Fire Alerts in 2014 and 2020 (analyzed using [16])

An important impact of the forest coverage was that between 2001 and 2020, forests in Harghita emitted 994KTCO₂E/YEAR, and removed -3.21MTCO₂E/YEAR, this representing a net carbon flux of -2.21MTCO₂E/YEAR these results showing a net removals as a negative value of the forest-related GHG in Harghita. (figure 6)

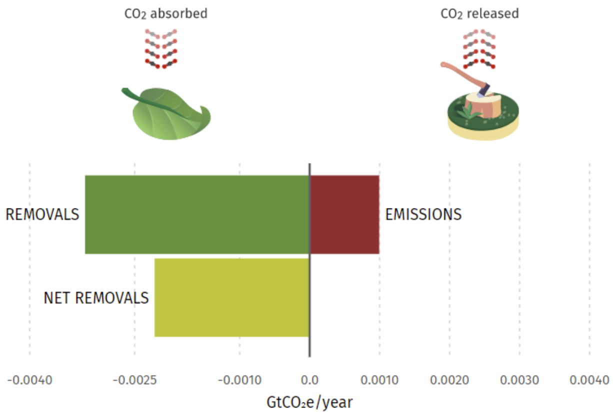

Figure 6 - Forest-related GHG in Harghita, Romania (analyzed using [16])

The graph from figure 6 displays the average annual emissions from removals (sequestration) by, and net flux of greenhouse gases between forests and the atmosphere between 2001 and 2020. The methods used to calculate these are described in [13], which introduces a geospatial monitoring framework for estimating global forest carbon fluxes, following IPCC Guidelines for national GHG inventories [14].

From 2013 to 2020, 99% of tree cover loss in Harghita occurred within natural forest. The total loss within natural forest was equivalent to 7.03Mt of CO_2e emissions. As of 2000, 49% of Harghita, Romania was natural forest cover, Natural Forest 323kha, Plantations 4.24kha, Non-Forest 338kha. Wood fiber/timber represent the largest plantation area by type, spanning 6.21kha and 0.93% of land area.

In figure 7 it was analyzed (in Mapbuilder App) the land cover composition.

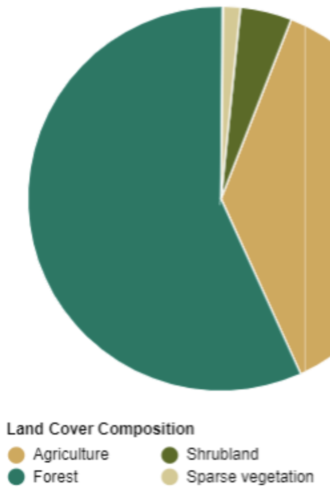

Figure 7 - Land Cover Composition (analyzed using MapBuilder App)

Figures 8, 9, 10,11 looked at Tree Cover Loss overlapped on Tree Cover Height, Forest GHG Emissions overlapped on Tree Cover Height, Harghita Forest landscape Integrity Index using High Resolution Imagery.

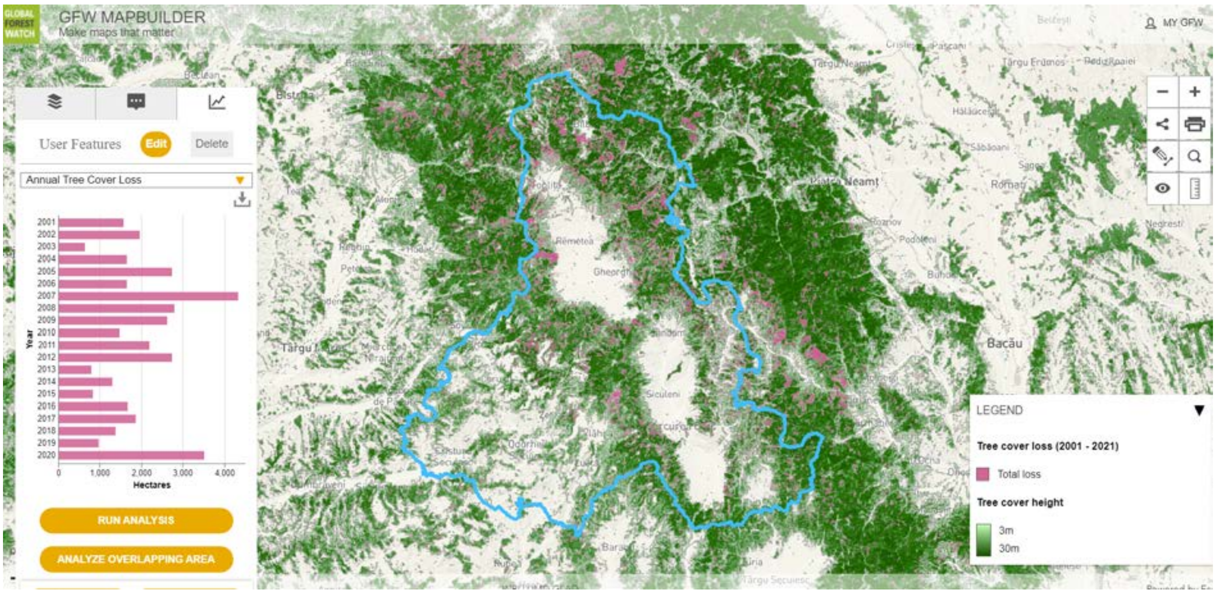

Figure 8 – Analysis of Tree Cover Loss overlapped on Tree Cover Height (analyzed using [16])

Figure 9 – Analysis of Forest GHG Emissions overlapped on Tree Cover Height (analyzed using [16])

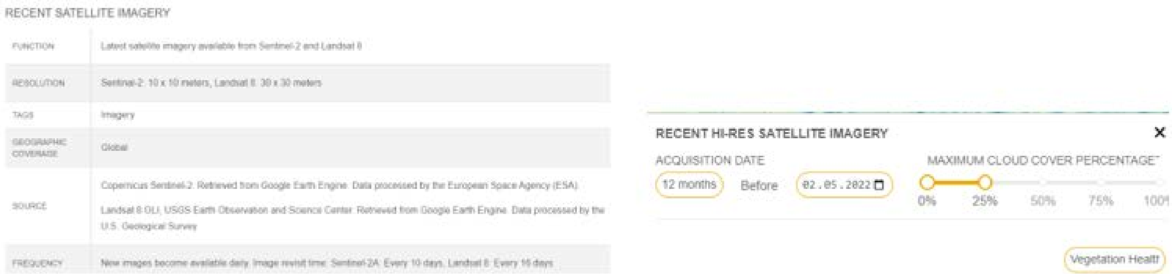

Figure 10 – Adding High Resolution Imagery [16]

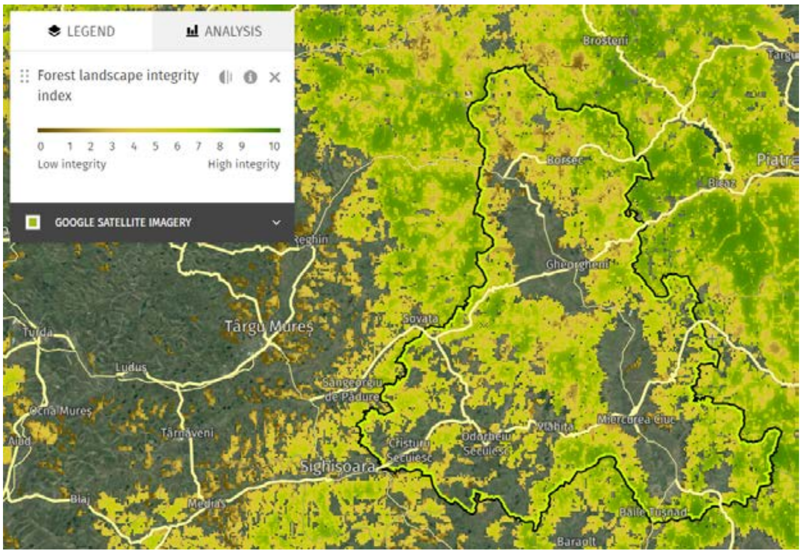

Figure 11 - Harghita Forest landscape Integrity Index (analyzed using [16])

The following layers have been loaded into ArcGIS Pro : Land Cover Vulnerability Change 2050, Hansen_GFC-2020-v1.8_lossyear_50N_020E and WDPA (figure 12). National statistics and WDPA statistics might differ due to difference in what is considered as protected areas, methods followed to calculate the area, and datasets used to assess protected area coverage. [1919] For the Land Cover Vulnerability Change 2050, only the values 0.8-1 were taken into account. A model for analysis has been developed. (figure 13) Based on these elements, the vulnerable protected areas at the level of year 2050 have been determined. The vulnerable areas were obtained by designation: international, national, regional, a total of 268ha in this county. In figure 14 is given an example of a Special Protection Area vulnerability result.

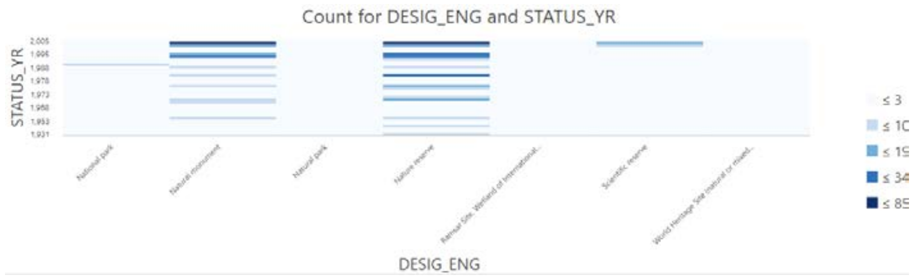

Figure 12 – WDPA Dataset on Years by Type

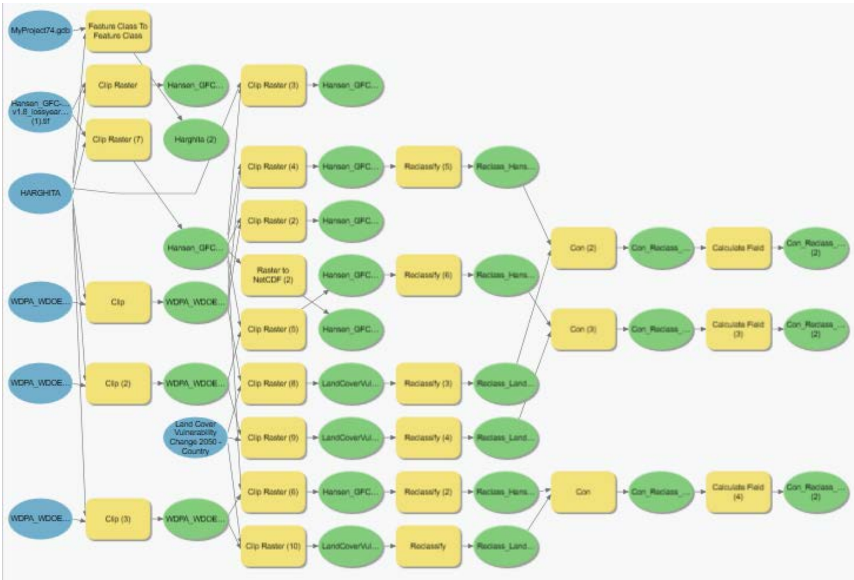

Figure 13 – Extract from the Workflow in ArcGIS Pro, designed in Model Builder

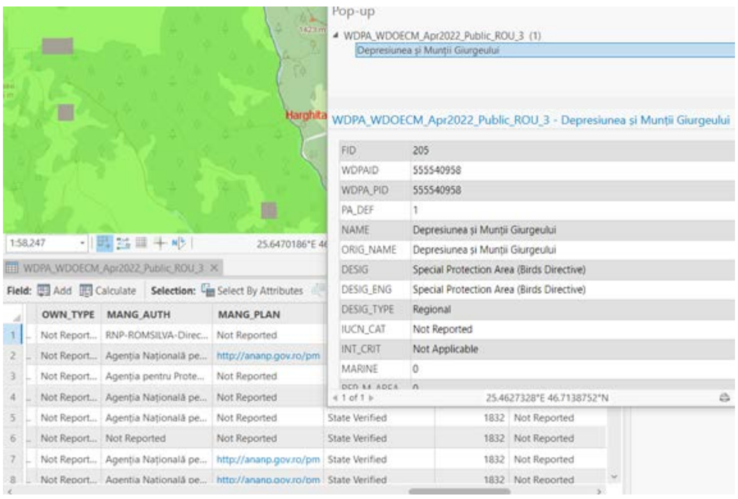

Figure 14 – Example of Vulnerability Areas in a Special Protection Area

4. Conclusions and Limitations

It is important that the administration at the county level takes into account this open data regarding the vulnerability of forested land areas. In this study we have highlighted both the open data sources that can be used, but also the integration for obtaining the overall information with impact on the environment.

In general, we must follow the use of open datasets that are becoming more and more accessible, both globally and at European level, be it raster datasets or vector, made available through geoportals of spatial data.

The obtained result draws attention to protected areas vulnerable to change by 2050, and also present in loss areas, constituting a starting point for the thorough monitoring of these areas. Basically, areas highlighted as having a high vulnerability coefficient should be monitored in the future, by investigating the situation in the field.

For a larger study, the data from the local forest districts can also be integrated, so that the dynamics of the surfaces highlighted in this study can be verified. The conclusions may support the taking of some measures at the level of the Romsilva National Forest Administration (RNP Romsilva) and whose implementation is the responsibility of the County Forestry Directorate.

5. References

1. *DeFries, R., Achard, F., Brown, S., Herold, M., Murdiyarso, D., Schlamadinger, B., & de Souza, C. (2007). Earth observations for estimating greenhouse gas emissions from deforestation in developing countries. Environmental Science & Policy, 10(4), 385–394. https://doi.org/10.1016/j.envsci.2007.01.010*
2. *Forests and agriculture. (n.d.). Retrieved April 12, 2022, from https://ec.europa.eu/clima/eu-action/forests-and-agriculture_en*
3. *Land use and forestry regulation for 2021-2030. (n.d.). Retrieved April 12, 2022, from https://ec.europa.eu/clima/eu-action/forests-and-agriculture/land-use-and-forestry-regulation-2021-2030_en*
4. *Forests and climate change. (2017, November 11). IUCN. Retrieved April 12, 2022, from https://www.iucn.org/resources/issues-briefs/forests-and-climate-change*
5. *Land Use, Land-Use Change and Forestry (LULUCF) | UNFCCC. (n.d.). Retrieved April 12, 2022, from https://unfccc.int/topics/land-use/workstreams/land-use--land-use-change-and-forestry-lulucf*
6. *https://www.ipcc.ch/site/assets/uploads/sites/4/2020/07/03_Technical-Summary-TS_V2.pdf retrieved April 12, 2022*
7. *Cherlet, M., Hutchinson, C., Reynolds, J., Hill, J., Sommer, S., von Maltitz, G. (Eds.), World Atlas of Desertification, Publication Office of the European Union, Luxembourg, 2018, Retrieved April 12, 2022 from https://wad.jrc.ec.europa.eu/sites/default/files/atlas_pdf/JRC_WAD_fullVersion.pdf*
8. *https://wad.jrc.ec.europa.eu/sites/default/files/atlas_pdf/JRC_WAD_fullVersion.pdf retrieved April 12, 2022*
9. *Badea, A. C., Badea, G., Vasilca, D., Semen, C. (2016) Aspects about Deforestation Areas using GIS, 16th International Multidisciplinary Scientific GeoConference SGEM 2016, www.sgem.org, SGEM2016 Conference Proceedings, ISBN 978-619-7105-60-5 / ISSN 1314-2704, June 28 - July 6, 2016, Book2 Vol. 3, 79-86 pp; DOI: 10.5593/SGEM2016/B23/S11.011, ISI WOS;*
10. *Sensitivity to desertification index map—European Environment Agency. (n.d.). [Figure]. Retrieved April 12, 2022, from https://www.eea.europa.eu/data-and-maps/figures/sensitivity-to-desertification-index-map*
11. *Forest Map of Europe | European Forest Institute. (n.d.). Retrieved April 12, 2022, from https://efi.int/knowledge/maps/forest*

12. *Badea, A.C., Badea, G. (2015) Specific issues in green resource management in Romania - (93), Proceedings of the world cadastre summit 2015, TS 8.2 - GIS & Planning Implementations, 854-863 pp., ISBN 975-99999-0-0, TKGM - General Directory of Land Registry and Cadastre - Tapu ve Kadastro Genel Müdürlüğü, http://wcadastre.org/files/fulltexts/fulltext93.pdf*
13. *Harris, N. L., Goldman, E., Gabris, C., Nordling, J., Minnemeyer, S., Ansari, S., Lippmann, M., Bennett, L., Raad, M., Hansen, M., & Potapov, P. (2017). Using spatial statistics to identify emerging hot spots of forest loss. Environmental Research Letters, 12(2), 024012. https://doi.org/10.1088/1748-9326/aa5a2f*
14. *Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. “High-Resolution Global Maps of 21st-Century Forest Cover Change” Science 342 (15 November): 850–53. Data available on-line from: https://glad.earthengine.app/view/global-forest-change. Accessed through Global Forest Watch on 12/04/2022. www.globalforestwatch.org*
15. *UNEP-WCMC and IUCN (2022), Protected Planet: The World Database on Protected Areas (WDPA) and World Database on Other Effective Area-based Conservation Measures (WD-OECM) [Online], April 2022, Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net*
16. *https://www.globalforestwatch.org/map/*
17. *https://www.arcgis.com/*
18. *Grantham, H. S. et al. (2020). Anthropogenic modification of forests means only 40% of remaining forests have high ecosystem integrity. Nature communications, 11(1), 1-10., retrieved on May 3, 2022*
19. *Juffe-Bignoli, D., Bingham, H., MacSharry, B., Deguignet, M., Milam, A., Kingston, N. (2016) World Database on Protected Areas User Manual 1.4, http://wdpa.s3.amazonaws.com/WDPA_Manual/English/WDPA_Manual_1_4_EN_FINAL.pdf, retrieved on May 7, 2022*

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