PRATIQUE

ENHANCEMENTS OF PEST RISK ANALYSIS TECHNIQUES

D 2.7 A generic integrated model for pest spread and impacts

PD No. D2.7

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Submission date: February 14, 2013

EU Framework 7 Research Project
Enhancements of Pest Risk
Analysis Techniques

(Grant Agreement No. 212459)

SEVENTH FRAMEWORK PROGRAMME

PROJECT OVERVIEW: PRATIQUE is an EC-funded 7th Framework research project designed to address the major challenges for pest risk analysis (PRA) in Europe. It has three principal objectives: (i) to assemble the datasets required to construct PRAs valid for the whole of the EU, (ii) to conduct multi-disciplinary research that enhances the techniques used in PRA and (iii) to provide a decision support scheme for PRA that is efficient and user-friendly. For further information please visit the project website or e-mail the project office using the details provided below:

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Disclaimer:

This publication has been funded under the small collaborative project PRATIQUE, an EU 7th Framework Program for Research, Technological Development and Demonstration addressing theme: [kbbe-2007-1-2-03: development of more efficient risk analysis techniques for pests and pathogens of phytosanitary concern call: fp7- kbbe-2007-1].

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1 Introduction

1.1 Background

The objective of PRATIQUE is:

1. To assemble the datasets required to construct PRAs valid for the whole of the EU (WP1)
2. To conduct multi-disciplinary research to enhance the techniques used in pest risk analysis (PRA) for:
    a. the assessment of economic, environmental and social impacts (WP2)
    b. standardizing and summarising risk (WP3)
    c. pathway analysis and systems approaches (WP4)
    d. guiding actions during pest outbreaks (WP5)
3. To ensure that the PRA scheme is fit for purpose and user-friendly (WP6).

The execution of the project has resulted in an enhanced qualitative assessment scheme for PRA (see PRATIQUE Deliverable 6.4) linked to modules that enable pest risk analysts to quantify and/or map the following components of risk:

- Climate suitability
- Spread
- Economic impacts
- Endangered areas.

In addition to linking to the qualitative PRA scheme, linkages between each module are also required. In figure 1.1, these linkages are demonstrated graphically.

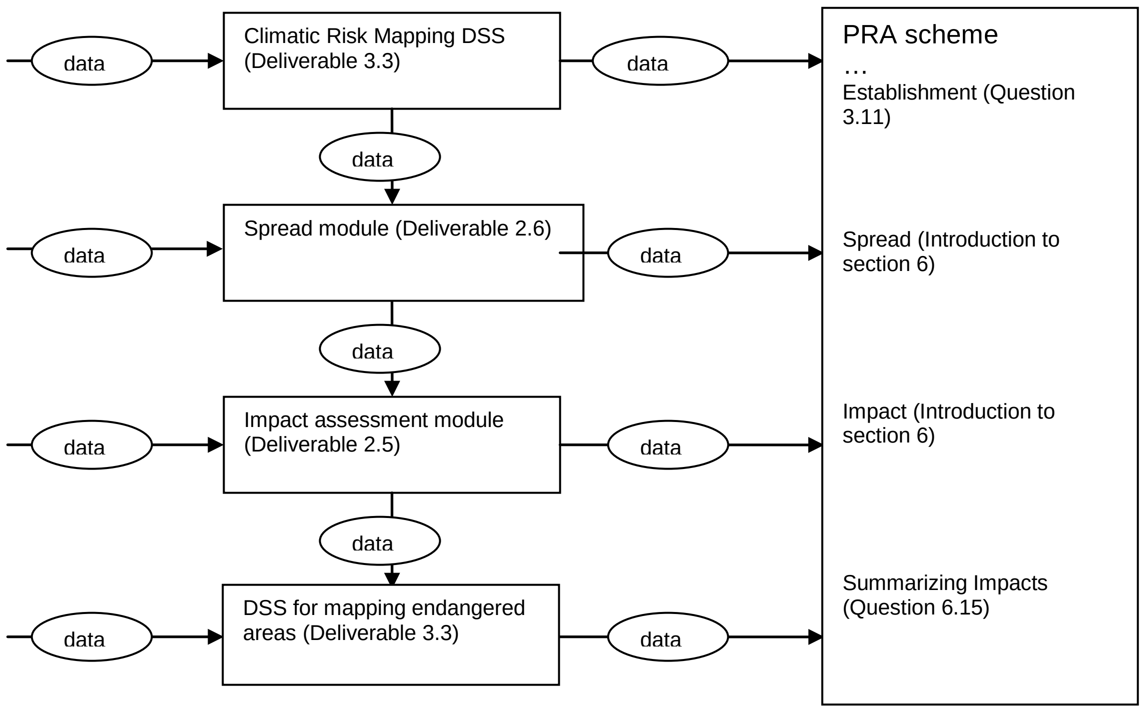


Figure 1.1. Graphical outline of the dataflow connecting the modules and the PRA scheme. References to the PRATIQUE deliverables (D2.5, D2.6 and D3.3) that describe each module in detail are provided and the places (questions and section introductions) where the modules are linked to the qualitative PRA scheme are specified.

This deliverable describes how the modules link together to form the generic integrated framework that ensures there is a consistent flow of information throughout the PRA process. In the Description of Work, this is described as a generic integrated model but it is more appropriate to call it a framework because it links several models. The generic integrated framework outlines the relationships between the spread and impact models and between models for other key factors, e.g. climatic suitability, that influence the magnitude and distribution of spread and impacts. The models themselves are described in separate PRATIQUE deliverables:

- Partial budgeting and partial equilibrium models for assessing economic impacts are provided in PRATIQUE D2.5.

- PRATIQUE D2.6 contains a review of the different approaches for modelling pest spread and a detailed description of the spread models that have been developed with instructions for their use and worked examples.

- PRATIQUE D3.3 provides a decision support scheme (DSS) for mapping endangered areas that includes a DSS for mapping climatic suitability. The mapping of endangered areas requires the construction and integration of maps of the area of potential establishment (based on, e.g. climatic suitability and host distribution) and maps of the areas at highest risk from impacts (based on, e.g. crop yield and value). In order to display the likely progression of the invasion, the results of spread models are required. In order to guide the way that the datasets and the results of quantitative models are combined to map risk, PRATIQUE D3.3 applies the generic integrated framework described in this document.

1.2 Objective

The objective of this report is (i) to compare different approaches for the creation of a generic conceptual framework reflecting the relationships between the spread and impact models and between spread, impacts and the other key factors and (ii) to present the conceptual framework.

1.3 Structure of the report

Section 2 describes how the generic integrated framework can be developed. The framework itself is presented in section 3. A discussion and the conclusions follow in section 4.

2 Approaches to create a generic integrated framework

2.1 Introduction

In PRATIQUE, by utilizing a variety of datasets and models, several methods for quantitative risk analysis have been constructed that need to be linked to questions in the qualitative EPPO DSS for PRA. Some of the model outputs provide information or generate knowledge which serve as inputs for subsequent questions (figure 2.1). Since the simple linking of data sets and tools to questions in the EPPO DSS for PRA scheme may cause inconsistencies and inefficiencies there is a need for guidance on how to use the datasets and tools throughout the whole scheme. The objective of the generic integrated framework is to provide this guidance.

The generic integrated framework provides guidance to the user when utilizing the data, models and other sources of information to assess potential impacts (figure 2.2). The key modules that need to be linked are the DSS for mapping the endangered area, the spread and impact assessment models.

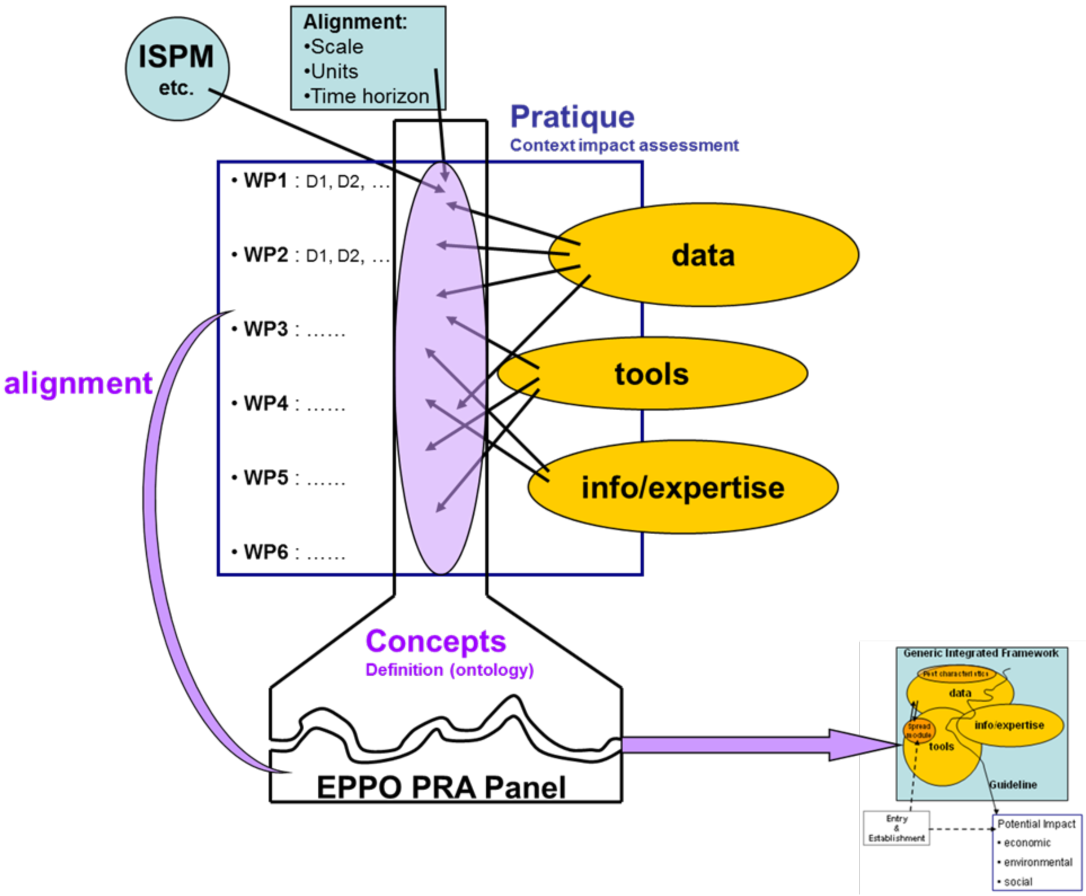


Figure 2.1 Alignment of the Decision Support Scheme for PRA and the deliverables of PRATIQUE

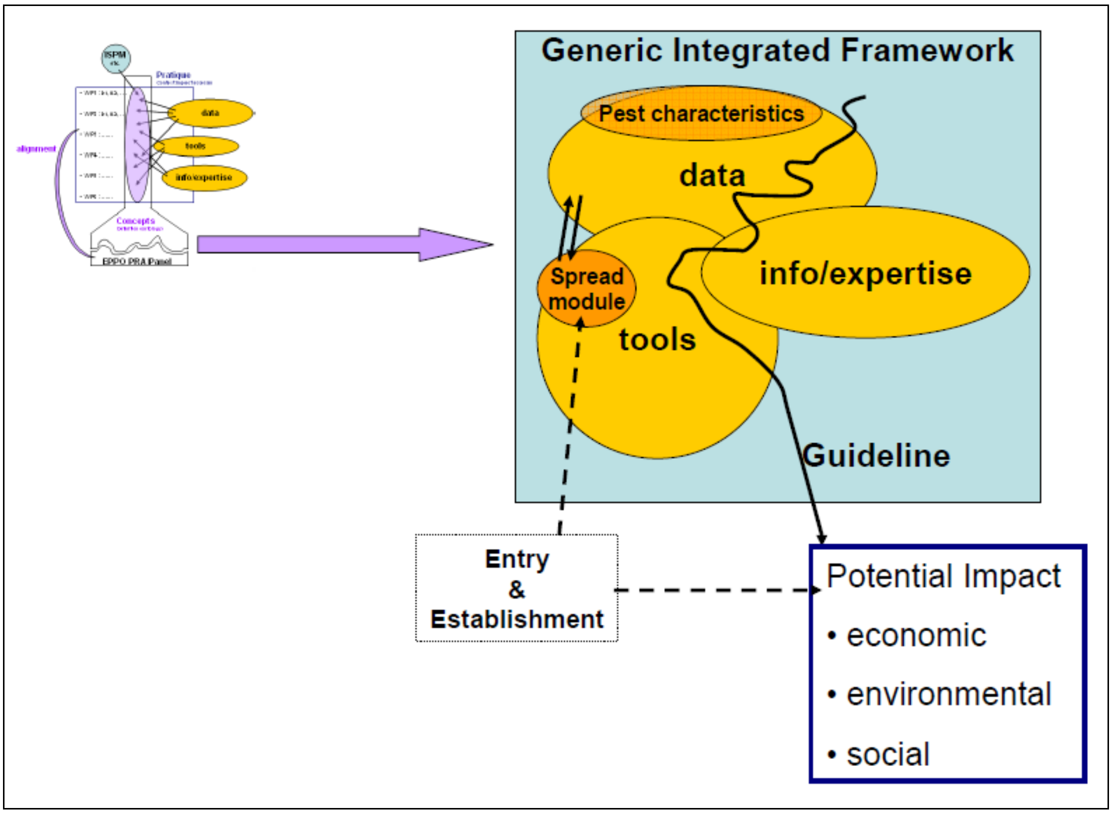


Figure 2.2 Guidance to estimate impacts with a generic integrated framework

Demarcation
1. The datasets useful in undertaking PRAs are described in PRATIQUE deliverables D1.2, D1.3 and D1.4 and are accessible through the data explorer provided within the computerized scheme (Capra) outlined in PRATIQUE deliverable 6.4.
2. This deliverable focuses on the tools and data which link directly or indirectly to the impact assessment module.
3. The generic integrated framework is restricted to describing the conceptual links between the questions in the EPPO DSS for PRA, the data sets, and the quantitative modules. The actual links are provided in PRATIQUE deliverable 6.4.

Methods for presenting the generic integrated framework
Several methods can be used to present the generic integrated framework. These methods are used in systems where qualitative reasoning is followed based on expertise. The following methods were considered for elaboration and are discussed briefly in the next paragraph:

a. Frames. This method makes use of a hierarchy and is object-oriented.
b. Logic. This method is goal driven and based on relationships. Prolog is often used as the programming environment.
c. Decision tree. A simple tree-like structure with branches from decision points..
d. Rules. Use of IF-THEN-ELSE rules to prove a conclusion or to come to a judgement based on a series of decisions based on the data.

e. Flow chart. This method is often applied in computer science and highlights the states and state transitions. The whole process can be followed using such a chart.
f. Case-based reasoning. This method is based on similarities and requires data from many case studies.

2.2 Approaches for guiding systems

Frames
A few decades ago, frame-based systems were widely used to represent systems with a large knowledge base. According to Abraham (2005), “A frame […] relates an object or item to various facts or values. A frame-based representation is ideally suited for object-oriented programming techniques.” The method is rather complex to implement and the results are difficult to interpret.

Logic
Guidance is based on the mathematical rules of formal logic (e.g. De Morgan laws). The drawback is that it is hard to implement and the results are difficult to interpret. It has limited applications since it is difficult to present a graphical overview of the different components.

Decision tree
A decision tree (or tree diagram) is a decision support tool that uses a tree-like graph or model for decisions and their possible consequences and is commonly used in decision analysis and for calculating conditional probabilities). As a guide it is appealing since the decision process is very clear from the tree. A simple decision tree may be replaced by one or a limited number of decision tables (e.g. risk matrix).
The drawback is the difficulty in in making every possible pathway explicit without structuring or combining comparable sub-pathways. A tree can easily “explode” and become less understandable and cumbersome to work with. Although a simple tree is understandable and easy to implement, it is recommended that the decision tree approach is not used because of the limitations when they are implemented in knowledge-rich structures.

Rules
The use of IF-THEN-ELSE rules is very familiar to the way we reason. A decision tree can be transformed to a set of rules. It is possible to make an enriched decision tree, since rules can use links between branches of a tree, or be used to “update” a condition from another rule. Rules are often used in knowledge-based systems; the constraints occur in the IF-part. Rules may be not so strict (or be ambiguous), e.g. when two rules have equal conditions (IF-part) but different conclusions (THEN-part). With many rules an overview is lost. In such a situation the use of rules is less comprehensive.

Flowchart
According to ISO/IEC (2009), a flowchart is a control flow diagram in which suitably annotated geometrical figures are used to represent operations, data, or equipment and arrows are used to indicate the sequential flow from one to

another. They are commonly used in software engineering for describing programs, but are also common when managing processes. Compared to other methods, flowcharts are often used as guidance. They are intuitive and easy to use for the acquisition and representation of knowledge, for communication and clarification and as a guide they are appealing and useful. For example, Hennen (2003) applies flowcharts as a representation format for mapping the reasoning strategies of legal experts. A drawback is that a flowchart may become complex and less comprehensive with a large number of concepts and decisions, but other methods have comparable drawbacks in such situations.

Case-based reasoning

Since this method can only be applied when many comparable case studies are available, this method is not relevant in this situation.

Conclusion

It is proposed to use the method of flow chart for the development of the guidance because of the advantages of this method mentioned above. In chapter 3, the flow charts reflecting the generic integrated framework are presented.

3 The generic integrated framework

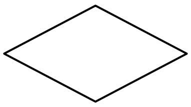
3.1 The framework

Figure 3.1 shows the flow chart for the generic integrated framework. The flow chart contains the following elements:

1. It follows the structure (questions) of the impact section of the EPPO DSS for PRA, which are clustered in the scheme and indicated with this shape (document):

   Questions 6.01 to 6.07 relate to the economic impacts, 6.08 and 6.09 the environmental impacts, 6.10 and 6.11 the social impacts. Questions 6.12 to 6.14 are optional if the highest scores on economic, social and environmental impacts are at most ‘moderate’. In Question 6.15 the impact is summarised and the endangered area is described.
2. The risk assessor has to follow the arrows and has to take decisions, which are indicated by the following shape:

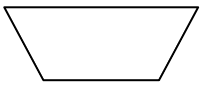
   Three types of decisions have to be taken:
   - whether economic, environmental and social impacts are expected
   - whether the risk assessor wants to apply the module for impact assessment or not and
   - whether necessary conditions are fulfilled to apply the modules
3. When positive decisions have been made, the risk assessor follows the green, continuous arrows, when negative decisions have been made, the risk assessors follows the red, interrupted arrows. The blue continuous arrows are information flows resulting from actions.
4. The modules are indicated with the following shapes:

5. Data input is represented with the following shape:

6. Finally, manual operations are indicated by the following shape:

To prevent the flow chart from becoming too complex, the application of the modules for mapping the endangered area and spread are summarized in a rectangular shape.

In any such process, it is important to establish a consistent glossary of terms. However, in plant health, this is not required because internationally accepted definitions are already given in the international standard for phytosanitary measures (ISPM) number 5 (FAO, 2010).

3.2 Mapping Endangered area

In figure 3.2, the process for mapping the endangered area is presented according to the description in D3.3 (Protocol for mapping endangered areas taking climate, climate change, biotic and abiotic factors, land use and economic impacts into account accessed via a hyperlink in a project web page and integrated into the web-based EPPO PRA scheme). The map of endangered areas is based on the area of potential establishment (where suitable climate, other abiotic factors and host/habitats are present), the areas at highest risk area from economic, environmental and social impacts and predictions of where pest densities are likely to exceed the economic injury level.

3.3 Relationship between the generic integrated framework and flow chart of mapping endangered area

Figure 3.1 shows that both the protocol for mapping the endangered area and the spread module provide input to the impact assessment module. The protocol for mapping the endangered area can be used to determine the area of potential establishment (questions 3.01 – 3.21) that demarcates the area for impact assessment and highlights the areas at highest risk. The spread module can be applied to investigate which part of the area of potential establishment has been infested over time (questions 4.01 - 4.05). The results feed into the impact assessment modules. In this process the emphasis is on the accuracy of the impact assessment. When the quantitative economic impact assessment module is applied, the emphasis is not only on direct impacts but also on indirect impacts. Indirect impact assessments take into account the distribution of impacts between the producers affected and other stakeholder groups such as consumers and other producers. Indirect impacts cannot be made explicit, because market processes and not the pest determine who will be affected.

In figure 3.2 the protocol for mapping the endangered area is represented graphically. The objective of this protocol is to present spatially explicit information on the pest and the distribution of impacts. Since it is rarely possible to model pest densities and relate these directly to an economic injury level, the emphasis is placed on mapping the areas at highest risk rather than attempting to map the actual area where economic impacts (yield/quality loss, additional production costs and indirect impacts) are likely to occur (the endangered area).

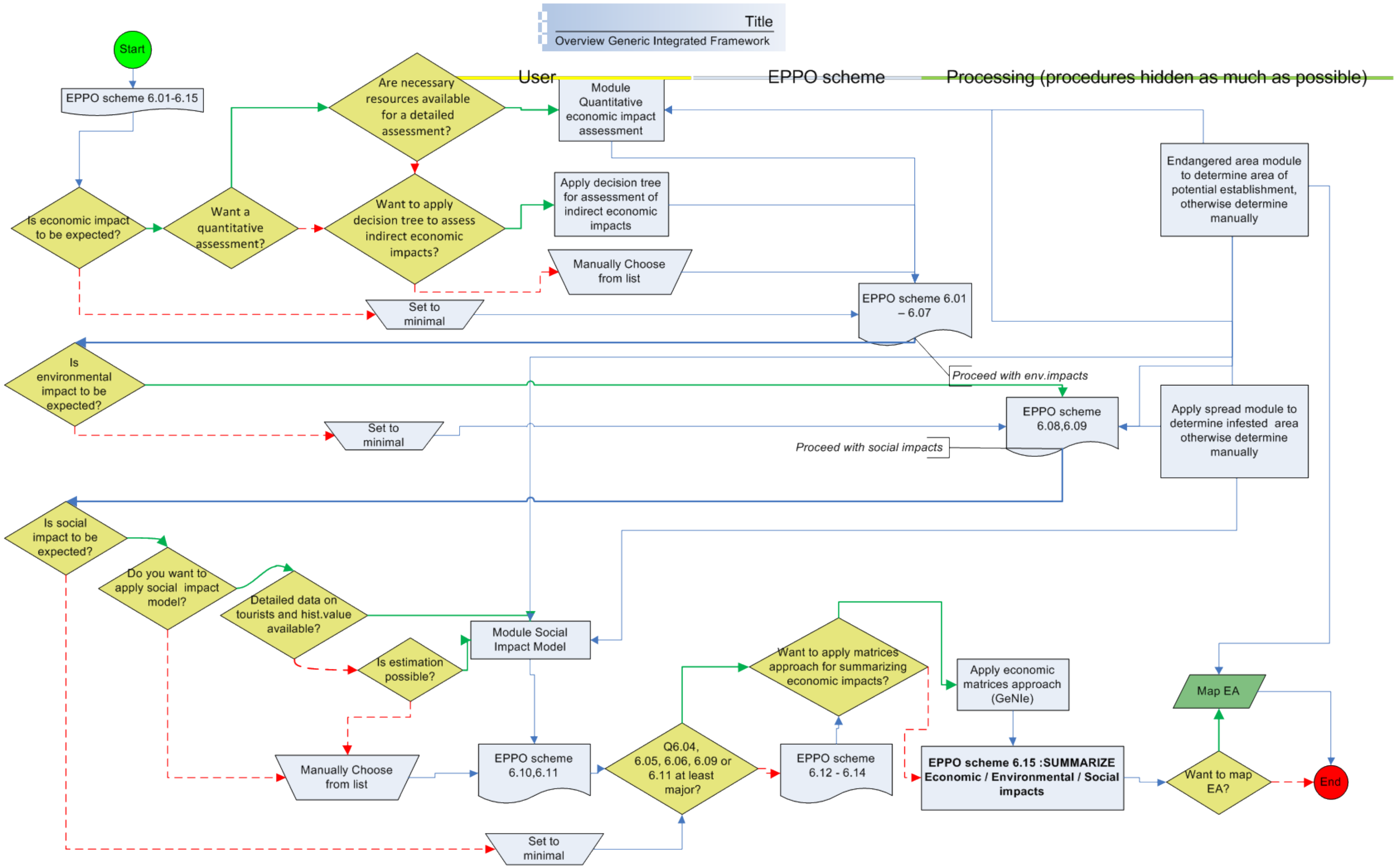


Figure 3.1 The generic integrated framework

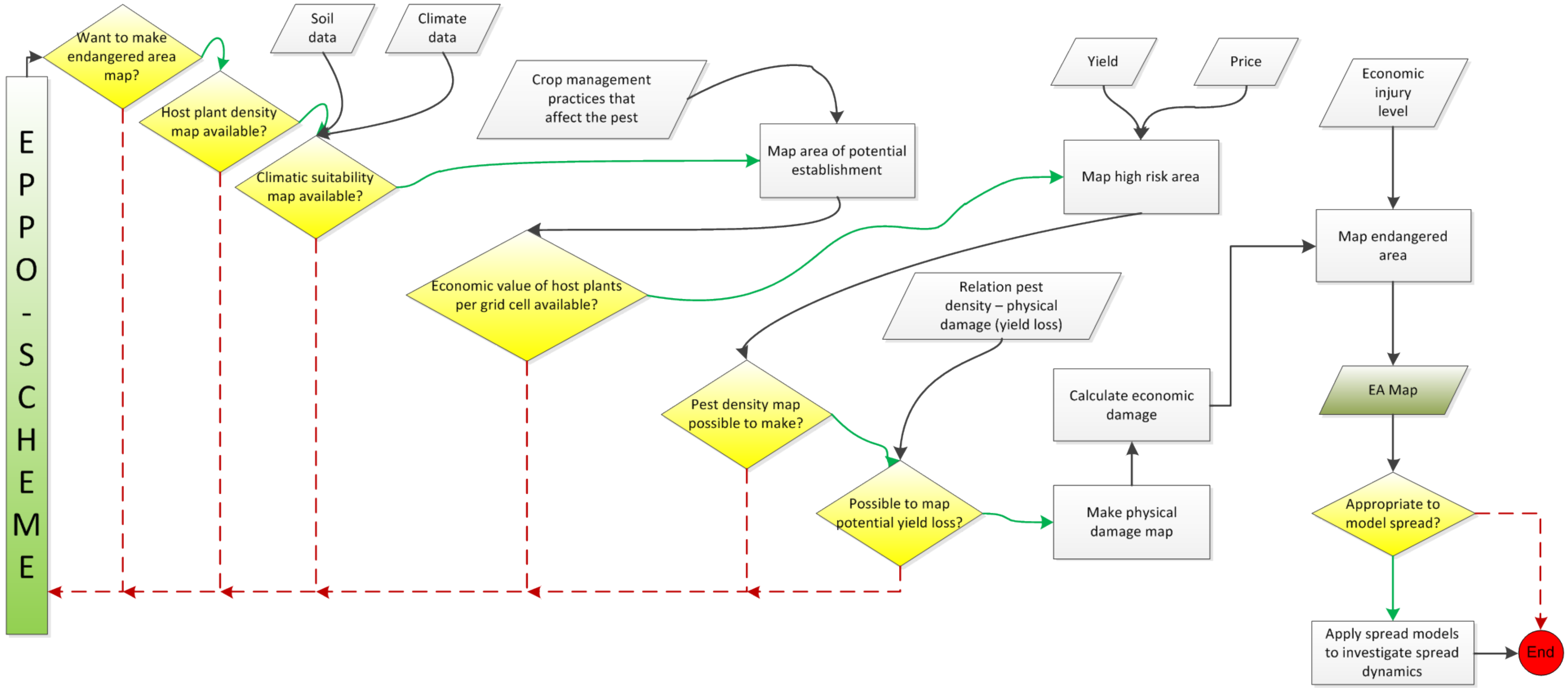


Figure 3.2 Flow chart for mapping the endangered area.

4 Discussion

The flow charts as presented in this generic integrated framework provide only a broad overview of the relationships between the modules that can be used to quantify and/or map risk as it is more appropriate to provide the detail within the deliverables that describe the modules themselves. The main objective of those flow charts is to present relationships between the modules which are not directly digitally linked to each other. Including all details would make the flow charts too complex.
Other deliverables, such as D2.5 (the economic impact assessment module) and D3.3 (the DSS for mapping endangered areas) include elements such as scaling up impacts from farm to field to industry and how to assess indirect impacts. Scaling up impacts implies that specially explicit information about the damage is combined with the spatially explicit information about the production per ha and the production size. Scaling up from field to industry implies not only the assessment of the total direct impacts on the affected producers in the endangered area, but also the inclusion of the impacts on stakeholders in the production and trade chain.

The flow charts can also serve as a blueprint for further integration in future. However, care should be taken to ensure that the system does not lose flexibility. The risk assessor is currently able to choose which modules can be applied to support the PRA process, depending on the objectives to be met and the data available. Therefore it is not recommended to fully integrate all modules digitally.

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