DECISION

Subject: Memorandum of Understanding for the implementation of the COST Action "Integrated DSS for delivery of ecosystem services based on EU forest policies" (DSS4ES) CA22141

The COST Member Countries will find attached the Memorandum of Understanding for the COST Action Integrated DSS for delivery of ecosystem services based on EU forest policies approved by the Committee of Senior Officials through written procedure on 12 May 2023.

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MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA22141
INTEGRATED DSS FOR DELIVERY OF ECOSYSTEM SERVICES BASED ON EU FOREST POLICIES (DSS4ES)

The COST Members through the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action, referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any document amending or replacing them.

The main aim and objective of the Action is to establish a research network for facilitating the conceptualization and development of new methodological approaches of the next generation of DSS covering the relations between forest, forest landscape management and stakeholders of the landscape. This will be achieved through the specific objectives detailed in the Technical Annex.

The present MoU enters into force on the date of the approval of the COST Action by the CSO.

OVERVIEW

Summary

Forests are significant part of surrounding landscape and every management decision in forest affects the landscape as well, and vice versa, management decision in surrounding landscape affects the forests.There is thus a need for an integrated DSS framework that addresses all objectives of sustainable forest management in the landscape appropriately by linking all mutual relations between forests and surrounding landscape. Such integrated DSS framework will require the consideration of information and approaches from different rural and landusing activities and sectors. In this context, juxtaposition and integration of the knowledge from DSS (developed for farming, animal husbandry, forestry, ecosystem management, etc.) will be an excellent starting point for advancing toward an integrated system for sustainable assessing the provision of ecosystem service (ES) at landscape scale, including provision of resources for bio-based economic activities, protection and regulation, or cultural services. The main aim of this Action is to establish a research network for facilitating the conceptualisation and development of new methodological approaches in decision support systems including important relations between forest and landscape. The emphasis is on screening, evaluating and proposing existing and future tools to support holistic planning approaches to increase sustainable forest management, considering various ecosystem services and products addressing the associated risks and uncertainties.

Areas of Expertise Relevant for the Action	Keywords
● Agriculture, Forestry, and Fisheries: Sustainable forest management	● Forest Management ● Sustainibility ● Multicriteriality

Specific Objectives
To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

Research Coordination
● Review and explore various DSS designs and solutions for integrated forested landscape management
● Identify gaps of current solutions and propose alternative options on
possibilities of including multiple ecosystem services and participatory decision-making process

Capacity Building
● Facilitate learning across multiple levels of governance and natural resource sectors
● Improve access and usage of DSS in the sense of sensors, big data, IoT, NO-SQL-data-bases and similar technologies
● Train students and early stage researchers on the needs and requirements for a successful implementation of DSS and ICT tools

TECHNICAL ANNEX

1. S&T EXCELLENCE

1.1. SOUNDNESS OF THE CHALLENGE

1.1.1. DESCRIPTION OF THE STATE OF THE ART

Forests are an integral part of the landscape and management decision in the forests affects the provision of ecosystem services of the landscape, and vice versa, management decisions in the surrounding landscape affects the forests dynamics over time. Disregarding the intimate relations – environmentally, economically, and socially – that forests have with other constituent parts of a landscape could severely limit the possibilities to address the challenges facing the member states of EU and expressed in several EU policies. Under the 'Fit for 55' initiative there is a comprehensive set of policies to approach both the environmental and energy crises. One main objective is to achieve net zero greenhouse gas emissions by 2050. A step towards this objective is to attain 40% renewables in the EU energy mix by 2030. The current need to reduce Russian energy dependence has increased the urgency to move in this direction. Today 60% of renewable energy comes from biomass, of which 60% is wood-based. Concurrently, 'Fit for 55' demands an upgrade of measures to protect the primary forests and the forests with high biodiversity value. The decision space would be reduced further by the ban on forest residues for energy purposes proposed by the EU Parliament.

Partial solutions to the dilemmas may cause unforeseen and detrimental side effects. For the forest based sector to be able to contribute proficiently, there is need for analytical capabilities to handle the complexity and the entirety of the problem. Furthermore, a solution is not only, or foremost, a matter of technical arrangements. In fact, a possible solution or part of a solution is a matter of devising a smart management planning process that accommodates social involvement in decision making and forecasts the future availability of renewable resources over time (sustainability) with the advanced set of decision making tools and methods. In line with the European Landscape Convention, human activities and their institutions are constituent and integrated parts of the forest socio-ecological system rather than as external agents. Therefore, forest landscape management approaches usually involves some form of multi-stakeholder interventions to negotiate and implement management actions for local livelihoods, health and well-being. The diversity of natural, social, and institutional conditions of European landscapes is well recognized. Decision making tools and methods for landscape analysis should therefore be versatile enough to accommodate different problem foci and different implementation strategies.

To this end, landscape management has relied on computerized decision support systems (DSS). DSS support planning and decision making in semi- and unstructured decision problems. In that context database systems are linked with analytical models and expert knowledge to take informed and data-driven decisions over complex systems allow managers visualizations by various graphical and tabular means. The first generation of DSSs was typically designed to address relatively narrow, well-defined problems for one ecosystem (ES). Examples include DSS for ES like timber production or increasing the resistance against storms, respectively. Over the past decades, there has been a pronounced trend towards the development of more general-purpose DSS simultaneously covering a broader range of ES such as habitat for biodiversity conservation and water provision. However, there are few DSS applicable for landscape management. This concerns the ability to make uses of remote

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sensing data to depict the full extent of the landscape, analyses of spatial aspects concerning ES (like green infrastructures), as well as the integration of methods to illustrate landscape processes and bridge separate sectors (forestry, agriculture, terrestrial water, and urban areas) in order to engage stakeholders.

There are three main challenges motivating the proposed COST Action DSS**4**ES: (i) The limited capabilities of current DSS for forest landscape management; (ii) the significant advances in computing and mathematical methods that enable development and implementation of the next generation forest DSS; (iii) the urgency of forest landscape management strategies that contribute to the solution of the many dilemmas of environmental and energy policies facing EU and its member states.

1.1.2.   DESCRIPTION OF THE CHALLENGE (MAIN AIM)

The main aim of this **Action** is to establish a research network for facilitating the conceptualization and development of new methodological approaches of the next generation of DSS covering the relations between forest, forest landscape management and stakeholders of the landscape. The emphasis is on screening, evaluating, and proposing decision-making tools and methods. The results of the Action will support holistic landscape planning approaches, which enhance sustainable forest management, considering a full range of ES, and address the policies and regulations across Europe. In this respect, an **integrated DSS** for sustainable provision of multiple ES at landscape scale includes support for the provision of resources for bio-based economic activities, protection and regulation, and cultural services.

The starting point for formulating a **DSS framework** will require the consideration of spatial forest information and approaches from different rural and land use knowledge domains, such as agriculture, forestry, hydrology, biodiversity related areas, and land-use change processes. A major challenge concerns the harmonization of concepts, data sources, and the temporal and spatial structure of decision-making tools. Another challenge concerns the ability to bring in the various problem perspectives of high relevance to different parts of Europe. For example, land-use matters associated with urban sprawl are more acute in certain regions, whereas protecting forests from pests, draught and storm is more at focus in other areas. The combination of data, quantitative analysis methods, and problem focus forms the basis for approaches to involve multiple actors for informed decision making. The landscape perspective brings to the forefront different challenges, like how to present and illustrate results of different landscape management strategies, how to design multi-stakeholder processes that encompass participants from various landscape sectors (not only forestry), and how to make results available for policy processes at national and EU level. The last point puts focus on governance and implementation issues.

1.2.   PROGRESS BEYOND THE STATE-OF-THE-ART

1.2.1.   APPROACH TO THE CHALLENGE AND PROGRESS BEYOND THE STATE OF THE ART

The role of digital technologies continuing to enhance sustainability of value chains grounded in renewable resources has been well acknowledged (Digitising European Industry initiative https://ec.europa.eu/digital-single-market/en/digitising-european-industry-digital-day).   Within these technologies, the advanced DSS with embedded Operations Research/Management Science (OR/MS) methods has proven to be indispensable tools for long-term sustainable production of forest products and services. In this context we propose a framework for an integrated forested landscape management DSS considering different ecosystem services and their integration into decision making, the evaluation of various DSS methods and tools focusing on their architecture and design structure, assessment of various management policies and guidelines across various jurisdictions and the formulation of management scenarios with an emphasis on climate change and bioeconomy supported by the practical forested landscape planning process with appropriate digital technologies.

There are five focal points within the framework, corresponding to five tasks with working groups (WG) (Figure 1). **WG 1**, data and knowledge promises to the gathering and the utilization of forest characterization and management data from various sources such as expert knowledge, empirical data, NFIs and remotely sensed data for both quantifying ecosystem services and preparing management plans. **WG 2**, models and methods, refers to the review and assessment of the development, architecture and design of DSS and the methods such as artificial intelligence, operational research techniques, meta- heuristics, multi-objective, and multi-attribute techniques. It will demonstrate the capability of such models and methods in addressing multiple ecosystem services as management objectives, multiple ownerships, multiple spatial scales, bioeconomy and climate change issues based on the sustainability concept and considering various disturbance agents (e.g. wind, fire, bark beetles). **WG 3**, on the user perspective, will evaluate the process of involving stakeholders, options for conflict resolution and consensus among multiple stakeholders, the visualization of information and means of communication, and eliciting preferences focusing on social learning processes linked to DSSs. **WG 4**, DSS integration, will involve the integration of various ES, user demands, stakeholder's requirements, policies / legislations, data requirements, as well as models and methods in management planning. It will address innovative ways of connecting processes for information extraction from Task 1, with the forest management decision making tools (Task 2). It will focus on the core aspects of the framework how to integrate all these elements by proposing criteria for the successful development and use of DSSs as well as the assessment of forest DSSs against these criteria. **WG 5,** governance, focuses on the approaches and tools in the realization and translation of the results of DSS into practicality. It will elaborate on the policy setup, legal documents, training material for converting DSS results to the practicality in different use cases.
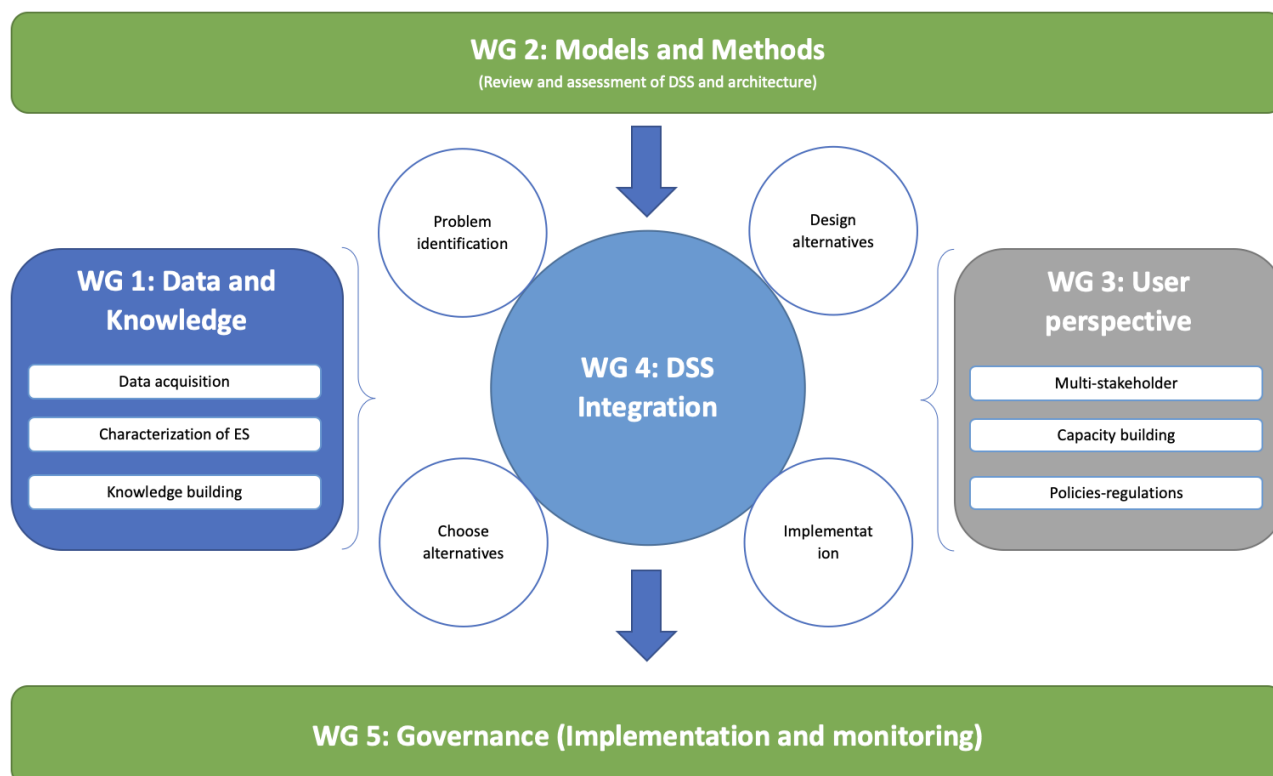

Fig. 1. The framework of the Action DSS**4**ES with the relation between the WGs of the Action

Current advances in IT technology allow the development of more sophisticated DSSs that can support the complex interaction between land-uses and support cross-sectoral decision making. One area undergoing rapid development is data acquisition by remote sensing. Airborne laser scanning (ALS) is one technology indicating that accurate and comprehensive landscape information can be retrieved on a regular basis. The Internet of Things (IoT) brings possibilities to use the information in

automated system based on expert system principles. Cloud computing will allow new user groups and decision making opportunities to take advantage of sophisticated DSS otherwise unavailable. These are a few examples of the opportunities that the advanced technology frontier gives for the future DSS development going beyond the state of art. Accommodating the DSSs to the wealth of information and linking the development efforts to the needs of policy makers at EU level and other stakeholders are paramount for reaching the development goals set forth.

1.2.2. OBJECTIVES

1.2.2.1. Research Coordination Objectives

The overall research coordination objective of the Action DSS**4**ES is to establish a network of experts for tools and methods to model the forested landscape system in an integrated DSS for delivery of ecosystem services based on EU forest policies and include the necessary relationships within and between different sectors. Only the interdisciplinary know-how from researchers, policy makers, stakeholders and practitioners of different countries and thematic fields can provide results applicable in practice and scalable to all bioclimatic regions and political contexts of Europe. The international and interdisciplinary cooperation and coordination will allow to address the following partial research coordination objectives:

- **REVIEW AND EXPLORE VARIOUS DSS DESIGNS AND SOLUTIONS** for integrated forested landscape management, that can make use of digital technologies for inventory, surveys and management to serve the needs of forest managers and policy makers

- **IDENTIFY GAPS OF CURRENT SOLUTIONS AND PROPOSE ALTERNATIVE OPTIONS** on possibilities of including multiple ecosystem services and participatory decision-making process at landscape level into the DSS. This could be successfully solved by the integrated use of advanced operations research techniques as well as modern Information and Communication Technologies (ICT).

1.2.2.2. Capacity-building Objectives

The **Action** DSS**4**ES helps foster knowledge exchange and develop a joint research agenda around DSS for integrated forested landscape management. Bridging separate fields of science to achieve breakthroughs will be supported by the **Action**. At the same time, it is envisaged to involve teams from countries with less capacity in the field of the **Action**. The partial capacity-building objectives are:

- **FACILITATE LEARNING** across multiple levels of governance and natural resource sectors, involving all actors affecting natural resource management

- **IMPROVE ACCESS** and **USAGE of DSS**: Make use of the existing DSS, sensors, big data, IoT, NO-SQL-data-bases and similar technologies and identify how different tools are to be utilised in cross-sectoral/policy and cross-societal contexts for decision supporting.

- **TRAIN** students and early stage researchers on the needs and requirements for a successful implementation of DSS and ICT tools in the context of the emerging challenges in the bioeconomy.

2. NETWORKING EXCELLENCE

2.1. ADDED VALUE OF NETWORKING IN S&T EXCELLENCE

2.1.1. ADDED VALUE IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

The **Action** DSS**4**ES takes advantage of the three-year research project PEGASUS (Public Ecosystem Goods and Services from land management – unlocking the synergies), which is coordinated by IEEP (Institute of European Environmental Policy). The outcome of the PEGASUS project will support our aims through an operational framework for mapping, valorising and determining what public goods and ecosystems provisions are needed and feasible within particular territories and sectors. The Action also uses the results of projects HERCULES (Sustainable futures for Europe's HERitage in CULtural landscapES: Tools for understanding, managing, and protecting landscape functions and values) funded through the European Commission's Horizon 2020 programme initiated in 2015, and "LANDSCAPEPARTNERS - The contribution of multi-stakeholder partnerships to sustainable landscape management" (MC-IEF - Intra-European Fellowships (IEF))

ongoing in 2010-2012 seek to empower public and private actors integrating into the landscape management to protect and sustainably manage the landscape and will support the **Action** through the knowledge about stakeholders integrating into the planning process. The **Action** will use the results of the projects "INTEGRAL - Future-oriented integrated management of European forest landscapes" (CP-IP - Large-scale integrating project) from 2011-2015 and "ALTERFOR - Alternative models and robust decision-making for future forest management" (Topic ISIB-04b-2015 - Improved forest management models), the former with focus on scenario analyses and participatory processes and the latter with focus on landscape management under challenges due to climate change. The **Action** will use partial knowledge based on this project and extend it by other aspects of landscape management. Furthermore, we will use the results of the EU-funded project "FOCUS – Advances in Forestry Control and automation Systems in Europe) (FP7, NMP, 2014-2016), specifically as a starting point to address new digital technologies present for remote data collection over the forest-based value chains and its integration with DSS.

The StarTree project (Multipurpose trees and non-wood forest products: a challenge and opportunity; 2012-2016) will support the **Action** through identifying challenges and proposing solutions to enhance the management, product development, innovation, multi-stakeholder dialogue and marketing of non-wood forest products to support the sustainable exploitation of forest resources for rural development in the field of bio-economy.

The **Action** significantly extends the completed COST Actions FP0804 "Forest management decision support systems - FORSYS" which was aimed mainly to the forest management DSS. The **Action** is much broader extending from a forest perspective to a landscape perspective. Moreover, the **Action** continue with the COST Action FP1207 "Orchestrating forest-related policy analysis in Europe - ORCHESTRA" and builds on the finalised COST Actions FP1304 "Towards robust PROjections of European FOrests UNDer climate change – PROFOUND" and FP1201 Forest Land Ownership Change in Europe: Significance for Management and Policy (FACESMAP).

Thanks to network members, the iberoamerican network bigDSSagro, which focuses on big data and DSSs applied in agiculture, and EURO Working group on Agriculture and Forest, will also be significantly involved in the **Action**. Moreover, the **Action** will connect to the H2020‑LANDSUPPORT project, focusing on developing a web-based, open-access GeoSpatial Decision Support System (S-DSS).

2.2. ADDED VALUE OF NETWORKING IN IMPACT

2.2.1. SECURING THE CRITICAL MASS, EXPERTISE AND GEOGRAPHICAL BALANCE WITHIN THE COST MEMBERS AND BEYOND

The suggested **Action** network includes experts from different areas of expertise covering the different forest and landscape management knowledge. The members of the network have been chosen for their scientific and policy contacts and networks so that the results of the **Action** can be further disseminated and benefited from feedback of these contacts and networks.

2.2.2. INVOLVEMENT OF STAKEHOLDERS

The audience targeted for the different dissemination efforts are the members of the following bodies: Organisations (public, company, different landscape owners organisations) responsible as resource managers and users or potential users of landscape DSSs; IT-specialists engaged in the development of DSSs; Public and private research organisations engaged in the development and use landscape DSSs; Research departments in areas of landscape planning and management, ecology of landscape, forestry, agriculture, etc., higher educational institutions responsible for teaching landscape management, forestry, agriculture and water management. The **Action** DSS**4**ES will make use of the Community of Practice of Forest DSS in reaching out to relevant stakeholders. The CoP has a well-established users' community with members from research, public bodies, business and NGOs of existing FP 7 projects and former Cost Actions (FORSYS, ECHOS, ForestModels). The CoP will connect and mobilize developers and users of forest DSS to support the analysis of the NEEDS for decision support for integrated landscape management planning.

The **Action** will organise series of workshops and public conferences as stated below. These events will take place in different Europe regions organised by Action participants, preliminary as follows:

central Europe (Czech Republic), north (Sweden, Finland), southeast (Romania), western (Spain,

Portugal). Each workshop and public conference will attract participants of most relevant stakeholders from the hosting country and Europe region as well. It will ensure keeping stakeholders updated on DSSs.

Moreover, a European wide survey is planned, where the different stakeholder groups (as a potential end user of DSS) can provide feedback to the network activities and present their attitudes, preferences, expectations towards an integrated DSS for delivery of ecosystem services based on EU forest policies.

3. IMPACT

3.1. IMPACT TO SCIENCE, SOCIETY AND COMPETITIVENESS, AND POTENTIAL FOR INNOVATION/BREAK-THROUGHS

3.1.1. SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS (INCLUDING POTENTIAL INNOVATIONS AND/OR BREAKTHROUGHS)

Scientific and technological potential breakthroughs of the **Action** DSS**4**ES are based on a multi-sectoral approach. Only an **integrated forested landscape management** considering ecological, economic and social objectives can be the starting point for ensuring a functioning society in the future under all ongoing changes.

Supporting forest management for different ecosystem services, has not only a scientific potential break-through. Such kind of management is naturally connected with the design and use of various DSS supported by the contemporary information technologies and methods which should be taken into account as well.

The Big Data and IoT concept applied in the natural resource and forested landscape management together with the proposed framework for integrated DSS are technological potentials, bringing new perspectives to DSS development (e.g. probably more explorative, more interconnected) and more bottom-up participation, which includes bio-economy and policy (with great attention to communication with stakeholders) socioeconomic innovation breakthroughs.

To ensure a long-term impact, the Pan-European political process Forest Europe, will be invited to attend all planned **Action** activities (workshops, conferences). The purpose of this cooperation is to transfer scientific findings not only to national level through particular national stakeholders, but to create awareness among scientists for the importance of the political framework within Europe and among politicians for the challenges in implementing EU strategies with the help of DSS and based on a sound scientific understanding.

3.2. MEASURES TO MAXIMISE IMPACT

3.2.1. KNOWLEDGE CREATION, TRANSFER OF KNOWLEDGE AND CAREER DEVELOPMENT

The **Action** DSS**4**ES will provide an original synthesis of multidisciplinary research efforts, results and an innovative European-wide quality reference for development and application of DSS for an **integrated forested landscape management**. Such a synthesis will promote sustainability assessments that are essential to the EU strategies and policies for the long-term socioeconomic impacts. Operational tools for analysing trade-offs between different goods and services are key to finding efficient solutions to landscape management problems. This will improve management from site to landscape scales, and will support small private non-industrial land-owners and users as well as policy makers at regional and national levels. It will also contribute to: strengthening the different sectors through landscape products and their value chain; improve assessment of environmental goods and services; enhance communication to better address public participation in landscape management planning; and finally, disseminate information about landscape products to consumers and society at large. From the short-term technological impacts´ point of view, the Action will also help raise students' and early stage researchers´ knowledge and research capabilities about landscape management or ICT-tools development and use, as a basis for their professional scientific or other career. The **Action** builds on the concept of the relationship of the landscape structure to the quality of

the ecosystem functions and puts an emphasis on the bio-economy. Combining ICT-tools, including DSS with digital technologies for landscape inventory and monitoring (e.g. remote and in situ sensors, big data, IoT), will allow contributing to the emerging field of ICT. Another focus is on the current issues of the increasing frequency and intensity of extreme climate events (especially droughts and floods) and the possibility to regulate these phenomena through appropriate forest management planning strategies. The **Action** will contribute to the implementation of selected sustainable development goals (e.g. affordable and clean energy; responsible consumption and production; life on land, etc.). The complex knowledge based on presented original synthesis of multidisciplinary research will have positive long-term technological impacts on DSS development.

3.2.2. PLAN FOR DISSEMINATION AND/OR EXPLOITATION AND DIALOGUE WITH THE GENERAL PUBLIC OR POLICY

Dissemination goes through the following channels:

Two public conferences: The conference is intended as a broad meeting place where DSS developers, users/practitioners and researchers from related fields will confer and discuss the results of the **Action**. Each conference will be designed to exchange ideas, strengthen the cooperation of participants and result in a report. Organisation in cooperation with already established international research organizations will be considered.

Four workshops: Experts relevant to the topics of the workshops, both members and non-members of the **Action**, will be invited to the thematic workshops focusing on bio-economy, landscape management and decision support. The workshops will focus on a specific theme and will result in guidelines for the application of DSS. The organisation will be done in cooperation with already established international research organizations. Each of them will be organized in another region of Europe (south, west, central-east, and north) for better access to a wider audience of experts and policy makers. The conferences and workshops will aim mainly at consolidation and dissemination results of the **Action** and at a dialogue with the general public.

Two training schools: The training schools will be organized during the **Action** for co-creation and dissemination of the **Action** outputs among the broad field of PhD students. The training school will cover multifunctionality of forest landscape management, climate change issues, participatory planning and emerging ICT technologies used in forested landscape management.

MC and WG meetings: The meetings will represent a forum for organization and dissemination of activities in the Action They will be as synchronised as possible, not only to save on cost but also to facilitate discussions and the distribution of the results across the **Action**.

Publications - Reports: The reports are the publicly available publications from the **Action**. They will be available through the public websites.

Publications - Articles: International peer-reviewed articles may be overviewed that pertain to the results emerged from the **Action**.

Public Project Website: A publicly accessible website will be created as the main dissemination channel for termed reports, flyers and non-technical reports for dissemination. The **Action** will also cooperate with the existing webplatform of the Community of Practice of Forest DSS in reaching out to relevant stakeholders (www.forestdss.org).

25-30 Short term scientific missions (STSM): At least 5-6 STSMs will be organised for each working group, within the limits of available funding, in conjunction with the WGs and STC work according to the milestones. By integrating the activities of the young scientists in STSMs into the structure of the Action, a strong collaboration with senior scientists and the achievement of objectives are ensured. The STSM instrument is important for the long term formation of a European body of

knowledge and experience in the area. The exact timing of individual STSM will always be scheduler for the upcoming year due to other work responsibilities of the members of the **Action**.

Dissemination plan: The above mentioned methods form the main elements of the dissemination plan. This plan is the responsibility of the MC and will be elaborated on the first MC meeting following the kick off. It is continuously monitored by the SG and revised at every MC meeting. Given the stated objectives and applied character of the **Action**, the distribution of public knowledge forms the major steering document of the **Action** since it builds directly on the milestones of the **Action**. The European policy organizations like Forest Europe will be invited to all workshops and conferences.

4. IMPLEMENTATION

4.1. COHERENCE AND EFFECTIVENESS OF THE WORK PLAN

4.1.1. DESCRIPTION OF WORKING GROUPS, TASKS AND ACTIVITIES

WG1: DATA AND KNOWLEDGE

This task focuses on the utilization of data sources, expert knowledge, empirical data, NFIs, remote sensing data, big data for quantifying ecosystem services. It will result in reports on data types, data sources, data quality, verification and validation of data and knowledge to assist overall system design, quality control, integration, sharing, and use in planning process. It will deal with the data structure and architecture to build a spatial database system. It will address innovative approaches for data extraction from forest inventory/NFI, use of monitoring systems such as Remote sensing, as well as traditional knowledge sources (e.g. project results, scientific publications). Therefore, this task defines and documents data resources necessary for other working groups.

T1.1: Review existing digital technologies for landscape inventorying and monitoring (e.g. LIDAR, UV's) EU-wide, with special emphasis to those already used in combination with DSS to support natural resources management, making a distinction between early stage research prototypes and fully commercialized solutions.

T1.2: Review of IoT and Big Data for landscape management. Document, analyze and compare projects and other initiatives for using IoT and Big Data in the context of landscape management EU-wide, pointing-out key players and future trends.

T1.3: Evaluate global forest databases and national forest Inventory (NFI) data, assess data quality, identify missing data components and verify and validate knowledge base to harmonize the data for common uses

T1.4: In cooperation with WG4 develop concepts for interfaces for linking new data sources to DSS.

Activities

A1.1: Working group meetings every year during the Action for setting the work plan of WG and monitoring the progress for meeting the WG tasks.

A1.2: Two workshops in 2nd and 4th year of the Action for knowledge exchange, preparing publications (manuscripts or books)

WG2: MODELS and METHODS

The scientific work will address the requirements of a conceptual framework for the multifunctional forest management planning focusing on models and methods used to characterize ecosystem services. It will focus on the integration of various modelling approaches at the landscape level. An assessment of existing criteria and indicators for sustainable use of ES is central to the Action. This is done first by screening the full range of sectors having interest on a certain set of ES, specific

approaches used to identify, classify, quantify and integrate ES into forest management planning, the Strategic Research Agenda of the EU Forest Technology Platform and bio economy initiatives. As well, the relevant international conventions and EU level forest policy documents prepared for designing future forest management interventions will also be screened in documenting and cross examination of management models and methods used in various EU countries. The case studies provide a basis for integrating the work of the different tasks.

T2.1: Review of existing ES indicators at the landscape level. Criteria and indicators (C&I) have proven valuable tools to define, assess and monitor periodic progress towards the sustainable use of ES. Selected indicator systems (e.g. protection against natural hazards, habitat requirements for game species and recreation) will be screened for their potential in assessing ES on the landscape. Especially, the data requirements will be evaluated considering the heterogenic statistics at the landscape level. The scan and analysis of the global initiatives such as Millennium Ecosystems Assessment (MEA), The Economics of Ecosystems and Biodiversity (TEEB) and The Common International Classification of Ecosystem Services (CICES) will help defining a common platform to identify and classify ES on a sound basis. Various quantification methods for prevailing ES across EU will be compiled and evaluated.

T2.2: Screen existing platforms for mapping ES at the landscape level. The practice of mapping and assessing ES is increasing and several platforms provide information on the spatial distribution of ecosystem services. This task will screen the existing platforms (e.g. Ecosystem Services Partnership Visualization tool (ESP-VT), Mapping and Assessment of Ecosystems and their Services (MAES) digital atlas, Mapping Ecosystem Services to Human Well-Being (MESH)) and identify the current shortcomings and needs for an integrated assessment.

T2.3: Evaluate the existing knowledge on models and methods to quantify and integrate ES into management planning. Different methods are known for quantifying, assessing and predicting ES and evaluating ES trade-offs (e.g. MADM, MODM techniques). This task will screen the existing approaches for their potential to consider ES on different spatial and temporal dimensions. As well, the international and EU level policy documents will be reviewed and documented for applying various methods in forest landscape management planning

T2.4. Evaluate various approaches of valuation of ES for economic analysis in forest management planning. The wide range of methods for assessing ecosystem services (eg. monetary and non-monetary) will be screened for their potential to be used in an integrated DSS.

T2.5: In cooperation with WG4, new approaches for interfaces for linking new methods and models to DSS will be assessed and proposed.

Activities

A1.1: Working group meetings every year during the Action for setting the work plan of WG and monitoring the progress for meeting the WG tasks.

A1.2: Two workshops in 2nd and 4th year of the Action for knowledge exchange, preparing publications (manuscripts or books)

WG3: USER PERSPECTIVE

This WG will address user perspectives, identify stakeholder conflicts and in general support social learning processes. The activities will review the involvement process of various stakeholders across different jurisdictions or EU countries in forest management decisions. The nature of participatory processes, the use of various MCDA tools and need to accommodate local experiences and knowledge, as well as concerns in landscape planning are all central to the Action.

T3.1: Identify stakeholders (i.e, types of actors) with their profile across EU. This task will address policies and guidelines for stakeholder's involvement in creating awareness, defining management

goals, setting policies, developing guidelines and generating innovative alternative solutions. The task will also review the existing methods for stakeholders' preferences and demands survey including the existing best practices or case studies in different countries under changing socio-economic conditions and human perception of forests and landscape while trade-offs of preferences will be evaluated simultaneously.

T3.2: Analyze how different jurisdictions envision and various forms of participatory processes (e.g., discussion forums, virtual communities, workshops, and conferences) are implemented in resource management. Find out the contribution of participatory process to problem recognition and novel problem solution in the decision-making process. Identify and evaluate any qualitative and quantitative MCDA tools (e.g., SODA, A´WOT, AHP, ANP, TOPSIS, VIKOR, Expert systems) successfully used to structure and evaluate user perspectives and create new knowledge and decision support for pluralistic landscape management decisions. Based on the best practices and case studies, suggest the participation process applicable for landscape level.

T3.3: In cooperation with WG4 suggest users´ interface of DSS which enable incorporate different stakeholders into the participation planning problem. This task will form the basis for synthesizing current experiences of participatory planning and analyzing gaps in current approaches to meet future demands on forest landscape management.

Activities

A1.1: Working group meetings every year during the Action for setting the work plan of WG and monitoring the progress for meeting the WG tasks.

A1.2: Two workshops in 2nd and 4th year of the Action for knowledge exchange, preparing publications (manuscripts or books)

WG4: DSS INTEGRATION

This task will focus both on the assessment of DSS designed to accommodate various ES, user demands, stakeholder's requirements, national and international (particularly at EU level) policies / legislations and data requirement in management planning. It will emphasize the assessment and combination of approaches to address multiple objectives and sustainability, multiple ownership, multiple temporal and spatial scales through multifunctional DSS. Further, it will address emerging technological developments and functionalities of DSS (interoperability, hybridization, cloud computing, new OR techniques etc) in forest landscape management planning. Finally, it will support the integration of data, methods and models for the analysis of the complex interactions of forest management at the landscape level, considering the needs and requirements of stakeholders.

T4.1: Review the widespread use of DSS, their common features and uses in projecting forest development at landscape level considering various ES, data requirements and user demands.

T4.2. Assessment of the involvement of various groups of stakeholders (actors in various sectors) in developing management alternatives and analyzing the trade-offs in decision-making process with DSS

T4.3: In cooperation with WGP1, WG2 and WG3, address integration issues related with the digital technologies, methods, models and user perspective for forested landscape DSS. Study interoperability mechanisms that are used or can be used to successfully link digital technologies for landscape inventory and monitoring and methods and models for integrating ecosystem services on landscape level with DSS for planning and decision support. Systematize the technological requirements for interoperability and integration.

T4.4: Suggest the conceptual framework for DSS for forested landscape including ecosystem services.

Activities

A1.1: Working group meetings every year during the Action for setting the work plan of WG and monitoring the progress for meeting the WG tasks.

A1.2: Two workshops in 2nd and 4th year of the Action for knowledge exchange, preparing publications (manuscripts or books)

WG5: GOVERNANCE (IMPLEMENTATION AND MONITORING)

This task will focus on the approaches and tools in the realization and translation of the results of DSS into practicality. European Commission policy documents for both protection and sustainable management of forest ecosystems will be reviewed, synthesized and interpreted for applying forest management practices across European countries towards the harmonization of national governance policies and practices. Policy setup, legal documents, training for converting DSS results to the practicality, criteria and indicators for monitoring the performance, GIS and Remote Sensing tools to monitor forest activities and their effects on ecosystem services are central to the success of the Action.

T5.1: Review forest management policies, regulations and administrative structure across EU and evaluate the pros and cons of various management setups (state, private, corporation) in implementing the results of DSS on the ground.

T5.2: Assess the practicality of applying DSS results on the ground, determine the common problems in translating the DSS results to the practicality and provide vision on the solution to better reflect models results on the ground.

T5.3: Review and analyze the C&I used for monitoring forest management planning activities (i.e., DSS results), investigate the potential implementation of adoptive management process, document the procedure in using GIS and RS in monitoring forest developments under various anthropogenic interventions and natural disturbances.

Activities

A1.1: Working group meetings every year during the Action for setting the work plan of WG and monitoring the progress for meeting the WG tasks.

A1.2: Two workshops in 2nd and 4th year of the Action for knowledge exchange, preparing publications (manuscripts or books)

4.1.2.   DESCRIPTION OF DELIVERABLES AND TIMEFRAME

Each WG has defined major deliverables that will help to integrate the activities implemented during the joint work for the different tasks in the groups. The timeframe for the Action is set by Milestones for each WG.

List of major deliverables
Aside from the conferences, workshops, training schools, group meetings and the short term scientific missions outlined in Section 3.2.2, other major deliverables are described here.

D1.1: A report about the Review and characterization of ICT for landscape inventorying and monitoring. The report focuses on the current ICT used to acquire spatial data for management planning, their potentialities and future lines for integrating ICT and DSS for forested landscape management.

D1.2: A scientific article about the Review and characterization of the role of IoT and BigData for landscape inventorying and monitoring. This paper includes data quality and standards regarding inventory through remote sensing and ground survey, and identify knowledge gaps in data acquisition and database management process.

D1.3: Research Agenda in respect to ICT for landscape management. The relevant future research topics, challenges and proposals on data acquisition pertaining to forest landscape planning will be covered in the agenda.

D2.1: A report about the metrics used to characterize (identify and quantify) ES, and the methods and tools used to integrate ES into forest management planning. The list of metrics will help to define needed models and methods for incorporating ES into the DSS.

D2.2: Review of methods, models and platforms for evaluating and mapping ES in a Wiki. There are many existing approaches for evaluating different ES on the landscape level. The joint web sources will enable systematic development.

D2.3: Scientific paper about the utilization of DSS in various practical forest management jurisdictions focusing on the climate change and bio-economy principles. The paper will focus on the development and use of practical national/international management policies and guidelines as used in the DSS.

D3.1: A report on the participatory planning process across EU and documentation of users and stakeholders' preferences, demands and participation at landscape level. Recognition of relevant stakeholders in the accurate numbers which enable effective and successful participation process is crucial step.

D3.2: A scientific paper on drivers of stakeholder decisions in sustainable forested landscape management. The multicriterial approach is crucial for sustainable forested landscape management.

D4.1: A scientific article outlining the directions for developing new and improving existing DSS to function in a landscape context.

D4.2: A report on strategies for the adequacy and requirement of DSS for sustainable forest management. One of the main outputs of the Action are definitions of new DSS development for sustainable forested landscape management including all relevant aspects.

D5.1: EU policy report analysing the different national policy arrangements (e.g., policy objectives and instruments, rules, discourses, actors, and resources) governing the forested landscape using bio-economy sectors

D5.2: A scientific review focusing on the main perceptions of different actors involved in landscape management concerning the bio-economy;

D5.3:_A scientific publication assessing the trade-offs and synergies in the perceptions and governance arrangements between landscape using bio-economy sectors and landscape management/biodiversity conservation across the EU level and national/subnational levels.

Milestones
MS1.1: Data collection and data analysis completed

MS1.2: Report on digital technologies for landscape inventorying and monitoring

MS1.3: Report on Big Data and IoT for landscape management

MS1.4: Report on Research Agenda for Digital technologies for landscape management

MS2.1: Report on the methods and architectural design of various DSS.

MS2.2: WG meeting to design a common survey for reviewing ES concepts and mapping approaches

MS2.3: List of indicator sets made available for characterization of ES

MS2.4: Report on the possible integration of bioeconomy and climate change issues into the decision-making process

MS3.1. Establishment of project website: An internal project website will be generated for effective communication and coordination of activities during the operation of the Action.

MS3.2: Identification of major stakeholders involved in preparing policies, guidelines and management plans

MS3.3: Needs and expectations of decision makers for development and effective use of DSS are identified

MS4.1: Report on the need for DSS improvements for commensurability between domains.

MS4.2: Report on the development needs of DSS for forest management on landscape level assessment considering multiple ecosystem services.

MS4.3: Report on technological requirements for integration/interoperability between digital technologies and DSS

MS5.1. Report on the use and harmonization of management policies and guidelines across Europe

MS5.2: Research dissemination and policy support through a Policy-science-practice conference

4.1.3. RISK ANALYSIS AND CONTINGENCY PLANS

Although the results of each WG will be used as additional information in other WGs, the work plan of WG2 to WG5 can progress independently. The risk of achieving WG2 to WG5 will therefore be minimized by the appropriate management of the WG and MC. The success of WG1 is directly dependent on achieving the results of other WGs. However, we expect minimal risk of achieving WGs results, and therefore, this risk is also minimal. The greatest risk appears in implementing results and communicating with stakeholders who are traditionally thinking in many countries, and the promotion of new practices and tools is not successful because of the unwillingness of stakeholders.
Therefore, the involvement of major stakeholders is expected from the start of the Action. Several workshops are planned for the duration of the Action and all stakeholders with potential interest in the results will be invited to participate. Great emphasis will be placed on the development of case studies by individual WGs, which can be of great help in communicating and implementing results.

4.1.4. GANTT DIAGRAM

	1st year	2nd year	3rd year	4th year
Action				
WG1				
WG2				
WG3				
WG4				
WG5				

- ⬛ Kick-off and final meeting of the Action
- 🟦 Conference
- 🟪 WG meeting
- 🟧 Workshop
- 🟥 Milestone
- 🟦 MC meeting
- 🟩 Training school

Two months are always reserved for one activity. The exact date and duration of the event will be determined operably in line with the majority opinion.