



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

**ACTION C3**  
**Socio Economic Impact of the project actions on the local economy and population**

**Deliverable**  
**Analysis of post-project assessment**

**Firenze, 21/05/2020**

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## **Aims**

The Italian Academy of Forest Science is the coordinator beneficiary of the FRESH LIFE project, directly responsible for Action C3 - Socio Economic Impact of the project actions on the local economy and population. In this action, a socio-economic impact assessment will be used to examine how the proposed use of advanced remotely sensed data will affect current and future activities of the involved stakeholders.

To this end the following indicators will be considered:

- Changes in the way the forest managers are able to set up their routine work;
- More sustainable use of forest resources according to the set of indicators defined by Forest Europe, the former Ministerial Conference on the Protection of Forests in Europe;
- Changes in employment and income levels from the forest sector;
- Changes in the aesthetic quality of the forest landscape

Analysis of such factors is an important component of the socioeconomic impact assessment. Another important step in conducting a socioeconomic impact assessment, is gain an understanding of community values and concerns about forest resources and management.

## **Milestones e deliverables**

In the Action C2, the following deliverables are expected:

<i>Name of the milestone</i>	<i>Deadline</i>
M1 - Post-project socio-economic assessment	31/01/2019

<i>Name of the deliverable</i>	<i>Deadline</i>
D1 - Analysis of ante-project assessment	31/12/2016
D2 - Analysis of post-project assessment	31/10/2019

## **Analysis of ante-project assessment**

This analysis was carried out by the coordinator in the first stages of the project, thanks to the support of the local Universities and within the framework of the local forest authorities involved in the project, in order to produce questionnaires that were distributed at the different stakeholders: forest managers, private companies, and citizens, to analyze both the ante-project situation.

The questionnaire was implemented on the google platform "modules" in order to easily disseminate it between the project's stakeholders. This platform allows to easily analyze the questionnaire's answers by viewing them as graphs, step by step, meanwhile that the peoples answered the questions. Overall, we received 139 answers, which is a sufficient number to analyze the ante-project assessment of the demonstration areas. From the analysis of these answer a strategy was elaborated in order to maximize the impacts of the actions during the project's phases.

From this analysis it was clear that there was a lack of knowledge about the RPAS systems and their application, all around the different actors of the forest sector. In addition, it was evident the need of information accessible for all stakeholders to give them the opportunity to better understand the potentiality of the forest ecosystems and the necessity of their management. All the respondents confirmed that the project's activities meet some needs really present in the territories examined. More

details about the structure of this first questionnaire and the analysis of the collected answers is available in the previous deliverable of this action named “Analysis of ante-project assessment”.

## **Analysis of the post-project assessment**

Working for four years strictly in contact with the local realities of the demonstration sites allowed to better understand the situation highlighted by the ante-project assessment. The local dynamics that lead to this situation became clearer by discussing with local managers and stakeholders during the project activities that were continuously updated in order to maximize the impacts. Feedbacks from local partners, especially in the last year of project activities, were all collected and became the base for the post-project assessment. Having a good understanding of the situation, also given by discuss with the audience of the events that we organized, gave us the possibility to go through the post-project assessment without the need to resubmit the same questionnaires of the beginning.

Important information for this action are also derived by the analysis of the KPIs performed in the Action C2. More details about the changing in the way the stakeholders perceive and use RPAS technologies and data derived are available in the deliverable “Report of the large-scale monitoring”, together with a discussion about how local people interact with the forest ecosystem of their territory.

To complete the understanding of the dynamics triggered by the project activities a new questionnaire was also prepared. The questions are more related to the up-scaling activities so details are explained in the Action B5 but the analysis of the answers gave us information also useful to the post-project assessment indicators analysis.

The most significant impacts on the indicators come from the introduction of the Forest Information System in the demonstration sites. Despite the system was similar for each site, the peculiarities of the three situations resulted in different uses of the FIS so the analysis on the changes in the way the forest managers are able to set up their routine work need to be performed separately.

### Rincine – Tuscany

In the demonstration site of Rincine the FIS has been made available for the guards and office employees that use it during their daily work of forest management. The office located in Rufina, not far from the demonstration site, has the responsibility regarding cutting authorizations in relation to the management of the hydrogeological protective restrictions.

During this kind of activities, the FIS can help in different ways:

- evaluation of the residual coverage after the various types of forest chop;
- accurate measurement of the cutting surfaces that determine total uncovering for best environment control;
- more correct evaluation of the maximum annual surface area allowed for cutting;
- accurate description of the forest structure for thinning purposes;
- technical support in the creation of new tracks and forestry roads;

The analysis allowed by the FIS, results in an easily set up of the manager’s daily work due to the very high resolution data which also reduce the risk of incurring penalties in the event of an offense. Further the introduction of the SFM indicators also results in a more sustainable use of forest resources, the availability of these data at the scale of the single forest unit is extremely useful regarding more conservative and monitoring activities. The classification in European Forest Types

change the way how the decision maker planning the activities in the forest like with the “Defoliation” indicator map that easily allow to monitoring pests and results of the fighting activities.

Other activities of the forest manager in which the FIS can help are:

- analysis of the forest structure for «one tree silviculture»;
- technical support for tracks and forestry roads planning and realization (due to the high resolution of the Digital Terrain Model produced from the LiDAR data);
- easy control of the Introduced Tree Species evolution with the possibility of acquired data frequently and during the different phenological phases;
- evaluation of the evolution of artificial and natural forest gaps;
- evaluation of damage due to wild animals grazing.

These new tools change the way how local authorities manage the forests and influence directly the employment and income levels from the forest sector. Better managed territories need more people to work on it and increase the value of forest resources, automatically results in more opportunities and good income levels for the person involved. For instance, the decision taken by the Forest Manager of Rincine to extend the surveys from the demonstration site to the entire forest, in order to have the necessary data to base the new management plan on the methodologies developed by FRESH LIFE project, create new job opportunities. The spin-off of the University of Florence “BlueBiloba”, in charge for these acquisitions, hired a group of young researchers for the field survey and involved further freelance professional workers in technical evaluations.

### Bosco Pennatato - Molise

In the demonstration site of Bosco Pennataro managed by Molise Region, the FIS replaced the old Decision Support System (DSS) already in use in the offices. This one allowed to collect information as text, excel and access formats only. On the other side, the cartographic approach of the FIS has changed completely the way in which the employees are able to set up their daily work and lead to a higher quality of the results that they can achieve. The staff of regional office utilizes FIS to assess: forest cover, tree species abundance, forest health and damage and forest productivity. All this information can be displayed within a layout as thematic maps, highly useful to support discussion among forest decision makers. Such tool reduces the possible delays due to misunderstanding in the collaboration with other managers of the territory like the Carabinieri Forestali, which are in charge for surveillance activities.

Further important application fielded by Molise Region with the support of the University of Molise, regards the possibility to install the FIS on portable device such as smartphone or tablet. This function is on test by the staff of the regional office and allows to add new georeferenced information (text and photos) directly in the field, and thus to get a real time update of the FIS based on real data. Based on the results achieved by this testing phase, the local manager will consider the possibility to make the FIS, or part of it, open access to all users. Provide who work in the forest sector with such an innovative tool will have key consequence on their employment and income levels.

Regarding the analysis of the changes in the aesthetic quality of the forest landscape the FIS could be use in the assessment of forest biodiversity, especially regarding the habitat trees abundance and distribution. The availability of information about the number and the habitat value of trees represent a further step for allowing the habitat identification directly in forest. It also helps in the assessment of the appropriate number of habitat trees to be released in the forest, balancing timber production and biodiversity conservation. The same could be in the management of sites of the Natura2000 network, fostering the identification of potential threats and the definition of priority functions of

lands, promoting dissemination activities useful to involve local people.

### Caprarola – Lazio

Since its implementation in the GIS software in headquarter of the Municipality of Caprarola, the FIS has offered a concrete opportunity to support local forest management decision-making in regulating and improving the public use of the forest. First of all, like in the other demonstration sites, the update data stored in the FIS led to an analysis of the changes occurred in the managed forest. The SFM indicator “Tree Species Composition” (#4.1) was used to highlight the evolution of the forest ecosystem and update the boundaries of the forest units’ map that is the base of each forest planning activities. Access to high resolution data help local managers to better understand the forest and consequently the way to set up their daily work.

Caprarola test site is included in a Regional Natural Reserve so that the public accessibility and use of the area for leisure activities are relevant. Using data from the SFM indicators “Growing Stock” (#1.3) and “Above Ground Biomass” (#1.4) the staff of the Municipality of Caprarola identified the position of the monumental beech and Turkey oak. Monumental trees differ from others of their species owing to their unusual size, their age, or their unusual shape, which means that they are of special natural, historical, cultural, or landscape interest. Based on the FIS dataset trails connecting very large trees are been identified and pointed out in the footpath map of the demonstration site in order to notify them to the general public and create an educational and natural itinerary.

## **Analysis of the costs and benefits of forest management plans developed with FRESH Life tools vs traditional forest management plans.**

### Traditional Forest Management Plans

Traditional Forest Management plans are designed to produce a plan (as a document) which directs the way in which the forest is managed through sustainable silvicultural activities. Usually, Traditional Forest Managements plans are designed to summarized in a traditional document using text, graph and tables the information of a forests using a traditional approach. The information summarized in the document are usually based on a subjective data acquisition of field plots in very limited portion of forest (usually in Italy 30/50 field plots of 530-1000 m<sup>2</sup> every 1000 ha) in the area where silvicultural activities are planned during the life of the plan (i.e. usually 10-20 years in Italy). The acquisition of field plots are usually done without following a rigorous statistical sampling; therefore, it is not possible to estimate SFM indicators (e.g. mean values, total values of SMF in the forests). The approach behind traditional forest management plans follow the old concepts of Sustainable forest management mainly oriented to quantify just the productive aspect of forest (e.g. wood and biomass amount). The forest management plans provide a summary description of forest areas and a detailed description is provided just for the areas where silvicultural activities will carry out during the life of forest management plans using the information acquired in the subject plots in conjunction with traditional cartographies maps (e.g. forest management units’ boundaries, forest types, and cadaster units). For that reason, forest management plan documentation do not provide a complete high-resolution overview of the forests, since the data described mainly the area where silvicultural activities for wood production will carry out. The mean cost of forest management plans in Italy is estimated in 15 €/ha for coppices and firewood forests and 25 €/ha for high forests (i.e. coniferous plantation), whit the costs of the measures of each field plots esteemed in 300 € with field protocol that required the measures of all diameters of trees and just a sample of tree heights.

However, the costs of forest management plans do not comprise the updating of information during the life of the plan, that usually required very expensive field campaign to obtain information for examples to design wood extraction roads, and to map cuts area. Usually, the costs of those acquisitions

are approximately between 350-3000 €/ha and are necessary when silvicultural activities are carried out.

### Forest management plans developed with FRESH LIFE tools

In the last years, EU and National EU authorities had underlined in the Forest strategies that there is a need of new methods and tools for the integration of spatial and temporal dimensions in forest to support sustainable forest management and updating the methods to design forest management plans that need to take in consideration different objectives and goals. In fact, they underlined that there is an evident need of new instruments able to design forest management plans that can link tagholder different forest issues as for example production of wood, touristic activities, biodiversity protections.

However, usually traditional forest management plans are designed just to support the issue related to the production of wood and biomass, without taking in consideration other types of information that potentially can maximize other forest ecosystem services and so found new economic values provide by Forests in the context of Payment for Ecosystem Services (PES). In fact, Forests managed following different aims maximizing different ecosystem services are considered crucial assets for sustainable rural development, and contemporary forestry is an industry where production, environmental and social goals can—and should—be handled simultaneously.

The first advantage provide by FRESH LIFE was derived by the field plots data acquisition that follow a rigorous statistical sampling scheme. In fact, just implementing a sampling designed scheme, comparing to the subject plots used by traditional forest management plans, it is possible to estimate, through statistic estimators, the mean, the total values, and the standard error of each one of the SFM indicators with high accuracy, as done in the context of traditional forest inventories at regional and national level. The costs to acquire the data of each field plots for FRESH LIFE was esteemed in 360 € that is comparable with the one of traditional forest management plan field plots. However, it is important to remember that the protocol used to acquire the field data of FRESH LIFE comprise the measures of all the tree height, tree crown, position of trees and micro habitat that is more complex than the ones used for traditional forest management plans. So, we can say that the costs related to field sampling are comparable with the ones of traditional forest management plans, while the results provide by the sampling scheme are of higher values, since we can esteem the SFM indicators, while with traditional approach it is not possible.

However, it is important to underline the high values provide by FRESH LIFE is related with the tools that we used in conjunction with field data (i.e. UAV data, and FIS). FRESH LIFE demonstrated that, with high resolution data acquired by UAV (i.e. LiDAR and Multispectral) used in conjunction with field plot measures and FIS, it is possible to orient different types of forests for multiple purposes and not just for productive aspects. In fact, for example FRESH LIFE demonstrated that the data and the FIS in Rincine can improve the ability in deciding the boundaries of the area of cuts (i.e. traditional silvicultural activities) but also in modelling different forest structure indices that can be used to assess the biodiversity habitat for animal species communities (Figure 2). Moreover, in Rincine demonstration site the LiDAR data are now used not only to map the SFM indicators but are used to support other Forest Management activities such as the design of wood extraction forest track/roads (Figure 1). Therefore, the UAV data are so useful to reduce also the costs of the expensive field campaign that are usually necessary when traditional forest management are applied. So, the LiDAR data can reduce the costs of activities that are not usually directly associate with the costs of forest management plans costs but are usually associate with the costs of forest management activities (i.e. usually 1500-3000 €/ha for wood road extraction design).

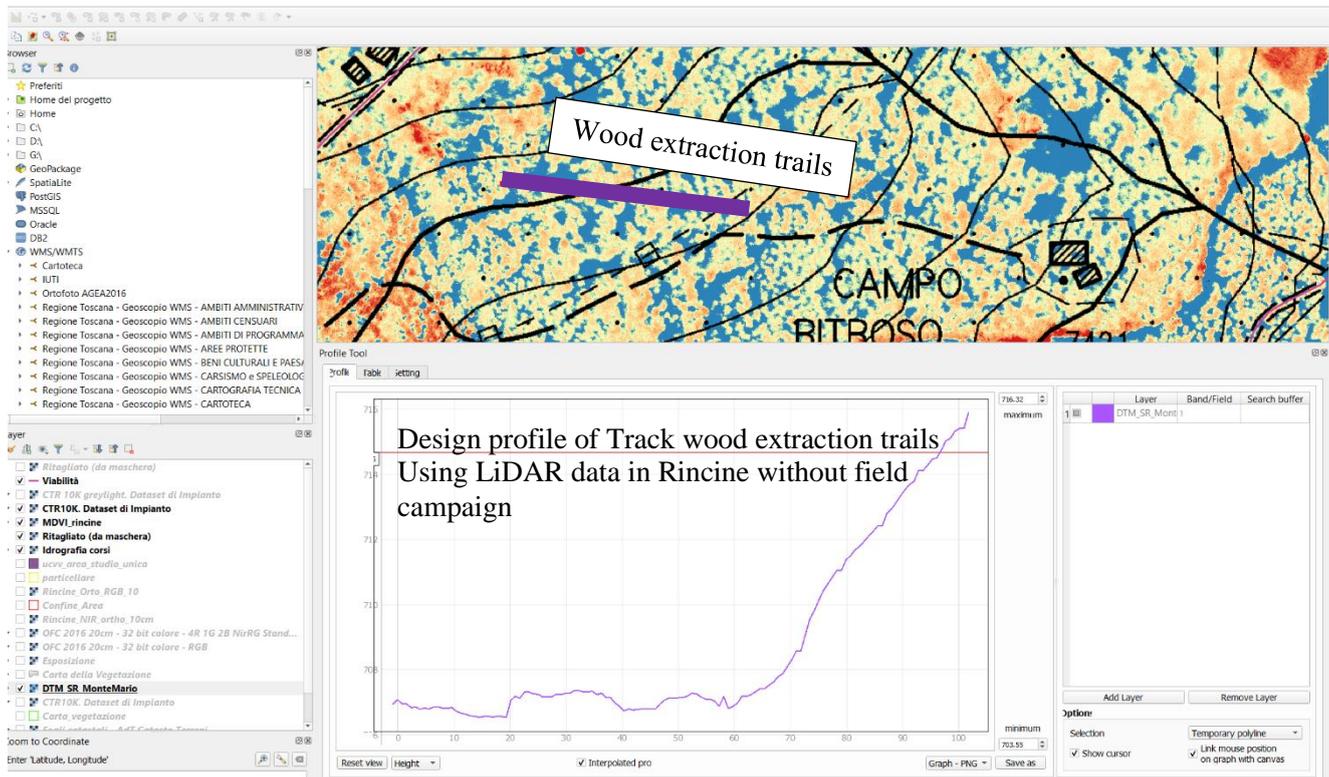


Figure 1 - Use of LiDAR data acquired in FRESH LIFE useful to support other Forest Management Activities as for example the design of wood track extraction trails without traditional field campaign

In Caprarola, the high-resolution UAV data (i.e. LiDAR and Multispectral) and field data measures were used to redesign the management units for the civic uses, but also to detect the monumental plants of Beech forests and micro-habitats. In that case traditional forest management plans are not able to mix the two issues and so two different forest surveys will be necessary to detect the same amount of information. We demonstrated that with FRESH Life methodology that information are acquired together since the data can be analyzed for the two different issues and the issues can be analyzed together.

In Bosco Pennataro, several objectives have been achieved using the Forest Information Systems, the UAV and field plots data acquired. In fact, it was possible to monitor habitats, forest cuts and conservations, that usually with the traditional forest management plans are not managed with a unique system but using different plans (e.g. documents) as for example the forest management plans, the biodiversity plans that are not designed tagholder and so can potentially be in contrast each other's. Since the maps developed by FRESH LIFE can be read by different authorities that work in the reserve and so can be used to create a unique overview of the Forest useful to mitigate the conflict.

Moreover, in Vallombrosa the map of Growing Stock map we developed was used to update the traditional forest management plans, without the need of acquisition of new information. In fact, the map was used to derive the traditional tables, and graph required for compile the documents of traditional forest management plan following the Tuscany forest law. The update forest management plan of Vallombrosa with FRESH LIFE tools (e.g. Growing Stock forest map, forest structure indices maps and FIS Figure 2) will be adopted in the next months by the manager of the reserve. An analysis of the costs of updating the traditional plans using as benchmark the costs of the previous updating made possible to found that with FRESH LIFE methodology, we can save approximately 120 €/ha comparing the costs that were necessary in the past to update the traditional forest management plans. In fact, with that methodology for example we were able to reduce the number of field plots acquired in the field (i.e. 70 plots comparing to 150 plots). It is important to note that in Vallombrosa additional site we used available LiDAR data acquired by Tuscany Region with public investment, and we just acquired eBee Multispectral data that have a cost of 100 €/ha. So, at the end the cost was lower, because

the data of LiDAR were already available, and because the field plot were half.

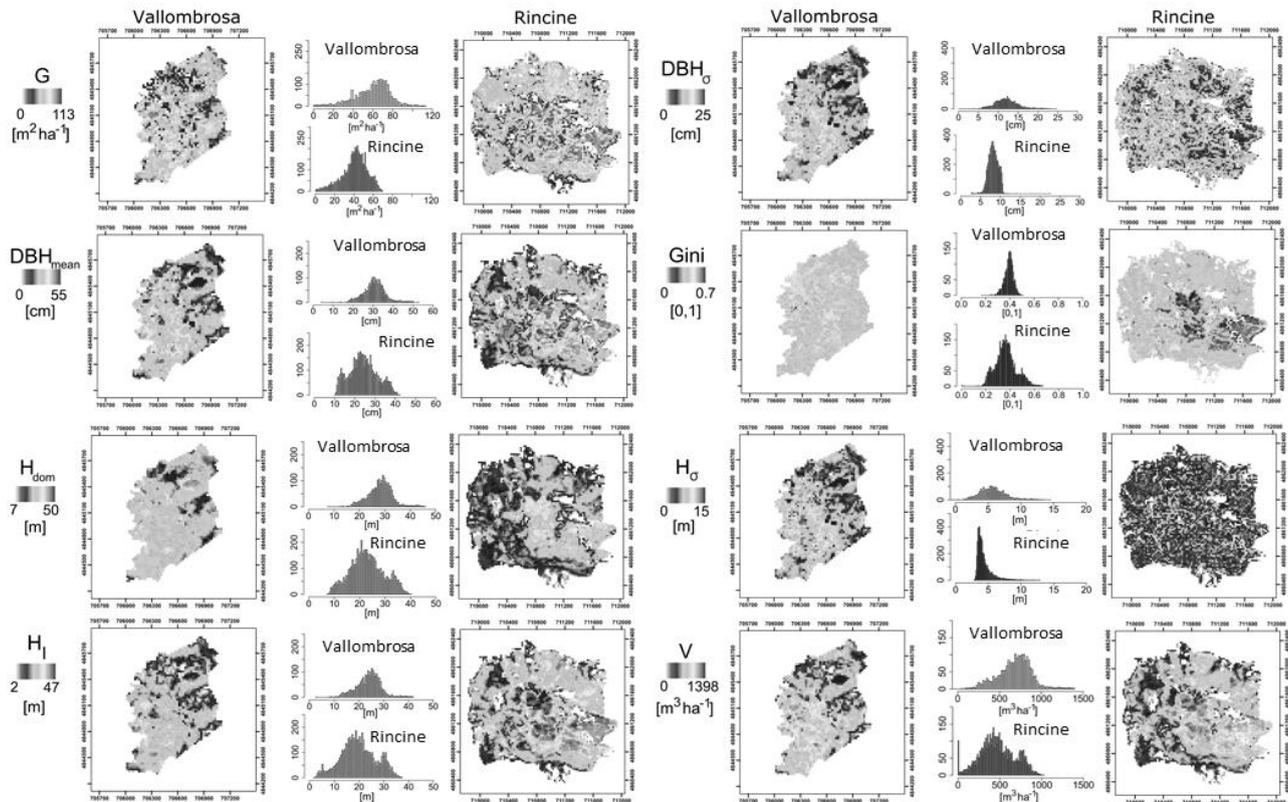


Figure 2 - Maps of different Forest Structure indices spatialized in Rincine and Vallombrosa to monitor biodiversity indicators using FRESH LIFE UAV multispectral data and Field Data

In details, the acquisition of LiDAR UAV data, and Multispectral data are esteemed to be 500 €/ha and 100 €/ha respectively. At the end we can esteemed that implementing the FRESH LIFE methodology cost 960 €/ha that appears to be higher than the cost of traditional forest management plans (i.e. 10€/ha – 25€/ha). However, those data are also used to produce information that are not calculate for traditional forest management plans (e.g. to design wood extraction track, to monitor mico-habitat), and the data can be used for different purposes that usually are acquired by other types of field surveys. Moreover, we can estimate that traditional field sampling to acquire the same level of information are of the same magnitude of FRESH LIFE cost since for example biodiversity monitoring field survey can have a cost of approximately 360 €/ha and the additional field campaign during the life of forest management plans are estimated in 500 €/ha. So, if we sum all these costs the traditional ways to acquire the same level of information of FRESH LIFE with traditional approach is 885 €/ha. However, the information that are acquired by traditional approach are just a sample of the forests, while FRESH LIFE methods produce data that cover all the forest area.

It is important to underline that FRESH LIFE demonstrated that the use of high-resolution RS data improved the estimation of SFM and give the ability to obtain map that can be used in Forest Information Systems (FIS) that cannot be realized with traditional forest management plans. In addition, we demonstrated that the three-dimensional data, which can describe tree or canopy high, have been demonstrated by FRESH Life to be essential to quantify with high accuracy SFM, especially growing stock volume and biomass that are the main target of traditional forest management plans.

In fact, the 3D data that we used were obtained by both UAVs:

- LiDAR data from optocopter UAV

- Photogrammetric data from fix-wing UAV.

We demonstrated that LiDAR data acquired by UAV are good data on which it is possible to obtain Canopy Height Model (CHM) because can detect terrain and top canopy structures. However, as mentioned by other authors in literature, in the last years, from 3D photogrammetric data, that can describe the top of forest canopy, it is also possible to derive CHM if the data are used in conjunction with high resolution Digital Terrain Model (DTM).

So, it is important to take in consideration that photogrammetric UAV are less expensive comparing to the one equipped with LiDAR. In fact, in the last two years a lot of photogrammetric UAV, that can flight automatically, are present in the market with a cost of around 1000€. So, forest owner can buy photogrammetric UAV to obtain 3D data and optical data could that can be used to map SFM indicators.

Moreover, it is important to remark that in some EU countries, as for example the Nordic countries such as Norway, Sweden, Finland, in the past 20 years, the use of airborne laser scanning (ALS) has been widely used for forest inventory purposes and has become the standard data source for operational forest inventories. So, forest managers do not need to acquire these types of data using UAV, reducing a lot of the cost of deriving SFM maps because they can use free available data acquired by the governments. However, in some countries, such Italy, the use of UAV equipment with LiDAR is mandatory because there is not a full cover of ALS data.

## **New strategies in adding values for Forest owners and managers implementing FRESH LIFE tools**

The maps of sustainable Forest Management Indicators that we developed can be used, not only for management purposes but also to calculate the value of each one of the indicators for implementing Payments for Ecosystem Services (PES) schemes to create new economic values from forests.

We demonstrated that the FRESH LIFE tools are useful in quantify and queries SFM using FIS but are also important to design **New Forest Management Plans** using the new EU concepts of multiple forest management issues, while traditional forest management plans are not able to answer to these goals. For that reason, all the beneficiaries of the project, directly involved in manage the FRESH LIFE demonstration sites, underlined the importance of the FRESH LIFE tools to implement the new concepts in Sustainable Forest Management plans. In fact, to plan and conduct site-specific forest management activities the maps representing the forest environment (i.e. different SFM indicators) under different points of view are considered crucial (Corona et al., 2017; Fardusi et al., 2017). The FRESH LIFE demonstrated in an operative way the possibilities of creating a multifunctional property, i.e., the options to generate “new” goods and services from the forest’s social values as a supplement and/or alternative to long-standing biomass/wood extraction. In fact, the FRESH LIFE tools (maps, FIS) given the possibilities to the forest managers of demonstration sites to maximize different forest ecosystem services tagholders adding new economic values and new objectives to their forests. In fact, the new concept of PES or the forest certifications results easier to be implement in the demonstration site thanks to the SFM maps that can be used to convert the SFM indicators in economic values following the PES (Payment for ecosystem services) scheme, or in indicators useful in the context of forest certifications. In fact, the SFM maps can be used to quantify in any area of the forest ,with high accuracy, the different indicators and so open the possibilities for example to calculate the trade-off and related economic values of the ecosystem services in all the forest (Sacchelli, 2018). In fact, for example, following the example publish by Sacchelli et al., 2018 the SFM maps developed in FRESH LIFE can be used to quantify the value of Cultural services of forests given an assessment of €/ha of that ecosystem services that forest owners can “sell” in the context of PES. Moreover, it is important to remember that the traditional information (i.e. graph, table, description) that are reported by Traditional Forest Management plans, and so required by Forest Regulation, can be easy derived with

high accuracy by the FRESH LIFE tools, while Traditional Forest Management plan can not produce the information of FRESH LIFE.

In conclusion, also if the cost of Forest Management plans developed with FRESH LIFE tools is slightly higher than the costs of traditional Forest Management plans, the advantage given by the new FRESH LIFE methodology can produce additional values that can potentially pay the over costs. Moreover, thanks to the high-resolution data collect with UAV also the field campaigns that are usually necessary to update the forest information when traditional forest management plans are used can be reduced using FRESH LIFE tools. In fact, for example UAV can be used to map automatically the cuts and to design the roads for wood extraction, while usually those activities required very expensive field campaigns that are not considered costs of Traditional Forest Management plans but influence a lot the costs of the site-specific forest management activities. So, the higher initial costs of Forest Management plans developed with FRESH LIFE tools, have a potential lower cost in updating the information comparing to the traditional forest management plans, as we found in Vallombrosa. Moreover, it is important to remember that the information on the forests that can be derived by the FRESH LIFE methodology are not comparable with the ones obtained by Traditional Forest Management plans, because the FRESH LIFE methodology provide spatial data of all forests, while traditional forest management plans, provide information just for a sample of forest, where some silvicultural activities will carried out during the life of forest management plans (i.e. in Italy 10/15 years).

## **References**

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