LIFE14 ENV/IT/000414
Demonstrating Remote Sensing integration in sustainable forest management
FRESh LIFE

ACTION B5
Upscaling Project Result

Deliverable
Guidelines for improving regional and national forest policy tools

Firenze
30/11/2019

1. Introduction

The aim of this action is to analyse the results obtained at local level in the demonstration sites investigating the possible impacts on the Italian Forest Plan and the replicability at European level, to provide suggestions and new guidelines for improving the future updates of the forest plans through the adoption of new remotely sensed imagery. The analysis of the upscaling possibilities follows different levels starting from the European to the local scale.

2. EU Forest Strategy

The EU Forest Strategy is the framework to coordinate and ensure coherence in forest-related policies, and to ensure the contribution of EU forests and the forest-based sector to the EU's objectives and targets.

The *'Our Forests, Our Future*' conference, organized by the EU Commission, took place in Brussels on 25-26 April 2019 to analyze and discuss opportunities and challenges for enhancing the contribution of the forest sector to the main EU priorities. During the conference was clearly confirm that the Strategy's objectives are: ensuring that all forests in the EU are managed according to sustainability criteria; and strengthening our contribution towards sustainably managing forests and reducing deforestation at global level. A recent review of the strategy found out significant progress implementing the planned action towards achieving these objectives. The Strategy and its priorities are fit for addressing the role of forests and related EU policies for the implementation of the 2030 Agenda in the EU and globally.

Pursue aims such as "*coordinate and ensure coherence in forest-related policies*" and "*ensuring that all forests in the EU are managed according to sustainability criteria*", results in the needs of tools and methodologies that allow to collect, share and elaborate, harmonized data from all over Europe. To ensure a Pan-European point of view, harmonized and quite simple methodologies are essential in order to allow all country to "do their part" in collecting these data. Indicators, and in particular the idea to map it, are extremely useful to monitoring the diffusion end the impacts of Sustainable Forest Management (SFM) criteria.

During the FRESh LIFE project, we make strong efforts to ensure that the methodologies used were replicable at different scale and adaptable to different forest ecosystems. European Forest Types Classification was used and database were created by following the guidelines from the COST Action E43 and the INSPIRE Directive for the harmonization of metadata. We developed a strong and efficient workflow that could give an important contribute in a bottom-up approach to the EU Forest Strategy.

Going through one of the document presented by the Directorate General for Agriculture and Rural Development during the *'Our Forests, Our Future*' conference (https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/events/documents/forestry-conference-2019-brochure_en.pdf) we will try to outline how some of the results achieved by the project could be integrated in the EU Strategy to help achieve its goals.

2.1 EU Forests contributing to innovation, growth, jobs, and the circular bioeconomy

"*Wood and other forest products make an essential contribution to economic growth and to raising living standards. In the EU, they are still a significant source of welfare in some countries and regions."*

In this section we can read, for example, that "*60 % of the EU forests are privately owned, with approximately 16 million forest owners*". Tools like the Forest Information System (FIS) developed within our project are extremely useful to allow private owners to have access to high precision data and indicators that are essential on the way of a harmonized SFM approach. In situation like Italy, where the single private forest unit have typically also a small extension (in ha), decision support systems such as the FIS are the only way private owners can access to these kind of data. The poor economy of the small forest private owners wouldn't allow them to reach the standards of the public forest management creating problems in ask them to follow the SFM criteria. The FIS approach, if developed at a regional, national and even European scale, could allow all actors of the forestry sector to access harmonized and wall-to-wall data and indicators to following the SFM aims. Give a Pan-European point of view, starting from the single private owners, could results in a better understanding of the EU Forest Strategy allowing everybody to accept national and international dispositions in forest management that sometime may seems incomprehensible at local level.

In the same section were underlined how in the last years both the Common Agriculture Policy than the EU-funded research have tried to "*connected to innovation and deployment, also by the revised Bioeconomy Strategy that will further scale-up the role of forest-based biomass to replace non-renewable materials and products, whilst protecting the environment and ensuring circularity*". Despite this, while "*forest stocks in EU forests are steadily increasing, the EU harvests less than 70% of its annual wood growth*". The availability of Pan-European data and indicators on the SFM could be useful also in this case to improve people knowledge about the complexity of forest sector. In period like this one, with a renovate attention to climate change topics, give free access to good and complete information about the Europe forest assessment allow people to better understand the meaning of the EU Forest Strategy and reduces the likelihood of protests triggered by a lack of knowledge. Meanwhile, the availability of harmonized and high precision data could improve the precision of the growing stock estimation and consequently the efficiency of a European forest management planning that take into consideration the different aspects of SFM.

2.2 EU Forests fighting climate change

"*Sustainable forest management is necessary to fight climate change. Forests and forestry are key contributors to EU's ambitious energy and climate policy and the targets defined for 2030*"

In this section that talking about the key role of forests and wood in carbon storage and sequestration become clear how much Sustainable Forest Management is important to maintain and improve these ecosystem services provided by our forests. The commission underline also the importance of SFM in "*address forest fires, pests and other disasters, promoting prevention, supporting coordinated and quick response mechanisms, and assisting restoration of damaged areas*".

The use of UAV's due to low cost of flight campaigns and the quite short time needed to organize it, have a key role in this emergency situation. The methodologies tested in our project allow to create decision support system that can be up-dated easily by acquiring new remote sensing images by drones. During the emergencies, such as forest fires or wind storms, this could be fundamental to monitoring the forest damaging and quickly elaborate information useful to the managers during and after the disasters. The advent of new satellites services that gives daily images of the entire globe is also useful in these emergency situation and these products can be used combined to the images taken by drones to "feed" the decision support systems.

Although sometimes the "forest management" is seen as one of the factors that affect negatively the biodiversity and ecosystem services providing, SFM goes completely in other direction by has a central role in conserve and restore also these ecological aspects of the ecosystems. The EUs

biodiversity and rural development policies promote the integration of biodiversity and sustainable forest management and projects like FRESh LIFE giving tools to better understand and disseminate these topics. The mapping of the SFM indicators taken into account by our project is an example of how different forest variables, called "indicators" in this case, can be estimated for big areas in order to create maps useful both for monitoring than dissemination activities. Focusing in our project to the forest health and wood production, the same methodologies could be applied to study more biodiversity related aspects in order to obtain information useful, for example, in Natura 2000 areas management. The quantitative approach developed within these methodologies has also strong potentials in estimate and "quantify" the ecosystem services provided by the European forests, helping the EU in addresses how ecosystem services can be better enhanced through policy design and implementation.

2.3 EU addressing international forest challenges

"*The EU and the Member States actively promote Sustainable Forest Management in pan-European (FOREST EUROPE) and international forest-related fora and processes (e.g. UNFF, FAO, ITTO, the UN Convention on Biological Diversity), including the 2030 Agenda and its Sustainable Development Goals (SDGs).*"

Looking to a Pan-European or international point of view projects such as FRESh LIFE are fundamental due to their harmonized approach. All the methodologies developed in our project are replicable and extensible both in different than in larger area. The project workflow to obtain the SFM indicators maps were simply codify and could be applied to any kind of ecosystems and scales with small adjustments related to the remote sensing data acquisition. The decision to adopt international standard such as the guidelines from the COST Action E43 and the INSPIRE Directive for the harmonization of metadata, allow us to share data and elaboration with collaborators from all over Europe. Tools like the FIS that we have created for the demonstration sites, could be extremely useful in a Pan-European forests management planning to quantify all the indicators needed in the ratification and respect of international agreements and agenda.

This is true even more at global scale where the EU is involved in development cooperation to support improved governance and promote forest conservation through FLEGT and REDD+ (Reduced Emissions from Deforestation and Forest Deg- radation) activities. Especially in developing countries where the lack of data is the norm, methodologies like the ones developed in our project could help, for example, in REDD+ strategy developing and promoting. The forest inventory is often missing in these countries but is the base for all the following activities such as FLEGT and REDD+. The estimation of variabilities like the Growing Stock or the Above Ground Biomass in countries where is not so easy to access both to existing data than to the territory at all could take advantage of the results achieved from our project. The integration of different vectors in data acquisition (UAVs, satellites, etc.) to create a workflow that allow the up scaling of the project results at a scale useful in these contexts take the name of hierarchical sampling

3. Report on the state of forests and forest sector in Italy (RAF Italia)

Last year the Forest Office of the Ministry of Agricultural, Food and Forestry Policies (Mipaaf) published the first "Report on the state of forests and forest sector in Italy". The report makes a review on the *state of art* of different aspects that involved forests, from the policies to the economic and ecological situation, describing also best practices developed in these years all around Italy. The report, in Italian, is available at this link:
https://www.reterurale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/8%252F4%252F1%252FD.f8bffe877b6ff2584b21/P/BLOB%3AID=19231/E/pdf

Our coordinator, Professor Gherardo Chirici, contributed to the report with a chapter on the Precision Forestry in Italy where he included some of the results achieved by the project. Lessons learned during project activities are used to present the new trends in forestry, to remark the potential of remote sensing data and the importance of Spatial Decision Support Systems (like our Forest Information System) as a tools to meet the goals of Sustainable Forest Management. Furthermore, data harmonization and free access have been indicated as one of challenges for future development of the sector following what has been made clear by FRESh LIFE.

Going through the report there are others topics on which our up scaling activities will concentrate in the future. The third Italian Forest Inventory was almost ready and recently changing in the data access policy are allowed researchers of our team to test some of the methodologies developed at larger scale by using data from the field plots of the inventory sampling. This kind of studies, together with the will expressed by the ministry in the report to improve the spatial and informatics capacities of the forest inventory, will give us the possibility to raise project impacts on forest policy at national scale. First results are already available with the publication of the paper "*Wall-to-wall spatial prediction of growing stock volume based on Italian National Forest Inventory plots and remotely sensed data.* Chirici et al. 2019" available for download at this link: https://www.sciencedirect.com/science/article/pii/S0303243419305306

In the chapter focused on the forest policy the authors of the RAF Italia 2019 emphasize how the lack of harmonization of laws and prescriptions between different regions doesn't help to having a clear understanding of the Italian situation in the field of forest management. The competence for these issues is left to the regions but a coordination effort would be necessary at least to obtain a unique statistic system which allows photographing and monitor the state of the forests regarding, for example, forest harvesting. The Forest Information Systems developed for the three demonstration sites of FRESh LIFE project are a good starting point to think over the possibility to harmonized data and methodologies even from different regions and forests ecosystems. Using the lessons learned during our project, different regions could start this harmonization effort for example by: giving free online access to the data for the private owners, adopt the European Forest Types classification, according on a unique coordinate reference system, standardize the metadata following guidelines from the COST Action E43 and the INSPIRE Directive. This approach would be necessary in order to more easily connect the forest planning at different scale and increase the capability to pursue the aims of Sustainable Forest Management.

On 2018 a new national law was approved in Italy trying to give the direction for a national forests strategy. Despite the competences for forests management remains to the regions, this law introduces important news for the forests sector, regarding for example the new technologies. Our coordinator and other people from the team actively participated in the discussion that led to the approval of the new law. The collaboration is continuing during the writing of the implementation decrees by sharing knowledges achieved by FRESH LIFE and assure that lesson learned are taken into account to move the national forest strategy towards Sustainable Forest Management.

4. Impacts at regional level

At regional level the up-scaling activities will contribute in setting up new programs for helping and boosting the forestry sector from an economic and technological point of view.

Starting from the forest complex of Rincine, where the potential of the Forest Information System provided by the project has led the forest manager to consider the possibility of extending the surveys from the demonstration site to the entire forest in order to have the data necessary to base the new management plan on the methodologies developed by FRESh LIFE project.

The same occurs for an additional forest area in Tuscany: "Riserva Naturale Statale Biogenetica di Vallombrosa" where we developed a Forest Information System (FIS) to support the revision of Forest Management Plan and to give to the students of forestry courses of University of Florence the opportunity to use FIS during their field courses. The area covered this FIS is around 1000 ha and the spatial data related to Forest Indicators were generated using UAV photogrammetric data acquired by eBEE and the LiDAR data acquired by aircraft in 2015 by Tuscany Region.

In Italy the management plan is required for all the properties that exceed 100 ha, so the relationship between the Sustainable Forest Indicators provided by the FIS and the management plans is extremely important. Not only for the state forests like Rincine and Vallombrosa but for all the forest owners of the territories around. The management plan is one of the most important tool in the forest sector because it gives the direction of the management both regarding how much and where to cut than for the monitoring and conservation of all the other ecosystem services provided by the forests.

These experiences are important to push the regional administrations to include the new methodologies and technologies, proposed by project like our, in the implementation of new Rural Development Programs (PSR). The PSR is the greater way for financing and supporting agriculture and forestry at regional level. Our local partners, together with the universities associated, are in continuous dialogue with regional representatives to give them the information needed to move the regional forest policy towards Sustainable Forest Management through Precision Forestry methodologies. In this way, strong network was already established with Tuscany and Molise Regions also to lay the groundwork for harmonization efforts at national level as explained in the previous paragraphs.

On a smaller scale "Blue Biloba" the spin-off born by the FRESh LIFE experience, is working with private forest owners selling services of remote sensing acquisition, indicators estimation and creation of small decision support systems for forest plans and others activities. Disseminate these new approaches to forest management among different stakeholders has a key role in increasing their awareness and allow them to access the new funding lines proposed by the Rural Development Programs.

5. Technical challenges for the project results up scaling

Results achieved by FRESh LIFE project demonstrate the potential on the integration of high resolution remote sensing data in Sustainable Forest Management. The scale on which the projects was focused was related to the single forest unit in order to give local forest managers tools specific designed for their territories.

Remote Sensing (RS) data acquired by UAVs (Unmanned Aerial Vehicle) proved their effectiveness by improving the precision of indicators estimation compared to other kind of RS data. Starting from 2014 when the project was approved, the use of UAVs data for forest application increase year by year together with the availability of new models and sensors. Studies, carried out in different types of forest ecosystems, have shown that the use of UAVs data offers new opportunities for monitoring forest resources at high spatial and temporal resolution. Nevertheless, their use for forest inventory is hindered by the high costs of acquiring UAV data with full coverage (wall-to-wall) of areas larger than, say, 10 km^2 (Dandois and Ellis, 2013; Whitehead et al., 2014). Besides the costs, another serious limitation to the practical use of UAVs in forestry is national aviation regulations. Regardless of the large differences among national legislations, current aviation regulations in general play a main role in defining the area- range for which UAVs can be operated and the size of the aircrafts used. The requirement of conducing UAV operations within a visual line of sight (VLOS) often limits the area that can be covered by each flight as the UAV must be visible at all times with the naked eye.

Limitations of the allowable weights of UAVs also indirectly affect the range of operation of these systems by hindering the use of large, heavy, and long-lasting batteries.

It is therefore clear that the methodologies proposed by FRESh LIFE project needs some kind of adaptation to applied it to a larger scale. Thinking to an up scaling of the project results to regional or national scale immediately confronts us with the problem of the impossibility of acquiring wall-to-wall UAVs data of the entire study area. In the demonstration sites where the area was around 200-300 ha, this is not a problem; even in the small up scaling activities related to the forest management plan of Vallombrosa and Rincine where the area, around 1000 ha, allowed a full coverage by UAVs with a still low cost.

The technical challenge to explore the potential of UAVs data in forest inventories has been taken up by many authors in the past years. Where a full coverage acquisition isn't possible, even in the presence of a large field survey database, another wall-to-wall data is required to link together the different layers and improve the accuracy of the estimation models. The proposed way is to combine multiple RS data using, in our case, UAVs samples and a wall-to-wall satellite coverage as suggested by Puliti et al. (2018). According to his method, the combination of UAV data with satellite imagery might lead to an increase of the precision of estimators of key forest properties and also enable the production of maps. This approach may therefore benefit from the high resolution UAV data and from the large coverage of satellite imageries and, potentially, offer a cost-effective alternative to existing methods for large-area forest surveys. The satellite data used in this study are those of Sentinel-2 multispectral mission that also lend well with our cases for their high spectral, spatial, and temporal resolution (Drusch et al., 2012).

Taking into account the results achieve by these studies and the ones of FRESh LIFE project an up scaling activities could concern the improvement of the estimates of the Italian National Forest Inventory with a hierarchical model-based inference framework (Saarela et al., 2016). With the same method proposed by Puliti et al. (2018) we can try to combine inventory data from the Italian National Forest Inventory (INFC) plots with RS data from Sentinel-2 and UAVs. Adding a sample of RS data acquired by UAVs flying on the inventory plots it is possible to increase the accuracy of the variables estimation both compared to the Model-based inference procedure (inventory data simple spatialization) and the Model-based inference method with wall-to-wall Sentinel-2 data. As indicated in the project proposal the use of UAVs data in this workflow result in the possibility to update the INFC values by entering new UAVs RS data that are easier and faster to acquire than RS data from other vectors.

As already indicated in the previous paragraphs within the collaboration with some Regions and with the Forest Office of the Ministry of Agricultural, Food and Forestry Policies (Mipaaf), our coordinator and the rest of team are promoting these new methodologies trying to get them included in the new national forest strategies.

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