LEGVALUE

Fostering sustainable legume-based farming systems and agri-feed and food chains in the EU

Deliverable D1.6

LegValue Decision-support system

to include legumes in cropping systems (LegBox)

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1. Summary

Farmers are increasingly questioning how to diversify their cropping systems, whether to aim for more robust farm performances or more services delivered by biological processes in order to reduce inputs, or to meet the exponential demand for plant proteins. The question of introducing leguminous crops emerges quite logically, both among those who know them well and those who have little knowledge of them or have preconceived ideas.

The H2020 LegValue project European partners have designed the LegBox, a decision-support system (DSS) for the choice and management of legumes in cropping systems. Sharing current knowledge on the crops but also on the effects of these crops into the cropping systems and on the components of the environment is crucial to facilitate the development of legumes in Europe. LegBox aims to facilitate such a sharing for farmers and advisors who should design systems and practices at field level.

This report summarizes the method used to design this DSS and the two outputs: (i) the proposed structure of LegBox and (ii) the French prototype, Atout(s)LEG, the first version of which is focussed on grain legumes.

LegBox **aims to facilitate the design of legume-based cropping systems that can enhance the provision of targeted ecosystem benefits in a specific agricultural situation, for** reaching agronomic & economic priorities as well as environmental services.

The LegBox raises awareness among stakeholders (farmers and advisors in priority) who have little or no knowledge about these crops and help them to understand, through an economic calculator at the rotation scale, the economic benefits of growing a new grain legume crop in a given context, as well as the main existing outlets and markets for these crops. For producers who use grain legumes, the tool will provide recommendations for choosing the crop according to the pedoclimatic context and on how to design their system in order to benefit from the services provided by the presence of legumes: better soil fertility, lower input use (nitrogen or crop pesticides), lower greenhouse gas emissions, or improved harvest quality of the cereals in the rotation, etc.

This transnational concept has to be **translated into operational tools with regional data.** Indeed, the LegBox should then be tailored to local context by relevant native advisory entity in order to adapt the related data bases and to reach farmers and advisors in their own language and context for an effective dissemination. The fact that one or several local actors from the advisory system take this in charge will enable to ensure the operational development and uses of the tool in a medium and long-term vision.

A core group has defined the version adapted to French conditions and focused in a first step on the insertion of monospecific grain legumes in cropping systems. Terres Inovia has forecasted to develop a French numerical tool in 2021, called "Atout(s)LEG" (i.e. Legumes, the trump card to benefit from their panel of assets).

The prototype thus provides knowledge and answers tailored to the situation to be considered, with **six entry keys**:
- Let's get rid of preconceived ideas,
- What are the economic benefits?
- Which crop(s) according to the pedoclimatic context,
- What benefit(s) for what problem(s),
- Which market(s) and which value chain(s),
- How to be supported with field expertise.

2. Introduction

Farmers are increasingly questioning how to diversify their cropping systems, whether to aim for more robust farm performance or more services delivered by biological processes in order to reduce inputs, or to meet the exponential demand for plant proteins. The question of introducing leguminous crops emerges quite logically, both among those who know them well and those who have little knowledge of them or have preconceived ideas.

How can we best provide elements of answers to these questions? The H2020 LegValue project European partners have designed a decision support tool for the insertion of legumes in cropping systems. Sharing current knowledge on the crops but also on the effects of these crops into the cropping systems and on the components of the environment is crucial to facilitate the development of legumes in Europe. The LegBox aims to facilitate such sharing for farmers and advisors who have to design systems and practices at field level.

The LegValue partners wish to set up a tool **for facilitating the design of legume-based cropping systems which can enhance the provision of targeted ecosystem benefits in a specific agricultural situation.** Such a system design should target to reach agronomic & economic priorities as well as environmental services.

3. Materials and methods

3.1. To get farmers' opinion

The WP1 partners launched a **questionnaire survey** over the EU on-farm networks of LegValue project in order to get the opinion of farmers about legume services. This survey allowed us to understand the motivations of farmers growing legumes, the way they grow them, and the benefits they observe in the field. It has also provided a list of perceived or measured services.

The aims of the survey were (i) to understand the reasons why farmers grow legumes (what are their motivations?), (ii) to describe the benefits and limits they observe in their fields, (iii) to analyse if they are satisfied with their legumes or what kind of additional information they need, (iv) to analyse how they adapt the crop management of legumes and other crops to improve the performances of their cropping systems.

There were 134 answers from 10 countries: Denmark, France, Germany, Italy, Lithuania, Latvia, the Netherlands, Portugal, Switzerland, United Kingdom. 40% of the interviewed farmers had an organic farm (among them 55% with livestock) with an average of 3.4 grown legumes species. Conventional farmers (58% of the interviews, among them 68% with livestock) grew an average of 1.5 legumes species. 2% of the farmers had a mix farm (organic and conventional), without livestock, and an average of 3.3 legumes. 14 legume species were recorded in the whole survey, mostly grown as sole crops (67%) before intercropping (25%) and before cover, companion or relay crop (8%). The average rotation length is 5.2 years (4.8 and 5.9 for conventional and organic, respectively). The average legume frequency is 36% (25 and 57% for conv. and org., respectively).
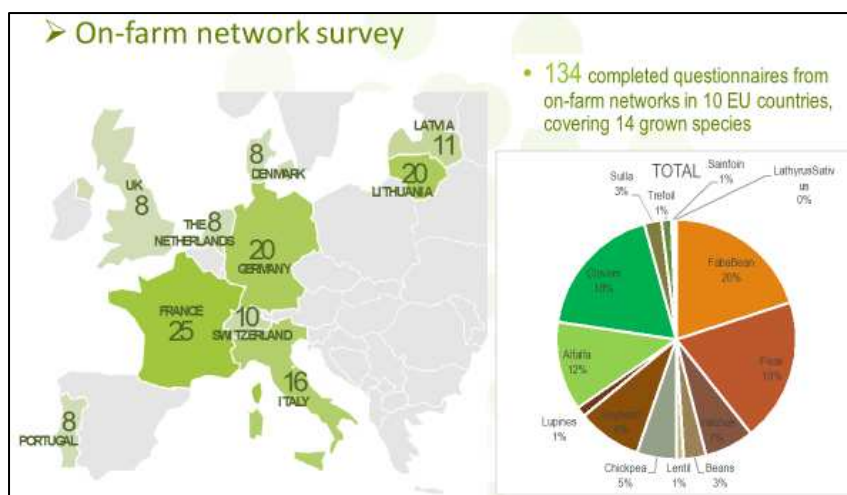
Figure 1. Overview of the OFN survey to get the farmers' needs.

The most cited motivations to grow legumes and observed benefits concerned agronomy: system diversification, soil biological quality (microorganisms, organic matter, etc.) and structure, N supply, yield and quality of the legume or of following crops, and finally weed, pest and disease control with low pesticide. The second category cited was economy and management: improved farm profit (e.g. feed self-production), input use efficiency (e.g. less fertilizer use). 59% of farmers were satisfied with their legume crop, crop management and crop performance, and 73% with the benefits brought by legumes at the cropping system scale. Supplementary information needed varied according to the level of satisfaction. Farmers satisfied with their legume crop and cropping system still lack information on crop management, particularly weed, pest and disease control on these crops. Those not satisfied also lack information on crop management, but above all, they require cooperation and information sharing: feedback from other farmers experience, collective discussions and exchanges, particularly at local scale, experiments conducted with researchers in farmer fields, field visits and practical demonstrations, etc.
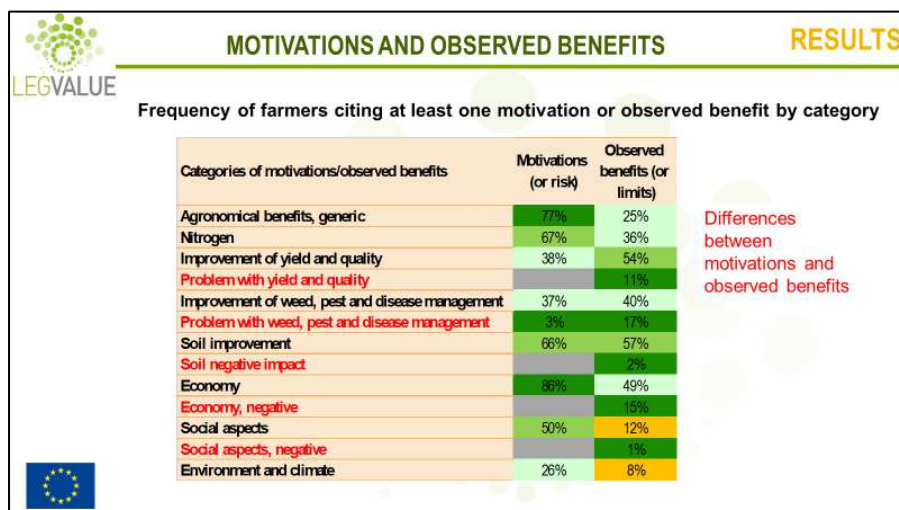

Figure 2. Motivation and observed benefits or limits issued from the LegValue OFN survey.

Four clusters were identified (FAMD): (1) conventional farmers growing a low number of annual legumes as sole crops, (2) conventional farmers growing a high number of annual and perennial legumes as sole crop and intercrop, (3) organic farmers growing a low number of perennial legumes, and (4) organic farmers growing a high number of annual and perennial legumes as intercrop. Farmers of these clusters expressed different motivations and limits that have been identified. They also are differently satisfied with the performance of their legumes as well as cropping systems with legumes.

Globally, the survey was interesting (i) to analyse the profile of some European farmers who grow legumes (even if data are not representative of the ten countries, but this was not the aim), (ii) to see that farmers are rather satisfied with the performance of their legumes and especially with the benefits they bring to the cropping system, and (iii) to notice that farmers still need knowledge to improve the performance of legumes in their cropping system. These results have been presented at the European Conference on Crop Diversification held in Budapest on 18-21 September 2019 (Pelzer et *al.*, 2019).

3.2. LegValue decisions for scope and features of the tool

The proposals from Terres Inovia and INRAE about the DSS objectives, amended through exchanges among the WP1 partners at their workshops, have been regularly shared with LegValue partners' brainstorming at General Meetings. It was decided that LegValue Decision support system should take into account the Task 1.4 and Task 3.4 to include the calculation tools in the LegValue DSS. A brainstorming to discuss the major outputs to be targeted by the DSS functions was organised in Soest in Germany in June 2019 (see Annex 2).

Based upon the survey analysis, the partners' brainstorming and the progress of the WP1 partners, **decisions** were taken collectively to define scope & features of the tool:

- ✓ It should **address strategic advice to support in priority farmers and advisors.** The scale is the **field**, the temporality is the **crop rotation**. The targeted users are first the farmers and the advisors. It could also interest the other stakeholders related to territory level (decision makers or production-basin-based activities such as harvest collecting or product industrial transformation) to get information of importance for field actors views, and therefore to be able to extend it at the territory or value chain scales.
- ✓ **It should ensure a multi-dimensional approach, i.e. covering issues related to delivered** services, crop feasibility, related economics and possible value chains, etc.
- ✓ It is a **transnational concept** to **be translated into operational tools with regional data.**
- ✓ To design the tool, the first step will be implemented **with the case of grain legumes insertion,** using the principle of the lean-up method, in order to build a "minimum viable product" (MVP) and to improve it with successive iterations, especially thanks to interactions with a panel of users. France is the case study the working group.

3.3. Core group for designing the tool, upon the case study of grain legumes in France

A **working group** has been defined at Terres Inovia to get different expertises (studies and analyses, advisory for regional development, numerical expertise, etc.): Véronique Biarnès, Frédéric Muel Quentin Lambert, Vincent Lecomte, Agathe Penant, Bastien Rémurier, Mayssa Ben Sassi, Frédéric Salvi, Anne Schneider, with also Maëlle Simmen from Terres Univia.

Terres Inovia working group Regular "sprint" meetings were organised to progress in agile mode to clarify the objectives to be achieved and the value to be created for the user; elaborate the user pathway and its functional structure, shape the prototype according to the needs at each stage.

The works were based upon the **"lean startup"** approach which is product-oriented, iterative and incremental, and which takes place in 3 phases:

- prototyping, which should lead to an MVP (Minimum Viable Product) that allows the future user to project her or himself in the use of the tool
- technical development leading to a first version of the tool, which will enable to check that the tool is suitable and adapted to the needs of the users
- enrichment of the first version and wide dissemination to the target users

Exchanges in a **core group** enables to capitalise the working group in the WP1-WP3 activities, with representatives from INRAE, Fachhochschule Südwestfalen and Terres Inovia working group: Rémy Ballot, Bruno Kezeya, Marie-Hélène Jeuffroy, Anne Schneider, Vincent Lecomte, Véronique Biarnès, Frédéric Salvi.

The brainstorming and works in a series of working meetings have enabled to: (i) define more precisely the general objective of the tool and draw the **pathway** enabling to reach the targeted users; (ii) define incrementally **the functions and the screens** to be associated to the different sections of the decision support system.

Meanwhile, the working group has defined a panel of users of about 10 **archetype-farmers** in order to interact with them and to incrementally improve the tool**.**
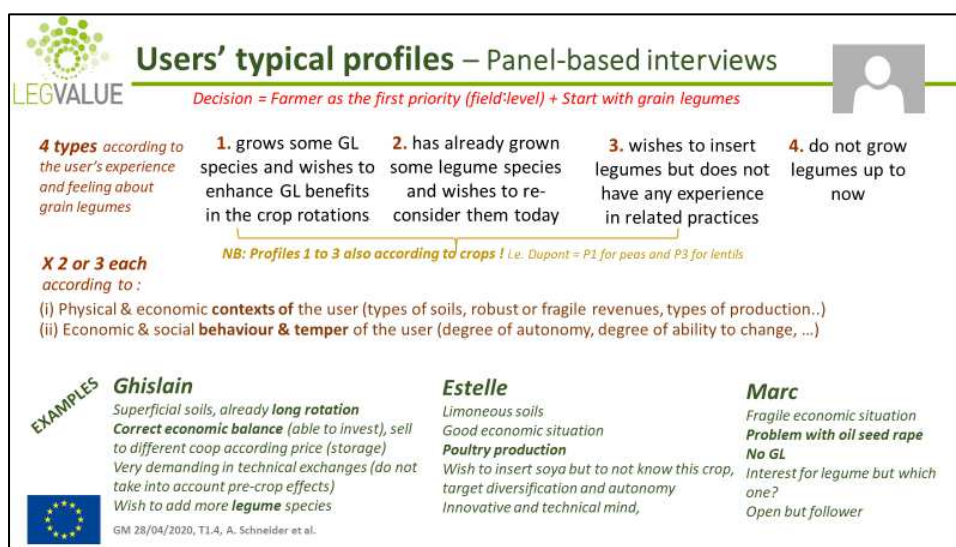
3.4. Tool concept to be tested with panel of users in the different countries

The archetype-farmers, "Personas", represent 10 typical user profiles that have been predefined, using the four type of situations:
#1: Farmer already cultivating grain legumes (GL) and wishing to improve their benefits within the crop succession
#2: Farmer who has grown GL and who would like to reintegrate them into the economy
#3: Farmer wishing to insert GL but not having any hindsight on practice
#4: Farmer who does not grow GL and has never been interested in them.

Within these four types, the profiles are mainly distinguished by:
- a different degree of knowledge, mastery and experience of GL (more or less maturity to act);
- degree of autonomy (more or less need for counsellors etc.);
- degree of ability to change.

Figure 3. Setting-up the national panel of users for the incremental construction of the tool concept.

A panel should be defined per country in order to consider how to adapt the concept to the local or national context: specific requirements or demands, data available and possibly to organise them, relevant ecosystem for ensuring a sustainable deployment of such a tool, etc.

Each On-farm network (OFN) leader is in charge to carried out the interviews: after local discussion for setting up the 10 PERSONAS, the real people to represent them are identified among about 10 existing

farmers covering well a full range of diversified profiles. The interviews themselves enable to collect more details and check the relevance according to the defined profiles and therefore adapt the complemented interviews to be carried out to cover the full range of profiles.

In each national context, the interactions with the panel of users were organised in two steps:

- a series of "problem interviews" in a first step to get their demands: the discussions aimed to know their viewpoints before and ended with the presentation of the general pathway of a possible tool;
- a series of "solution interviews" in a second step to get their preferences, by sharing the different screens of the six possible modules in order to analyse their reactions on the content and the way to display the information.

The interview guides were shared among partners, especially OFN leaders in the different countries in summer 2020, together: (i) LegValue DSS Guide for problem-type interviews for the panel of users (first series of interviews), including the interview forms and the figure of the general pathway; (ii) LegValue DSS Guide for solution-type interviews for the panel of users (second series of interviews), including the interview forms and the proposed modules and related screens.

Up to now, a panel of users have been set up and interviews have been carried out in four countries, France (10 farmers), Germany (6), Lithuania (10) and Portugal (7).

3.5. From the concept to the prototype

The LegValue DSS is a transnational concept to be translated into operational tools with regional data and local adaptation and maintenance. Indeed, the target users being farmers and advisors, the tool should be undertaken by an entity adapted to the regional advisory services ecosystem for an effective deployment and a sustainable vision with possible up-dates and maintenance.

In these conditions, the next step is the organisation of the data bases required for the implementation of the tool and the definition of the digital specification to prepare the prototype.

In France, the partner Terres Inovia has decided to undertake the digital development of the French tool called "Atout(s)LEG" in 2021 to test the prototype by the end of the year (see annex 6.3).

3.6. Keeping connection with other tools developed for supporting crop diversification

Since EU Horizon 2020 has supported six projects focused on crop diversification, a Crop Diversity Cluster has been set up to increase the impact of crop diversification research and to look at synergies between tools but also to identify gaps where new tools are needed. The six projects address crop diversity in different ways and at different scales. Intercropping is a specific focus of two of the projects (ReMIX and Diversify) and insert of legumes into farming systems is the specific focus of two other projects (LegValue, True) but they are also a component of others (Diverfarming and DiverIMPACTS) that address crop diversification in a broad context including rotations and multicropping. Some of these will support decision making in the farm (all tools) and field (e.g. DiverIMPACTS, ReMIX, LegValue) but others work at the level of the landscape (Diverfarming) and supply chain (DiverIMPACTS, TRUE, LegValue) or policy. A typology of tools (TypoCrop) is being created (Watson et al, 2021). The typology aims to assist end users in choosing appropriate tools to support decision making in relation to crop diversity that have been developed as part of the six EU projects.

The complementarities are also facilitated. Since other tools focused on intercrop, LegValue is focused on monospecific crops in the first version.

4. Result - Design of LegBox concept

4.1. Tool pathway

The tool pathway has been conceptualised by the working group in order to be adapted to a wide range of users' profiles (figure 1), in order to:

- raise awareness and interest for people who have little knowledge of these crops or have even reluctancy to use them,
- support legume producers who wish to get further expertise or data.

The information delivered by the tool should help the user to:

- better understand the assets and risks related to legumes in cropping systems (sharing testimonies, knowledge and up-dated information or tools),
- choose the legume species and modes of insertion in the systems according to the situation (soils, climate, cropping systems) and required services (priorities in constraints or in objectives) and according to possible markets (outlets, possible value chains or services payments).

Using the tool should help the user by the decision to grow legume crop, with a clear idea of the way to proceed in his or her situation.
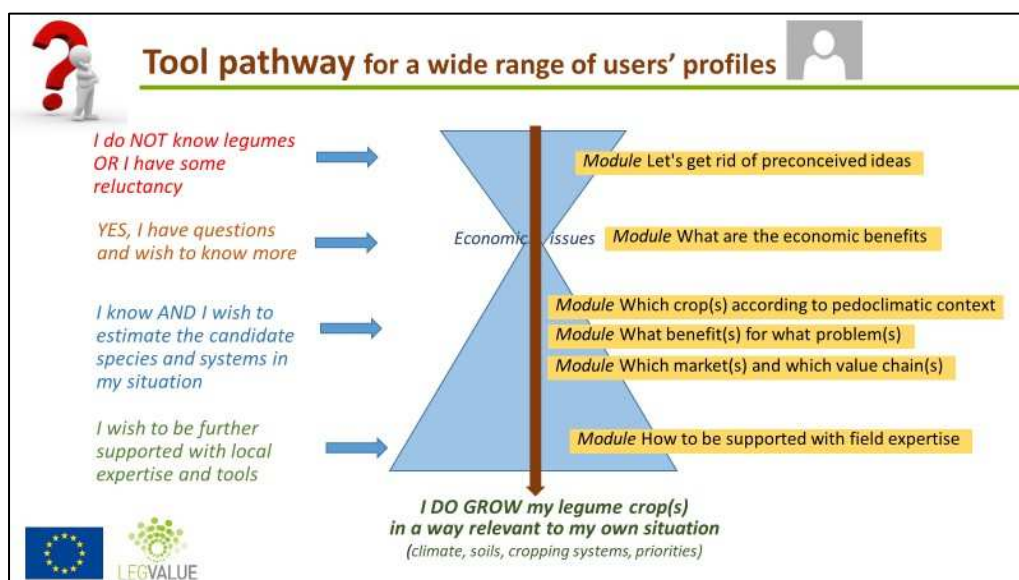
Figure 4. *General pathway of the user in the LegBox, adapted to several user' profile for accessing information into six thematic modules.*

LegBox is a DSS with 6 modules *(figure 5),* addressing 6 types of questions:

- The first module aims to get rid of preconceived ideas, by sharing updated knowledge and farmers' testimonies;
- The next module, in order to better understand the economic benefits of inserting a new legume crop in a given rotation;
- Two other modules will help to choose within the range of possibilities for the user's specific situation: Which crops according to soils and climates? And which benefits
- Another module to inform the main existing outlets and markets for these crops
- The latest module to access to further local support (contacts documents or tools)

For some modules, the user is invited to fill some information on his/her context: for example, information about location and soils, size and mode of production, etc and also more details if legumes are already present in the cropping systems.

The six modules could be reached and run independently but they can also be undertaken one after the others and sometimes using the outputs from one module to support the results of other module.
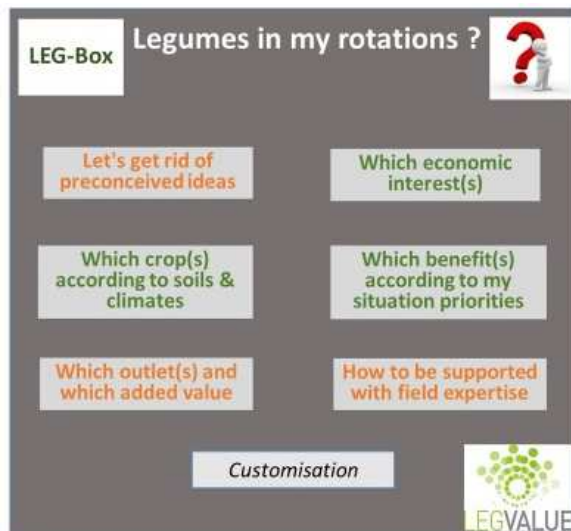

Figure 5. *Home page of LEGBOX.*

4.2. Module 1 – Let's get rid of preconceived ideas

A series of information is displayed for sharing up-dated information related to cultivation uses and management of grain legumes through two types of format:

- A quiz with a series of questions to test the user knowledge, with the results developed with explanation about the answers, both for each grain legume crop and for legume-based cropping system: for each, 5 to 6 questions "True or False", 3 to 5 "Do you know that ..?" and "The technical management in 3 key points".
- A set of testimonies: either through videos or through page format about the farms using grain legumes with success or with some difficulties. This includes the set of technical leaflets issued from some farmers of the On-farm-Networks of LegValue.
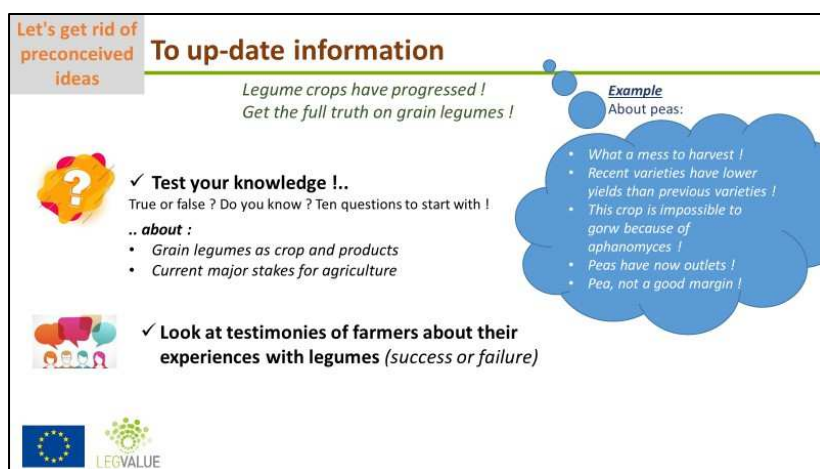
Figure 6. *Structure of the module Lets' get rid of preconceived ideas.*

4.3. Module 2 – What economic benefits?

This module aims to share this **new paradigm**: the real economic value of legume crop is much more than its single crop margin (figure 7).

The module home page gives access to illustrations of such economics-based information, for example, illustration on the statement that the real value of pea crop is at least 35% higher than what is usually defined as crop margin "Yield x Price". Indeed, the presence of a legume crop has both effects on the level of production of the following crops and is also linked to positive externalities. The set of ecosystem services delivered by the legume-based cropping systems are key components of the real value of legume cultivation. The way to get the additional value in addition to the "Yield x Price" level is dependant of the expression of the maximum level of each service and of the recognition of the societal or environmental services which needs to get also an economic value.
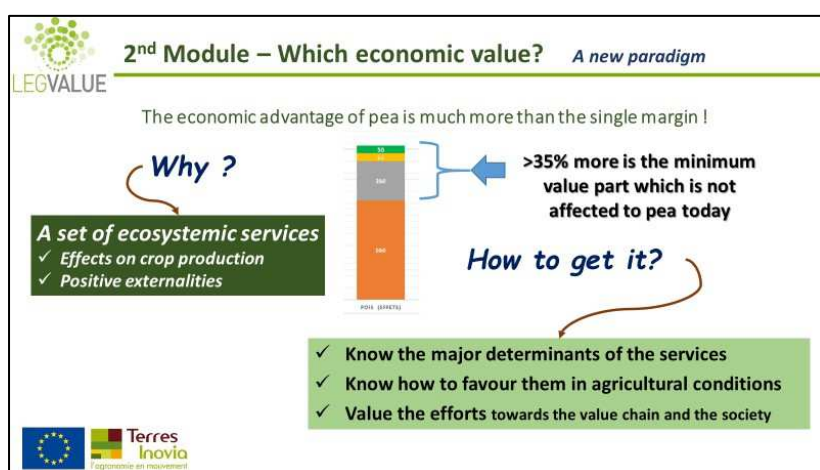
Figure 7. *The new paradigm to be illustrated in the content of the economics module.*

The module **home page** offers four entries to the user to get different types of data (figure 8) on:
- Statistics on performances of past regional cropping systems according to their crop successions
- Possible optimised cropping systems with legumes compared with regional references
- Alternatives of the user's cropping system
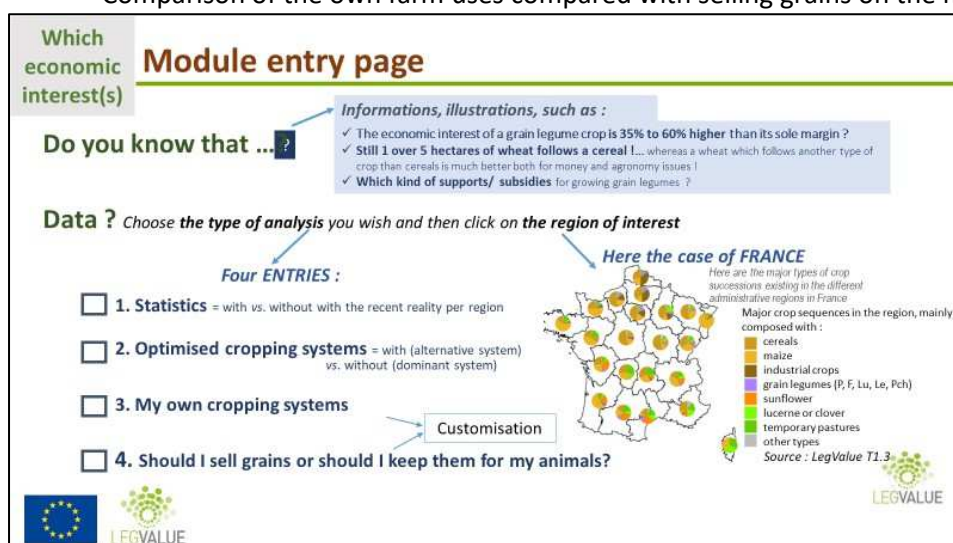- Comparison of the own farm uses compared with selling grains on the market.

Figure 8. *Example of output screen for module on economic interest – Case of statistic on regional farmers' cropping systems.*

After having chosen one type of analysis (among the four) and one region (on the map), the tool shows the comparison between the current dominant system without legume and the alternative system with legume crops, with both a graph on the rotational performances of the two systems and a graph on the real value of the considered legume crop.

Explanation on the sources of the data used can be reached and if it also possible to enter the user's figures for some variables involved in the economic calculation for getting a presentation of the news calculation.

Figures 9, 10 and 11 show three examples of outputs when the user has chosen the region "Burgundy" and two possible types of analyses (Statistics or Optimised cropping systems).
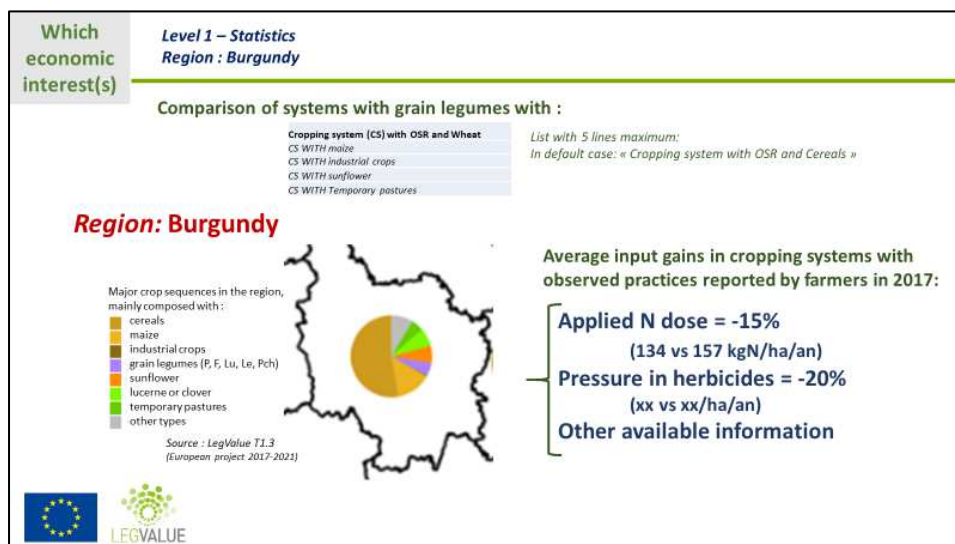
Figure 9. *Example of input screen for module on economic interest – Case of optimised cropping systems.*
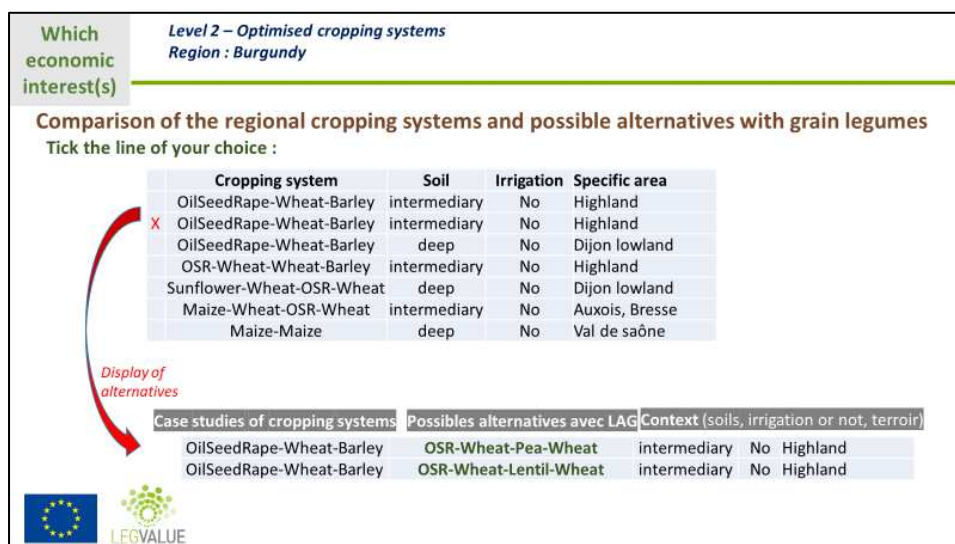
Figure 10. *Example of input screen for module on economic interest – Case of optimised cropping systems.*
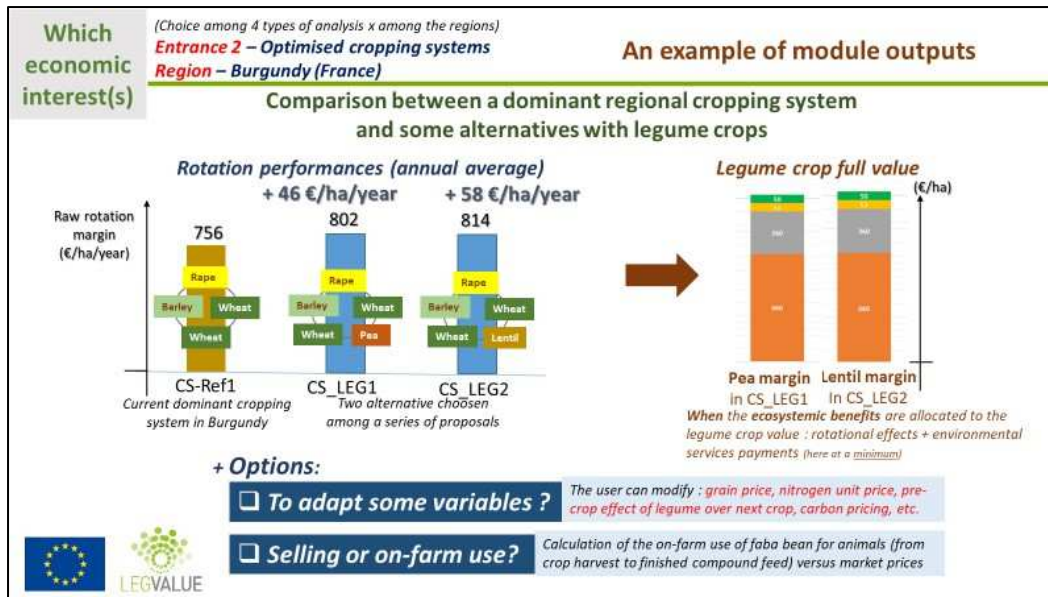
Figure 11. Example of output screen for module on economic interest – Case of optimised cropping systems.

The fourth entry is devoted to the farmer who has also animal productions and who is wondering about the comparative interest in using the grains as on-farm feed materials and in selling them on the market.

The calculation proposed enables the user to estimate the respective costs to get the difference of the two situations (figure 12 below). The details of the calculation are described in LegValue Deliverable D3.4 "Calculation tool for farmers".
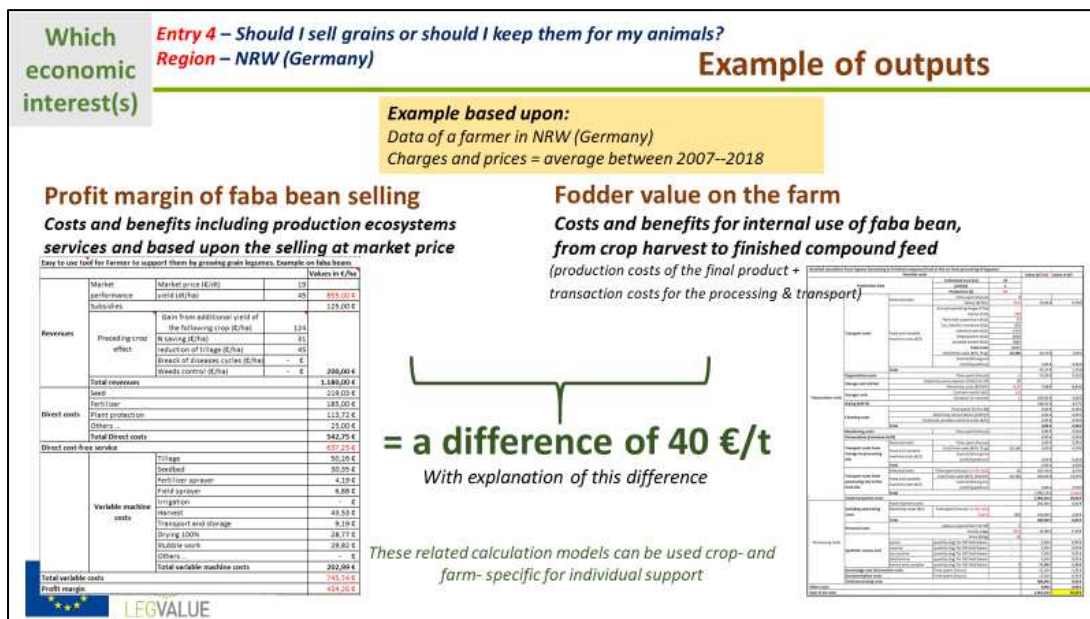
Figure 12. Example of output screen for module on economic interest – Case of uses comparison.

4.4. Customisation entry

The user can enter the specific situation in order to get more customised outputs. The first version of the tool should at least enable to take into account the climatic and soils context of a given farm as well as the related legume cultivation history. A long-term objective of the tool is to give the possibility to enter the full details of the current cropping systems to analyse possible alternatives with legume-base systems in the specific situation with the range of criteria (economic, agronomic, environmental and societal issues).

The concept below gives the customisation related to the minimum level of information of the user's situation at the field level (figure 13), information which can be duplicated for several field situations.
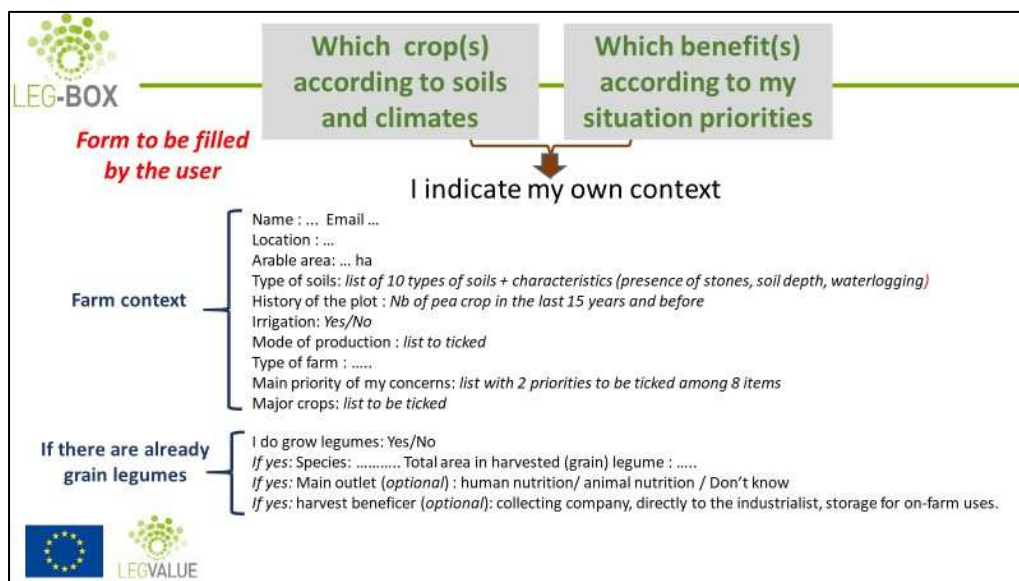
Figure 13. *Screen of user's information about the farm context for more details in Modules about crop feasibility and about benefits*

4.5. Module 3 – Which crop(s) according to the pedoclimatic context

This section aims to indicate the legume species candidates for the user's situation in term of climatic and soil contexts and to indicate the expected yield to be expected.
According to the information given by the user, the tool will characterize the technical feasibility, for each grain legume, sorting out the candidate legume crops on the basis of their pedo-climatic feasibility.
A first sorting criteria is linked to the soil type and other criteria (history of the plot and irrigation). A second level of criteria sorting is linked to the basis of agro-climatic calculations (sensitivity of crops to different limiting factors of climatic origin acting at different stages of the crop).

The main output page of this module is presented in the figure 14. Two levels by indicating the list of possible crops, possible but more or less risky or not recommended. An expected yield level in the given situation will also be proposed, based on results already acquired in the same geographical context and soil type and for an advised sowing date. A median yield will be indicated as well as a

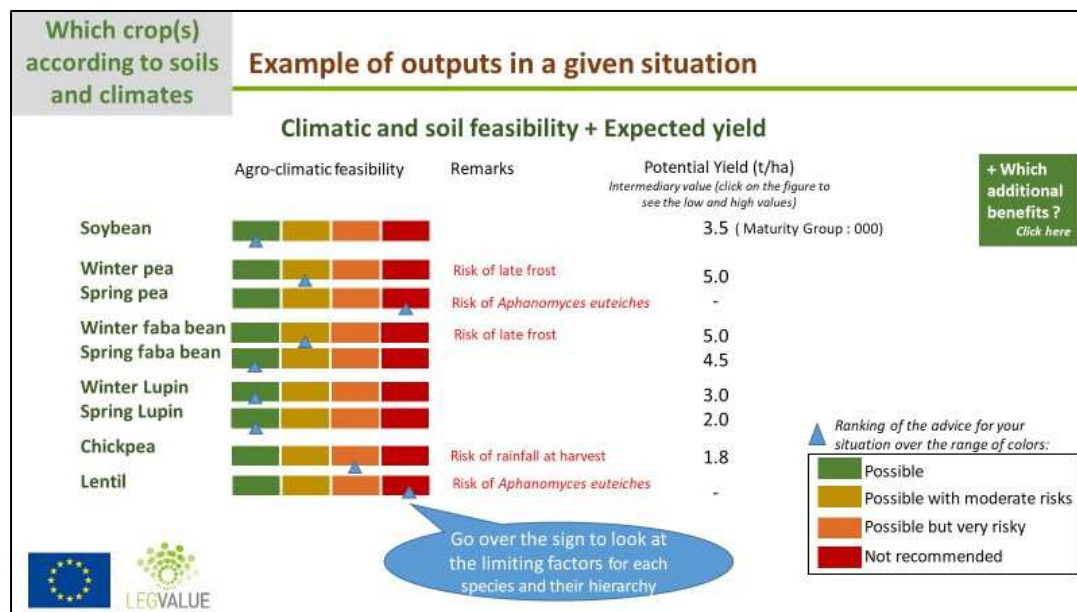rather low value (linked to non-optimal conditions) and a rather high value (close to optimal conditions).

Figure 14. Example of output screen for module on crop feasibility.

When the user will go over the sign indicating the level of feasibility, information on the limiting factors and their relative ranking will be explained in a new screen in order to share information with farmers and advisors. Indeed the purpose is to contribute to provide a better understanding of the major constraints so that the farmer can adapt this information to the specific context in order to take the relevant decisions with all the local farm information and experiences.

4.6. Module 4 – What benefit(s) for what problem(s)

This section aims to support farmers to choose the candidate species not only upon technical feasibility, but also upon the cropping systems and the priorities in terms of production constraints or objectives. It should also help to design their system in order to benefit as far as possible from the services provided by the presence of legumes: better soil fertility, lower inputs (nitrogen or crop pesticides), lower greenhouse gas emissions, or better harvest quality of the cereals in the rotation, etc.

The home page is illustrated in the figure 15.

The first part of this module ("What?") will enable to share the information and current knowledge on the key stakes related to agriculture and the key services that are delivered by legume presence in the cropping systems. This include one page per stake and one page per service where the description and values on legume services are displayed and where the multifunctional profiles of the different legume species are shared.

Figure 15. Screen of module home page "Which benefits according to my situation priorities".

The second part of the module ("How") aims to display the information on the service values and on the conception of legume-based systems according to major priorities of the farmer (production constraints and objectives).

Here the tool will identify the key issues of the legume-based cropping systems which are coherent with these priorities and according to the most relevant GL candidate (identified by the crop feasibility module) and to the major non-legume crops in place, some recommendations will be provided for designing the relevant cropping systems (figures 16 and 17).

Figure 16. Objectives of the module "Which benefits according to my priorities?"

Figure 17. Components of the outputs in the module 4 (Benefits).

The display of the service values (data or classes) should be based upon the LegValue data bases (Task 1.1 services database, T2.2 Potential yields data bases, T1.3 EU cropping systems data bases and scenarios) or any more specific national or regional data bases which can be available and more detailed for the regional context.
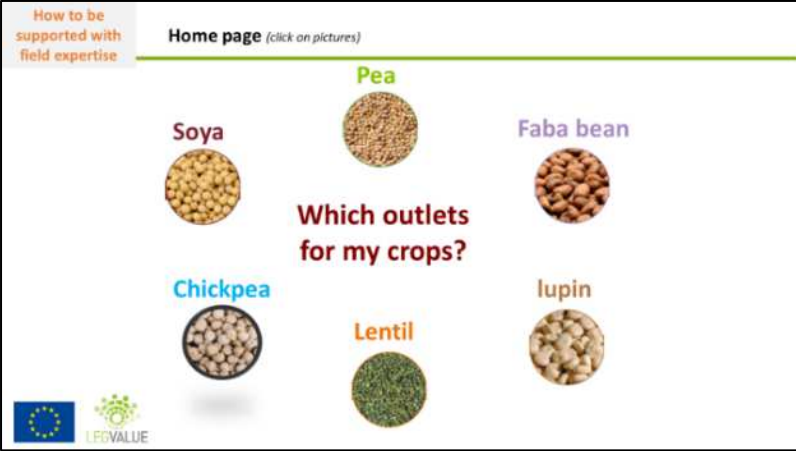
For the French case study, the French partners are mobilising relevant data bases to set classes for each service of interest (for both the farmer and the society), with both literature and experiment data as well as field expertise.

4.7. Module 5 – Which market(s) and which value chain(s)

The module aims to deliver information for knowing better the markets for grain legumes in a given country (outlets, quality requirements and related market prices) as well as to be able to target relevant existing value chains and to negotiate with partners in a win-win contract.

Figure 18. Home page of module 5 (outlets).

The module home page is organised per grain legumes and gives access to full description of the markets and related conditions as well as links to get further information at local or national level. The illustrations in the figures 19 and 20 are based upon the French case study.

In addition, access to overview on UE and international exchanges and markets will be included as well as links to the databases and reports from workpackage 3, especially the LegValue Deliverable D3.1 (Report on legume markets in the EU).
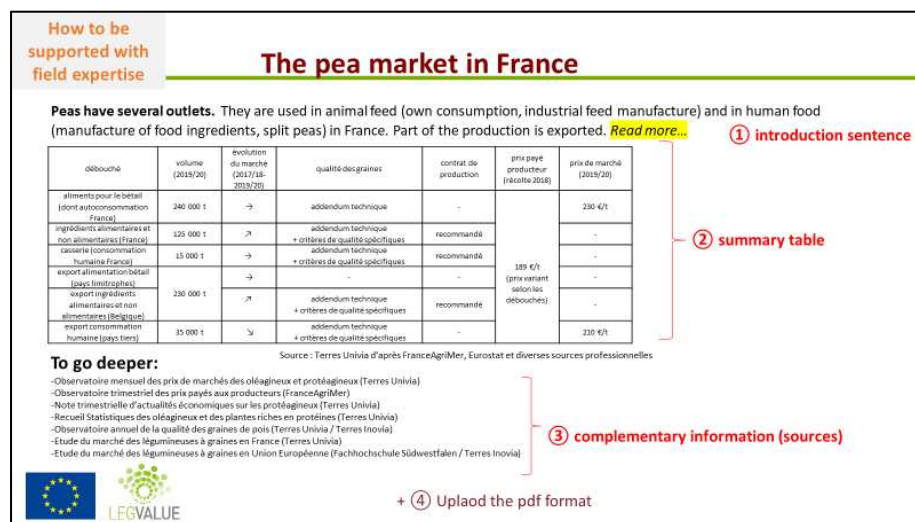
Figure 19. Species market in a country presented in module 5 (outlets).
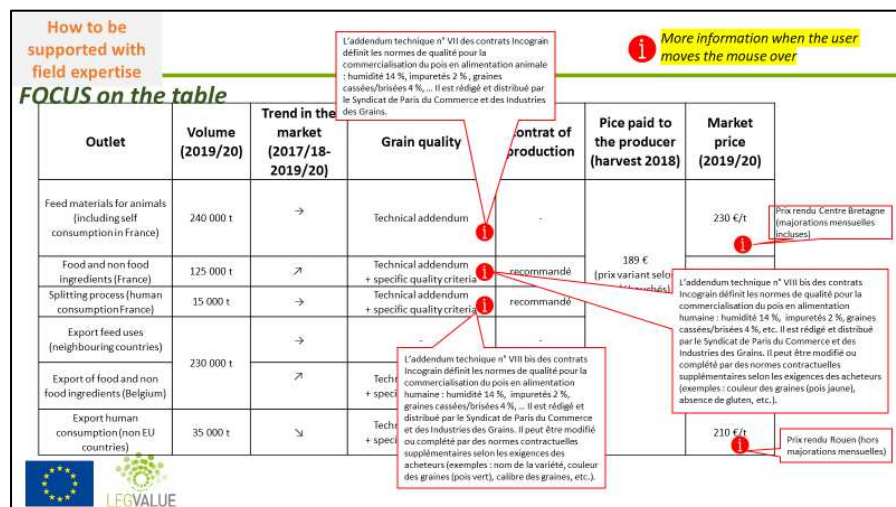
Figure 20. Details of the market table of the module 5 (outlets).

4.8. Module 6 – How to be supported with field expertise

This section will enable to provide national or regional resources of interest which could facilitate the user to implement the development of legume-based cropping systems relevant for her or his situation: contacts and technical resources (including guides for crop cultivation or tactic tools) with information about on-going activities and related links. The international activities and tools relevant to enlarge the content of the LegBox is also included (see 3.6).

The proposed screens to structure the information are illustrated in figures below.

Figure 21. *Home page of the module 6 for contacts and resources.*

Figure 22. *Details about the access to European resources in Module 6.*

5. Conclusions

The LegValue Decision-support system is the transnational concept, called LegBox (Schneider *et al.* 2021), focused on the first version upon the inclusion of grain legumes in cropping systems (adding new species or enlarging the surfaces). The main objective of LegBox is to share knowledge on legume-based cropping systems with farmers and advisors (and any other stakeholder): by raising awareness among people who have little or no knowledge of these crops, by sharing the indirect benefits from the ecosystem services they provide, by providing recommendations according to the user's soil-climate or socio-economic context, so that the farmer can adapt this information to his/her own situation.

LegBox still needs to be adapted to the national or regional context in order to cover the different agricultural conditions in European countries. This will also ensure its integration into the local advisory ecosystem to reach farmers and advisors effectively.

The design of the LegBox should be continued in order to complement and improve it, by:

- enlarging (i) the scope for the type of legumes to be included and (ii) the diversity of systems to be considered,
- going deeper in each module information and functions
- targeting a more precise customisation
- adapting it with more regional data.

In addition, the enrichment of knowledge from both R&D activities (up-dated knowledge and references) and field and farmers experience (issued from regional activities or feedback through the tool uses) should enable to feed more information and decision rules in the tool (limiting factors, economic data, characterisation of the different services and related benefits, etc.)

LegBox is indeed a tool OPEN for collaborations in order to enrich and disseminate legume-based information for agricultural transition.

6. Annexes

6.1. Publications

Pelzer, E., Modotti, M., Ballot, R., Jeuffroy, MH. (2019). Motivations and observed benefits and limits from farmers growing legumes. European Conference on Crop Diversification, September 18-21 September 2019, Budapest, Hungary.

Schneider A., Biarnès V., Ballot R., Jeuffroy M.-H., Lambert Q., Lecomte V., Penant A., Rémurier B., Simmen M., Ben Sassi M., Salvi F., Muel F. (2021). Mettre à disposition un outil d'aide à la décision pour insérer des légumineuses à graines dans les systèmes de culture français. RFL3, Rencontre Francophone des Légumineuses 3ème édition, Angers (Webinars), 24-25 février 2021.

Schneider A., Biarnès V., Kezeya B., Ballot R. (2021). LegBox, LegValue Decision Support System to insert legumes in cropping systems. Optimising Legume Production, 20th April 2021. In the LIN Webinar series "European Legumes in Transition".

Watson C.A., Debeljak M., Baresel P., Bertelsen I., Canali S., Di Bene C., Farina R., Finckh M.R., Hüppi R., Vanino S., Piccini C., Schneider A., Vandewalle A., Topp C.F.E. (2021). Creating a Typology of Tools that support decision making for increased crop diversity (TypoCrop). Aspects of Applied Biology XX, Intercropping for Sustainability.

6.2. Results from the 2019 brainstorming among LegValue partners

Brainstorming results for the major outputs that DSS functions should provide. LegValue T1.4&T3.4 – Internal pre-test – GM in Soest, June 2019.

My objective	What the DSS functions could provide to me	UK	Portugal	Lithuania	Italy	Germany	Latvia	France	SW	Denmark	NL	TOTAL	
Define my st	I can estimate the potential for growing legume crops in my supply area (	14%	0%	20%	20%	23%	33%	7%	0%	25%	25%	18%	
Define my st	I can estimate the interest for developping legume crops on my supply a	21%	25%	20%	7%	0%	33%	0%	25%	50%	0%	0%	
Define my st	I can estimate the economic interest for developping robust legume-bas	0%	0%	0%	0%	8%	0%	4%	0%	0%	0%	25%	
Levers to red	I have information about the levers to get low N losses with legume-base	7%	25%	20%	20%	15%	0%	11%	0%	0%	25%	4%	
Levers to red	I can find knowledge about nitrogen dynamics related to legume-based s	29%	0%	0%	20%	38%	0%	22%	0%	0%	25%	10%	
Sustainabilit	I can estimate the possible price difference I need to forecasted to convi	0%	0%	0%	7%	8%	0%	30%	25%	0%	0%	30%	
Sustainabilit	I can identify an entity able to estimate the ES linked to the developpem	14%	25%	40%	7%	0%	33%	4%	25%	0%	0%	6%	
Sharing with	I can identify entity to accompany the possible developpement of my leg	14%	25%	0%	20%	8%	0%	22%	25%	25%	25%	7%	
Sharing with	*TOTAL answers*	*13*	*2*	*3*	*15*	*10*	*0*	*19*	*3*	*3*	*3*	*71*	Nb
Define my st	I have tools for choosing the best legume species for my own objectives	0%	0%	33%	13%	18%		0%	0%	0%	0%	8%	
Define my st	I have tools for choosing the best legume-based cropping systems for my	20%	100%	33%	27%	36%		47%	33%	33%	33%	35%	
Define my st	I know better understand why I should take into account the major enviro	20%	0%	0%	0%	0%		0%	33%	0%	0%	5%	
Define my st	I get explanations of opportunities for being an actor of the Climate Char	0%	0%	0%	7%	0%		0%	0%	33%	0%	3%	
Define my st	I get explanations of opportunities for getting added value of ES from leg	40%	0%	0%	20%	9%		24%	0%	0%	0%	18%	
Define my st	I get explanations of opportunities for getting added value of ES from leg	0%	0%	0%	0%	0%		0%	0%	0%	0%	0%	
Define my st	I can know the nutritional values of the legume crops for feeding animals	10%	0%	0%	7%	27%		12%	0%	33%	67%	15%	
Define my st	I get information about the major PAC regulations possibly related to leg	10%	0%	33%	27%	9%		18%	33%	0%	0%	17%	
Define my st	*TOTAL answers*	*10*	*1*	*3*	*15*	*8*	*0*	*17*	*3*	*3*	*3*	*66*	Nb
Economic ev	I get assess the higher benefits for the performances stability for my crop	0%	0%	0%	13%	10%	33%	6%	0%	0%	0%	6%	
Economic ev	I get the value of the gross margin of the legume crop according my costs	35%	0%	33%	25%	10%	0%	0%	33%	0%	25%	18%	
Economic ev	I can calculate easily the transaction costs (transport & logistics) related t	6%	25%	0%	0%	10%	33%	0%	0%	0%	0%	5%	
Economic ev	I can include the initial investments needed to get the know-how for leg	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Economic ev	I get the value of the gross margin of the legume crop taking into account	29%	25%	33%	0%	10%	33%	0%	0%	0%	0%	11%	
Economic ev	I get the value of the gross margin of the legume crop taking into account	18%	50%	0%	25%	40%	0%	22%	33%	50%	0%	24%	
Economic ev	I get the pluriannual gross margin to assess the legume-based cropping s	0%	0%	33%	19%	0%	0%	33%	33%	0%	25%	15%	
Economic ev	I can estimate the value of the own-farm use of my legume crop	12%	0%	0%	19%	20%	0%	39%	0%	50%	50%	21%	
Economic ev	*TOTAL answers*	*17*	*4*	*3*	*16*	*7*	*3*	*18*	*3*	*2*	*4*	*80*	Nb
Assess possi	I am informed about the expected values for external-farm ES for a speci	20%	50%	50%	44%	80%	100%	20%	50%		0%	35%	
Assess possi	I can assess the possible external services linked to my legume-based cro	10%	0%	50%	22%	0%	0%	20%	0%		0%	14%	
Assess possi	I can estimate the total ES value provided by my legume-based crop syste	60%	50%	0%	22%	20%	0%	60%	50%		100%	47%	
Assess possi	I can assess the interest to join an initiative for accessing to carbon marke	10%	0%	0%	11%	0%	0%	0%	0%		0%	4%	
Assess possi	*TOTAL answers*	*10*	*2*	*2*	*9*	*3*	*1*	*15*	*2*	*0*	*3*	*49*	Nb
Enhance tech	I have access to recommendations for the best cultivars of specific legum	33%	25%	40%	45%	0%	33%	17%	33%	33%	0%	26%	
Enhance tech	I have access to crop management guide on a legume species of my inter	25%	25%	20%	9%	33%	0%	28%	33%	33%	33%	24%	
Enhance tech	I get assess the higher possible yield of legume species in my context	17%	25%	20%	9%	67%	33%	0%	0%	0%	67%	15%	
Enhance tech	I can find technical management guide for a legume-based crop system	25%	25%	20%	36%	0%	33%	56%	33%	33%	67%	35%	
Enhance tech	*TOTAL answers*	*12*	*4*	*5*	*11*	*4*	*3*	*18*	*3*	*3*	*3*	*68*	Nb
Crop system	I have access to data quantifying the differences in crop system robustne	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Crop system	I can quantify the pre-crop effect of legume and adapt the technical man	14%	0%	20%	20%	23%	33%	7%	0%	25%	25%	15%	
Crop system	I can know how to insert legumes in cropping systems for sustainable ma	21%	25%	20%	7%	0%	33%	0%	25%	50%	0%	11%	
Crop system	I am informed about the expected values for on-farm ES related to a spec	0%	0%	0%	0%	8%	0%	4%	0%	0%	0%	2%	
Crop system	I am informed about the expected values for on-farm ES related to a legu	7%	25%	20%	20%	15%	0%	11%	0%	0%	25%	13%	
Crop system	I am informed about the expected values for on-farm ES related to a legu	29%	0%	0%	20%	38%	0%	22%	0%	0%	25%	20%	
Crop system	I can access to some examples of legume-based systems tested or conce	0%	0%	0%	7%	8%	0%	30%	25%	0%	0%	12%	
Crop system	I can access to data from experimental crop systems with legumes (multi	14%	25%	40%	7%	0%	33%	4%	25%	0%	0%	10%	
Crop system	I can share my experience of legume-based cropping system with other f	14%	25%	0%	20%	8%	0%	22%	25%	25%	25%	17%	
Crop system	*TOTAL answers*	*14*	*4*	*5*	*15*	*10*	*3*	*27*	*4*	*4*	*4*	*93*	Nb
Sharing with	I can understand better key legume specific process (legume nodulation	10%	0%	0%	11%	11%	0%	0%	0%	0%	50%	8%	
Sharing with	I can contact a local advisor for being accompany during crop campaign	10%	50%	0%	22%	56%	33%	30%	50%	50%	0%	28%	
Sharing with	I can get the contact of a regional advisor (or technical web site)	30%	0%	25%	11%	22%	33%	0%	0%	0%	0%	15%	
Sharing with	I can join a group of farmers interested in legumes	30%	50%	25%	11%	11%	0%	10%	50%	0%	0%	17%	
Sharing with	I can hear about legume eperience from other farmer (a species or legum	10%	0%	25%	33%	0%	33%	30%	0%	50%	50%	21%	
Sharing with	I can share my expertise (or data) about : growing a legume crop/ legume	0%	0%	0%	11%	0%	0%	0%	0%	0%	0%	2%	
Sharing with	I can share the situation during the growing campaign to share informatic	10%	0%	25%	0%	0%	0%	30%	0%	0%	0%	9%	
Sharing with	*TOTAL answers*	*10*	*2*	*4*	*9*	*6*	*3*	*10*	*2*	*2*	*2*	*53*	Nb

6.3. Specification for numerical development

The specification details are being written in French for numerical development by Terres Inovia for the French tool called "Atout(s)LEG".

Three of the six modules are based upon information shown according to the user's wishes or with simple results displayed according to the entry of the user :

- Module 1 – Let's get rid of preconceived ideas
- Module 5 – Which market(s) and which value chain(s)
- Module 6 – How to be supported with field expertise

The three other modules are more interactive modules possibly using the user's data for calculation and choice:

- Module 2 – What economic benefits?
- Module 3 – Which crop(s) according to the pedoclimatic context
- Module 4 – What benefit(s) for what problem(s)

Further information and documents can be shared upon request to Terres Inovia.