Development of methodologies and standardized services for supporting forest economics

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Abstract. In the Mediterranean region, many types of forests are non-productive or degraded, although they could substantially contribute to growth of local economies. In Greece, 30% of the total area is covered by forests, however their contribution to the GDP is almost non-existent. An example is the chestnut production in Thessaly region of Greece, and especially in Mouzaki municipality, which is almost abandoned due to insufficient agricultural policies concerning establishment of alternative crops, and consequently leads to loss of potential income for the rural economy. The ARTEMIS project, funded by the Greek Secretariat for Research and Technology, aims at delivering an innovative information platform providing systematically high quality Earth Observation based products and services for monitoring forest health and supporting eventually the growth of forestry related economy and market. The architecture of the proposed platform will incorporate new OGC / ISO technologies, while the applicability of existing metadata standards for management of geospatial datasets will be evaluated. A pilot implementation of the developed system will be conducted in a selected area in Thessaly region of Greece.

Keywords: Forest economics, forest monitoring, Earth Observation, forestry metadata.

1 Introduction

Forests provide a wide range of products and ecosystem services, including wood supply, food security, raw materials, energy resources, biodiversity conservation. In addition, forests provide a multitude of environmental, social and cultural benefits related to climate regulation, human health, recreation, fresh water supply, to name just a few. At the same time, forests provide substantial economic benefits at local to national level through wood and non-wood related industries and investments in the forest sector [1]. More specifically, economic benefits are usually measured in monetary terms and may include: income from employment in the sector; the value of the production of goods and services from forests; and the contribution of the sector to the national economy, energy supplies and international trade. The economic viability or sustainability of the sector can be assessed by measures such as the profitability of forest enterprises or the level of investment. Currently, the EU strategy aims to place forests and the forest sector at the heart of the path towards a green economy and to value the benefits that forests can sustainably deliver, while ensuring their protection.

In the Mediterranean region, many types of forests are non-productive or degraded, although they could substantially contribute to local economies, at least [2]. For example, in Greece, 30% of the total area is covered by forests but their contribution to the GDP is almost non-existent. An example is the chestnut production in Thessaly, Greece, and especially at the forests of Mouzaki municipality, which is almost abandoned due to insufficient agricultural policies concerning establishment of alternative crops and the lack of support policies for enhancing rural economies, thus forcing younger populations to move to urban areas.

A sustainable forest management that would also foster commercial exploitation of forest resources and market development of non-wood products should take into account the following: a) selection of crops, b) compliance with rules and protocols; and c) adaptation and modification of cultivation practices using new monitoring technologies, such as remote sensing, near-real-time satellite meteorology combined with rural data and ICT/computer vision technologies.

The ARTEMIS project, funded by the Greek Secretariat for Research and Technology, aims at delivering an innovative information platform providing systematically high quality products and services for assessing forest condition and threats, both abiotic and biotic. The proposed services and products will be potentially useful for exploitation of raw materials, for creation of product certifications and for supporting market development of non-wood goods thus increasing employment and healthy economic growth. This monitoring system will be capable of processing multi-scale forest related geospatial and in-situ datasets and will be initially implemented for chestnut or similar cultivations. Based on the data requirements of ARTEMIS, we are going to evaluate the applicability of existing metadata standards in our application in order to select/define an appropriate forest information metadata standard, while the ISO 19115 will be used for describing geospatial metadata.

2 Proposed approach

The proposed methodological approach of ARTEMIS is displayed in Fig. 1. The envisaged output is the creation of a reliable forest health monitoring platform based on the seamless integration of Earth Observation data and products as well as data stemming from a multi-sensor system designed to assess the status and changes of indicators of forests health condition. Modern state of the art remote sensing technologies will provide the means for wide coverage measurement of forest health with reasonable accuracy.

The satellite data to be used will be provided from modern satellite receivers (spectral, hyperspectral and SAR) [3, 4]. Particular emphasis will be given to satellite data and products provided from the European Union's Earth Observation Copernicus Program[1]. Satellite data from the Sentinel missions and other contributing satellites offer high temporal and spatial resolution and facilitate systematic vegetation monitoring.

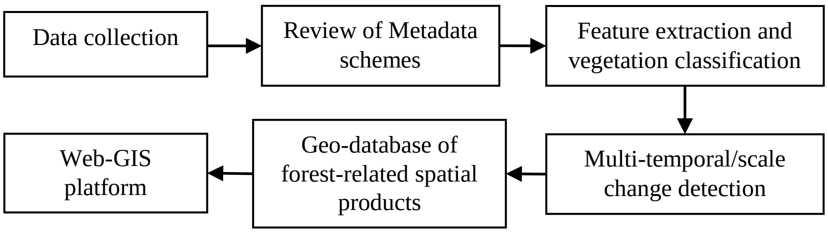

Fig. 1. Proposed methodology for forest monitoring

The main methodological steps related to data processing and algorithm development can be summarized as follows:

- Collection and pre-processing of satellite images and vector datasets from multiple sources (aerial, terrestrial field measurements, existing spatial databases). Radar (SAR) and optical and images from Sentinel-1&2 missions respectively and contributing satellites will be employed.
- Development of advanced semi-automated techniques for classification and mapping of vegetation types and species. Such techniques will be based on advanced deep learning techniques (e.g. Convolutional Neural Networks, CNNs), dual tree complex wavelet transform [5], and texture and dynamic feature analysis [6, 7].
- Appropriate combinations of SAR polarities (Sentinel-1 VV, VH and VH / VV) will be selected to identify different land uses and distinguish between different types of vegetation or crops.
- Specific vegetation indices will be selected, which are related both to plant physiology characteristics, and structural variations of forests. Indicators based on visible and infrared wavelengths such as the broadband NDVI, SR and EVI, and narrowband indices using reflectance at specific wavelengths (e.g. TCARI and MCARI1 indices) will be investigated.
- Synthesis of indicators to create multi-temporal forest condition/health maps.
- Development of a time series analysis algorithm, based on vegetation indices, for accurate spatio-temporal monitoring of vegetation changes. Forest areas and cultivations will be monitored by combining multi-modal satellite imagery and their derivatives (vegetation and health indicators). The aim is to identify and discriminate areas of gradual (plant disease, water stress) or abrupt (logging, fires) change.

The final step is to design and develop the architecture of the WEBGIS platform that will incorporate the following features: a) Free access to the products by the users

[1] http://copernicus.eu/main/sentinels

by implementing new OGC / ISO technologies for the dissemination and processing of data through services (WMS, WFS, WCS, WPS), b) Development of an online platform for data processing folders and databases in near real time; c) Development of specific software that will test, homogenize and merge the measurements that will result from field campaigns. For faster processing operations, it will be possible to automatically create pyramids and thumbnails when listing new data and convert their metadata according to ISO 19115, the industry standard for geospatial metadata. The display and navigation will be in two (2D) or three (3D) dimensions for improved visualization of the forests. The developed algorithms and chains will be imported to the system and will be executed as a Web Processing Service (WPS). Finally, the user or stakeholder will be able to create a database search form via SQL queries and visualize the results on the map, as well as to generate reports through an Incident Reporting module.

The proposed approach will be evaluated within a pilot setup of the system for selected forests in Mouzaki municipality, in the Thessaly region, Greece during a 14 month period. During this period, the services will be implemented and evaluated extensively in selected forest areas with chestnut trees. Producers will be trained to use the new service and become familiar with the modern geospatial technologies.

3 Forestry metadata formats

Metadata is data about other data [8] and have a vital role for digital information management as they facilitate search, allowing users to identify important information and resources. For the specific fields of agriculture and forestry, a recent overview of the standards of metadata areas is provided in the work by Santos and Riyuiti [9]. Specifically, a number of standards (Dublin Core, Darwin Core, AgMES, AGRIS, Agrovoc, AgroXML, agXML) are reviewed and their scope of use and characteristics are described and their quality is assessed. A metadata schema for forestry related information resources based on the Dublin Core Metadata (DCMI) was developed by NEFIS project [10]. This model is then extended in Tilsner [11], where a metadata model for the European Forest Information and Communication Platform (EFICP) is presented, in order to support online access and exchange of forestry specific statistical data. Beyond Europe, other initiatives include the Canadian National Forest Information System and the GeoGratis portal [12]. The latter infrastructures focus on interoperability between geospatial data sources and provide web services to geospatial information, based on the Open Geospatial Consortium (OGC) Standards.

Based on the data requirements of ARTEMIS, we are going to evaluate the applicability of these standards and related geospatial formats (e.g. shapefile, Geotiff, geodatabase, .xls, xml, etc.) in our application in order to define an appropriate forest information metadata standard. Commercial and open-source metadata software tools, designed for data integration in database systems, will be additionally evaluated. In order to ensure compatibility with the requirements of INSPIRE[2] directive on geo-

[2] http://inspire.ec.europa.eu/documents/Metadata/MD_IR_and_ISO_20131029.pdf

referenced data, it is strongly recommended to apply the rules laid down in ISO 19115 for creating a metadata profile. A good example of an INSPIRE-based profile for geographic metadata that can be employed, is the European Environment Agency (EEA) Metadata Profile[3], which has been developed to meet the needs and demands for interoperability of metadata. Due to ARTEMIS requirements, two basic categories of metadata are foreseen:

- *Metadata related to the final geospatial products and corresponding services*. These products will contain detailed information on forest condition, vegetation species, temporal changes, etc., as described previously. ARTEMIS will perform an extensive review on established schemes as implemented by international agencies. For example, the EUNIS habitat classification will be reviewed, which is the classification standard for the INSPIRE Directive. EUNIS is a comprehensive pan-European system that facilitates harmonized description and collection of habitat data across Europe. The pan-European components of the Copernicus Land Monitoring Service will be also considered. These include the CORINE Land Cover classification scheme, as well as the High Resolution (HR) Layers. Specific attention will be given to the Forest HR Layer.
- *Metadata related to Earth Observation (EO) and remote sensing data.* A common metadata framework will be defined to support metadata from all ARTEMIS input data sources, and especially the remote sensing ones, based on recent geospatial metadata standards, such as the ISO 19115. Given the abundance of EO imagery mainly due to free data access policies for Landsat and Copernicus missions, the thorough study and mapping of metadata can greatly benefit research and operational applications. Existing comprehensive guides, such as the NASA ESDIS Unified Metadata Model (UMM), and software libraries, e.g. the HDF-EOS5 Data Model[4], are extensively utilized for management of EO metadata information. The continuous and seamless data flow within the ARTEMIS platform will require a specific adaptation of these standards.

4 Conclusions

A new approach for forest monitoring is presented aiming at preserving the quality, health and sustainable development of economic forests and particularly chestnut forests. The forest health platform outputs are expected to provide timely and updated information on forest condition, which will be considered a valuable supplement to standard forest management plans and reporting at regional level. Furthermore, the proposed monitoring system will promote health status reporting at broad scales, beyond local needs, enhancing cooperation among various agencies. Through the incorporation of widely accepted metadata standards and formats, the establishment

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[3] https://taskman.eionet.europa.eu/projects/public-docs/wiki/Cataloguemetadata_guidelines
[4] https://cdn.earthdata.nasa.gov/conduit/upload/4880/ESDS-RFC-008-v1.1.pdf

of links and potential collaborations with current platforms, such as the ESA driven Forestry Thematic Exploitation Platform (Forestry TEP) and forest information agencies (European Forest Institute, EFI) will be promoted.

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