IPM Decisions

D5.1 A catalogue with structural and performance feature profiles for all included DSS

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1 Public Summary

The typology of the four basic steps for building decision support systems has been used to obtain a wide range of new structural and functional characteristics of 80 decision support systems for integrated pest management. The catalogue will help users to select the DSS that meets their practical and technical needs.

2 Executive Summary

The deliverable is the report of the results obtained in WP5 task 5.1: 'Description of the DSS as vectors of characteristics'. The reported results address the following two objectives of the IPM decisions project: (i) Understand constraints with current routes of access to DSS, by engagement of the end users and (ii) Guide users of the DSS Platform towards DSS that suites their needs the most.

A catalogue with structural and performance features of the 80 DSS describes the following four aspects of the assessed DSS:

1. Information about **who is the target user** of the assessed DSS and what the spatial, temporal and technical constraints are for the problem in question.
2. Information about **the decision problems** that could be solved by the assessed DSS and what kind of decision alternatives this DSS can provide.
3. Information on the **decision analysis method** on which the assessed DSS is based and the required input data.
4. Information on the **required knowledge** of the end-user for the daily use of the assessed DSS.

We used a typology whose development was based on expert knowledge of four fundamental steps for building decision support systems. The characteristics of the 80 DSS described in Deliverable 4.9 were complemented by a wide range of new structural and functional properties. Their descriptions were given from the perspective of the end user. The obtained characteristics are provided in a catalogue that is broken down by all the subcategories of the applied typology. The catalogue is in the form of an Excel file containing information for all typological categories of the 80 DSS. The Excel form of the catalogues provides many opportunities for additional detailed examination of the structural and performance characteristics of the DSS included. The catalogue that is the final result of this deliverable is a qualitative improvement to Deliverable 4.9 and will make significant support to WP3 which aim is to develop the platform that farmers, advisors and researchers will use to select the most appropriate DSS that meets their needs, training and technical requirements and expectations. The outputs described in this deliverable form positive synergies with the outputs of other tasks in this work package, as well as with WP3 and WP4 and other work packages of the project IPM Decisions.

3 Introduction

The purpose of this deliverable is to provide an overview of the structural and performance characteristics of 80 available DSSs, systematically described from an end-user perspective. Based on the work and the results of WP4, reported in deliverable 4.9 and titled "Catalogue of DSSs with details of inputs, outputs and functionalities", we have produced a catalogue of DSSs that includes a detailed description of each of 80 DSS according to its underlying technical components and perceived functionalities for the end user. The description of each DSS as a vector of features was done in a systematic and consistent way, which facilitates the assessment of the partial and overall performance of the assessed DSS from the end user's perspective.

The profiles of structural (objective, technical descriptors) and performance (usage-based) characteristics describe the following four aspects of the assessed DSS:

1. Information about who is the target user of the assessed DSS and what are the spatial, temporal and technical constraints for the problem in question.
2. Information about the decision problems that could be solved by the assessed DSS and what kind of decision alternatives this DSS can provide.
3. Information on the decision analysis method on which the assessed DSS is based and the required input data.
4. Information on the required knowledge of the end-user for the use of the assessed DSS.

These four aspects of structure and performance served as the main objectives of this deliverable. The approach we used to achieve these objectives is described in the following sections of the report. First, the methodology we used to obtain information on the assessed DSS features is described. We included a brief introduction to the DSSs in our study in the second section of the report. The results of the descriptions of the DSSs included are presented in the third section. The following section provides detailed responses to each of the four objectives described above. The last section provides a discussion and conclusions on the results obtained. Detailed information on the examined features of the studied DSS can be found in the appendix.

4 Methodology for the assessment of structural and performance characteristics of DSS

The assessment of the structural and performance characteristics of the decision support systems collected and described in deliverable 4.9 required the development of a new assessment methodology that provided objective descriptions of various aspects of DSS. Both the structural and performance characteristics are largely defined by the applied DSS development approaches, reflected in their structures, their application purpose and the specific needs of the targeted end users.

To cover the wide range of decision support systems described in deliverable 4.9, we developed a new methodology based on the basic principles of building decision support systems. A **decision**, by definition, is the choice of one of several alternatives, and the process of making that choice is called decision-making, which is based on the **final outcomes** of the system. To improve the effectiveness of complex decisions on complex problems, the support of decision makers by interactive computer tools, called decision support systems (DSS), is required. These basic principles can then be broken down into somewhat more specific, interrelated areas or development steps of decision support systems (Fig. 1).

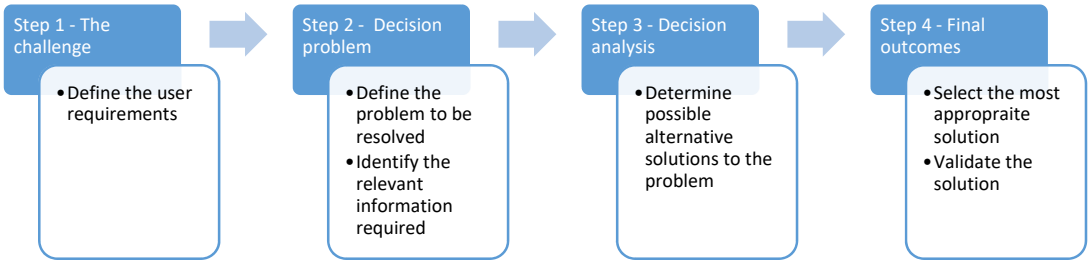

Figure 1: Four steps in the development of reliable and trustworthy decision support systems.

4.1 Four steps to DSS development

Step 1: Defining the challenge

The first development step, **'The challenge'**, contains all the necessary descriptions and arguments for the problem to be solved. The problem owners provide a verbal or written definition of the problem. The description also includes the spatial and temporal dimensions of the problem as well as the constraints that need to be taken into account in the search for a solution. (e.g. water pollution by pesticides: problem owner is an environmental authority).

Step 2: Defining the decision problem

A **decision problem** is the second step of building the DSS, which introduces the definition of the decision problem, its decomposition into less complex subproblems, and the definition of a set of alternative solutions from which the user selects the most appropriate one. (E.g. choosing the appropriate active substance, its concentration and the time of its application. The owner of the decision problem is a farm advisor or farmer).

Step 3: Decision analysis

Decision analysis focuses on the selection of data analysis and modelling methods used to develop decision models, and on the definition of the data required to describe the problem at hand. The methods may address assessment, prediction or management tasks. (E.g. models to predict the concentration of pesticides in runoff from the field. Decision analysts are experts in data management and modelling).

Step 4: Final outcomes

The last, fourth step is represented by the decision makers. They are the end users of the DSS and their task is to implement the developed DSS. To make the DSS applicable and trustworthy, the development of the DSS must take into account the frequency and nature of the use of the DSS, preferences regarding the format of the DSS and the availability of communication facilities at the location where the DSS will be used. (E.g. a farmer using a personalised Android application on a mobile phone that suggests applying isoproturon before the drainage season at a 50% reduced concentration according to the manufacturer's recommendations).

To extract the structural and performance features described above, we developed a typology. It was used to obtain an ordered/structured representation of the concepts and terms in the form of a hierarchy. The typology is a semantic classification scheme and represents a knowledge map (Lambe, 2007) of the field under study. Since it groups related terms/concepts, it represents a classification scheme. This means that terms that are in a category are related to other terms in the same category, which makes searching easier. The typology thus provides an overview of the overall structure of the knowledge used in the creation of the assessed DSS. In addition, the hierarchical tree structures of the typology are the most intuitive representation of the relationships between categories and subcategories. For each of the pillars, our expertise in building DSS was used to create typologies (Figure 2), which we later used to describe the structural and performance features of the collected DSS.

Hierarchical typological structures describing the structural and performance characteristics of the assessed DSS through the perspective of the four development steps described above are shown in figures 2 to 5. All DSS included in this catalogue, address problems related to plant protection according to integrated pest management criteria.

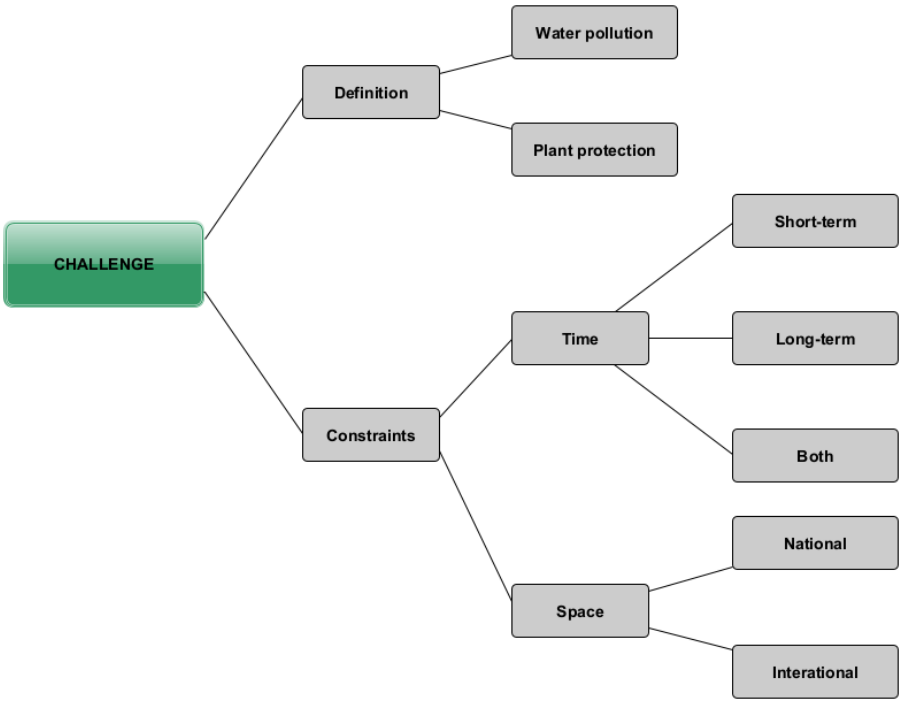

Figure 2: Typology of challenge

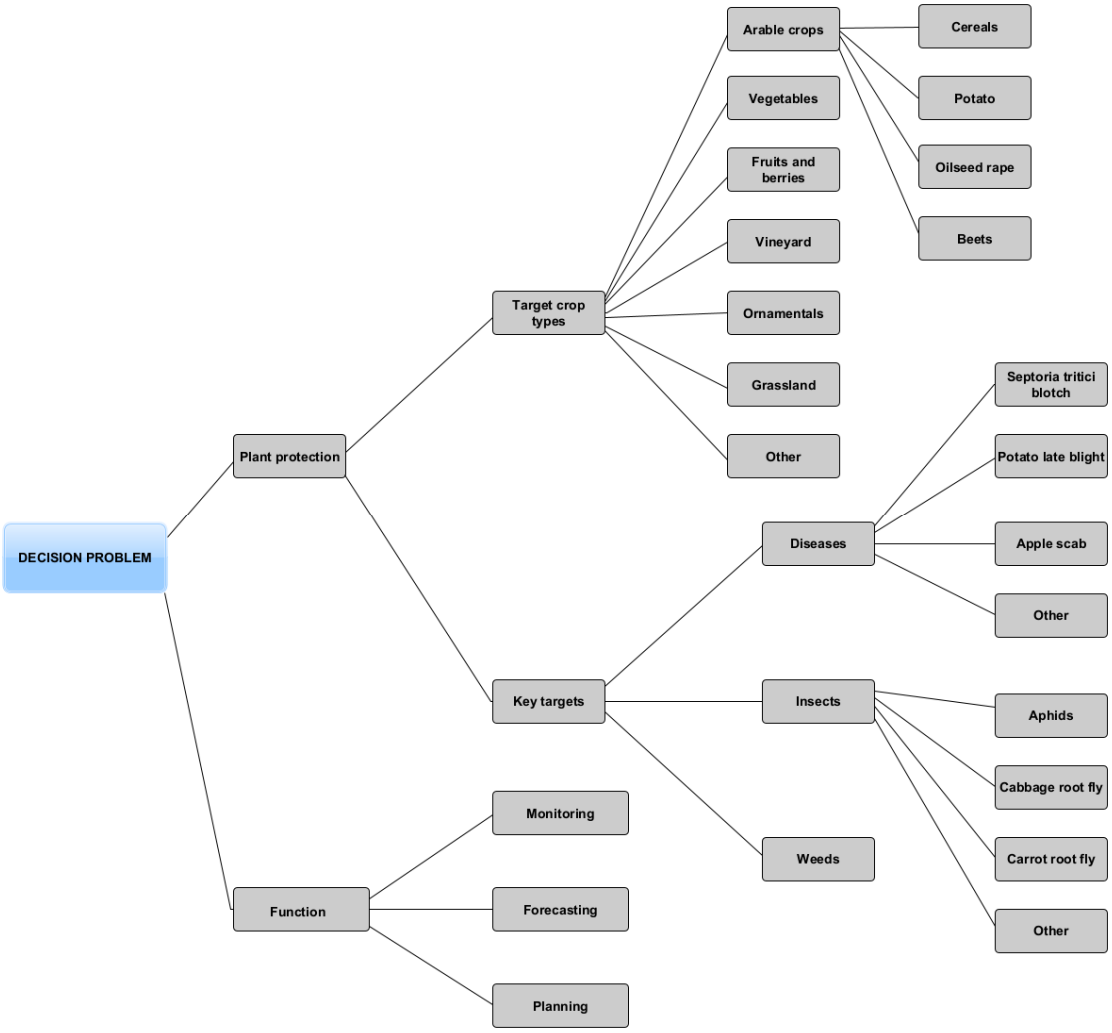

Figure 3: Typology of decision problem

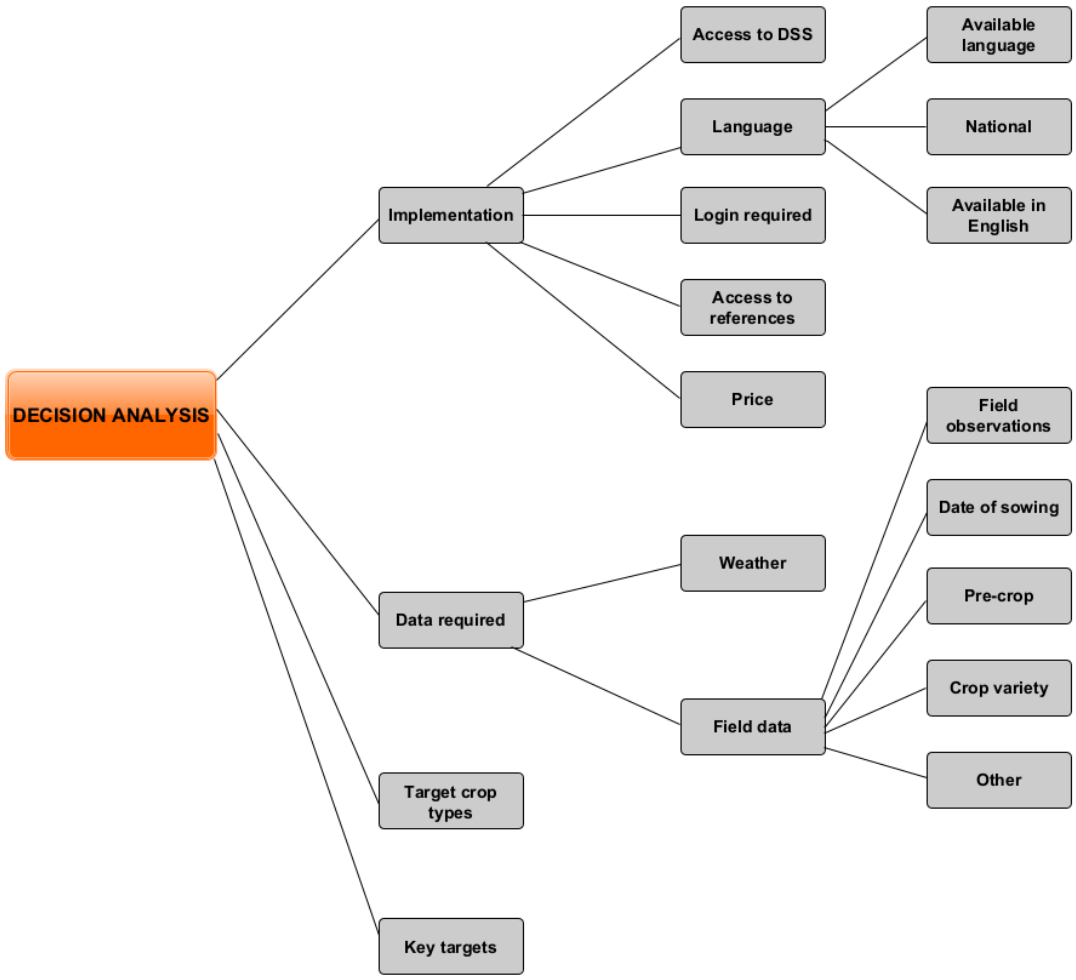

Figure 4: Typology of decision analysis

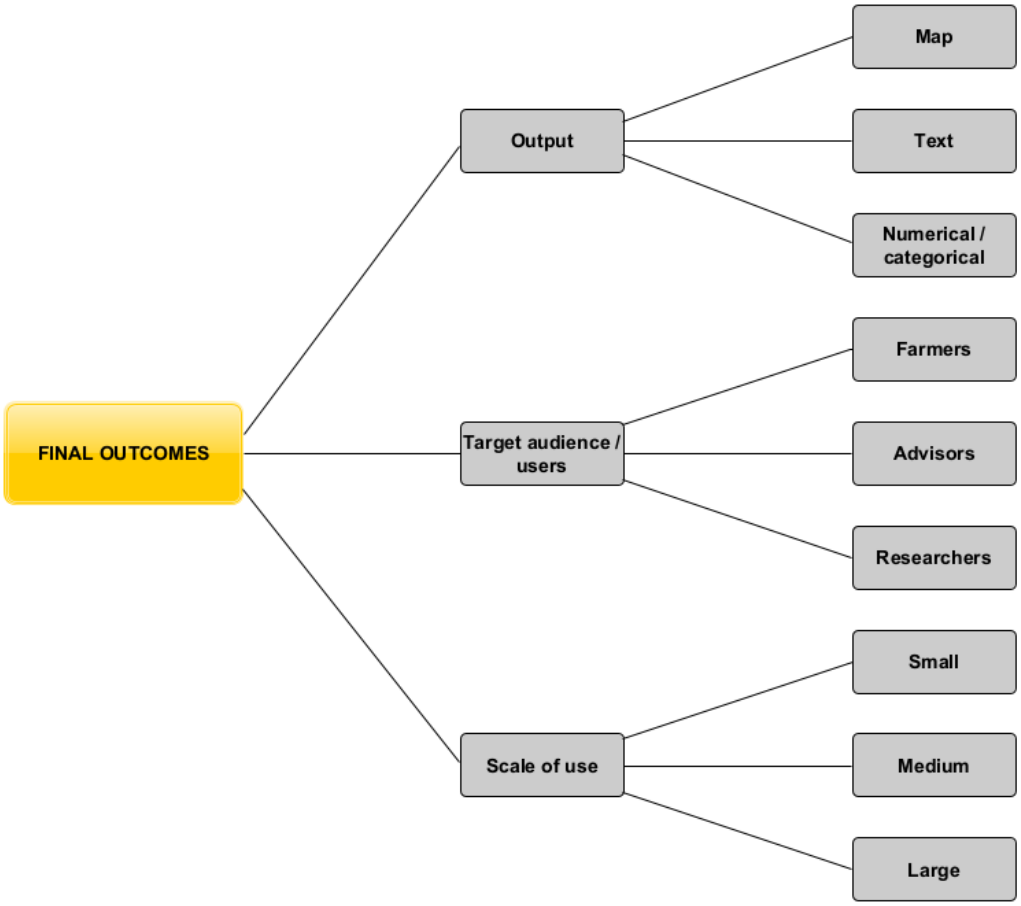

Figure 5: Typology of final outcomes

5 Assessed DSS

The methodology described in the previous section was applied to 80 DSSs described in the full catalogue of DSS developed in WP4. The catalogue served as the central source of information for deliverable 4.9, which describes 80 DSSs in detail. The aim of deliverable 4.9 was to provide an updated and expanded catalogue of DSSs, building in part on the ENDURE catalogue of DSSs (Anon 2009, 2010). Despite the efforts to obtain as much relevant information on DSSs as possible, the full catalogue does not provide the features needed to answer the four main objectives described in the introduction of this deliverable. The information compiled in the full catalogue was the central source of data for our research work reported in this deliverable, supplemented with additional information by directly exploring some available DSSs. A summary of the 80 studied DSSs can be found in Tables 2 and 3, which list the countries where they were developed and their target application area. All further details on the structural and performance features can be found in the Results section.

Table 2: Region and country of origin of the considered DSS

Region of origin	Country of origin	Number of considered DSS
North EU	Norway	20
Central EU	United Kingdom	20
Central EU	Netherlands	10
North EU	Denmark	9
South EU	France	7
North EU	Finland	5
Central EU	Germany	3
North EU	Sweden	1
Central EU	Belgium	1
North EU	Lithuania	0
Central EU	Slovenia	0
South EU	Greece	0
South EU	Italy	0
n/a		4
Total		80

More than 60 % of DSSs included in the catalogue were developed in just three countries (Norway, UK and Netherlands). North EU and Central EU are similarly well represented while South EU is represented with only 7 DSSs that are developed in France. The target application of most of the DSSs that are included in the catalogue are diseases (56 %). Only 6 DSS are meant for use against weeds.

Table 3: Target application of the assessed DSS

Application of DSS	Number of DSS
Diseases	45
Insects	23
Weeds	6
Other	6
Total	80

6 Results

We have used the subcategories of the developed typology (Section 4) to describe the structural and performance features of the 80 DSSs. They correspond to the described perspectives of the four main steps of the development of DSSs. The catalogue with all the newly obtained information broken down by the subcategories of the typology is in a form of an Excel file which is provided as an appendix of this deliverable. In order to obtain the information needed to achieve the goals of the four subtasks, described in the introduction section, we have formed corresponding subsets of information obtained through the typologies. The results show how the DSSs are classified in the individual subcategory of typological structures. To allow for additional interpretation of the results, we have presented the distribution of DSS into three target groups for their application, which in turn are divided into three European regions according to their spatial application. Since the catalogue of DSSs (Excel file in the appendix) contains information about all typological categories, additional exploration of structural and performance characteristics is possible.

Countries of DSS origin were grouped into three agro-climatic zones (regions) as suggested in the project proposal (North EU, Central EU and South EU) (IPM Decisions, 2018). The same structure of the regions provided in Table 4 is used both in the catalogue and in this deliverable.

Table 4: Regions and countries of DSS origin

Agro-climatic zone (Region)	Countries
North Europe	Denmark, Finland, Lithuania, Norway, Sweden.
Central Europe	Germany, Netherlands, Slovenia, United Kingdom, Belgium.
South Europe	Greece, Italy, France.

Fungal and other agents which cause plant diseases are named hereafter diseases. Insects and arachnids and other invertebrate pests that have an adverse effect on crop quantity or quality are named hereafter insects and all undesirable plants are hereafter named weeds.

The numbers in Tables 5-14 represent numbers of assessed DSSs in different categories and are not always necessarily 80 since not all required data were available or the same DSS can be used by several end users or can be applied on several key targets and/or crops (multiple counting of the same DSS).

6.1 Target users and usage constraints

The first subtask of Task 5.1 was to obtain information about the target user of the assessed DSS and what spatial, temporal and technical constraints exist for the problem in question.

Table 5: Target user of assessed decision support systems

End users	Arable crops	Vegetables	Fruit and berries	Vineyard	Ornamentals	Grassland	Other
Farmers	49	27	14	8	5	3	7
Advisors	47	24	13	8	4	3	7
Researchers	13	10	2	0	0	0	0
Total	50	27	14	8	5	3	7

Target users of most of the assessed DSSs are farmers and farm advisors of arable crops, while researchers have access to only a few DSSs. Just a couple of DSSs is intended for use in vineyards, ornamentals and grasslands regardless of the user type.

Table 6: Temporal constraints of assessed DSS

End users	Short-term	Long-term	Both
Farmers	69	4	2
Advisors	65	3	2
Researchers	23	0	1
Total	69	4	2

Temporal constraints are defined with the type of decision for which the DSS is intended. Definition of short-term temporal constraints for this purpose is a day, a week or a couple of weeks, while long-term is meant for strategic purposes (e.g. a month, whole growth season). The majority of DSS (86%) are intended for short-term decisions. This is anticipated since decision to use or not to use plant protection agents, needs to be made according to the assessed risk. Accurate predictions for pests or diseases can only be made for a couple of days in advance or as far as the weather forecast can be accurate.

Description of technical constraints of the assessed DSSs such as price, login requirement, access to DSS and language of a user interface are given in Tables 6 to 10.

Table 7: Price of assessed DSS

End users	Free	Limited	Payable
Farmers	30	25	21
Advisors	29	25	18
Researchers	1	19	4
Total	31	25	21

31 of assessed DSSs are free. 25 DSSs have a limited set of functions that are free, but additional features are payable or free for selected groups of users (e. g. farmers from one country). 21 DSSs are payable only. While most of the DSSs intended for farmers and advisors are free, the majority of DSSs intended for researchers are have limited free accessibility. Price of DSS has been highlighted as one of the major barriers to DSS uptake on the initial workshop of this project (Brinks and Manshanden, 2020) so it is very encouraging to see that many of DSS are available for free.

Table 8: Login requirements for assessed DSS

End users	Yes	No	Not yet available
Farmers	27	46	1
Advisors	24	46	1
Researchers	5	19	
Total	27	48	1

The majority of DSSs, regardless of user type, do not need the user to create an account and login to use DSS. One of the systems assessed was still in development so the data about its login requirement has yet to be decided.

Table 9: Way of accessing to assessed DSS

End users	Online	Offline
Farmers	67	7
Advisors	63	7
Researchers	24	0
Total	68	7

The vast majority of assessed DSSs (85%), regardless of the user type, are accessible online. Only 7 DSSs are applications located on a computer or downloadable Excel files that do not need an internet connection to function.

Table 10: Languages of a user interface of assessed DSS

End users	National language	Available in English
Farmers	75	45
Advisors	71	44
Researchers	23	15
Total	77	45

Almost all assessed DSS are available in national languages. We do not have complete data for which country the DSS was developed but we have the information about the country of its origin. For the purpose of our research, we assumed that the country in which the DSS was developed is also the country of its application. Some of the systems have multiple language options (e. g. English, national language of DSS origin and others). Almost 60 % of the assessed DSSs are available also in English. DSS developed in the United Kingdom (20) are included in both categories. Our data suggest that the language of the user interface of a DSS should not be a barrier in DSS uptake, because almost all (97%) DSS are supported in the national language of the country in which (and probably also for which) the DSS was developed.

6.2 Decision problems

The second subtask of this deliverable was to collect information about the decision problems that could be solved by the assessed DSS and what kind of decision alternatives this DSS can provide.

Table 11: Type of decision problems that the assessed DSSs are developed for

Key targets	Arable crops	Vegetables	Fruit and berries	Vineyard	Ornamentals	Grassland	Other	Total
Diseases	31	8	6	3	2	0	0	50
Insects	9	14	3	0	3	0	0	29
Weeds	5	2	2	2	0	2	3	16

Most of the assessed DSSs are developed to address issues of diseases on arable crops. Problems of diseases are covered in all presented crop types except grassland, whereby vineyards and ornamentals are poorly covered. The problem of insect pests is best covered on vegetable crops, many DSS also cover a combination of insect pests and arable crops. The problem of weeds is best covered in arable crops. There are only a few DSSs concerning problems with weeds.

6.3 Decision analysis methods and input data

The third objective was to describe the decision analysis methods used to develop the 80 assessed DSSs and the input data required to populate these 80 DSSs.

Table 12: Type of decision analysis method used in the assessed DSS

Key targets	Monitoring	Forecasting	Planning
Diseases	4	34	1
Insects	7	17	0
Weeds	2	0	1
Total	12	51	2

Forecasting is the prevalent method applied in DSS for diseases and insects. DSS for weeds have monitoring or planning as the applied method. The result is anticipated since weeds do not need forecasting but rather monitoring or planning how to reduce their impact on the crops. DSSs that use forecasting methods of decision analysis in most cases require weather input data.

Table 13: Type of required input data for assessed DSS

Key targets	Weather	Additional (field or crop) data
Diseases	39	37
Insects	15	12
Weeds	3	6
Total	57	56

Almost all DSSs that are intended for decision problems regarding diseases and insects require both weather data and additional data, by which we mean field observations, date of sowing, crop variety and so on.

6.4 Required knowledge to use DSS

The last subtask we addressed and report on in this deliverable concerns the information on the required knowledge of the end user for the daily use of the assessed DSS.

Table 14: Required knowledge to use a DSS

End users	National Language	Available in English	IT knowledge	Field observations
Farmers	75	45	67	56
Advisors	71	44	63	52
Researchers	23	15	24	18
Total	77	45	68	56

As previously discussed, almost all assessed DSSs are available in national languages, so we do not expect language to be a major barrier in DSS uptake. Over 60% of the assessed DSSs are available also in the English language, so those systems can be used either for application or educational purposes, outside countries in which they were developed. The majority of DSSs need an internet connection. Therefore, basic IT knowledge is needed (e.g. to connect the computer to the internet, use browser, create an account, login, search for weather data and so on). A considerable amount of agricultural knowledge is needed to prepare the field observation data which are required by most of the DSSs such as identification of invertebrate pests, diseases, weeds; keeping a diary of sowing dates, growth stages, crop varieties, etc. We expect most farmers to have sufficient knowledge. However, we expecting that the user manuals for IPM Decisions platform will explain to the users that recording some field data is obligatory for later use of DSS.

7 Conclusions

In order to provide additional information about the DSS, we have supplemented the basic information about the 80 DSS described in D4.9 with a large number of descriptions of their functional properties. To obtain these new additional features, we used a typology whose development was based on expert knowledge of the four basic steps for building decision support systems. The set of already collected properties was complemented by a wide range of new structural and functional properties. Their descriptions were given from the perspective of the end user.

The catalogue, which is the final result of this deliverable, is a qualitative improvement to Deliverable 4.9 and will help WP3 to develop the platform that farmers and advisors will use to select the most appropriate DSS that meets their needs, training and technical requirements and expectations. In addition, the DSS typology can help users to systematically search for DSS that meet their needs. For example, a French farmer who grows arable crops and is interested in disease forecasting DSSs that are available in French, do not require manual input of weather data and are preferably free of charge can enter the appropriate filters in the Excel document and see if such DSSs are available, how many there are and in which main characteristics they differ from each other.

Similarly, the DSS typology can help developers to identify potential weaknesses in existing systems and their use. Using the defined typologies, we came to the following conclusions:

- Most of the systems collected under Deliverable 4.9 are designed for arable crops, while there are only a few DSS for some other crop types.
- The majority of systems evaluated and listed in the catalogue are intended for users in the Northern or Central EU. This information should inform the developers of the IPM Decisions Platform of the great lack of decision support systems intended for use in southern Europe.
- The DSS typologies show that not all assessed decision support systems have the option to automatically obtain weather data. DSSs that do not have this option can therefore be supported by the IPM Decisions platform by automating the uploading of input data.
- The vast majority of DSSs are available in the language of their origin, but only half also have some additional descriptions in English. When these DSS are integrated into the DSS platform, they should be translated into English to increase their use.
- Most of the DSSs examined are designed for short-term decisions. We note a lack of systems designed for long-term strategies such as preventing the emergence of resistance to pesticides.
- The assessed list of 80 DSSs are not particularly suitable for researchers. There are relatively few such systems in the catalogue and, at the same time, most have

limited functions that are available for free (which is not unexpected given the usually greater complexity of these systems).

- The use of most of the assessed DSSs requires a considerable amount of knowledge about harmful organisms. As these are identified through field observations, the identification process itself cannot be automated. To help users with identification, the IPM Decisions platform could provide descriptions and images of pests in one place. To make it easier to track the status of the farm (or field) on the platform, the DSS platform could also provide the possibility to keep a diary of agronomic activities and crop status (crop growth stages and dates, planting dates, varieties sown, etc.).

The outputs described in this deliverable form positive synergies with the outputs of other tasks in this work package, as well as with WP3 and WP4 and other work packages of the project IPM decisions.

8 References

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9 Appendix

A catalogue with structural and performance feature profiles. The Excel file (Catalogue20-1.xlsx) with the catalogue is attached to this pdf document.

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not available/out of order

| BASIC INFORMATION | | | | | | | | | CHALLENGE (Fig. 2) | | | DECISION PROBLEM (Fig. 3) | | | | | | | | |