Report on adoption, customization and implementation

D 5.1

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About OptFor-EU

OptFor-EU wants to co-develop a Decision Support System (DSS) with forest managers and other forest stakeholders, that provides them with suitable climate adaptation and mitigation options for science-based optimizing forest ecosystem services (FES) (including decarbonisation) and enhancing forest resilience and its capacities to mitigate climate change across Europe.

The project 'OPTimising FORest management decisions for a low-carbon, climate resilient future in Europe (OptFor-EU)' will build a Decision Support System (DSS) to provide forest managers and other relevant stakeholders with tailored options for optimizing decarbonisation and other Forest Ecosystem Services (FES) across Europe.

Based on exploitation of existing data sources, use of novel Essential Forest Mitigation Indicators and relationships between climate drivers, forest responses and ecosystem services, OptFor-EU has five specific objectives:

- Provide an improved characterisation of the Forest-Climate Nexus and FES;
- Utilize end-user focused process modeling;
- Empower forest end-users to make informed decisions to enhance forest resilience and decarbonisation;
- Provide a novel DSS service; and
- Bridging different EU strategic priorities, robust science, and stakeholders in the forest and forest-based sectors.

Based on a supply-demand approach, the methodology combines an iterative process of data consolidation, modeling, and co-development of solutions alongside forest managers and other practice stakeholders in all European Forest Types. The DSS will be designed and tested at 8 case study areas, to provide a ready-to-use service, near to operational (TRL7) at European level, while a user adoption and up-take plan will maximize the societal and business impact.

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EXECUTIVE SUMMARY

This deliverable has two parts, one theoretical (sections 2 and 3), forming a background for the activities and contributing towards a common theoretical basis for adoption and user-involvement in OptFor-EU, and as theoretical input to academic papers from OptFor-EU related to user involvement, co-creation and adoption of the DSS.

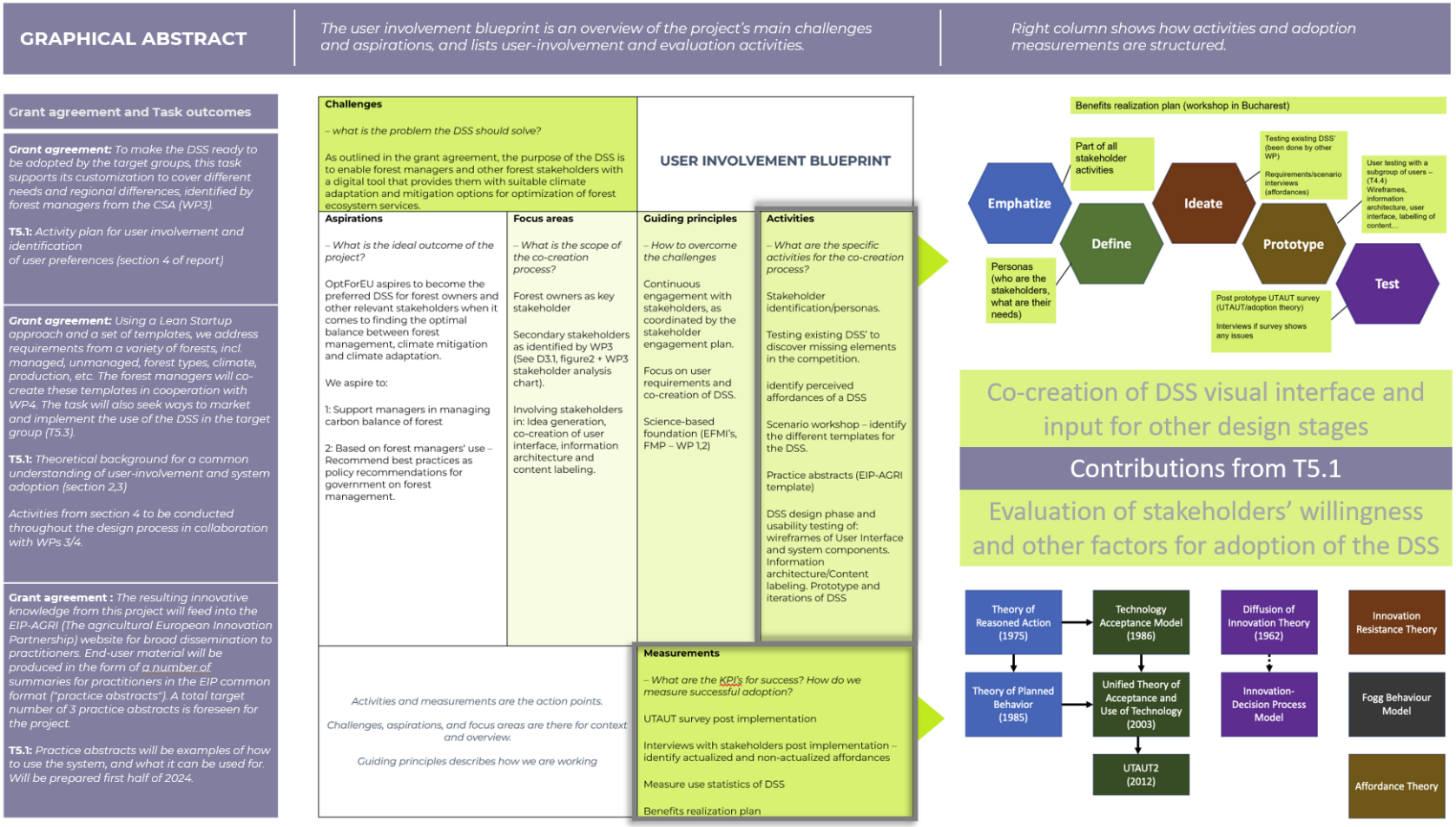
Part two (section 4) is more practical, with a set of activities that will contribute to development of the front-end of the DSS in T4.4 (the dashboard visual interface), and also provide input for T4.2 and T4.3.

Part one (Sections 2 and 3) present the theoretical background for user involvement and adoption processes in systems development projects. Section 2 describes the lean startup methodology and design thinking, as the foundation for co-creation of the DSS. This section describes relevant concepts and steps of user-centered systems development projects. Section 3 focuses on adoption of technological systems and provides a theoretical overview and background for the user involvement plan.

Section 4 presents the strategy for user involvement activities in the case studies. Here we outline user-involvement and adoption activities to be conducted at various stages of the DSS development process, activities which will provide input for WP4 when developing the DSS.

This deliverable complements deliverable 3.1 (stakeholder engagement plan) by focusing on systems development and user engagement activities relevant for design and implementation of the decision-support system (DSS). These user involvement activities build on deliverable 4.1 (DSS system architecture) and provide input to DSS design activities. The output of the activities presented in section 4 will inform task 4.4 (dashboard visual interface).

Graphical Abstract



Introduction

This report discusses the adoption and customization strategy and its implementation, following a design thinking logic. The adoption and customization strategy aims to make the **Decision Support System (DSS)** ready to be **adopted** by the target groups.

In the context of the OptFor-EU project, D.4.1 defines Decision Support Systems (DSS) as computer-based tools which provide support to solve ill-structured decision problems by integrating database management systems with analytical and operational research models, graphic display, tabular reporting capabilities, and the expert knowledge of scientists, managers, and decision makers to assist in specific decision-making activities.

This task supports the **customization** of the DSS to cover different needs and regional differences identified by forest managers from the Case study area (CSA, see deliverable 3.1).

Using a **Lean Startup** approach we address requirements from a variety of forests, including managed, unmanaged, forest types, climate, production, etc. These requirements will provide input for the design and development of the DSS (WP4), in the form of a set of scenario templates.

The forest managers will **co-create** these templates in cooperation with WP4.

Lean Startup relies on the **early involvement** of users, in this case, forest managers.

This report is divided into two main parts after the introduction. In sections two and three, we present relevant background and theoretical approaches to user-centered systems development processes and an overview of adoption models and theories for systems development. The purpose of section two is partly to present project partners with background on the issue of systems adoption, and partly to present relevant theory for later scientific publications from WPs 3, 4 and 5. There is a close connection between stakeholders (WP3), DSS design and development (WP4) and adoption/user involvement (WP5), and as such there is a need for a common set of theoretical approaches which we contribute towards here.

In section four we present a strategy with activities for user-involvement and evaluation of adoption in the different stages of the DSS development process. Co-creation is central to OptFor-EU (see D3.1 stakeholder engagement plan), and the activities in the user-involvement strategy are designed to address co-creation issues in the design and development of the DSS' front-end (dashboard visual interface, T4.4), and also builds on D4.1 (systems architecture and technical specifications). The activities in section 4 are to be conducted during stakeholder workshops and after a working prototype of the DSS is completed and tested by stakeholders.

Objectives

- Maximize the user adoption and exploitation of OptFor-EU outputs, particularly the use of the DSS during the project's lifetime and beyond.
- Co-develop regional templates - DSS activity scenarios for the various stakeholder groups.

Part 1: Theoretical foundations of user involvement and adoption

1 Lean startup methodology – an approach to user-centered systems development

The Lean Startup Methodology (Ries, 2011, figure 1) may be a viable approach to designing a Decision Support System (DSS) because it emphasizes avoiding waste, creating a Minimum Viable Product (MVP), gathering user feedback, and iterating on the product. By considering these principles, developers can create an efficient, effective, and adaptable DSS, and assess the viability of systems. For example, the lean methodology was used in the development of digital forest services in Finland (Kankaanhuhta, Packalen, & Väätäinen, 2021), where the method helped identify opportunities for new digital services such as protection of small, but highly important, areas of biodiversity. In a related study, Iacona (et al., 2019) applied a lean methodology to assess the viability of technological innovations to address biodiversity challenges.

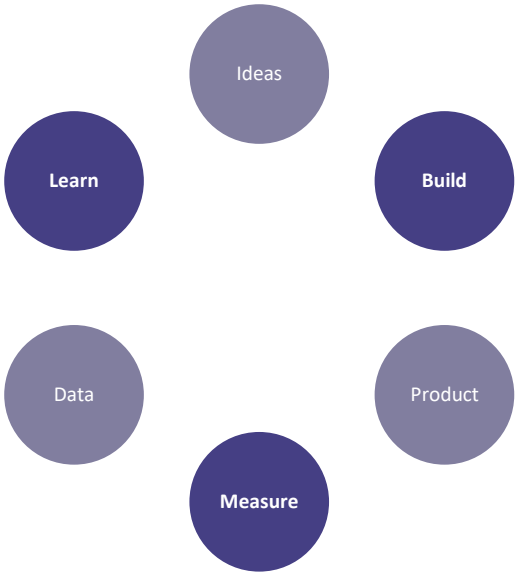


Figure 1: Build-Measure-Learn Cycle

The first advantage of applying the Lean Startup Methodology to DSS development is the ability to identify and address user needs quickly. By seeking user feedback throughout the development process, developers can more accurately target the specific challenges decision-makers face. This agile approach enables the rapid prototyping and testing of potential solutions, helping to ensure that the final product is functional and user-friendly. Furthermore, Lean Startup encourages using minimum viable products (MVPs), which can be quickly developed and tested to verify the assumptions made during the design process.

Another benefit of the Lean Startup Methodology is its inherent focus on validated learning. By continuously testing assumptions and validating hypotheses, developers can better understand the actual value and impact of the DSS on the decision-making process. This knowledge can then refine the system and optimize its performance. Additionally, this focus on validated learning allows developers to identify and rectify any shortcomings early on, reducing the risk of investing time and resources into a product that ultimately fails to meet user expectations.

Avoiding "waste", that is optimizing the use of time, resources and money, is a central tenet of the Lean Startup Methodology (Nobel, 2011), and it is particularly relevant when designing a DSS. By focusing on the essential features that directly address users' decision-making challenges, developers can eliminate unnecessary functionality and reduce the time and resources spent on development. This streamlined approach ensures that the DSS delivers the most value to its users while minimizing costs and maximizing return on investment, which in the OptFor-Eu context involves users' investment of time and resources for learning the system compared to perceived usefulness.

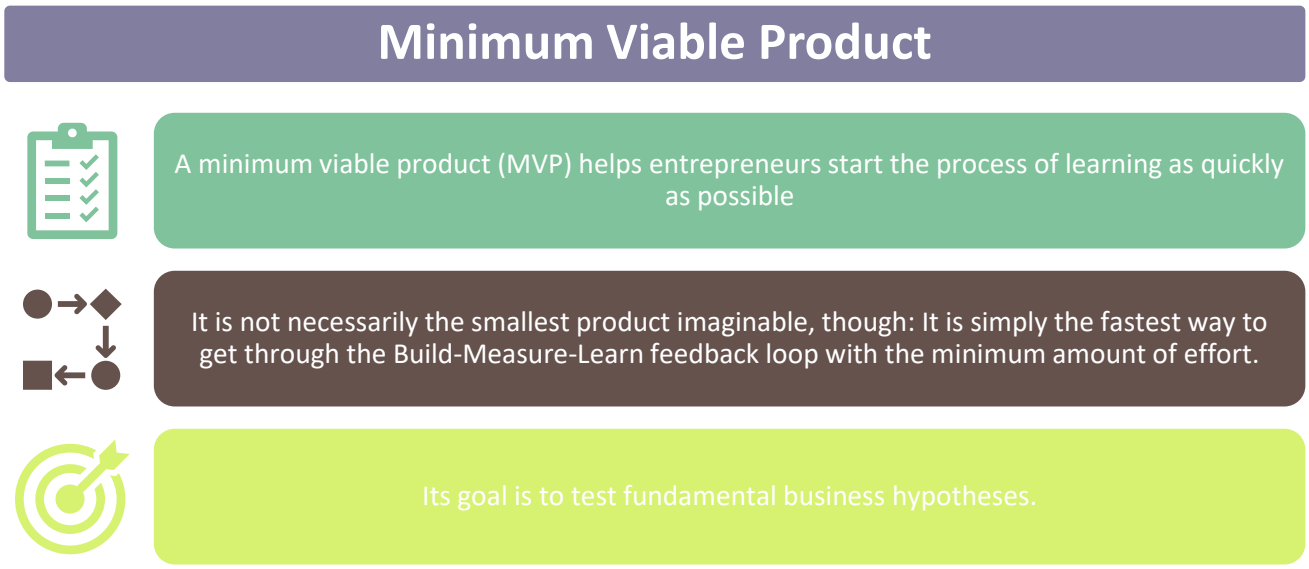


Figure 2: Minimum Viable Product

Creating a Minimum Viable Product (MVP, figure 2) is another crucial aspect of the Lean Startup Methodology. An MVP is a basic version of the DSS that includes the minimum set of features necessary to validate its core value proposition. In OptFor-EU, the fundamental value proposition/business hypothesis is that the DSS will provide added value for stakeholders compared to existing systems for forest management, through co-creation with stakeholders.

By developing and releasing an MVP, developers can quickly test their assumptions about the system and gather valuable user feedback without investing heavily in a fully featured product. This approach reduces the risk of building a product that does not meet end users' or scientific (EFMIs, data model etc,) needs, speeds up the development process, and enables faster uptake by the stakeholders in D3.1.

User feedback is invaluable when designing a DSS, as it allows developers to understand the needs of decision-makers better and refine the system accordingly. By continuously gathering feedback and making improvements based on this input, developers can ensure that the DSS is user-friendly and effective at supporting decision-making. This feedback-driven process helps create a product tailored to its users' specific needs and has a higher likelihood of the DSS becoming a genuinely useful aid in forest owners' decision-making processes.

Iterating on the product is the final essential principle of the Lean Startup Methodology. This approach encourages developers to continuously learn from user feedback, user research, addressing the needs of WP1 (database, EFMIs and API) and WP2 (representation

of data models), as well as performance metrics to make ongoing improvements to the DSS. By iterating on the product, developers can refine the system, optimize its performance, and ensure that it remains relevant and valuable in the face of evolving user needs and scientific conditions such as changes to climate data, forest type changes from climate change or other underlying climate-related changes.

1.1 Co-creation

The Stakeholder Engagement Plan (D3.1), produced under WP3, discusses the co-creation process as a method to address complex challenges such as societal, climatic, environmental, and socio-economic issues. Co-creation (Ramaswamy and Gouillart, 2010; Ramaswamy and Ozcan, 2014) promotes active community engagement and produces user-oriented outcomes by addressing the needs and concerns of various stakeholders. This approach bridges the gap between researchers and stakeholders, enhancing decision-making processes to better adapt to changing environments (Berntzen and Florea, 2023). Co-creation improves research capacity and sustainability by merging data collection with provision. Tudose et al., (2023) have developed a co-creation framework which consists of three iterative stages: co-design, co-production, and co-dissemination. This framework empowers society to make informed decisions by fostering a strong link between researchers and stakeholders.

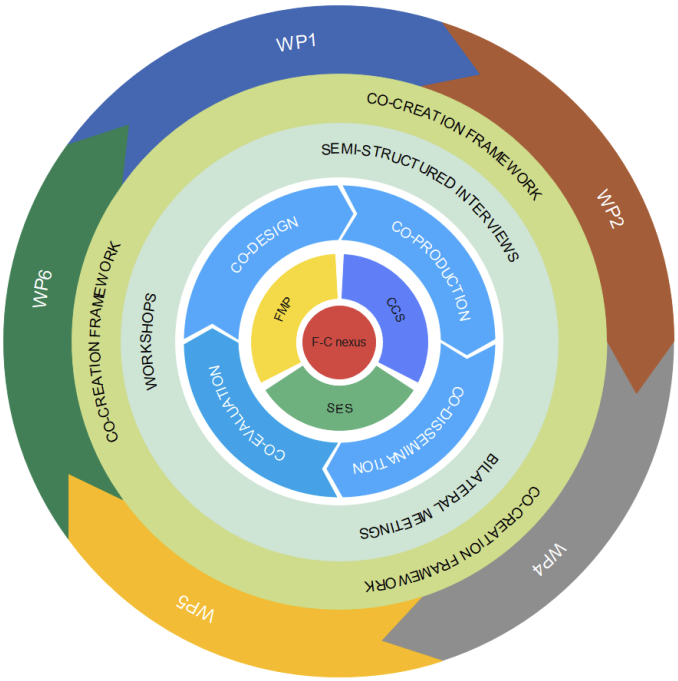


Figure 3: Co-creation Framework (Updated from Tudose et al. 2023)

Co-design

Involving users from the co-design stage of the co-creation process of a Decision Support System (DSS) is crucial for ensuring the system meets their needs and expectations and can help design and develop a more effective and user-friendly DSS (figure 3). This will be an iterative process where the users provide input based on the current state of the DSS. Starting from a collection of existing DSSs, the users identify what features they need and what features they miss. Following the Lean Startup Methodology, a minimum viable product is developed and verified with the users. This is used for further development of features based on the requirements wanted by the users.

Service-Dominant (S-D) Logic (Vargo and Lush, 2004) is a perspective that approaches service provision as a collaborative process of co-creating value. This view represents a shift away from traditional, goods-dominant logic which saw value as embedded in the products provided by companies. Instead, in S-D logic, value is co-created in interactions between service providers and customers, often using resources such as knowledge and skills. More recently and elaboration of the framework has moved the role of institutions in value co-creation to the forefront, and the role of disciplines outside of marketing has been emphasized more strongly (Vargo & Lusch, 2017)

1.2 Design thinking

Design thinking (Brown, 2008) is a human-centered, iterative problem-solving approach that emphasizes empathy, experimentation, and collaboration to develop innovative solutions to complex challenges (figure 4). Applying design thinking to the development of a DSS can significantly increase the likelihood of its adoption, as it ensures that the system is tailored to the needs, preferences, and context of its users.

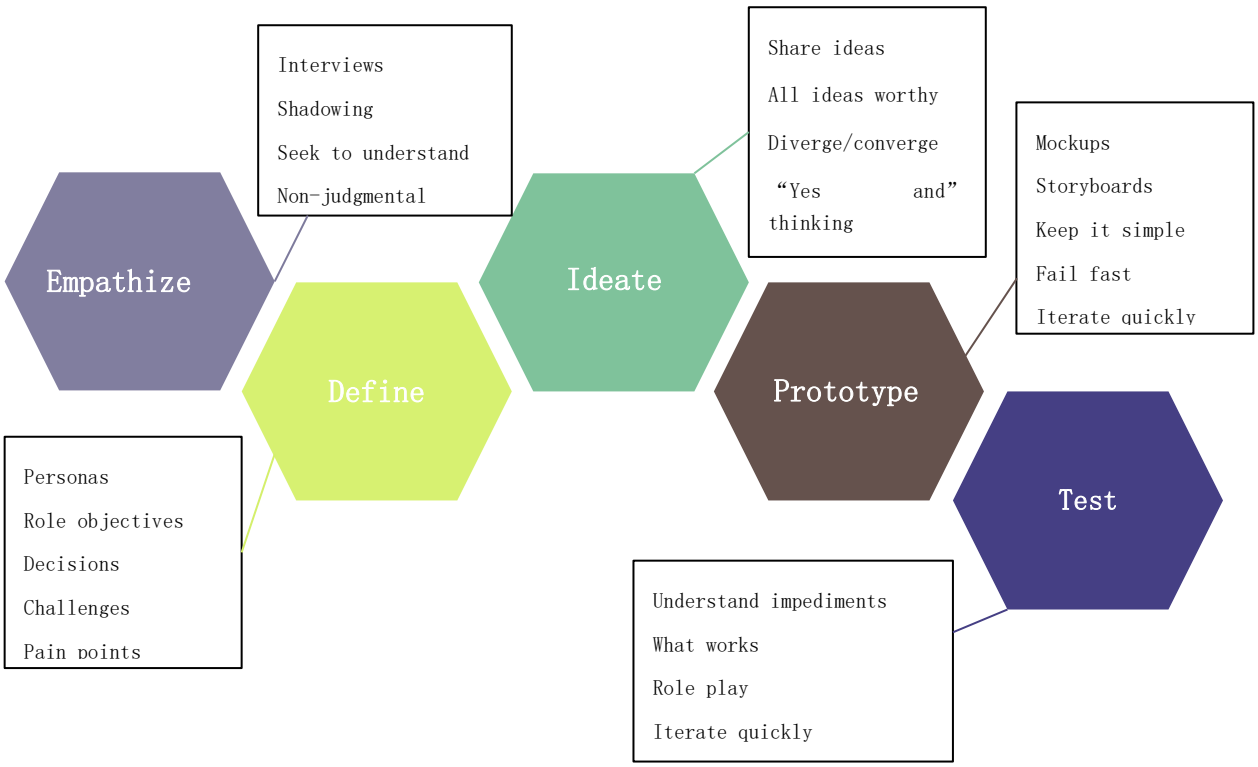


Figure 4: Design Thinking

There are several reasons why design thinking is well-suited for creating a DSS with a greater chance of being adopted.

Design thinking fosters a deep understanding of users by emphasizing empathy and user research (Liedtka, 2018). By conducting interviews, observations, and other qualitative research methods, designers can uncover the needs and goals of potential users, as well as the context in which they will use the DSS. This knowledge enables designers to create a system that is not only useful and relevant but also easy to integrate into users' existing workflows and practices, thus increasing the likelihood of adoption.

In section 4, we present our plan for activities in more detail. In general, the *empathize*, *define* and *ideate* steps draw on data from D3.1 and the CSA workshops, and the interviews

in T5.3. User testing of the *prototype* is done as part of T4.4 and finally *test* activities in the form of a user acceptance adoption survey will be conducted as part of T5.1 when the prototype is ready.

The iterative nature of design thinking allows for continuous improvement and refinement of the DSS. By prototyping and testing different versions of the system, designers can quickly identify areas that need improvement, as well as potential barriers to adoption. This ongoing process of iteration and feedback ensures that the final product is both functional and user-friendly, which is essential for successful adoption.

Design thinking encourages collaboration and interdisciplinary problem-solving (Lewrick, Link, Leifer, 2018)(Lewrick, Link, Leifer, 2020). Developing a DSS that is more likely to be adopted requires input from diverse stakeholders, including users, domain experts, and technical specialists. Design thinking provides a structured approach to facilitating these collaborations, ensuring that all perspectives are considered, and that the resulting system reflects the needs and expectations of the intended audience.

Like Lean Startup, Design Thinking promotes a focus on simplicity and usability. However, design thinking has more emphasis on the user and qualitative data, while lean startup talks about markets and customers, and emphasize quantitative data. (Müller & Thoring, 2012). Both emphasize innovation, and a successful mix between user needs, technological possibilities, and business viability[1] is essential for innovational success (ibid,). In the context of OptForEU as a government-funded project, we choose to emphasize Design thinking because of its user focus, but also include Lean startup and quantitative methods for evaluation of adoption and uptake.

By prioritizing the user experience and removing unnecessary complexity[2] designers can create a DSS that is more accessible and intuitive for users, which is crucial for driving adoption. A system that is easy to understand and navigate will encourage users to incorporate it into their daily decision-making processes and rely on it for support (Meinel, Weinberg, and Krohn, 2016).

Design thinking helps to identify and address potential barriers to adoption, such as resistance to change or lack of familiarity with new technologies. By engaging users throughout the development process and soliciting their feedback, designers can better understand and mitigate these barriers, ensuring that the DSS is useful, appealing, and

[1] In OptFor-EU, business viability refers to viability for forest owners and government, and the constraints of the project and project description.

[2] The definition of unnecessary complexity depends on the user role, user competence with digital tools, knowledge about the underlying science and purpose of the system. Generally, the aim is to make the system easy enough to use that it will be adopted, but not simplistic so that climate mitigation and adaptation goals are not met.

approachable to its intended audience. By addressing these potential obstacles early in the design process, the final DSS is more likely to gain widespread acceptance and use.

1.3 Data collection methods

Gathering requirements *before* the system's visual front-end is designed, is a critical step in the development process of a DSS, as it helps to ensure that the system meets the needs of its users.

Based on the D3.1. Stakeholder Engagement Plan framework developed under WP3, developers can employ various tools to effectively collect these requirements, such as workshops, interviews, focus groups, surveys, and observation. Each tool offers unique advantages and can be used to gain insights into user needs, preferences, and challenges. Regardless of tools, facilitation of interactions is perhaps the most useful skill for collecting relevant data. A literature review of user involvement methods (Wallisch et al., 2019) points out that the most important factors are 1) domain knowledge - the facilitator needs to understand what is being discussed, for example to figure out how the EFMIs should be visualized in the DSS, and 2) the ability to empathize and connect with the user, which is more or less the same for all qualitative research methods. Below, we list some of the typical activities of user involvement (Wallisch et al., 2019):

Workshops

Workshops are interactive sessions that bring together users, stakeholders, and development team members to collaboratively identify requirements, prioritize features, and explore potential solutions (Berntzen, 2018). Workshops encourage active participation and open discussion, enabling developers to better understand user needs and expectations. Activities such as brainstorming, role-playing, and scenario analysis can help participants to explore various aspects of the DSS, identify potential challenges, and propose creative solutions.

Interviews

Interviews are a highly effective tool for gathering requirements (Rubin and Rubin, 2011). Conducting one-on-one or group interviews with users, stakeholders, or subject matter experts can provide deep insights into their needs, preferences, and expectations from the system. During interviews, developers can ask targeted questions about the users' daily tasks, pain points, and the challenges they hope the DSS can address. The open-ended nature of interviews allows for a detailed exploration of issues, providing rich qualitative data

that can inform the design and functionality of the DSS. The interactive and personal nature of interviews also helps to build rapport with users, making them feel heard and involved in the development process, which can increase user satisfaction and adoption of the final system.

Focus groups

Focus groups are structured discussions involving a small group of users guided by a moderator (Liamputtong, 2011). Focus groups can be seen as a group interview, but with more emphasis on group discussion. These sessions allow developers to gather in-depth qualitative data on user needs, opinions, and expectations. Focus groups encourage open and candid conversations, enabling participants to share their experiences, discuss potential issues, and suggest improvements. By analyzing the insights gained from these discussions, developers can identify common themes and areas for further exploration. In OptFor-EU, focus groups are only relevant in cases where CSA workshops have very few participants.

Surveys

Surveys are a quantitative research tool that can be used to collect data from many users in a relatively short time (Rea and Parker, 2014). Surveys typically consist of questions designed to gather information on user preferences, challenges, and desired features. By distributing surveys to diverse users, developers can obtain a broader understanding of user needs and identify trends that may not be apparent through qualitative methods alone. Survey data can be analyzed to prioritize requirements and inform design decisions (Alreck and Settle, 2004).

Observation

Observation involves studying users interacting with existing systems or performing tasks relevant to the DSS. This method allows developers to gain insights into user behavior, identify pain points, and uncover opportunities for improvement. By observing users in their natural environment, developers can obtain a more accurate and holistic understanding of their needs and challenges (Kerlinger and Lee, 2000). Observation can be conducted through techniques such as shadowing, contextual inquiry, or video recordings, and the findings can be used to inform the design and development of the DSS.

1.4 Customization based on user input

Customization is essential when developing a DSS, as it enables the system to cater to a diverse range of users with varying backgrounds, work practices, skill levels, and needs. By providing customizable solutions, developers can create a more user centric and effective DSS that is adaptable to a wide range of situations.

To accommodate different users' specific requirements, the DSS inputs should be customizable. This flexibility allows users to easily configure input parameters based on their unique data sources, formats, and needs, resulting in more accurate and relevant decision support.

Figure 5 illustrates how the DSS can accommodate various stakeholders (customer settings) and regional differences (ie. if some settings are not relevant for certain regions, they should perhaps not be accessible). The input data is the same, but the output will depend on customer/user settings and the region the user is operating in. Users can for example ask for decarbonization measures, forest management climate mitigation measures and fine-tune settings as presented in WP 1 and 2 deliverables.

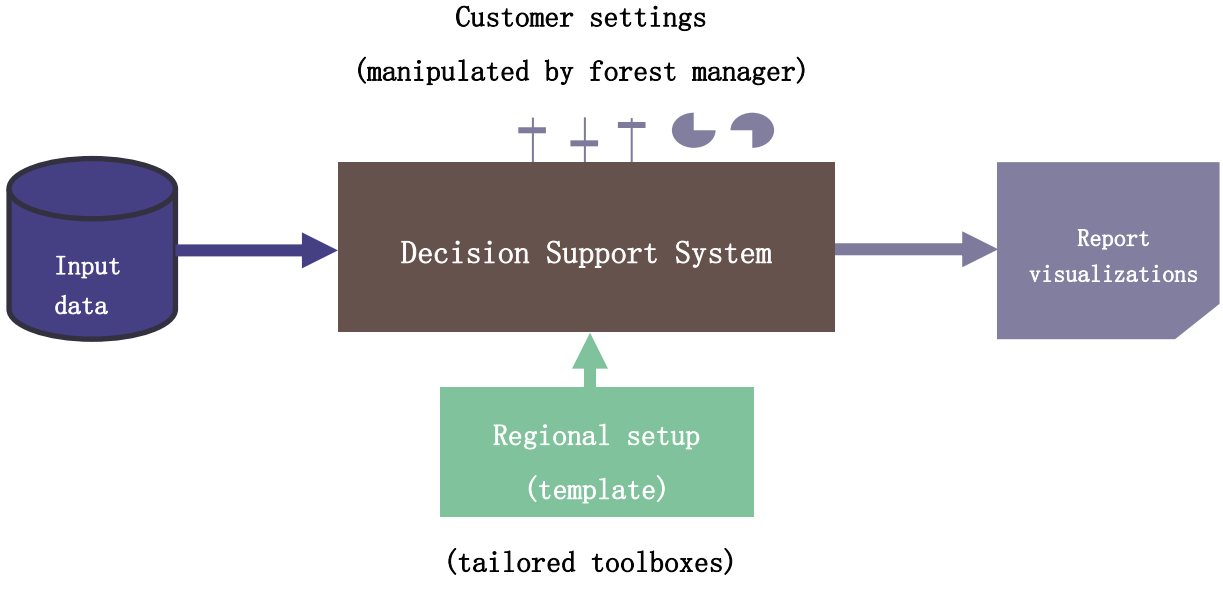


Figure 5: Customization of forest management

When co-creating a customizable system, there are many factors that needs to be considered, such as:

Heterogeneous users

A DSS user base can be diverse, with users from various backgrounds and roles. Offering customization options ensures that the system caters to the unique needs of each user, tailored on their specific context or background. This flexibility can lead to increased user satisfaction and adoption of the DSS.

Work practices

Users may have different work practices and processes that impact their interaction with the DSS. Allowing users to customize the system to fit their preferred workflows makes it easier for them to integrate the DSS into their daily routines, leading to increased efficiency, user satisfaction, and overall system effectiveness.

Different skill levels (ICT)

A DSS user base may include individuals with varying levels of expertise in information and communication technologies (ICT). Providing customization options tailored to different skill levels ensures the system is accessible and user-friendly for novice and expert users, helping reduce the learning curve and allowing all users to leverage the DSS for decision-making support effectively.

Varying needs

Users' specific needs and requirements may change over time or depend on the context in which they use the DSS. Offering customization options allows developers to create a system that can be easily adapted to meet these changing needs, ensuring that the DSS remains relevant and valuable to its users in the long term.

Simplicity with advanced options

Striking a balance between simplicity and advanced features is crucial for ensuring the DSS caters to a broad user base. Developers should design a system that is easy to use and understand while also allowing users to unlock more advanced features as needed. This approach enables novice users to quickly get started with the system while also providing expert users with the tools and functionality they require for more complex tasks.

This can be done through menu entries with checkboxes to enable advanced features or through a configuration file tailored to each individual user.

Users may not know what they want when asked

Users commonly require assistance in expressing their exact needs and preferences during the requirement-gathering phase. To overcome this challenge, developers can employ observation, prototyping (low-fi prototypes such as sketches), and iterative feedback to understand user needs better and refine the system accordingly. In practice, for OptFor-EU, this means that during CSA workshops (after T4.4 has commenced), workshop facilitators should have sketches of the visual design to show users, and also employ qualitative prodding techniques to have users reflect further on what they want (see ie. Roberts, 2020 for more on prodding). This involves for example asking simple follow-up questions such as "interesting observation, how do you think you would like to access that information in the DSS".

Provide options

Providing users multiple options or approaches to achieve their goals within the DSS can help accommodate different preferences and working styles. By offering flexibility and customization, developers can create a more user-centric system that caters to a broader audience and encourages adoption.

Start with a minimum viable product (MVP)

Developing an MVP involves creating a basic version of the DSS with the minimum set of features necessary to validate its core value proposition. The MVP allows developers to test their assumptions about the system and gather user feedback without investing heavily in a fully featured product. This approach reduces the risk of building a system that does not meet user needs and facilitates realization of the OptForEU climate change and mitigation objectives, faster market entry (forest owners and secondary stakeholders adopting the system), improving the chances of successful adoption.

Technology acceptance

The ease with which users can adopt and integrate new technology into their workflows impacts its success. The Technology Acceptance Model (TAM) suggests that perceived usefulness and perceived ease of use are critical determinants of technology acceptance. By designing a DSS that is both useful and easy to use, developers can increase the likelihood of user adoption.

Usefulness: How the DSS will create value for the user (forest manager)
Usability: How effortless the use will be (easy to use)

Create value for the user (usefulness)

A DSS should provide tangible benefits to its users, such as improved decision-making, increased efficiency, or reduced errors. By focusing on creating value and addressing user pain points, developers can create a system that users are more likely to adopt and integrate into their workflows. In the design process, CSA workshops should therefore uncover what aspect of the DSS can lead to an improvement (ie. quicker decisions, more transparent decisions, more rational decisions).

Make it easy to use (usability)

Usability is a critical aspect of any software, including a DSS. An easy-to-use system reduces the learning curve for users, increases satisfaction, and minimizes frustration. By prioritizing usability in the design process, developers can create a DSS that is more likely to be adopted and used effectively by its target audience.

1.5 Implementation, evaluation and benefits realization

Implementing a DSS effectively requires an iterative development process that emphasizes user feedback, real-world testing, and continuous learning. By adopting this approach, developers can create a DSS that is not only innovative but also user-centric and responsive to evolving user needs. When implementing the DSS, the following issues needs to be addressed/taken into consideration:

Digitalization is an iterative process

An iterative development process involves creating multiple versions or iterations of the DSS, with each iteration building upon the feedback and learnings from the previous one. This approach allows developers to incrementally refine the system, making improvements and adjustments based on user feedback, real-world testing, and new insights. By continually iterating on the DSS, developers can ensure that the system remains relevant, effective, and in line with user needs and expectations.

Test on real users in work settings

Testing the DSS with selected real users in their actual work settings is critical for gaining insights into how the system performs in real-world scenarios. Preferably, user testing should be conducted in all CSAs, but most important is that there are some tests. As a rule of thumb, 3 user tests will uncover around 80% of problems (Krug, 2014). This

type of testing enables developers to identify any issues, specific user needs, or areas for improvement that may not be apparent in controlled testing environments. By observing how users interact with the DSS in their daily work and gathering their feedback, developers can make informed decisions about the system's design, functionality, and usability, ultimately enhancing its effectiveness and user satisfaction.

Learn from user feedback

User feedback is an invaluable resource for developers, providing insights into user needs, preferences, and challenges. By actively seeking and incorporating user feedback throughout the development process, developers can create a more user-centric DSS that better addresses the users' needs and meets their expectations. This feedback can be gathered through various methods, such as surveys, focus groups, workshops, or interviews, and should be analyzed to identify trends, common themes, and areas for further exploration or improvement.

Innovation as a learning process

Implementing a DSS is not a one-time event but rather an ongoing learning process. Innovation in this context involves continuously refining and improving the system based on user feedback, real-world testing, and new insights. By embracing a learning mindset and viewing innovation as an iterative process, developers can create a DSS that is adaptable, resilient, and capable of evolving in response to changing user needs and technological advancements.

Evaluation and benefits realization

Evaluation involves two distinct activities: (1) Evaluation of the system itself, as perceived by the users, and (2) benefits realization. System evaluation is closely related to adoption, and will be addressed in the next section.

The purpose of any technological system is to realize a set of goals and objectives. To measure this, scholars suggest benefit realization measurement as a last stage of project evaluation and should measure benefits over time. In short, the plan is a set of expected gains or benefits from the project, with clear result expectations, deadlines and associated risks (Mamabolo & Marnewick, 2022). This provides a clear overview of what the project is intended to achieve, and what indicators to use for measurement. A benefit realization plan helps commit the project team, also after the project has been implemented, it helps communicate the expected benefits to stakeholders, and to clarify

the project objectives. The plan should be prepared and administered through the project management team, and should be a "living" document, open for change as the project progresses. A template for a benefit realization plan is included in annex 1, and addresses:

- Benefits/gains from the project
- In what area the benefit is expected
- Accompanying key performance indicators
- Responsible person/entity
- Timeline – when is the benefit expected to emerge?
- Measures – what do we need to do in order to realize benefits?
- Risk factors and consequence of risk factors
- Risk reducing measures

Figure 6 shows an example of two potential benefits from OptFor-EU to illustrate what a benefits realization plan can look like. We suggest a group of WP leaders sit down in the February 2024 meeting to create a complete plan.

Benefit	Result indicator	Benefit area	Responsible party	Time	Data capture		Measures/costs of realizing the benefits	Deadline/liability	Risk factors	Eventual consequence)	Any risk-reducing measures
					Data source	Measure and Reporting					
<Description of expected benefits/targets/benefits for the project>	*<Set the metric for measuring gain>*	*<Where the gain occurs>*	*<Specify overall responsibility for benefit realization as far as possible>*	*<Time stamp for when the win occurs>*	*<Provide a measurement data source>*	*<Time and responsibility for measuremen and reportingt>*	*<Identified measures that must be implemented to realise the benefits>*	*<Set the deadline for implementing the relevant measure and responsible for implementing>*	*<Identified risk factors that may prevent the benefit from being achieved>*	*<Impact assessment of current risk, which may necessitate risk-reducing measures>*	*<Specify any measures considered and, if applicable, responsible for measures>*
Benefit 1: Time gain for forest owners. No need to access multiple data sources or do additional processing of data (increased productivity)	Saved minutes/ hours Savings in Euro per year	Adoption willingness	WP5	One month after release (provide time for users to test and familiarize themselves with DSS)	Evaluation survey	Survey report (T5.1)	Ask prototype testers to self-evalute time spent to achieve goals using DSS compared to without DSS.	At release of prototype	Respondents not willing to reply to survey	Medium	Reminders to reply, personal contact.
Benefit 2: Increased data quality for forest owners in relation to climate mitigation measures	User satisfaction Proportion of users using an electronic solution Climate mitigation forest indicators	Users Climate	National government	One year after implementation	User survey Forest indicators	Annually state ombudsman	Information Integration between climate indicators, forest data. Integrate data on system users and non-users, and climate indicators from their forests.	One year after implementation, then annually for 3 years. Government agency responsible for CSA	Involves/relies on external stakeholders, Need to gain support from government for measurement Requires new data to be reported and collected	High	Government or EU-level decision to adopt DSS

Figure 6: Example benefit realization plan, with potential benefits for OptFor-EU (Based on DFØ, 2014)

2 Adoption and uptake theories and models

A meta-analysis of success factors for Information Systems adoption identified nine factors, which can be divided into three categories: Quality of information/data/service, usefulness/ease of use, and impact/benefits (Nguyen, Nguyen & Cao, 2015). Key stakeholders adopting the DSS are crucial for its long-term success and effectiveness. Ensuring user adoption requires careful consideration of these factors, with a focus on user expectations, options, technology acceptance, usefulness, and usability (ibid.) . (figure 7)

Figure 7: Factors impacting adoption

This section discusses some of the most important models to describe technology adoption and user behavior. The models and the relations between them are shown in figure 8. Some of the models have evolved by introducing new factors. We address the underlying theories here, and in the next section we address how they should be implemented in the user experience strategy, and which concrete activities that are to be implemented.

The purpose of this section is twofold: first, we deem it necessary to provide sufficient background for the user involvement plan we present in the next section, and second, it provides relevant theoretical guidance for research papers based on the DSS development process.

Figure 8 presents three different types of models and theories related to adoption. The first is related to adoption of technology, and these theories are used to quantitatively assess potential users' willingness to continue using the DSS after testing the prototype. We include the full family of theories here, but will apply UTAUT for the adoption survey, as UTAUT captures everything the other models capture. The second (diffusion of innovation, innovation decision process model, innovation resistance theory and Fogg behavior model) are more general theories of innovation adoption and dissemination. These are useful for tasks 5.3 and 5.5 as they provide theoretical insights into how new innovations can go from prototype to realization and actual uptake. The third is affordance theory, which addresses how to analyze users' perceptions regarding how to use the system, and for what purpose.

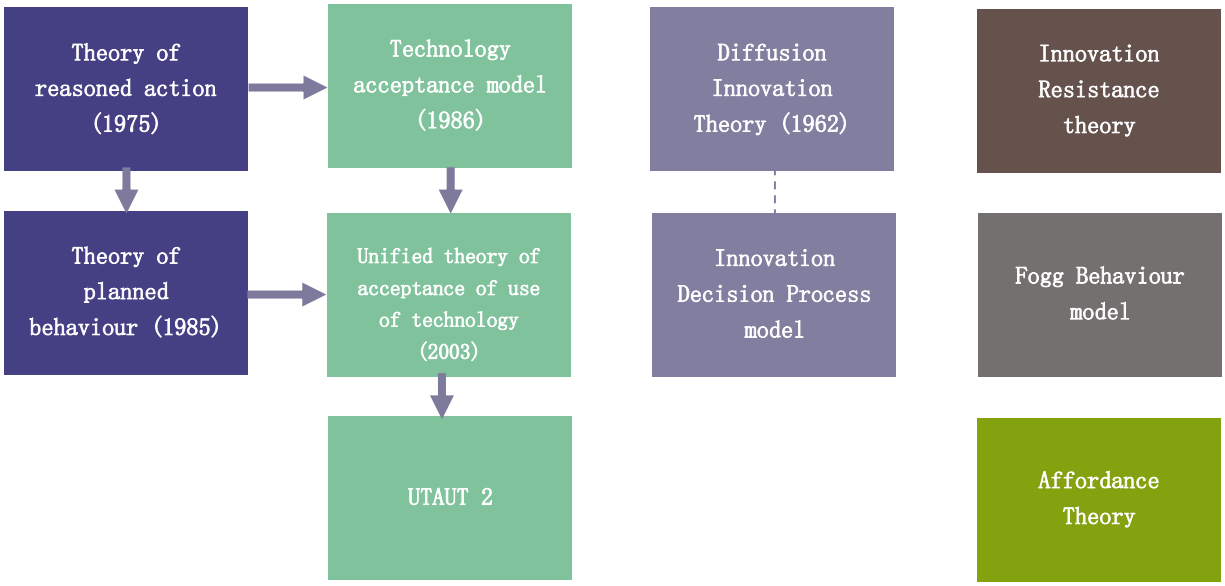


Figure 8: Technology adoption theories and models

2.1 Theory of Reasoned Action (TRA)

The Theory of Reasoned Action (TRA) is a social psychological model that explains the relationship between human behavior and the factors that influence it (Fishbein and Ajzen, 1975). TRA posits that an individual's intention to perform a specific behavior is the primary determinant of their actual behavior (figure 9). This intention, in turn, is influenced by two key components: the individual's attitude towards the behavior and the subjective norms surrounding it.

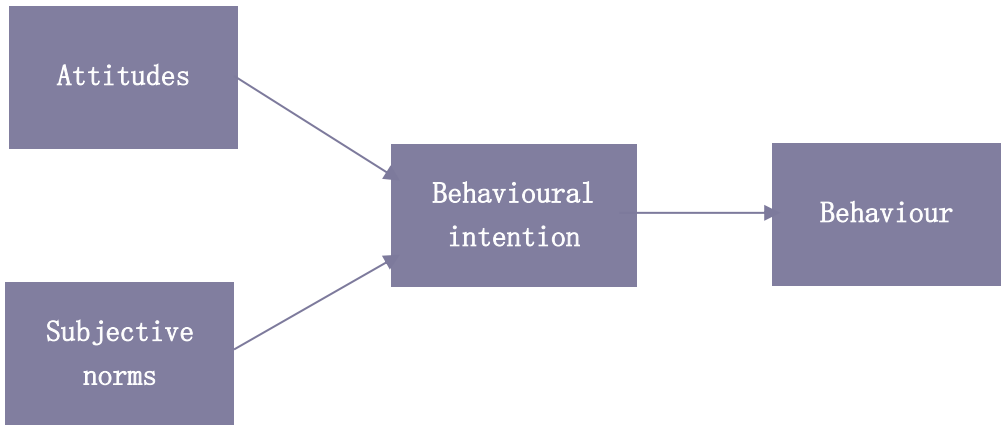


Figure 9: Theory of Reasoned Action

Attitude towards the behavior refers to the individual's overall evaluation of the behavior, which is shaped by their beliefs about the likely outcomes of performing the behavior and the perceived value of those outcomes. In other words, if a person believes

that a particular behavior will lead to positive outcomes and values them, they are more likely to have a favorable attitude towards the behavior. On the other hand, subjective norms represent the perceived social pressure to perform or not perform the behavior. These norms are influenced by the individual's beliefs about how significant others, such as friends, family, and colleagues, would view the behavior, as well as their motivation to comply with those expectations (Ajzen and Fishbein, 1980).

TRA has been applied to a wide range of contexts, including health behaviors, consumer behavior, and technology adoption. Although the model has its limitations, such as not accounting for factors like past experiences and perceived behavioral control, it has provided valuable insights into the complex interplay between attitudes, social influence, and behavioral intentions. By understanding these relationships, researchers and practitioners can develop strategies to promote positive behaviors or discourage negative ones, such as designing persuasive communications or interventions tailored to specific populations.

Relevance for OptFor-EU: Attitudes and intention are essential variables for Information Systems success. Capturing the users' attitudes and intentions towards the system should be part of the data collection. For example, it is likely that different stakeholders will have different attitudes towards how for what purpose the system should be used. Knowing these attitudes and intentions is the first step towards resolving any issues that might arise.

2.2 Theory of Planned Behavior (TPB)

The **Theory of Planned Behavior (TPB)** is a social psychological model that extends the Theory of Reasoned Action (TRA) to better predict and explain human behavior in various contexts (Ajzen, 1991). TPB incorporates the role of perceived behavioral control, in addition to attitudes and subjective norms, to account for situations where individuals may not have complete control over their behavior. The central idea of TPB is that an individual's intention to perform a behavior is influenced by their attitudes, subjective norms, and perceived behavioral control, which together determine the likelihood of the actual performance of the behavior (figure 10).

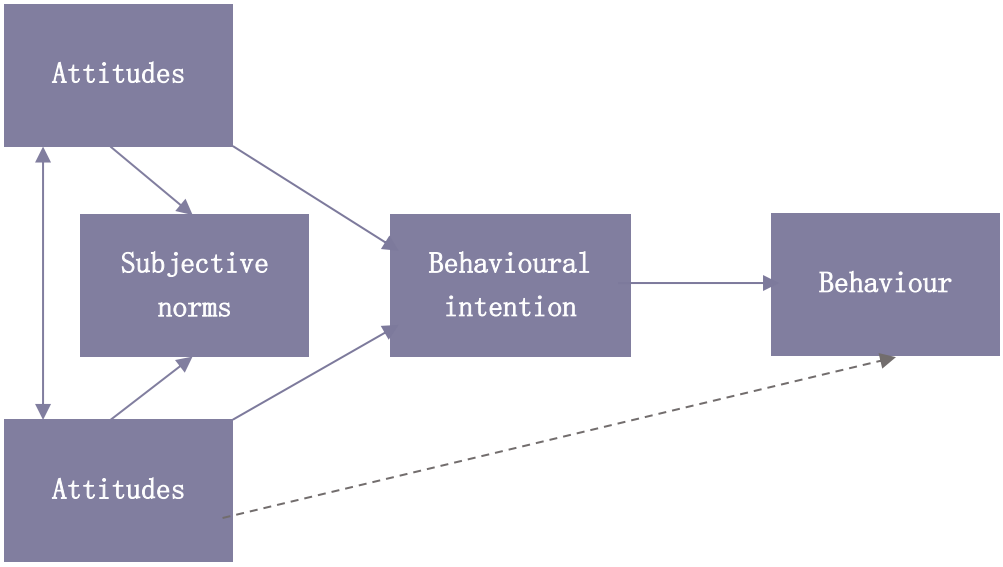


Figure 10: Theory of Planned Behavior (TPB)

Attitudes represent the individual's evaluation of the behavior based on their beliefs about the outcomes and the value they associate with those outcomes. Subjective norms refer to the perceived social pressure to perform or not perform the behavior, which is influenced by the individual's beliefs about how significant others would view the behavior and their motivation to comply with those expectations. Perceived behavioral control reflects the individual's perception of their ability to perform the behavior, considering both internal factors (e.g., skills, knowledge, and self-efficacy) and external factors (e.g., resources, opportunities, and constraints).

TPB has been applied to a wide range of contexts, including health behaviors, environmental behaviors, and technology adoption (Ajzen, 2011). TPB has proven to be a robust and valuable tool for understanding and predicting human behavior in situations where individuals may face varying degrees of control over their actions. By incorporating the role of perceived behavioral control, TPB helps researchers and practitioners develop more effective interventions and strategies to promote positive behaviors or discourage negative ones, tailored to the specific needs and challenges of different populations and contexts.

Relevance for OptFor-EU: The TPB is an extension of TRA, so the relevance is more or less the same as above. The difference between the two models lies in how it treats the variables. In TRA, attitudes and norms are seen as distinct variables. In TBP they are seen as connected. Further, the variable "perceived behavioral control" is added as an additional variable that extends the model compared to TRA. Both TPB and TRA emphasize factors that are relevant for acceptance of information systems in general. Users' attitude towards the system, perceived control when using the system and subjective norms

(such as attitudes towards digitalization in general, attitudes related to the usefulness of DSS' for forest management). These dimensions will be included in the adoption evaluation survey (see section 4.2)

2.3 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is a widely used framework for understanding user acceptance and adoption of new technologies (Davis, 1986). TAM was developed as an adaptation of the TRA to specifically address the context of technology use. The central premise of TAM is that an individual's behavioral intention to use technology is primarily determined by two factors: perceived usefulness and perceived ease of use (Figure 11).

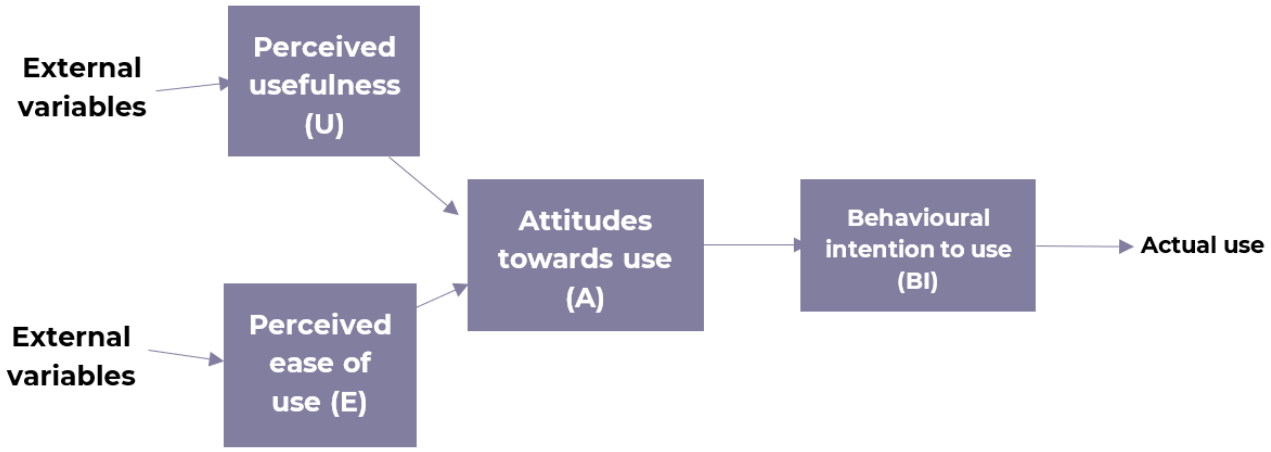


Figure 11: Technology Acceptance Model (TAM)

Perceived usefulness is defined as the degree to which a person believes that using a particular technology will enhance their job performance or help them achieve their goals. Perceived ease of use, on the other hand, refers to the degree to which a person believes that using the technology will be free from effort. These two factors influence an individual's attitude toward using the technology, which in turn, shapes their behavioral intention to use it. Ultimately, this behavioral intention is considered a key predictor of actual technology usage.

Over the years, TAM has been refined and extended to incorporate additional factors that may impact technology adoption, such as subjective norms, perceived risk, and trust. Despite its simplicity, TAM has demonstrated robust predictive power across various technologies and user populations. It serves as a valuable tool for researchers and practitioners seeking to understand and predict technology acceptance, as well as for designing interventions aimed at promoting the successful adoption of new technologies.

Relevance for OptFor-EU: TAM is both loved and hated by Information Systems scholars. It is loved because it points out the relevance of usefulness and ease of use for successful IT adoption. It is hated because it does little to explain how or why the system is seen as useful or easy to use. For OptForEU, the relevance of TAM lies mostly in that TAM is the model that established what is now seen as common sense in systems development: Systems need to be easy and useful. Perceived usefulness and ease of use will be included in the adoption evaluation survey (see section 4.2).

2.4 Unified Theory of Acceptance and Use of Technology (UTAUT and UTAUT 2)

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a comprehensive model that aims to explain the factors influencing the acceptance and adoption of new technologies (Venkatesh, Morris, Davis, and Davis, 2003), UTAUT integrates aspects of eight different technology adoption models, including the TAM and the TPB. The purpose of UTAUT is to provide a more holistic understanding of technology adoption by synthesizing key elements from the existing literature.

UTAUT (figure 12) proposes four core determinants of user acceptance and usage behavior: performance expectancy, effort expectancy, social influence, and facilitating conditions. Performance expectancy refers to the degree to which an individual believes that using the technology will help them attain gains in job performance or achieve their goals. Effort expectancy represents the degree to which an individual perceives the technology as easy to use. Social influence refers to the extent to which an individual perceives that others within their social network believe they should use the technology. Finally, facilitating conditions are the factors that support or hinder the individual's ability to use the technology, such as access to resources, training, and technical support.

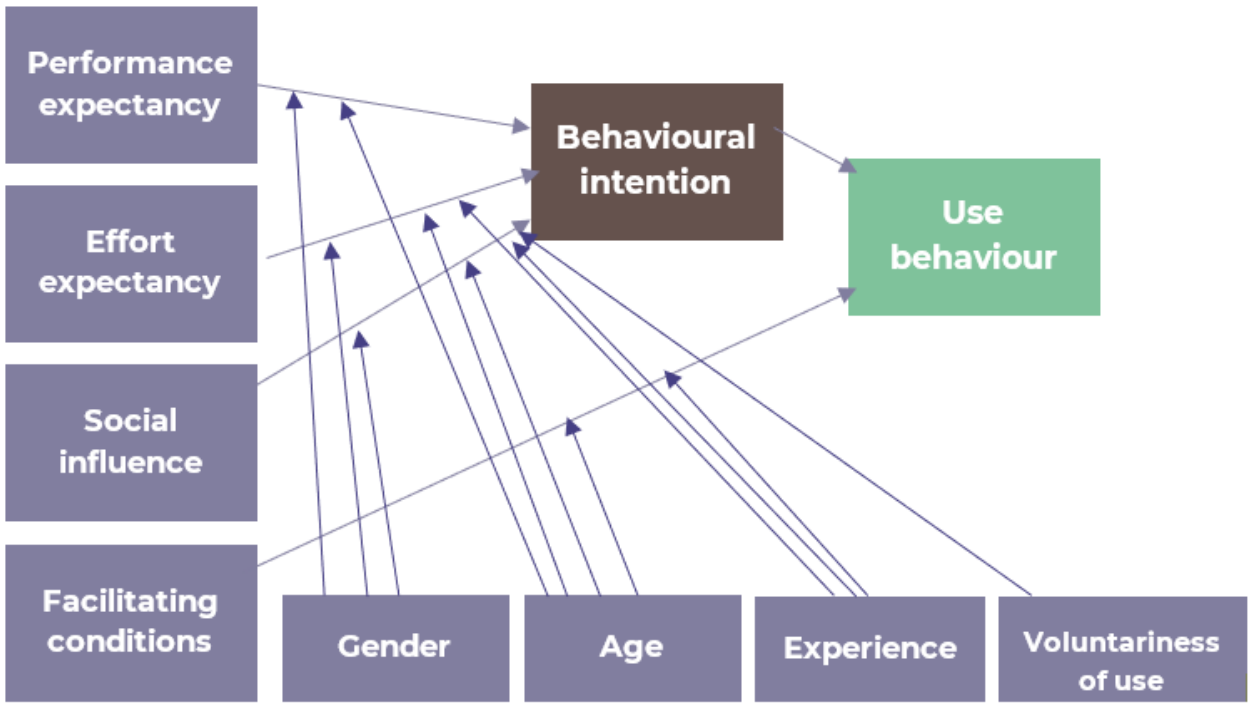


Figure 12: Unified Theory of Acceptance and Use of Technology (UTAUT)

The UTAUT model also acknowledges the moderating effects of individual and contextual factors, such as gender, age, experience, and voluntariness of use, on the relationships between the core determinants and technology adoption. Since its introduction, UTAUT has been widely adopted and validated across various technology domains and user populations. It serves as a valuable tool for both researchers and practitioners, providing a comprehensive framework for understanding and predicting technology acceptance, as well as for designing interventions aimed at enhancing the adoption of new technologies. In 2012 Venkatesh, Thong, and Xu extended UTAUT with three additional constructs: Hedonic motivation, price value, and habit (Venkatesh, Thong, and Xu, 2012).

Relevance for OptFor-EU: UTAUT extends earlier adoption models and adds several controlling variables, which provide added insights about users' perceptions, motivations, and background (age, experience, etc.). While they have been around for a while, these, or variations with some added contextual variables such as trust in government for public sector ICT, remain the most widely used models for understanding technology adoption.

UTAUT will be used for analyzing the main stakeholders' willingness to adopt the DSS, and will provide valuable insights into mediating variables and any measures needed to increase uptake of the DSS. The survey instrument is included in annex3. Further, the findings from

the UTAUT survey can be published at academic conferences on Information Systems, for example the Scandinavian conference on Information Systems.

However, these models still only tell us what is happening, not how or why. UTAUT can show that 43-year-old white males with high motivation for using a forest DSS, access to, and skills in, the necessary technology, and with a positive influence from their peers are more likely to use the system. But to understand why, we need to supplement the data with insights from other adoption-related theories that examine this on a meso and macro-level (sections 3.5 to 3.8), and if the UTAUT survey shows low intention to adopt the system from forest owners and government, additional interviews might also be required to further examine any measures that can be done to ensure adoption.

2.5 Fogg Behavior Model

The Fogg Behavior Model (FBM), developed by Dr. B.J. Fogg, is a framework that seeks to explain and predict human behavior by examining the interplay of three key elements: motivation, ability, and triggers (Fogg, 2009). FBM posits that for a behavior to occur, an individual must have sufficient motivation to perform the behavior, the ability to carry it out and be presented with an appropriate trigger or cue that prompts the action. According to Fogg, when these three factors converge at the same moment, the desired behavior is more likely to occur, as illustrated below in figure 13.

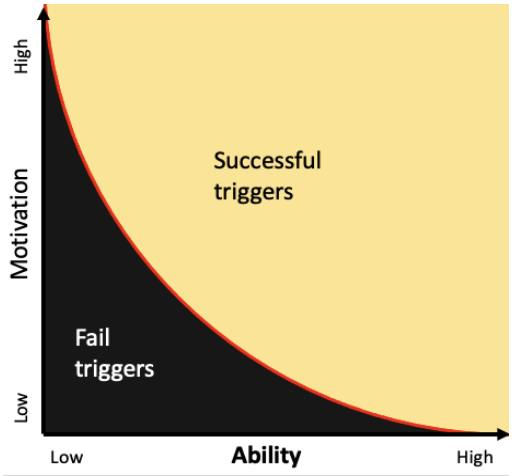


Figure 13: Fogg Behavior Model

Motivation refers to an individual's level of interest or desire to perform a particular behavior, which can be influenced by factors such as pleasure, pain, hope, fear, social acceptance, and social rejection. Ability represents the ease or difficulty of performing

the behavior, considering factors such as physical capabilities, mental effort, time, money, and social deviance. Triggers are cues or stimuli that prompt the behavior, such as a reminder, a notification, or an environmental change. In the context of designing products, services, or interventions aimed at promoting specific behaviors, the FBM provides a valuable framework for understanding the factors that influence behavior and developing targeted strategies to enhance motivation, ability, and the effectiveness of triggers.

Relevance for OptFor-EU: The FBM can be used together with TAM or UTAUT to extend and explain what lies underneath the motivational variables. TAM and UTAUT do not explain motivation, while the FBM goes a bit further in explaining and deconstructing the concept. Thus, we suggest adding motivation as a dimension in the adoption evaluation survey.

2.6 Diffusion of Innovations Theory (DOI)

The Diffusion of Innovations Theory (DOI) is a seminal framework that seeks to explain how, why, and at what rate new ideas and technologies spread through social systems. Developed by Everett Rogers in 1962, DOI draws on research from various disciplines, including sociology, psychology, and communication, to provide insights into the process of innovation adoption. At the core of DOI is the concept that innovations diffuse over time through a population, as individuals adopt the innovation based on their perception of its relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). The typical distribution of users is seen in figure 14 below.

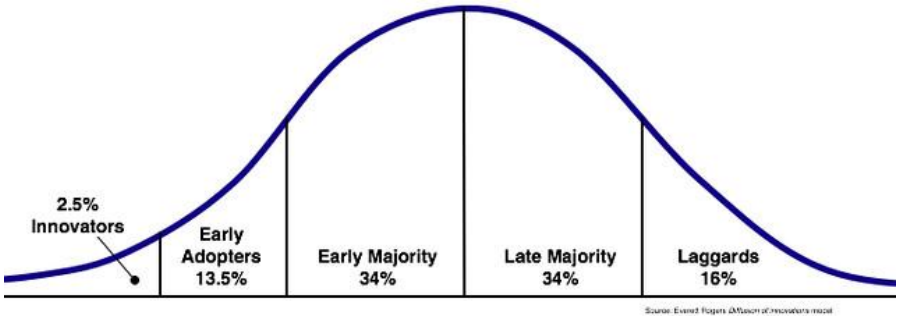


Figure 14: Distribution of innovation users

Relative advantage refers to the degree to which an innovation is perceived as better than the idea or technology it replaces. Compatibility represents the extent to which an innovation aligns with the potential adopters' existing values, needs, and experiences. Complexity denotes the perceived difficulty of understanding and using innovation.

Trialability refers to the extent to which an innovation can be experimented with on a limited basis, allowing potential adopters to evaluate its benefits before fully committing. Observability is the degree to which the results of an innovation are visible to others, which can influence the decision to adopt.

DOI also identifies several types of adopters based on their propensity to adopt innovations: innovators, early adopters, early majority, late majority, and laggards. These categories help illustrate the innovation adoption lifecycle and the factors that influence the rate of adoption for a given innovation. The DOI has been widely applied across various domains, including public health, marketing, and technology adoption, providing valuable insights for researchers, practitioners, and policymakers aiming to facilitate the successful dissemination and adoption of new ideas and technologies.

Relevance for OptFor-EU: The most important and relevant lesson from DOI for OptFor-EU is that we need to know who our potential users are. User preferences and tolerance vary greatly between innovators/early adopters and late majority adopters. Users who generally enjoy tinkering with technology will want very different things than users who just want their technology to work, with as little effort as possible. Innovators are much more likely to spend time with the DSS, seek external information and get involved in development. A study of innovation diffusion in agriculture for example, found that 63% of potential users were non-adopters, and only 13% were innovators or late adopters (diederen et al., 2003). This indicates that marketing, training and communicating the benefits of the OptFor-EU DSS is essential for lasting adoption. As such, all WPs, coordinated by WP6, should work towards government and forest associations to promote the DSS and train users.

The categorization and typical distribution of early/late adopters can be useful background variables in a stakeholder survey. By asking about the respondents' attitudes to technology in general, DOI can aid in predicting how quickly the DSS will be adopted. If most stakeholders are typical early adopters, the DSS is likely to become part of their toolbox a lot quicker than if most stakeholders are typical "laggards" when it comes to using new technology. See for example Johannessen (et al., 2021) for a demonstration of how DOI can be applied. In OptFor-EU we suggest adding a dimension on attitudes towards technology to measure what category the forest owners and other stakeholders belong to. It is easier to attract new users if the majority of the user group are early adopters of technology, while laggards need a lot more persuasion.

2.7 Innovation-Decision Process Model (IDPM)

The Innovation-Decision Process Model (IDPM), proposed by Everett Rogers as part of the DOI, describes a five-stage process that individuals go through when deciding whether to adopt an innovation (Rogers, 2003). These stages are knowledge, persuasion, decision, implementation, and confirmation (figure 15).

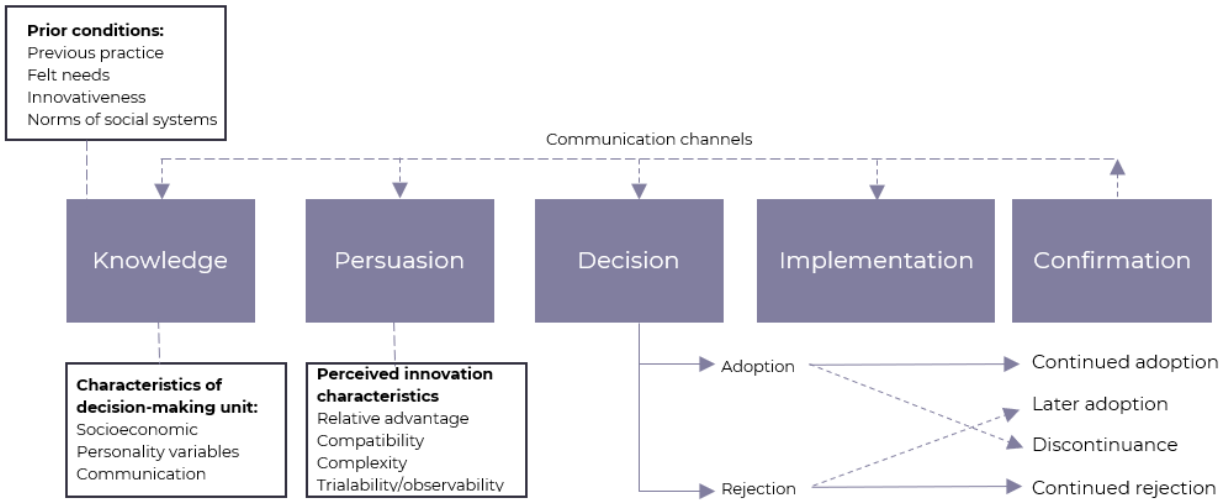


Figure 15: Innovation-Decision Process Model

In the *knowledge stage*, individuals become aware of the innovation and seek information about it. During the persuasion stage, they form a positive or negative attitude toward the innovation based on its perceived attributes and personal experiences. In the *decision stage*, individuals choose to adopt or reject the innovation based on their evaluation. The *implementation stage* involves the practical application and use of the innovation, while the *confirmation stage* is where individuals seek reinforcement for their adoption decision and either continue using the innovation or discontinue its use if they encounter conflicting information or experience dissatisfaction. Understanding this process can help researchers and practitioners develop targeted interventions and strategies to facilitate the successful adoption of new ideas and technologies at each stage.

Relevance for OptFor-EU: The IDPM extends DOI by providing variables for measuring which category of adopter a particular user belongs to and by laying out the process from being made aware of the system to the decision to adopt or refuse to adopt the system. The model can guide data collection activities (CSA workshops in particular) in the following way:

- Prior conditions – workshop facilitators should ask participants about their current knowledge of DSS' and experiences with digital tools in general (also in accordance

with DOI - early adopters of technology are more likely to adopt new tools such as the DSS)

- Knowledge and persuasion - these are already part of the CSA workshops, as we are working to inform stakeholders about the DSS. Also, WP6 dissemination activities are important to spread knowledge about the DSS. More knowledge equals better chances of wide adoption by stakeholders.
- Decision to adopt or reject, implementation, confirmation: These dimensions can be derived from the UTAUT adoption survey and possibly also from post-implementation interviews to supplement with qualitative data.

Collecting data following the IDPM model will lead to at least one scientific paper in an Information Systems journal, and will extend the academic knowledge base by demonstrating willingness to adopt digital innovation in the forest industry.

2.8 Innovation Resistance Theory

Innovation Resistance Theory (IRT) is a framework that seeks to explain why individuals may be resistant to adopting new ideas, products, or technologies, despite their potential benefits (Sheth, 1981). While many innovation adoption theories focus on factors that drive acceptance and usage, Innovation Resistance Theory provides insights into the barriers and challenges that may hinder adoption. Resistance to innovation can stem from individual-level factors, such as personal habits, preferences, and perceived risks, and broader social and cultural factors that influence the norms and values surrounding the innovation.

One of the key aspects of IRT is the distinction between active and passive resistance. Active resistance refers to the deliberate and conscious rejection of an innovation, often driven by factors such as perceived incompatibility with existing values, beliefs, or practices or perceived threats to social, economic, or cultural structures. Passive resistance, on the other hand, arises from factors such as inertia, lack of awareness, or difficulty in understanding the innovation. This may lead individuals to maintain the status quo rather than adopt the new idea or technology.

Understanding and addressing innovation resistance is crucial for researchers, practitioners, and policymakers who aim to promote the successful dissemination and adoption of new ideas and technologies. Identifying the factors contributing to resistance, targeted interventions, and strategies can be developed to overcome these barriers, such as providing additional information, demonstrations, or training, addressing potential misconceptions or concerns, and promoting social support and endorsement from influential

individuals or groups. By focusing on both the drivers and barriers of innovation adoption, the Innovation Resistance Theory provides a more comprehensive perspective on the complex process of innovation diffusion (Ram and Sheth, 1989).

Relevance for OptFor-EU: IRT theory can be a valuable part of the toolbox if it turns out that there is resistance towards the DSS or any of the DSS objectives from any of the stakeholder groups. It is likely that some forest owners and nature preservation organizations, for example, have differing opinions on the DSS, and in that case, we can apply innovation resistance theory in an attempt to resolve such differences.

Further, if data collection shows strong resistance from certain stakeholders or even stakeholder groups, combining the IRT with the IDPM model for a more comprehensive analytical model for the academic paper mentioned in section 3.7.

2.9 Uses and Gratifications Theory (U&G) & Media-Richness Theory (MRT)

The Uses and Gratifications Theory (U&G) and Media-Richness Theory (MRT) are popular theories for explaining the characteristics of the communication medium being used to present information. We present these in the same section, as the two theories complement each other.

U&G is a communication framework that focuses on understanding how and why individuals engage with various forms of media (Katz, Blumler, and Gurevitch, 1973). Emerging in the 1940s and 1950s as a response to the limited effects perspective, which viewed audiences as passive recipients of media messages, U&G posits that individuals are active agents who deliberately choose and use media to fulfill specific needs and desires. The theory's central tenet is that media users are goal-oriented and actively seek out content that will satisfy their particular gratifications, such as entertainment, information, social interaction, and personal identity.

The U&G approach emphasizes the psychological and social factors that drive media consumption. It suggests that individuals have diverse needs and motivations, which lead them to select, use, and evaluate media differently. Key factors influencing media usage include individual characteristics, social context, and the nature of the media content. By examining the gratifications that individuals derive from media consumption, U&G helps to explain the choices they make regarding media channels, the time they spend engaging with media, and the potential effects of media exposure.

Although initially developed to study traditional mass media, such as newspapers, radio, and television, the U&G has been adapted and extended to examine digital media and new

technologies, including social media, online gaming, and mobile devices. By focusing on the active role of media users, U&G provides valuable insights for researchers, practitioners, and designers seeking to understand the factors that drive media consumption and how different forms of media can be tailored to meet users' diverse needs and preferences.

The MRT (figure 16) suggests that communication effectiveness depends on the ability of a communication medium to convey rich information. It proposes that certain media are better suited for complex and ambiguous tasks due to their ability to transmit multiple cues, such as facial expressions, tone of voice, and immediate feedback. Rich media, like face-to-face interactions or multimedia-based technologies, are believed to foster greater understanding, reduce uncertainty, and facilitate problem-solving. In contrast, lean media, such as emails or text messages, are more suitable for simple and routine tasks with little ambiguity. The MRT emphasizes the importance of matching the richness of the communication medium to the complexity of the task at hand to enhance communication outcomes (Daft & Lengel, 1986).

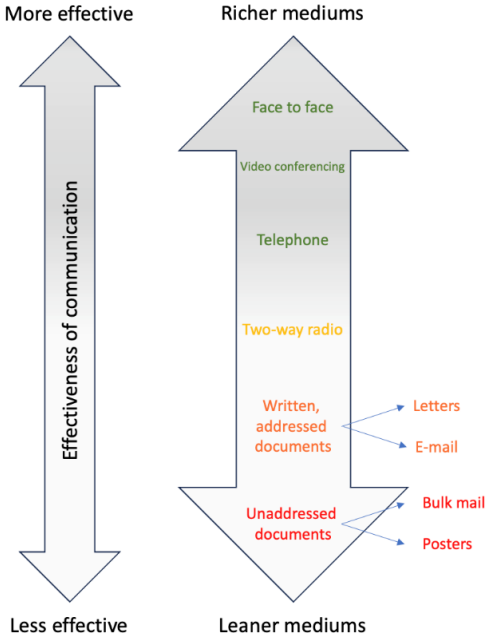


Figure 16: Media-Richness Theory

Relevance for OptFor-EU: These two theories demonstrate the need for rich, interactive media for disseminating complex information (MRT), and methods for examining users' motivation (U&G), supplementing the more quantitative data you get from UTAUT and UTAUT2. As such, they can be applied if we want to dig deeper into the underlying motivations for the different stakeholder groups by conducting interviews or including constructs from these theories in the stakeholder workshops. One important part of the user

involvement/requirements gathering should be to present users with existing DSS' of varying media richness and ask their preferences.

U&G data will be collected in planned data collection activities, including CSA workshops.

Further, the UTAUT adoption evaluation survey will be extended with variables related to media richness to examine if media richness is indeed a relevant effect for adoption of the DSS.

2.10Affordance Theory

Affordance Theory, originally proposed by psychologist James J. Gibson in the context of ecological psychology, is a framework that focuses on the relationship between an individual and their environment, particularly how objects or features within the environment offer possibilities for action, known as affordances (Gibson, 1986). Affordances are the perceived or actual properties of an object or environment that determine how an individual can use or interact with it. In essence, affordances are the opportunities for action that the environment provides based on an individual's abilities, needs, and goals.

Figure 17 illustrates how the Internet can be perceived to afford various action possibilities for the user (inclusion, Interaction, insight etc.) and the potential effects of these actions (inclusion can lead to democratic effects, interaction can lead to people sharing ideas).

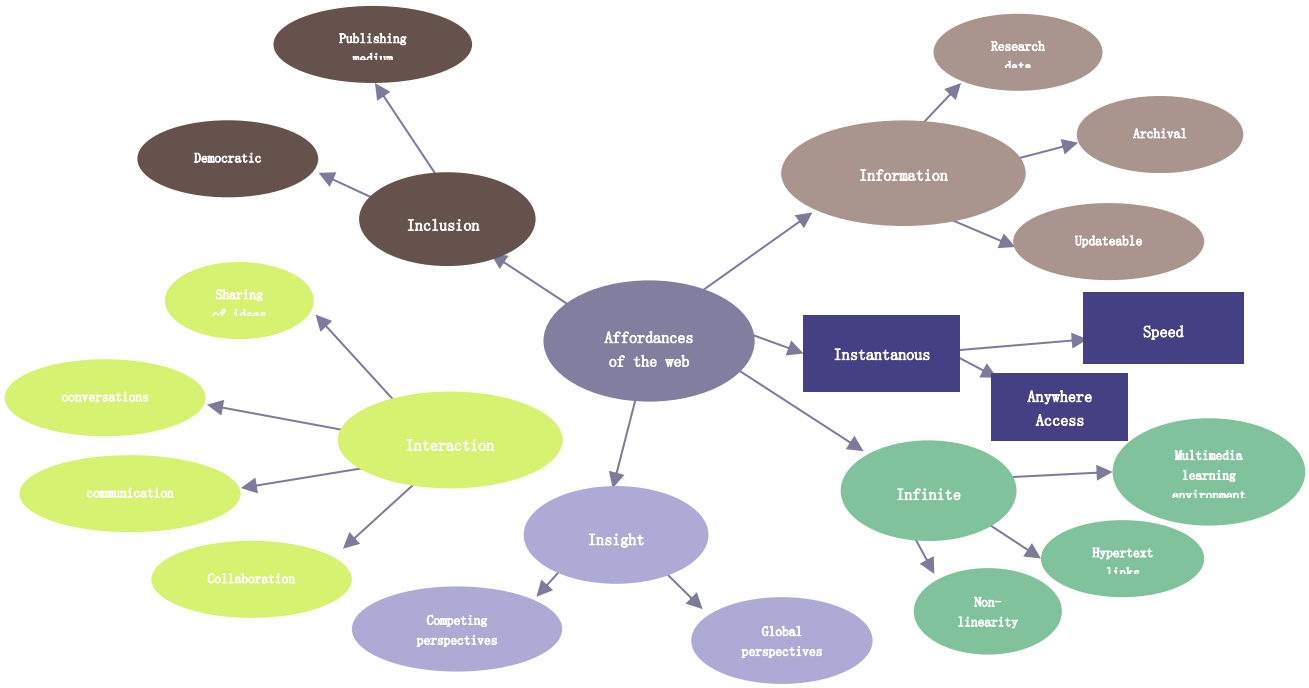


Figure 17: Illustration of perceived affordances of the Internet

In the context of technology and human-computer interaction, researchers such as Donald Norman have adapted the concept of affordances to better understand how users interact with and perceive the functionalities of digital technologies, including software, websites, and devices. Digital affordances refer to a technology's design elements or features that enable or constrain specific user actions. They can be perceptible, such as a button that indicates it can be clicked, or hidden, such as a gesture-based interaction. Understanding and designing for digital affordances is critical to creating intuitive and user-friendly interfaces that align with users' mental models and expectations.

Affordance Theory has been widely applied in various domains, including product design, architecture, and human-computer interaction, providing valuable insights into how individuals perceive and interact with their environments. Affordance Theory highlights the importance of designing objects, spaces, and technologies that support users' needs, goals, and capabilities by focusing on the relationship between an individual and their environment. This approach can help researchers and practitioners create more effective and engaging products, interfaces, and experiences that cater to users' diverse needs and preferences.

Relevance for OptFor-EU: Affordance theory, often coupled with secondary theories or constructs such as social presence, media richness, etc., is currently one of the most frequently used theories in Information Systems research. Affordance theory can be applied in several iterations in a Lean Startup and Design Thinking approach to systems design. In the ideas and brainstorming phase, users can be asked to describe their perceived needs

and wants from the DSS. When a prototype or MVP is completed, users can again be asked what they think this system can be used for (perceived affordances). This test will often show that what the designers intended and the user perceives is slightly (or highly) different. To provide a banal example: A chair is designed to be sat on. But to a short person needing to reach the box at the top of the cabinet, a chair can be perceived as a tool to stand on to reach the said box. For the user, the chair in this context has the affordance of a ladder.

For OptForEU, an example of an affordance for the general audience would be "information", which could then be extended to stakeholder groups - a forest owner affordance would be "information on how to optimize forest management in the forest I own", while for government it could be "information on how management practice A/B in [specific larger area] will affect the risk of nature-related disasters". Note that these are examples - possibilities for action are only affordances if the user perceives that is something they can use the DSS for.

T4.1 has designed an overview of the system's decision making-process (see D4.1, figure 1), and affordance theory should be applied in the CSAs to validate that the stakeholders identified in D3.1 find this useful.

Further, affordance theory has guided the interview guide in annex 3, and will be used in user requirements interviews in collaboration with T5.3. This will contribute positively towards uncovering user needs, and can lead to an Information Systems academic paper on "affordances of forest-related decision-support systems".

2.11Social Cognitive Theory (SCT)

Social Cognitive Theory (SCT), developed by psychologist Albert Bandura in the 1970s, is a comprehensive framework that seeks to explain human behavior and learning through the interplay of personal, behavioral, and environmental factors. SCT posits that individuals learn and develop behaviors by observing others, processing information about the consequences of those behaviors, and using that information to guide their actions. This process of observational learning, also known as vicarious learning, is facilitated by cognitive processes, such as attention, retention, and motivation, as well as by the individual's self-efficacy, or belief in their ability to perform the behavior successfully. The framework is outlined in figure 18.

A central tenet of SCT is the concept of reciprocal determinism, which suggests that an individual's behavior, personal factors, and environment mutually influence one another in a continuous and dynamic process. In other words, individuals are both influenced by their environment and can influence it through their actions. This interaction between

personal agency and environmental factors underscores the importance of considering the broader social and contextual factors that shape human behavior. SCT has been widely applied across various domains, including health promotion, education, and technology adoption, providing valuable insights for researchers, practitioners, and policymakers aiming to understand and influence behavior in diverse contexts. SCT offers a rich and nuanced perspective on human behavior and learning by emphasizing the role of cognitive processes and the reciprocal interaction between individuals and their environment.

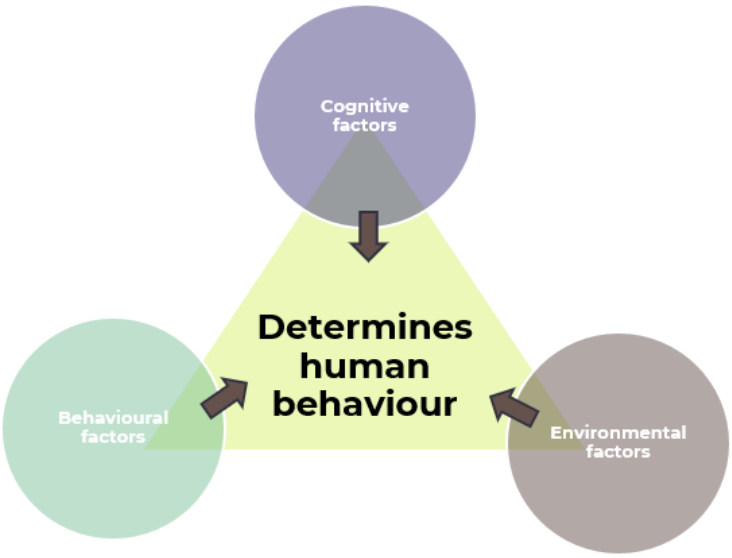


Figure 18: Social Cognitive Theory

Relevance for OptFor-EU: SCT has been used to examine how communication influences behaviors and attitudes. Bandura (2008) shows how SCT can be used in studies investigating attitude or behavior changes triggered by communication or media, such as anti-smoking campaigns. As such, SCT can be applied in the OptFor-EU dissemination and communication strategies in order to promote climate-friendly behavior and demonstrate how widespread uptake of the DSS can lead to positive changes in climate awareness.

Further, SCT can be applied in academic papers from WP6, for example a paper on climate communication and nudging techniques towards wanted behavior.

Part 2: User involvement activities

3 User involvement plan

In this section we present the user involvement plan, with concrete activities to be conducted in the case studies and in collaboration with other WP's, especially 3 and 4. Input from the plan's activities is first and foremost of importance to T4.4 (visual interface) and T5.5 (policy recommendations).

User involvement in the context of this deliverable refers to the entire user experience, not just of the system (T4.4, T5.3), but also from contextual factors such as climate adaptation and mitigation issues, the surrounding political and policy environment (to be addressed by deliverable 5.2) etc.

We begin by introducing the user involvement blueprint (figure 20) with associated activities for co-creating the user requirements of the DSS, and evaluation activities.

A central activity is the creation of "a set of templates", as per the project description. By template, we refer to various views/screens/customizable views when users access the DSS, based on different needs from the forest managers. These are identified through the scenario workshop and user stories.

The plan follows the lean startup/co-creation approach as outlined in section 2, and is based on User involvement research and the theories presented in section 3. In addition, we want to emphasize the practical consequences of user research, especially Morville (2005), who outlines what the system needs to deliver for successful adoption:

- Usable – The system needs to be easy to use, for the intended users.
- Useful – The system needs to meet the expectations of intended stakeholders
- Desirable – The design of the system should be seen as desirable by the stakeholders, i..e., as something they enjoy using, not just because it is useful. This could for example refer to graphic design, but also to the overall experience of using the system.
- Findable – The system needs to have a user interface and information architecture that makes sense to the intended stakeholders, so that users do not need to spend time learning how the system works.
- Accessible – The system needs to adhere to web content accessibility standards, and other relevant accessibility standards.
- Credible – The information provided by the system must be seen as credible and reliable by the intended stakeholders.

Together, these six areas lead to users perceiving the system as valuable – which in turn leads to user adoption.

The points from Morville require collaboration between WP 3 (stakeholder engagement, CSAs) 4 (Dss creation), 5 (uptake and user adoption). Credibility is handled by WP's 1 and 2 (database and EFMI's) and will not be addressed further here – although it should be mentioned that CSA1 was particularly concerned with credibility in the first stakeholder workshop.

To plan activities and maintain an overview of the project, we apply the user involvement blueprint (Kalbach, 2014, figure 20). The Challenges, aspirations, focus areas and guiding principles remind designers why, what and for whom we are designing the DSS, while the activities and measurements are activities to be conducted in order to collect data on user preferences and evaluate their intention to adopt the DSS. User involvement is an iterative process, so these activities will be conducted in collaboration with CSA workshops, with WP4 in the design of the DSS and with T5.3 in collecting forest managers' perceptions.

Challenges – *what is the problem the DSS should solve?* As outlined in the grant agreement, the purpose of the DSS is to enable forest managers and other forest stakeholders with a digital tool that provides them with suitable climate adaptation and mitigation options for optimization of forest ecosystem services.	USER INVOLVEMENT BLUEPRINT

Aspirations	Focus areas	Guiding principles	Activities
- What is the ideal outcome of the project? OptForEU aspires to become the preferred DSS for forest owners and other relevant stakeholders when it comes to finding the optimal balance between forest management, climate mitigation and climate adaptation. We aspire to: 1: Support managers in managing carbon balance of forest 2: Based on forest managers ' use - Recommend best practices as policy recommendations for government on forest management.	*- What is the scope of the co-creation process?* Forest owners as key stakeholder Secondary stakeholders as identified by WP3 (See D3.1, figure2 + WP3 stakeholder analysis chart). Involving stakeholders in: Idea generation, co-creation of user interface, information architecture and content labeling.	*- How to overcome the challenges* Continuous engagement with stakeholders, as coordinated by the stakeholder engagement plan. Focus on user requirements and co-creation of DSS. Science-based foundation (EFMI' s, FMP - WP 1,2)	*- What are the specific activities for the co-creation process?* Stakeholder identification/personas. Testing existing DSS' to discover missing elements in the competition. identify perceived affordances of a DSS Scenario workshop - identify the different templates for the DSS. Practice abstracts (EIP-AGRI template) DSS design phase and usability testing of: wireframes of User Interface and system components. Information architecture/Content labeling. Prototype and iterations of DSS
Activities and measurements are the action points. *Challenges, aspirations, and focus areas are there for context and overview.* *Guiding principles describes how we are working*	**Measurements** *- What are the KPI' s for success? How do we measure successful adoption?* UTAUT survey post implementation Interviews with stakeholders post implementation - identify actualized and non-actualized affordances. Measure use statistics of DSS Benefits realization plan		

Figure 20: User involvement blueprint

Figure 21 illustrates how the activities contribute towards different stages of the design thinking process. The details of design thinking are presented in section 2.2. Note that while the figure shows these as individual steps, design thinking strongly emphasizes iteration throughout the design process, so in reality designers move back and forth between steps as needed, in order to achieve the objectives laid out by Morville (2005).

The purpose of design thinking is to go from idea to evaluated product through insight, which is used for *design*, and finally *tested (Grimsgaard, 2022)*.

- *insight:* Acquire deep knowledge about user needs. Empathize, define and ideate phases.
- *Design*: Design and code the system. Ideate and prototype phases.
- *Test:* Evaluation of the prototype and users' willingness to adopt the system as-is. If needed, move back to later steps.

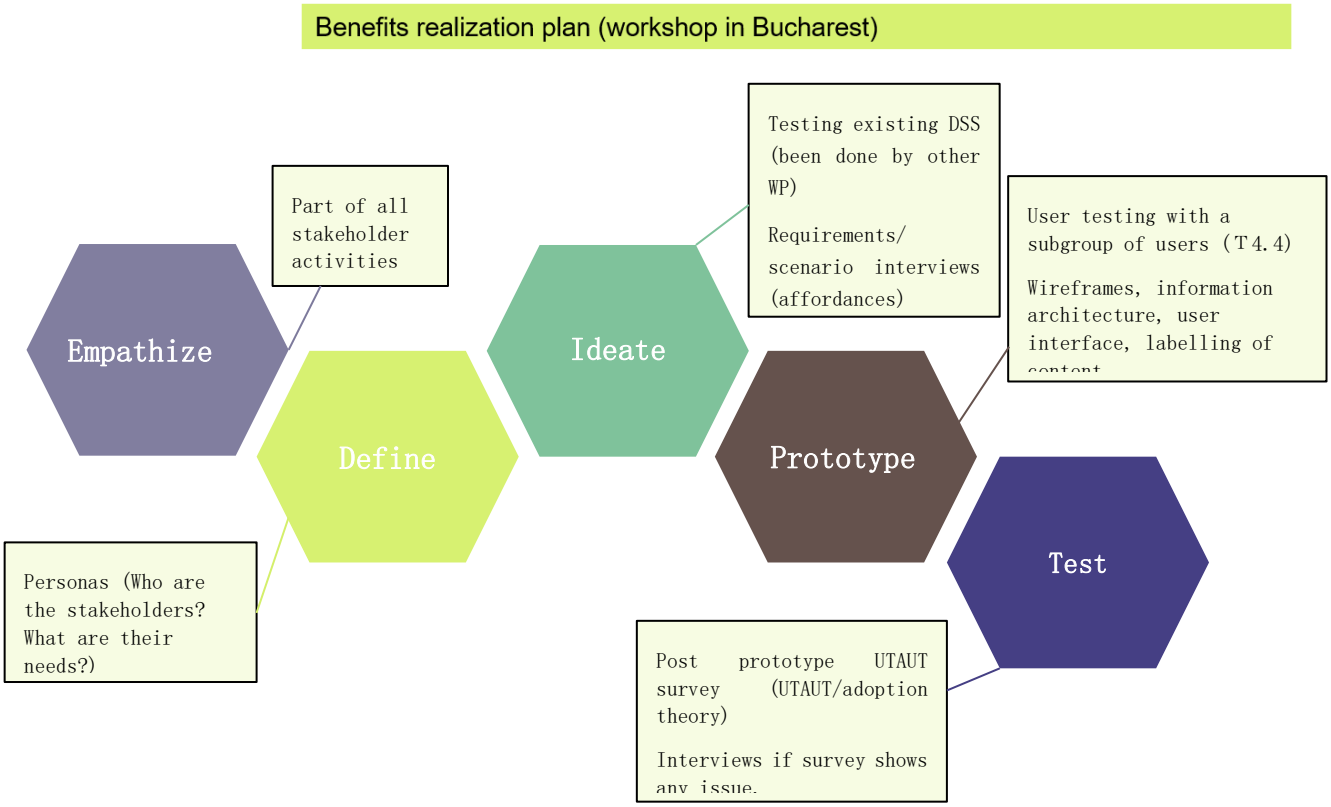


Figure 21: User involvement and evaluation as part of the design thinking process in OptFor-EU

Persona creation, testing of existing DSS', scenario workshop along with tasks 5.2 (institutional and governance factors), 5.4 (forest manager perceptions) will address the context, user, and organizational requirements, and thus provide insight for the design solutions, which cover the empathize, define, and ideate steps of the design thinking process. These first steps will complete the insight phase, where the objective is to understand the user and their needs/wants/characteristics – to be used as input for system design.

Prototype refers to the actual system design from plan to working prototype. WP4 is responsible for the actual system design, and will use input from the insight phase in

T4.4 (visual interface), possibly also for T4.2 (operational framework) and T4.3 (supporting decision-making).

Usability testing, post-implementation interviews with stakeholders and the UTAUT adoption evaluation survey will contribute to the testing stage of the design thinking process and provide data for T4.4 (visual design - if changes are needed), T5.3 (forest manager perceptions), T5.5 (policy recommendations), 6.2 (dissemination and exploitation of results), and 6.4 (as input to communication activities). In addition, we propose that WP7 create a benefit realization plan as part of T7.4, as this type of plan will contribute to evaluation of the project goals and can also be used for dissemination activities (T6.2).

3.1 Activities for insight phase

In this section we present a more detailed overview of the activities mentioned in the user-centered strategy blueprint. The activities are presented in chronological order, and relevant collaborating WPs are identified. Deliverable 3.1 (D3.1) has already presented detailed information on the co-creation process and planned activities, so in this plan we refer to D3.1 for details. Further, we have attempted to place the activities in conjunction with activities listed in D3.1, and especially in collaboration with T5.3.

Stakeholder identification and persona creation

The stakeholders have been identified in D3.1, and as such this activity has already been completed. However, stakeholder engagement is an iterative process, and the stakeholder database is continuously being updated throughout the lifetime of the OptFor-EU project. Further work should be undertaken to translate the stakeholders into a set of personas. A Persona is a fictional depiction of a typical representative of a stakeholder group, based on real-world data. The purpose is to create a template which contains relevant information about the stakeholder groups' needs and wants in relation to the system being designed. Personas typically include data about the stakeholder groups' personality, technical knowledge, opinions, attitudes, needs and wants - ie. Relevant information for the system development team when designing the system for a specific stakeholder group (Junior & Filgueiras, 2005). Personas are useful for design and implementation of system components, user interface and functionality, as they provide designers with a "target person" to have in mind in the design process. For example, the Norwegian national broadcaster's (NRK) radio channel P1 creates all their content, music etc based on the persona "Karen, 41" - designed to represent a typical mainstream radio listener.

Below in figure 22, we have included an example of a forest-related persona. "Freddy Forest" is 35 and a somewhat introverted owner of a small forest. He is often outside working and wants easy access to information that can help him optimize management of his small forest. He works to live and is not really into computers except for using them as tools to achieve an objective. These characteristics have some implications for how data is presented, and for how complex the system can be.

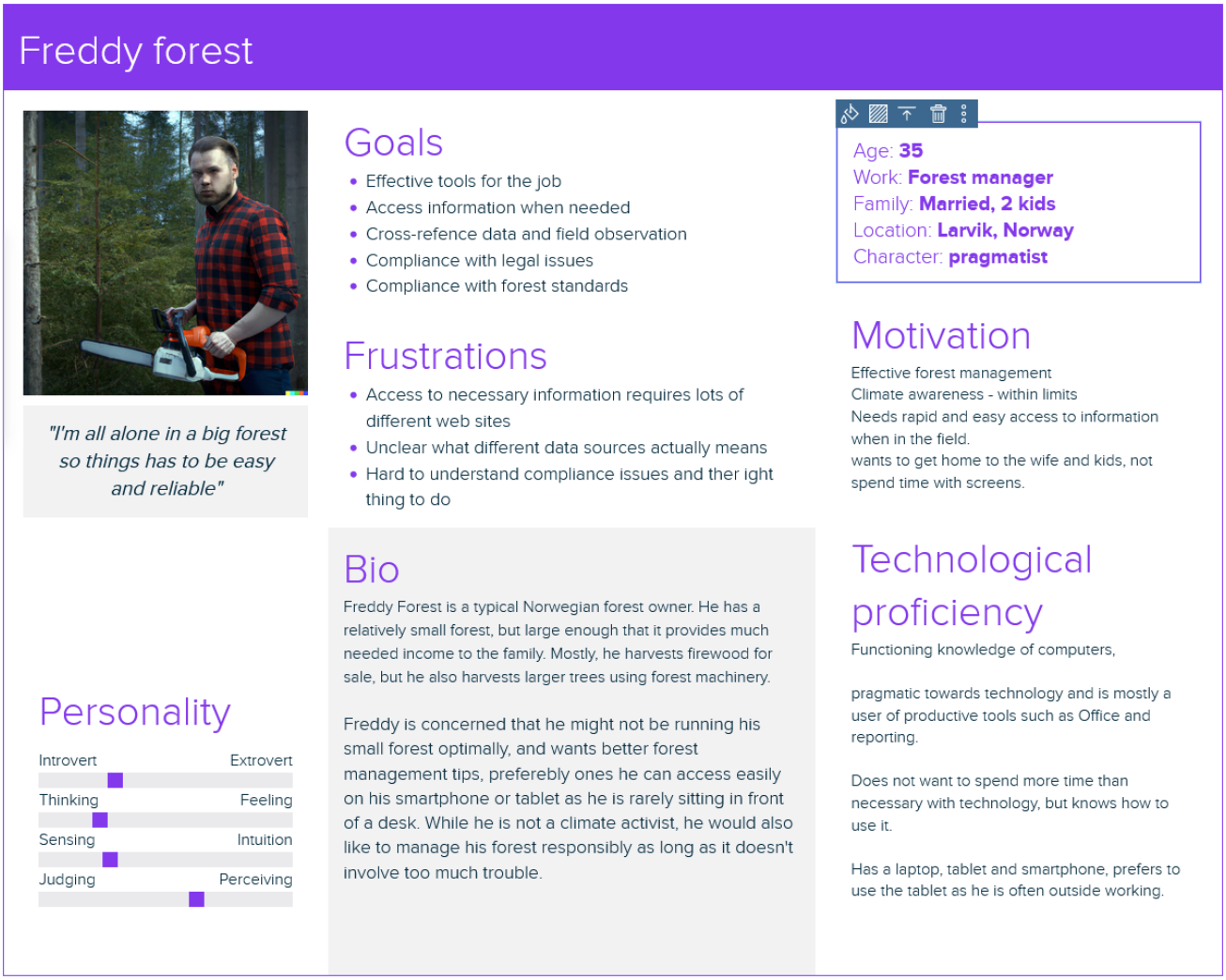


Figure 22: Example of a persona, created with extensio.com and Dall-E (profile picture)

Personas can be either goal- or role-based. A goal-based persona has a clear objective for using the system, while a role-based persona can be more open to exploration based on his/her role as a forest owner/manager, environmentalist etc. (Interaction Design foundation).

- Purpose:

  - Provide systems development team with user types to design for
  - Provide input to scenario maps/templates.
- To do - when:
  - Persona creation workshop based on D3.1 and CSA workshop 1, with partners from WP 3,4 (open for all WP's)
  - To be completed before T4.4
- Resources:
  - A full guide for persona development can be accessed at the Interaction Design foundation.
  - Mural has an online template and process for persona design
  - Amelia persona templates
  - MIRO - an online collaboration tool for workshops

Requirements gathering

This activity aims at increased understanding of stakeholder needs regarding the content and use of the DSS. Or what we in traditional systems development would call the requirements gathering process.

- Purpose:
  - Identify stakeholder expectations for the OptFor-EU DSS
- To do - when:
  - Requirements identification interview, with the purpose of identifying stakeholders' perceptions about the affordances they want from the DSS (see affordances section above). Can be a collaboration with T5.3.
- Resources:
  - Annex 3: Interview guide for perceived system affordances
  - Contextual inquiry - a technique for interviewing users in context - useful when users are uncertain about requirements.
  - Empathy mapping can be a useful technique when users are uncertain about what they want.

Scenario workshop

When we have the information about the stakeholders in the form of personas and have collected data on what the stakeholders need from the DSS, we suggest a short scenario workshop to be conducted across all CSAs.

Scenario mapping is the creation of a series of actions or events, which are typical use-cases of the DSS for different stakeholders. A scenario is defined as one (key) task a

specific stakeholder wants to achieve by using the DSS. Scenarios should be high-level and focus on the most important parts of the DSS. Example scenarios in our context could for example be using the DSS to figure out the optimal balance between decarbonization and monetization of forest resources (Salazar, 2021).

The conceptual DSS design in D4.1 shows an illustration of the decision-making process in the DSS, and presents five key requirements for the DSS:

- Support accessibility via the Internet
- support different types of knowledge and information.
- Support the use of different data sources.
- Support modularity (add functionality/tools)
- Target different users and problem types

Using scenarios (and user stories, see below), we can map what users want to achieve and provide data for the DSS' design. Figure 23 demonstrates an example scenario for use of the DSS, which provides input for the DSS key requirements and use-cases mentioned in D4.1, section 2.4.

Actor	Freddy Forest
Motivator	Wants to optimize his limited forest management budget
Intention	Needs to find management instructions optimized for the forest he owns, which takes terrain, climate and soil into consideration.
Action	Freddy accesses the DSS, marks his property on the map, inputs his restrictions (available time and money) and asks for management instructions.
Resolution	The DSS provides guidelines for how to manage Freddy's forest within his budget and time constraints.

Figure 23: Example of a scenario, which can be used as input for user story/requirements generation. From Salazar, 2021

- Purpose:
  - Generate insight on typical scenarios/use-cases for personas. To be used for requirements specification.
- To do - when:
  - After workshops 1/2: Conduct scenario-mapping workshop (across all CSAs with interested parties from the different WPs. WP4 needs to attend)
- Resources:
  - Nielsen Norman Group scenario-mapping workshop template
  - MIRO - an online collaboration tool for workshops

Design and prioritize user stories/requirements.

When we know what the stakeholders want from the DSS, and we have gathered additional insight via the scenario workshop, we can collect this information and use it to create a set of user stories.

A user story is part of User-centered design and agile software development and replaces the traditional use-case or functionality/user requirement diagram. Instead of stating "system X should have function Y", we define functionality in terms of what different users need to do with the system (Cohn, 2004). User stories should identify the user (stakeholder) and the need of the user. A typical user story follows the template:

As a [role], I want to [do something], in order to [purpose]

The role refers to a specific stakeholder/user and needs to be specific. For the DSS, the stakeholder database identified under WP3 should be used as system roles, in addition to various systems administrator and input type roles.

"Do something", or the action, is the behavior of the system, written as an action. In the context of the DSS this could be to "examine the total amount of carbon stored in the forest I am managing" for example.

The purpose is the reason why the role wants to perform the action. This is typically to achieve some goal or objective. The purpose should be a real-world result, and different user stories can share the same purpose. In the context of the DSS, a purpose could be "to optimize CO_2 uptake and logging operations".

User stories are typically co-created with actual users. Depending on the quality of data from the requirements interview, there might or might not be necessary to conduct an additional workshop with stakeholders to identify user stories (Visual Paradigm, n.d.).

If the list of user stories becomes long, prioritization might become necessary. For this, we recommend the Moscow prioritization technique (figure 24) (Marthazari et al., 2018). MoSCoW does not refer to the city, but is an abbreviation of "must have", "should have", "could have" and "won't have (this time)". The design teams apply the technique in order to prioritize within the resource and time constraints of the project.

Must have: The non-negotiable needs that have to be present. The functionalities needed to fulfil the project description and have the project approved. This is the "minimum viable product".

Should have: Important functionality, but not vital. Most of these should be in the final version of the DSS.

Could have: Nice to have functionality, but with small impact if not implemented. This is the list of things you do if you have time.

Won't have (this time): Functionality that will not be included (for now), but which could be useful or interesting in later iterations of the DSS.

Figure 24: Example Moscow prioritization of a project management app. Screenshot from draft.io

- Purpose:
  - Create a prioritized list of user requirements for WP4 development team
- To do - when:
  - After the case study workshops (interviews/requirements + optional additional workshop) create a spreadsheet of what users say they need and want from the DSS.
  - Collate/categorize user needs.
  - Create a matrix to count how many users have the same/similar needs. Include OptFor-EU objectives for prioritization.
  - Translate the needs into user stories
  - WP4: Prioritize user stories using Moscow prioritization
  - WP4 development team will discuss how to translate user stories into system functionality
- Resources:
  - What is a user story? Tutorial and information
  - User story mapping - a more advanced approach (mostly relevant for WP4)
  - MoSCoW prioritization tutorial
  - MIRO - an online collaboration tool for workshops

3.2 Design/development of OptFor-EU DSS

This is the responsibility of WP4 task 4.4, and we will not address the actual system creation here. The input from step 4.1 should inform tasks 4.3 and 4.4, as mentioned in D4.1 section 2.3.

There is however one activity specified in the grant agreement for T5.1 in the design phase: The resulting innovative knowledge from this project will feed into the EIP-AGRI (The agricultural European Innovation Partnership) website for broad dissemination to practitioners. End-user material will be produced in the form of a number of summaries for practitioners in the EIP common format ("practice abstracts"), based on the templates from the EIP-AGRI website. We target a total of three practice abstracts for OptFor-EU. The practice abstracts are scheduled for the first half of 2024.

3.3 Activities for test phase

During and after design and development, there should be several iterations of usability and accessibility testing. When we have a usable and functioning version of the DSS, we propose to distribute the survey based on the unified theory of acceptance and use of technology to measure user adoption.

There are many different types of tests, as the figure below shows (Figure 25). We suggest card sorting and usability testing as the most relevant activities during and after implementation.

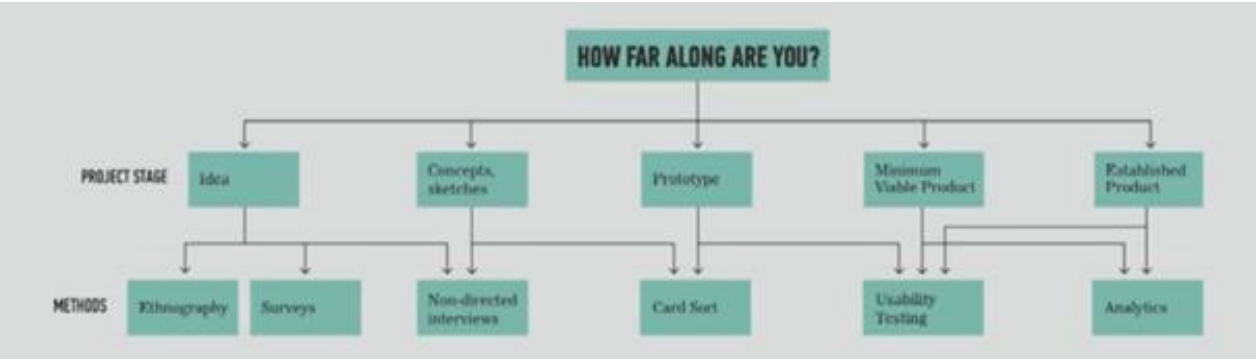


Figure 25: Different user involvement testing methods. From Interaction Design Foundation

Card sorting is a technique for sorting information and is used as input to the information architecture of the DSS (ie. How data is organized so users can find it).

This can be organized as an activity in one of the stakeholder workshops, after requirements and user stories are completed, and before/during development of the DSS.

Usability testing is a qualitative method for testing the user experience of a system. A usability test involves showing something (wireframes, sketches, prototype, finished DSS) to users, and asking questions about their experience. Testing is usually done in two parts. A "get it"-test, where you see if the user understands the purpose of the system, can figure out how to use it, identify all functionality etc, and a "task test" where you ask the user to conduct a specific task with the system, such as figuring out how to access a certain screen, find a specific piece of information etc. (Krug, 2014). Figure 26 outlines the usability testing process:

Number of users/testers	At least 3 people (enough to uncover 80% of issues)
Recruitment	Preferably someone familiar with the system purpose and context, but any user with some technical knowledge will do
Testing facilities	Can be conducted anywhere with access to the device you want to test the system on. For forest managers, field testing might be relevant if system is to be used while out in the forest.
Conducted by	Anyone with some patience and empathy
Preparation	A list of open-ended questions. Testing can be done at any time
When to test?	Several times over the duration of development. Wireframes, prototypes, completed version
Post-testing activity	One-page summary of key findings

Figure 26: Usability testing (Krug, 2014)

The unified theory of acceptance and use of technology (UTAUT). This is a tried and tested survey for adoption and the intention to use technological systems. The theory and components are detailed above in section 3. In addition to the traditional UTAUT components we will include some dimensions from related adoption models: We have added "motivation" from FBM and "attitude towards technology" from DOI. The survey instrument is included in the annexes. Results will be analyzed using Smart-PLS (Jöreskog & Sörbom, 1993) and presented in an evaluation report as part of T5.1.

- Purpose:
  - Verify and test the DSS to examine if it lives up to expectations and fulfil the goals as define by the project description
- To do - when:
  - During design and development phase (WP4 T.4.3,4.4): Card sorting for information architecture, user testing of wireframes and sketches
  - After implementation: usability testing of DSS. Analytics tools for statistics.
  - After implementation: UTAUT survey distributed to stakeholders.
- Resources:

- How to choose the right UX research technique
- How to set up a desktop usability test
- How to write a usability test script
- How to do card sorting
- UTAUT instrument. See Annex.

3.4 Timeline for activities, T5.1

Activity	Responsibility	Aims	Timeline	Outcome
Literature review (background, theory, methods) (artefact)	USN	Overview of relevant research. Develop theoretical basis for methodological approach and academic papers	20.09.2023	D5.1
Develop data collection tool for user-involvement/co-creation activities (artefact)	USN	User involvement plan with activities for DSS co-creation and evaluation/adoption, Methods, tools.	22.11.2023	D5.1
Persona creation (artefact)	USN, input from WP3,4,5	Create personas for the design team (T.4.4).	31.01.2024	Personas based on WP3 and CSA WS1 data
EIP-AGRI practice abstracts (artefact)	USN, with WP5 input	Create practice abstracts for end-users on DSS functionality	31.03.2024	Practice abstracts in EIP-AGRI format
Requirements collection (data collection)	USN, with T5.3 and CSAs	Solicit input from stakeholders on their needs and wishes for the DSS	To be coordinated with T5.3	Data from T5.3 and CSA workshops on stakeholder needs for DSS, based on affordance theory
Scenario creation (artefact)	USN, input from W3,4,5	Create scenarios/user stories for stakeholders' use of DSS. Scenarios act as input for WP4 requirements phase	Work backwards from WP4 needs	Scenarios as input for WP4, based in requirements
User stories (artefact)	USN + WP4	Prioritize functionality in DSS, based on input from stakeholders.	Work backwards from WP4 needs	User stories as input for WP4, based on requirements

measurement (data collection + artefact)	USN, WP4	Evaluate DSS during design (usability activities), after implementation of MVP (UTAUT survey, user interviews).	During development and after prototype has been tested	Evaluation report

Conclusions

In this deliverable, we have presented two distinct parts: First, in sections two and three we have presented co-creation in the context of Information Systems development, with lean and design thinking as a frame for user-involvement in the DSS. Further, we have presented an overview of methods and models for adoption and user-involvement. The purpose of this first part is to provide relevant background and context for user-involvement activities related to the DSS. The theory presented here will be applied in academic papers on adoption of the DSS, such as:

1. Adapting UTAUT to the forest management context (Information Systems conference)
2. IRT and IDPM applied as analytical model for a paper examining willingness to adopt the DSS (Information Systems journal)
3. Stakeholders' perceived affordances of forest-related decision-support systems (Information Systems or forest research journal)
4. SCT for climate communication and nudging techniques for enhanced adoption (Information Systems or communication conference)

The second part, section 4, has presented the user involvement blueprint, with user-involvement activities to be conducted as input for WP4 when creating the DSS:

- Personas summarizing the characteristics of stakeholders (input for T4.4)
- Scenario mapping of typical user scenarios (input for T4.4)
- User stories (input for T4.4)
    - scenarios and user-stories from different CSAs will become the templates mentioned in the grant agreement (input for T4.4, potentially also 4.2 and 4.3)

In addition, we will distribute a survey on user adoption (see annex2), which will inform the policy recommendations that are part of the overall objectives of OptFor-EU.

These activities build on deliverables 3.1 and 4.1, as well as data from the CSAs and contribute to ensuring the DSS is co-created with users, thereby providing input for WP4, primarily T4.4, but also potentially for T4.2 (input on content of forecasting tools) and T4.3 (how to enable optimal management options).

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Annex 1: Example/template benefits realization plan

Note: The benefits listed are for demonstration purposes.

Benefit	Result indicator	Benefit area	Responsible party	Time	Data capture		Measures/costs of realizing the benefits	Deadline/liability	Risk factors	Eventual consequence)	Any risk-reducing measures
					Data source	Measure and Reporting					
<Description of expected benefits/targets/benefits for the project>	*<Set the metric for measuring gain>*	*<Where the gain occurs>*	*<Specify overall responsibility for benefit realization as far as possible>*	*<Time stamp for when the win occurs>*	*<Provide a measurement data source>*	*<Time and responsibility for measuremen and reportingt>*	*<Identified measures that must be implemented to realise the benefits>*	*<Set the deadline for implementing the relevant measure and responsible for implementing>*	*<Identified risk factors that may prevent the benefit from being achieved>*	*<Impact assessment of current risk, which may necessitate risk-reducing measures>*	*<Specify any measures considered and, if applicable, responsible for measures>*
Benefit 1: Time gain for forest owners. No need to access multiple data sources or do additional processing of data (increased productivity)	Saved minutes/ hours Savings in Euro per year	Adoption willingness	WP5	One month after release (provide time for users to test and familiarize themselves with DSS)	Evaluation survey	Survey report (T5.1)	Ask prototype testers to self-evalute time spent to achieve goals using DSS compared to without DSS.	At release of prototype	Respondents not willing to reply to survey	Medium	Reminders to reply, personal contact.

Benefit 2: Increased data quality for forest owners in relation to climate mitigation measures	User satisfaction Proportion of users using an electronic solution Climate mitigation forest indicators	Users Climate	National government	One year after implementation	User survey Forest indicators	Annually state ombudsman	Information Integration between climate indicators, forest data. Integrate data on system users and non-users, and climate indicators from their forests.	One year after implementation, then annually for 3 years. Government agency responsible for CSA	Involves/relies on external stakeholders, Need to gain support from government for measurement Requires new data to be reported and collected	High	Government or EU-level decision to adopt DSS

Annex 2: UTAUT survey instrument

This is a survey instrument that will be distributed to forest owners and secondary stakeholders when the DSS is completed, and stakeholders have had some time to test it. Results will be analyzed using Smart-PLS (Jöreskog & Sörbom, 1993) and presented in a report as part of T5.1.

	Performance/benefit expectation
PE1	By using the DSS, I achieve what I want in a fast and efficient way
PE2	The DSS makes it easy for most people to speak their minds
PE3	The DSS feels like a quick way to express my opinion
PE4	The DSS can lead to better dialogue between the municipality and the citizen
	Expectations of user-friendliness (effort expectancy)
EE1	It was easy to learn how to use the DSS
EE2	It's easy to use the DSS once I learned how it worked
EE3	It was easy to familiarize yourself with the various features of the DSS
EE4	Using the DSS is an easy way to have your say
	Trust in government and regulation (trust)
TR1	I trust information when it is verified by the government
TR2	I am confident that public sector officials are working for the best interest of citizens
TR3	I am confident that government processes my information in accordance with privacy rules
TR4	I am confident that government uses the input from the DSS in a good way
	Environmental influence (social influence)
SI1	Family and friends often talk about the importance of speaking up about things
SI2	Family and friends often talk about politics and society
SI3	I'm more likely to use an DSS if my family and friends recommend it
SI4	The municipality and the mayor encourage me to share my opinion with them
	Knowledge and resources (facilitating conditions)
FC1	I have the equipment I need (web and phone) to use the DSS
FC2	I have the knowledge I need to use the DSS
FC3	If I need help and support, I have access to this

	Use behaviour
USE1	I would like to use digital solutions to learn about climate mitigation in my forest.
USE2	I would like to use digital solutions for opimizing my forest management practices
USE3	I would like to use digital solutions to learn about climate adaption of my forest.
USE4	Most of my information and decision-making practice takes place digitally
	Behavioural intention (behavioural intention) ***dependent variable***
BI1	If the DSS becomes available to everyone, I will continue to use it
BI2	I will probably continue to use the DSS if it becomes available after the test period
BI3	I will use the DSS if it becomes available after the trial period
	Anxiety
ANX1	I felt unsure how to use the DSS
ANX2	I was afraid of doing something wrong when using the DSS
ANX3	I found it a little scary to use the DSS
	Motivation, technology
MO1	I am generally positive towards new technological innovations in forest management
MO2	I am generally positive when faced with new technology
MO3	I believe that new technologies are generally useful
MO4	I spend time playing with new technology

Annex 3: Interview guide for affordance identification

The interview guide's objective is to help understand the affordances (functionality in the user's context) different stakeholders want from the DSS. Identifying potential affordances is important for the analysis and design stages of the DSS. And the same approach can be used during user testing at various stages of readiness/when MVP is ready.

General comment: Explore and note attitudes, feelings, body language and discuss the context the stakeholder is arguing from. Consider using and empathy map when taking down answers.

Guide is based on:

Maier, J. R., & Fadel, G. M. (2003, January). Affordance-based methods for design. In *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (Vol. 37017, pp. 785-794).

Maier, J. R., & Fadel, G. M. (2007). Identifying affordances. In *DS 42: Proceedings of ICED 2007, the 16th International Conference on Engineering Design, Paris, France, 28.-31.07. 2007* (pp. 841-842).

---important, because affordances are contextual and relational----

- Start with some demographics – position, company, stakeholder type, technological competence and interest.
- If optforEU is known – quick recap of the project and objectives.
- If unknown, spend some more time presenting the project, and discussing potential uses for the stakeholder.

- explore attitudes towards climate science/climate change and trust in science

--- present some existing DSS' related to forest management, OR present optforeu DSS prototype/wireframes/elements (depending on where we are in the process ---

- Discuss what the informant sees as relevant from these types of systems
- Discuss what is missing – what would the informant like to see, and why?
    - asking why is important, as this is relevant for grouping/structuring affordances later

---discuss how a DSS can help the stakeholder achieve his/her goals. step 1: Identify problems---

- Here, it is important to first identify what the stakeholder sees as primary and secondary goals/objectives for using the DSS.
- Ask about context, usage potential, how/why/when the stakeholder would use the DSS, and specific features that are needed for achieving the goals.
- This is related to the artifact-user affordances (what can I use this specific system for?)
- Identify as "point of view". We are looking for what the user needs from the DSS, not what we think the user should want. The objective here is to create several sentences in the form of problem statements, such as this:

    [specific user/stakeholder] ***needs to***
    [verb – do something] ***because***
    [reasons]

---discuss how a DSS can help the stakeholder achieve his/her goals. step 2: explore solutions—

- When we have collected the needs, it is time to explore solutions.
- Discuss with the stakeholder, ask "how might we" address these issues that you raised?
- This is related to the artifact-user affordances (what can I use this specific system for?)

---ask about the DSS in a wider context---

- Here, we are after the artifact-artifact affordances, or how the DSS relates to other systems, rules, regulations, habits (etc. all relevant artefacts).
- Ask questions such as:
  - How do you see the DSS complementing other digital systems you are currently using?
  - How would rate the DSS' ability to help you take decisions to mitigate or adapt to climate change?
  - Are there any rules/regulations that are relevant when it comes to using the dss? Would it help with compliance? Hinder compliance?
  - What would it take for you to become a regular user of the DSS and have it become part of your everyday work routine?

--- Questions related to affordances, use as needed ----

- How do you perceive this kind of system, do you think it could be relevant and helpful to achieve your goals?
  - Why do you think so?

- First impression from the artefact being observed (existing DSS or optforeu DSS/wireframes/elements?
- What do you think is the main goal/aim of this DSS?
- Do you see yourself using this type of system?
    - Why/why not?
- Is climate change an important issue to you?
- Would you use the system primarily for optimizing your own financial output, or also to learn how to balance finances and climate mitigation/adaptation?
    - …or do you see the two as one and the same?
- Do you trust the science behind DSS' such as this?
- What does it take for you to trust information you access in this or similar systems?
- Do research affiliations or certain certifications increase your trust in the data?
- What is the most important thing you think you could use a DSS for?
    - Ideation! This question is important, and should spend some time digging and exploring
- What is the benefit of using the DSS, to you personally, your company and the wider community?
- Are there any disadvantages also?
- How did you realize that (cross question about benefits or the disadvantages)?

- How would you use different features of the DSS?
- Which is the most important feature of the DSS for you?
- Can you relate digital tools in general, such as the Internet, specific web sites/data sources you use, to the benefits or disadvantage that we discussed?
- Any other comments?

Annex 4: Process overview

The following table provides an overview of the DSS design process:

Define objectives and scope (WP7, grant agreement)	Clearly articulate the goals and objectives of the DSS. Specify the scope of the customization, including the types of decisions and activities it should support.
Involve stakeholder (WP3)	Identify key stakeholders, such as forest managers, ecologists, and policymakers. Involve stakeholders in the customization process to ensure the DSS aligns with their needs and requirements.
Integrate data (WP1,2,4,5)	Determine the data sources required for the DSS, including forest inventory data, environmental data, and socioeconomic data. Develop a plan for data collection, storage, and integration.
Select the model and develop (WP4)	Choose appropriate decision models and algorithms that align with the DSS objectives. Develop or customize models to suit the specific needs of forest management.
Design user interface (WP4)	Design an intuitive and user-friendly interface for the DSS. Consider the needs and technical proficiency of the end-users.
Customize (WP3,4,5)	Customize the DSS to reflect the unique characteristics of the target forest or region. Implement parameterization options to allow users to adjust model parameters based on specific scenarios.
Analyze scenarios (WP 1,2,3,4,5)	Integrate scenario analysis capabilities, enabling users to explore various "what-if" scenarios and their potential outcomes.
Integrate the GIS (WP4)	Integrate Geographic Information System (GIS) capabilities to visualize and analyze spatial data related to the forest.
Test and validate (WP4,5)	Thoroughly test the DSS to ensure its functionality, accuracy, and reliability. Validate the DSS outputs against real-world data and expert knowledge.
Document and train (WP4,6)	Create user manuals and documentation for the DSS. Provide training and support for forest managers and other users.
Iterate (WP7,4,5)	Plan for ongoing updates and improvements based on user feedback and evolving forest management needs.
Assess data security and privacy (WP4)	Implement measures to protect sensitive data and ensure compliance with relevant data privacy regulations.
Deploy and maintain (post project, EU/governments)	Deploy the customized DSS in the target environment. Establish a maintenance plan to address bug fixes, updates, and data refreshes.
Monitor and evaluate (First evaluation: WP5. post project: EU/governments)	Continuously monitor the DSS's performance and user satisfaction. Evaluate its impact on forest management practices and outcomes.
Establish feedback mechanism (post project, EU/governments)	Establish a feedback mechanism to collect input from users and stakeholders, and use it to make further refinements to the DSS.

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