# METHODOLOGICAL APPROACHES IN ASSESSING THE ECONOMIC PRESSURE ON FOREST RESOURCES. CASE STUDY: APUSENI MOUNTAINS

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## ABSTRACT

Assessing the economic pressure on the forest fund is one of the greatest challenges for the scientific world due to the dynamics of the phenomenon and the difficulties in obtaining relevant data and in an optimal time. For this study, we wanted to analyze, compare and aggregate two sets of post-processed images from two different sources, such as CORINE Land Cover (with complementary datasets) and Global Forest Change, to get a more accurate and relevant result. For this we processed the post-processed images from both sources, then merged the information of the two sets of data by keeping the temporary resolution from Global Forest Change and taking quality information like the type of vegetation from CORINE Land Cover. The data set obtained was corrected and then processed. The results obtained have highlighted the limitations of each data source, temporal limitation and lack of information on forest type in the case of Global Forest Change and the methodological differences in data collection and lower temporal frequency within the CORINE Land Cover. Thus, in order to obtain more precise results on the dynamics of forestry in a region within the European Union using free / available online data sources, it is necessary to merge such data sets.

**Keywords:** Forest dynamics, deforestation, GIS, landuse, Corine Land Cover

## INTRODUCTION

Since the beginning of history, the forest has been a very important economic source [1], which has put it on a global economic pressure, becoming today one of the greatest challenges of contemporary society. [2], [3], [4], [5], [6], [7]. Moreover, a challenge also brings other challenges, so the assessment of the economic pressure exerted on the forest fund is in itself a challenge. The forest is a limited resource that extends over a large area of the planet [8] and implicitly requires tools and procedures for monitoring and analysis [9] in order to obtain relevant data in an optimal time, related to forest dynamics.

Research done so far has shown that the economic pressure on the forest fund over history has led to negative consequences at global, regional and local levels, the extent of which is directly proportional to the magnitude of the phenomenon. The main visible and perceived effects at global level are: producing environmental imbalances with disastrous impact on the habitats of millions of species [10]; the generation of negative global climate effects through the absorption of greenhouse gases [11]; producing a water cycle imbalance [12] in which the forest plays an essential role, but also intensifies the desertification process of the areas under forestry [13]; soil degradation due to changing use categories, by altering the physical and chemical properties of their surface, especially their erosion [14].

Taking into account all these effects that logging manifests globally, analytical methodologies developed for the systematic assessment of forest dynamics are needed. If we divide forest exploitations into two categories from a legal point of view, they can be legal and illegal. The legal ones can be quantified from the space-time point of view, being made on the basis of exploitation plans, but the illegal ones are spread as patches in large forest areas and can not be evaluated. As a result, specific techniques and methods have emerged throughout history to quantify the spatio-temporal dynamics of this phenomenon.

In the specific literature, quantification methodologies based on satellite imagery have been developed and are used for the effective assessment of forest areas in certain regions of the planet [15], [16], [17]. Today, however, technology has evolved a lot and part of this analysis is provided in regional satellite programs or researches.

With the advent of the products offered by remote sensing, with the launch of the first Landsat satellite (ETRS-1), for monitoring global resources [18] and vegetation indices such as the NDVI index - Normalized Difference Vegetation Index [19], some research has emerged which today offers available results at global level, as well as at regional level that provide information on forest fund or forest dynamics. Such research has materialized in a source available online providing information on the 21st century global forest dynamics, named Global Forest Change, and analyzes the vegetation changes based on Landsat images, across the entire surface of the Earth [20]. At regional level, however, there is the European Earth Observation System, Copernicus, which provides a land use database containing forest areas called CORINE Land Cover [21]. Despite the existence of several online data sources that can improve the results of the forest dynamics assessment in a particular region, the methodology for achieving them is or has been oriented towards a particular problem. In this case, some data sources can provide information on forests [20] and others on forest type reported over time [21].

The chosen approach will enable an improved data source to be obtained by merging two or more data sources in order to obtain more accurate results on forest dynamics, especially from a European Union region, and more precisely on an area of geographic study, for which there are no official statistical reports using post-processed online free data.

## METHODS

The Apuseni Mountains are part of the Western Carpathians being a subunit of these and overlapping over six counties (Bihor, Salaj, Cluj, Alba, Hunedoara and Arad) afferent to three development regions (North-West region, Central region and West region). The Apuseni Mountains Group is one of the most affected by the forest exploitation in Romania. For the assessment of forest areas, geospatial data sources were chosen: Global Forest Change and CORINE Land Cover.


**Figure 1.** Study area

## Global Forest Change database

Global Forest Change is a forest database distributed by the Department of Geographic Science, Maryland University, based on the extraction of information from Landsat's archive. The result of the research is an advanced forest analysis, such as change detection, through which it is highlighted in particular forest loss, alongside forest gain (reported for only one year). Research is based on the year 2000, according to which the forest loss is determined for each year, reaching 2017. This analysis provides three sets of data that are relevant to our study: image of the 2000 forest status that provides information on the Percent Tree Cover- displays in the image with percentage (0-100%) all trees with height over 5m; Forest Cover Loss that shows the changes that occurred between 2000 and 2017 which resulted from the removal of forest areas and reports the change for each year; Forest Cover Gain which is the opposite of Forest Cover Loss and shows us the land area acquired during the period 2000-2012 (fixed period).

## Copernicus CORINE Land Cover database

CORINE Land Cover (CLC) is a program owned by Copernicus, and is a territorial inventory initiated in 1985. The time-series within this program only highlight changes with areas larger than 5ha and in terms of time resolution it offers 5 sets of data: 1990 (gives the image between 1986-1998), 2000 (1999-2001), 2006 (2005-2007), 2012 (2001-2012) and 2018 (2017-2018). In terms of spatial resolution, however, CLC 1990 being analyzed based on Landsat 5, the resolution of images is less than or equal to 50m; the next series 2000, 2006 and 2012 offering a resolution of less than or equal to 25m, and 2018 less than or equal to 10 meters, the analysis being based on Sentinel 2 images. CLC provides qualitative information on usage categories, forests, such as forest type or predominant vegetation (broad-leaved, coniferous forests, mixed forests).

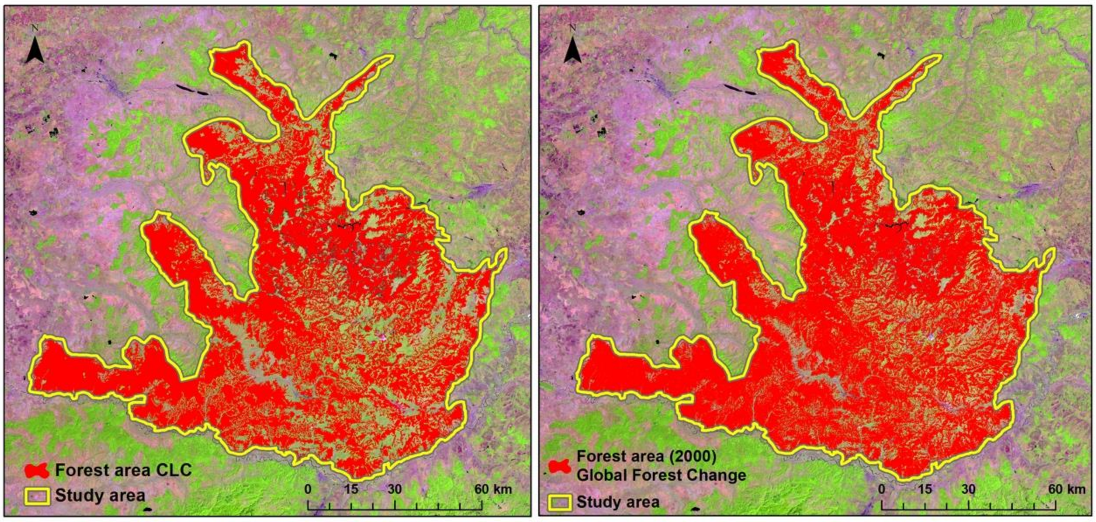


**Figure 2.** The forest cover from year 2000 – left CORINE Land Cover and right Global Forest Change

**Processing of analyzed data sources**

In the first phase, both sets of data were disseminated in such a way as to obtain the forest area for the study area. The images from Global Forest Change were reprojected from the WGS84 coordinate geographic system into the national stereo system of Romania, Stereo70, and the resulting images were transformed into polygon vector data and cropped, for the study area of the Apuseni Mountains. Thus, the surfaces in hectares of the forest fund from 2000 were obtained, to which corrections have been applied based on the degree of afforestation (0-100%). The same thing was done for each year of forest loss and for forest gain 2012. The results obtained were used to determine the area of the forest fund for each year in the period 2000-2017 by reducing the forest loss in total forest 2000 and increasing the forest gain only for 2012. Unlike Global Forest Change data, CORINE Land Cover data was downloaded directly as vector data and only required reprojecting in the national coordinate system and cropping all 5 datasets for the study area of the Apuseni Mountains. After obtaining the new data sets, filters were applied based on forest-specific codes, respectively 311 Broad-leaved forest, 312 Coniferous forest and 313 Mixed forest. For each interval, the forest areas were calculated. The second phase of the research is the merging of the data sets obtained. The vector data sets cropped for the study area from the two data sources, were spatially intersected, to retrieve information on vegetation and the areas before 2000 from CORINE Land Cover, but also to retrieve the frequency of Global Forest Change information. Finally, statistical information related to the study area, the group of the Apuseni Mountains, was generated.

## RESULTS

From the information on the dynamics of the Apuseni Mountain group, both the data provided by CORINE Land Cover and those provided by Global Forest Change, we can see that the forest loss dynamics is dependent on the forest legislation in force. High values can be observed in 2007 and 2012 (Fig. 3), indicating when the legislation was amended in favor of cutting the forests returned from state ownership to the private area. The trend of evolution of this phenomenon, from the statistical point of view, is decreasing.

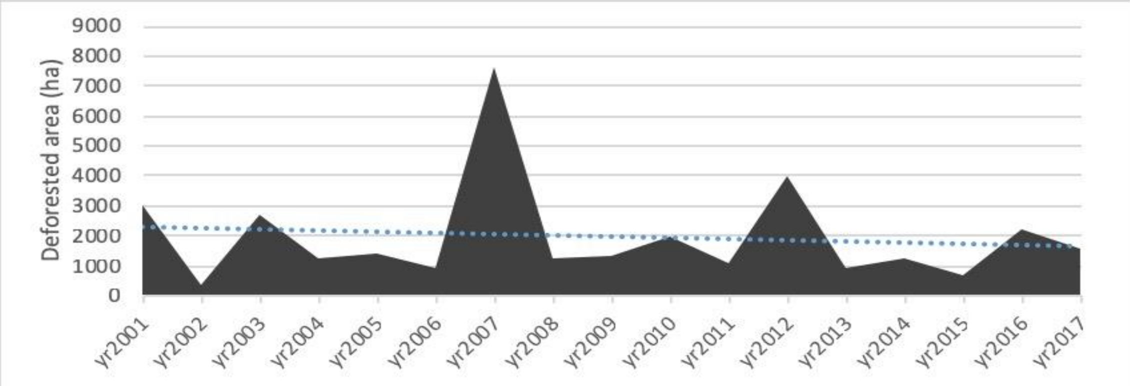


**Figure 3.** Evolution of forest loss areas in the Apuseni Mountain group during 2001-2017

The same thing can be seen below (Figure 4), where the forest area has some significant thresholds in the aforementioned years. We note that the tendency for general evolution of the forest area is descending. For the year 2012, the forest gain area was added, to obtain the approximate forest area (772,964 ha - 2012) in order to compare the results with those extracted from CLC.

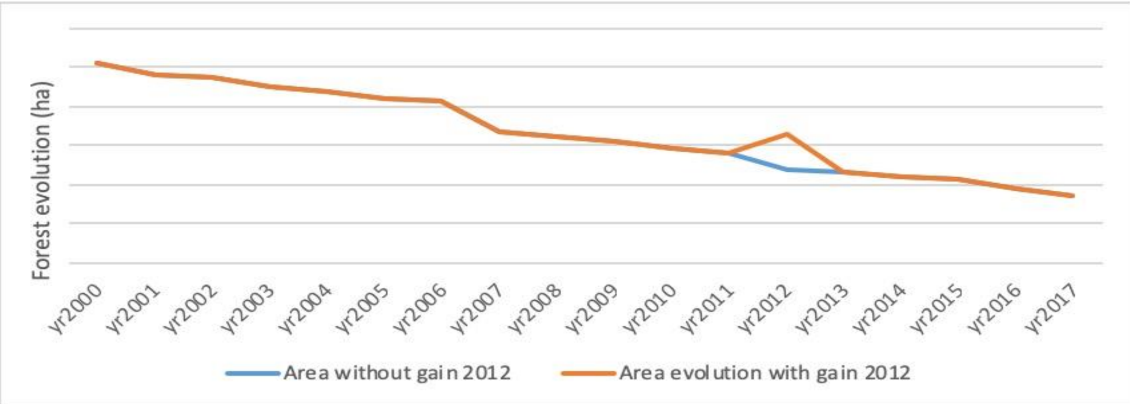


**Figure 4.** Evolution of the forest area (Global Forest Change)
in the Apuseni Mountain group during 2000-2017.

The results from the CORINE Land Cover source show that between 1990 and 2018 the forest area is growing. However, there is a much greater difference between 2000 and 2006.

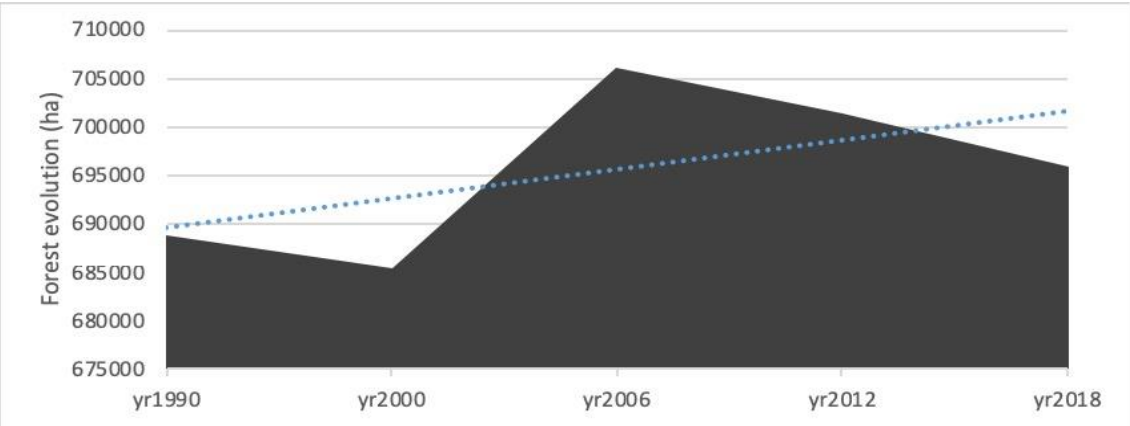


**Figure 5.** Evolution of forest areas (CORINE Land Cover)
from the Apuseni Mountain group during 1990-2018

By merging the two datasets, we have obtained the situation of forest loss areas by forest categories, Broad-leaved forest, Coniferous forest and Mixed forest. From the following figure it is pointed out that the Coniferous forest maintains the general tendency of the phenomenon from the level of the entire mountain group by highlighting the years 2007 and 2012. It is also noticed that Coniferous forest was generally preferred in favor of Broad-leaved forest or Mixed forest.

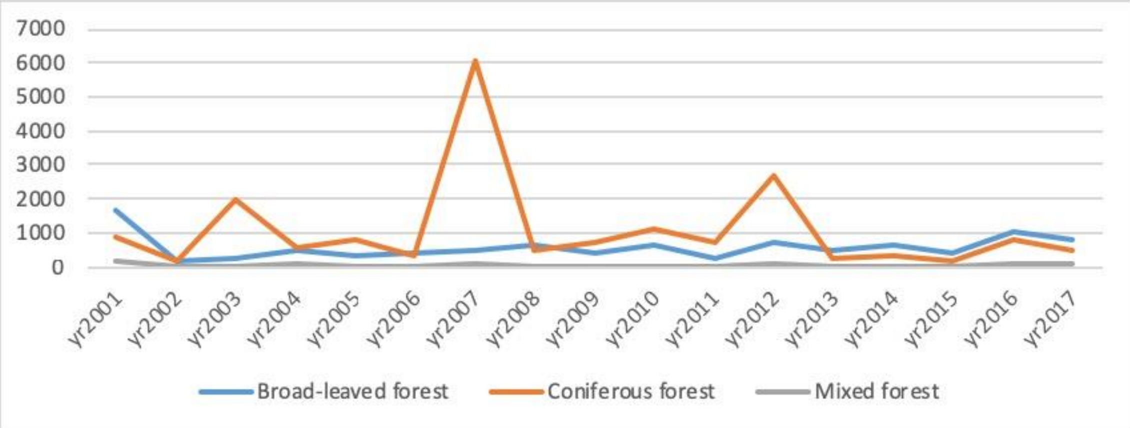


**Figure 6.** Evolution of forest loss areas from Global Forest Change on forest categories taken from CORINE Land Cover.

## CONCLUSIONS

In order to achieve more accurate results on forest dynamics in a region within the European Union, using online data sources that can be used for academic purposes, it is necessary to merge them. Through this analysis we find that although CORINE Land Cover offers a higher time resolution, the land assessment methodology is not oriented towards monitoring forest areas, but predominant forest categories can be very useful for determining patterns for the study area. Instead, the Global Forest Change information provides a better temporal frequency, with forest loss being reported each year. However, we do not know more about the exploitation pattern, the forest category of interest. By uniting the two data sources we can achieve better results, which can launch new assumptions for future research. Moreover, there are situation where, for some areas, such as geographic areas, where, there are no official national reports or other information from another specialized organization, which makes these online resources a very important starting point in assessing forest dynamics.

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