An expert model approach to assess the potential of non-wood forest products for forest owners

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Dissertation to obtain the Master Degree (MsC) in

Forestry and Natural Resources

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2016

“The best way to predict your future is to create it.”

Abraham Lincoln

ACKNOWLEDGEMENTS

I want to thank all of the people that helped and supported me or had an input in the development of this thesis. First I would like to express my sincerest gratitude to my supervisors:

Professor José Guilherme Borges, of the Instituto Superior de Agronomia, for inviting me to return to an academic career; for providing me with all the necessary facilities for the research; for the guidance, valuable advice, continuous support and encouragement in new challenges; and for helping me to complete this thesis.

Researcher Patrick Huber, of European Forest Institute Central-East European Regional Office, by promptly accepting the invitation to be my supervisor; for conducting and providing me the framework for this thesis; for the successful execution of the project; for his ready availability in clarifying doubts, and in providing advice and support during the work.

I am grateful for Professor Margarida Tomé, of the Instituto Superior de Agronomia, for sharing expertise and practical advice, and for the continuous encouragement and motivational spirit.

I would also like to thank to Luis Fontes, of the Instituto Superior de Agronomia, for his support and availability to answer questions; and for helping with questionnaires.

Thank you to Professor Harald Vacik, of University of Natural Resources and Life Sciences Vienna, for the explanations about AHP software and his support during the work.

A special thanks to Susete Marques, Brigite Botequim and Marco Marto, of the Instituto Superior de Agronomia, who embraced me from the beginning and have always been willing to provide me with their support and for sharing their knowledge.

Thank you to all my colleagues from ForChange, of the Instituto Superior de Agronomia, for their willingness and support.

My sincere thanks to all persons who contributed to this study in the frame of stakeholder participation and for their expert knowledge.

My heartfelt gratitude to my great friends Paula Amaral and Carla Miragaia who helped me stay positive through these last difficult years. Their support and care helped me overcome setbacks and stay focused on the good things of life. I greatly value their friendship.

I express my thankfulness to all my friends who contributed to a great learning process in my life and for their encouragement in some difficult moments, namely João Moreira, Tiago Pereira da Silva, José Sousa Uva, Carla Leite and Sybelle Barreira.

To Carla Patrícia Santos, who left this world too early, my gratitude for her friendship, support and ready availability to help.

A very special thanks to my family for their love and constant support.

Finally, I deeply thank Pedro for being by my side, for his endless patience and incredible support throughout this journey. He has been a constant source of unconditional strength during the tough moments all these years. I want to thank him for believing in me and encouraging me in new challenges.

The research for this dissertation has been financially supported by FP7 Project no. 311919 KBBE.2012.1.2-06 StarTree – Multipurpose trees and non-wood forest products a challenge and opportunity, and COST – Action FP1203: European non-wood forest products (NWFPs) network.

Thank you.

ABSTRACT

The interest in sustainable development and environmental management from non-wood forest products (NWFPs) has been growing during the past decade. These products are important in the bio-economy especially in regions where wood is not the most profitable product. As NWFPs cover a wide range of species they provide an array of alternatives to use more green products and are a relevant component of sustainable forest management.

We present an approach to characterize the potential of most promising NWFPs in the Alentejo region. We used the Analytic Hierarchy Process (AHP), one of many multi-criteria decision making methods, and a Delphi approach to support judgments collected from stakeholders and domain experts. In order to facilitate and manage the pairwise comparisons in the application of the AHP we selected seven regional NWFPs: boletus (*Boletus edulis*), cork (*Quercus suber*), pine nuts (*Pinus pinea*), pine resin (*Pinus* spp), yellow lavender (*Lavandula viridis*), honey from bees (*Apis mellifera*), and rabbit as game meat (*Oryctolagus cuniculus*). AHP incorporated the judgments (weights) from experts along a hierarchical decomposition of the problem into a set of criteria and sub-criteria, and generated a regionally explicit ranking of alternatives (NWFPs) by deriving priorities.

The three NWFPs with the highest potential were cork, pine nuts and yellow lavender. In a second level of importance were boletus, pine resin, honey and rabbit. These results further reinforce that cork is the product with the greatest potential in Alentejo region. However, yellow lavender has a significant potential and could be an interesting opportunity for forest owners that aim diversifying the basket of products supplied. The sensitivity analysis indicated that the model is robust because the ranking of NWFPs did not change much with the weights of criteria. This model also provides forest owners with information to develop management strategies or to engage in related NWFPs businesses.

Keywords: Analytical Hierarchy Process (AHP), Delphi, non-wood forest products (NWFPs), multi-criteria decision making (MCDM), Alentejo

RESUMO

O interesse pelo desenvolvimento sustentável e pela gestão multifuncional da floresta através de produtos florestais não lenhosos (PFNLs), também designados por produtos florestais silvestres, tem vindo a aumentar ao longo da última década. Isto deve-se ao aumento do reconhecimento dos PFNLs na contribuição para os objetivos ambientais, incluindo a conservação da diversidade biológica e uma alternativa no consumo de produtos ecológicos. Os PFNLs são importantes para a bioeconomia, especialmente nas regiões em que a madeira não é o produto mais rentável.

Estes produtos abrangem uma ampla diversidade de espécies (plantas, fungos, fauna), com peso significativo no comércio internacional. De acordo com o último relatório sobre o estado das florestas da Europa (FOREST EUROPE, 2015) o valor total de PFNLs na floresta europeia - dados considerados incompletos - foi estimado em 2.277 milhões de euros, dos quais 73% foram gerados por produtos de origem vegetal e 27% por produtos de origem animal.

Neste âmbito, apresentamos e aplicamos uma abordagem, desenvolvida por Huber et al. (2015), que permite disponibilizar, em particular aos proprietários florestais de pequena escala, uma ferramenta relativa aos PFNLs mais promissores na região do Alentejo. A metodologia proposta combina técnicas de decisão multicritério (MCDM), através do método de análise hierárquica (AHP - Analytic Hierarchy Process), com o método Delphi, no apoio de decisões de gestão integradas de grupo, relativas a peritos regionais na temática dos PFNLs.

O método AHP converte os julgamentos dos peritos em valores numéricos que podem ser processados e comparados sobre toda a extensão do problema, juntamente com a decomposição hierárquica do problema num conjunto de níveis de critérios e de subcritérios. Um peso numérico, ou prioridade, é derivado para cada elemento da hierarquia, permitindo que elementos distintos e frequentemente incomensuráveis sejam comparados entre si de maneira racional e consistente. Na etapa final, as prioridades numéricas são derivadas para cada uma das alternativas de decisão, gerando um ranking regional. A metodologia consiste em cinco fases principais.

Na primeira fase foram selecionados sete PFNLs regionais, representativos do Alentejo, tendo-se considerado como fatores de seleção: o comércio, a contribuição para a socioeconomia da população local (principalmente rural) e ainda o interesse inovador para o mercado nacional e internacional.

Os produtos selecionados foram: cogumelos boletos (*Boletus edulis*), cortiça (*Quercus suber*), pinhão (*Pinus pinea*), resina de pinheiro (*Pinus* spp), lavanda amarela (*Lavandula viridis*), mel de abelha (*Apis mellifera*) e coelho-bravo (*Oryctolagus cuniculus*). Esta seleção teve como objetivo facilitar a aplicação do modelo e o processo de comparações de pares, o qual se torna de difícil processamento comparativo para os peritos quando consideradas mais do que oito alternativas.

Na segunda fase, o problema de decisão foi organizado numa estrutura hierárquica. O objetivo era "identificar os PFNLs mais promissores na região do Alentejo". Para espelhar diferentes ambientes ecológicos e socioeconómicos foram definidos cenários de ponderação regional explícitos de acordo com quatro critérios (específicos para a região): "Potencial de mercado", "Potencial Institucional", "Requisitos" e "Recurso potencial" e ainda os respetivos subcritérios (15 no total), específicos para o proprietário florestal. O principal objetivo é destacar a relevância de cada critério na região do Alentejo e descrever a sua importância atual para a produção sustentável de PFNLs. Os pesos atribuídos afetam os resultados finais na medida em que colocam especial ênfase em critérios individuais e respetivos subcritérios, ou seja, a influência na classificação dos PFNLs é expressa de acordo com a ponderação relativa dos critérios.

A terceira fase diz respeito à seleção dos peritos regionais, que estão ativamente envolvidos na gestão regional de PFNLs e/ou são especialistas, a fim de obter classificações de preferência para os critérios e subcritérios da AHP (ou seja, chegar a um acordo consensual sobre a importância relativa dos mesmos). Neste estudo, decidimos escolher como peritos regionais os 12 membros portugueses do Grupo Regional das partes interessadas do projeto StarTree. A fim de obter um ranking cardinal das alternativas (ou seja, os PFNLs selecionados) por comparações de pares, foi necessário nomear peritos especializados, pelo que decidimos escolher dois professores e dois investigadores do Centro de Estudos Florestais, do Instituto Superior de Agronomia.

Na quarta fase aplicou-se o método Delphi para apurar as opiniões dos peritos regionais, através da realização de questionários em duas rondas. Este método é uma das poucas metodologias que permite analisar dados qualitativos, sendo sobretudo utilizado para facilitar a formação de uma opinião de grupo, identificando padrões de acordo. As preferências/pesos (importância relativa) referentes aos critérios e subcritérios foram atribuídos diretamente pelos peritos regionais, atribuindo 10 pontos no total para os quatro critérios e até 10 pontos no máximo para um único subcritério. A escala espacial para a avaliação foi normalmente regional para nacional, apenas para alguns subcritérios foi considerado o nível europeu.

Os resultados dos questionários da primeira ronda, relativos aos onze peritos que responderam, foram agregados num único ficheiro e realizada a devida análise estatística. O ficheiro agregado foi posteriormente enviado a todos os peritos regionais para uma segunda ronda de julgamento, juntamente com o questionário que responderam na primeira ronda. No quadro da segunda avaliação o perito regional foi livre para reconsiderar as suas avaliações e adotá-las para a síntese final, que irá então contribuir para o cenário de ponderação para a região do Alentejo. Como resultado pretendeu-se derivar um acordo consensual da importância relativa dos critérios e subcritérios analisados.

A quinta fase refere-se à adequação dos diferentes PFNLs através da aplicação do método de comparações de pares, a fim de obter um ranking cardinal de alternativas (ou seja, todos os PFNLs regionalmente relevantes). Com recurso ao software *Expert Choice*, os peritos especializados avaliaram a preferência relativa de uma alternativa (determinado PFNL) sobre a outra através da comparações de pares, relativamente a cada subcritério. Na classificação de cada PFNL o perito teve de indicar um número relativo à ordem de preferência na comparação de pares: 1 = primeiro, 2 = segundo, 3 = terceiro, ..., n = menos preferível. A escala espacial para a avaliação foi normalmente regional para nacional (a fim de avaliar o potencial regional dos PFNLs selecionados); apenas para alguns subcritérios foi considerado o nível europeu.

As comparações realizadas por este método são subjetivas. O método AHP tolera inconsistência através da quantidade de redundância na abordagem. Na sua análise o AHP fornece uma medida da inconsistência em cada conjunto de julgamentos. Este valor é calculado por um índice de consistência (CI) e um rácio de consistência (CR). Se o CR for superior a 0.10, os julgamentos não são confiáveis porque são demasiado próximos para o conforto de aleatoriedade, e o exercício não tem valor ou deve ser repetido, através da revisão dos julgamentos subjetivos. Na comparação de pares dos PFNLs selecionados, para cada subcritério, o CR foi sempre inferior a 0.10.

De acordo com os resultados finais os três PFNLs com maior potencial no Alentejo são a cortiça, o pinhão e a lavanda amarela. Num segundo nível de importância encontram-se os boletos, a resina de pinheiro, o mel e o coelho-bravo. Estes resultados reforçam ainda mais o facto de a cortiça ser o produto com maior potencial no Alentejo. No entanto, a lavanda amarela apresenta um potencial significativo e poderá ser uma das principais prioridades para os proprietários florestais numa perspetiva de diversificação do portfolio de produtos explorados. A lavanda amarela apresenta um peso aproximado ao do pinhão, um produto explorado em grande escala na região.

O coelho-bravo é o PFNL com menor peso no ranking, provavelmente porque a sua caça é limitada a zonas concessionadas e, em alguns casos, não apresenta um retorno financeiro direto para os proprietários florestais, o que levará a desinteresse económico.

A análise sensitiva indica que a classificação final dos PFNLs pode mudar se os critérios tiverem pesos diferentes. O modelo demonstrou ser robusto porque, em geral, o ranking dos PFNLs não se alterou significativamente com os pesos dos critérios atribuídos pelos peritos regionais. A lavanda amarela e os boletos foram os PFNLs mais afetados pelos critérios ponderados.

Os resultados demonstraram o potencial do modelo AHP como uma ferramenta para fornecer aos proprietários florestais informação para desenvolverem (também) estratégias de gestão ou para a realização de atividades relacionadas com PFNLs, nomeadamente: a) diversificação do seu portfolio de produtos numa perspetiva económica sustentável; b) distribuição dos riscos socioeconómicos; c) contribuição para a conservação da biodiversidade; d) estratégia alternativa como nicho de mercado; e) promoção dos PFNLs numa sinergia complementar com os outros produtos e/ou serviços (turismo, recreio), ou seja, outros operadores económicos.

Na sequência do desenvolvimento desta metodologia será relevante a sua aplicação e extensão a outras regiões de Portugal, para diferentes PFNLs, na perspetiva de apoio à definição dos produtos a considerar no âmbito das suas atividades por parte de proprietários florestais, populações rurais, associações de produtores florestais, investigadores, e contribuir para a evolução e diversificação da bioeconomia. Para além disso contribui para definir, de forma fundamentada, os objetivos a considerar no âmbito do planeamento da gestão da floresta e dos recursos naturais.

Palavras-chave: método de análise hierárquica (AHP), Delphi, produtos florestais não lenhosos (NWFPs/ PFNLs), decisão multicritério (MCDM), Alentejo

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LIST OF ABBREVIATIONS

AHP - Analytic Hierarchy Process

CI - Consistency Index

CR - Consistency Ratio

FAO - Food and Agriculture Organization of the United Nations

GDP - Gross Domestic Product

GVA - Gross Value Added

MCDM - Multi-Criteria Decision Making

NUTS - Nomenclature of Territorial Units for Statistics

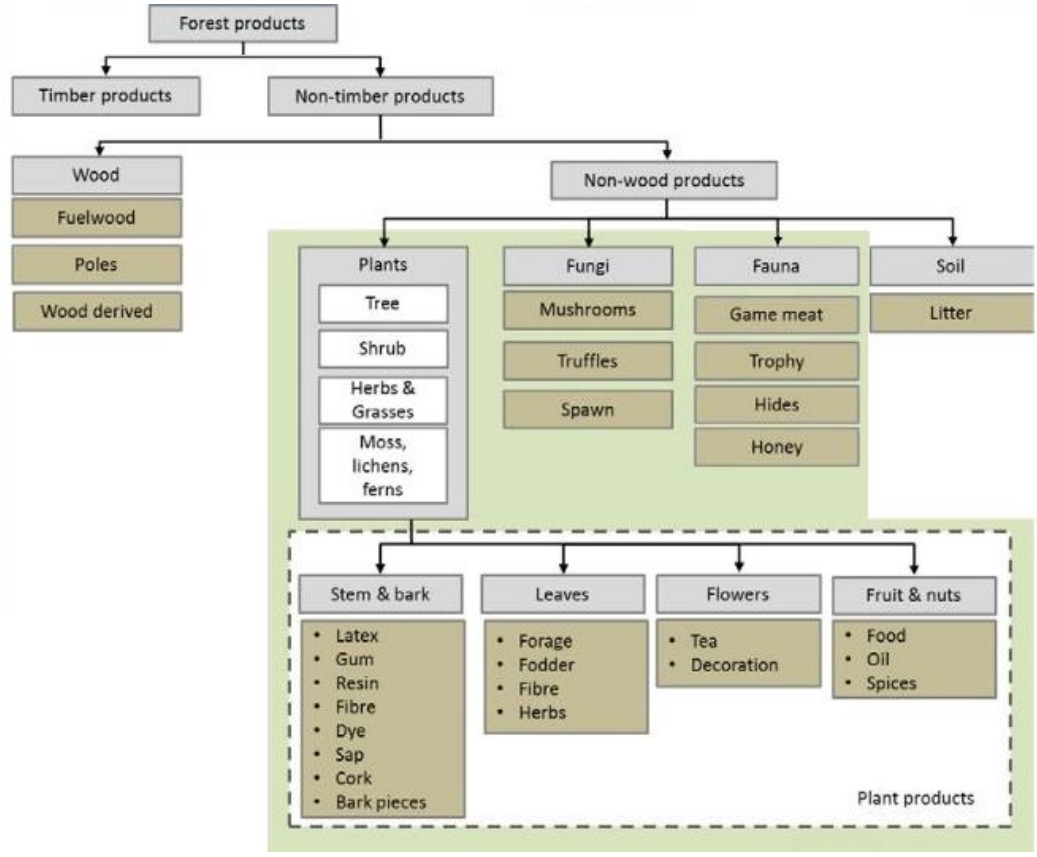
NWFPs - Non-Wood Forest Products

RI - Random Index

1. INTRODUCTION

1.1. WORK SCOPE

The interest in non-wood forest products (NWFPs), i.e. products of biological origin other than wood derived from forests, other wooded land and trees outside forests (FAO, 1999), has increased in recent years. They have thus become an important topic of research. Moreover, they are also a very important element for sustainable forest management and to environmental objectives, including the conservation of biological diversity. NWFPs are considered as important means to the sustainability of the bio-economy and for business diversification, especially in regions where wood-based products are not the most profitable product. NWFPs may be gathered from the wild, or produced in forest plantations, agro-forestry schemes and from trees outside forests. At present, at least 150 NWFPs (plant and animal species) are significant in terms of international trade, including honey, cork, nuts, mushrooms, resins, essential oils, and plant and animal parts for pharmaceutical products (FAO, 2016). In this study we target the NWFPs of *plants*, *fungi* and *fauna* origin as described in the FAO forest product classification (Figure 1).



Source: FAO (1999) in Wong & Prokofieva (2014), modified

Figure 1. Products of the forests

The latest report on the state of Europe's forests (FOREST EUROPE, 2015) reported that the total value of NWFPs in the Forest Europe region – considerably incompletely reported – was estimated at EUR 2.277 million, of which 73% was accounted by marketed plant products and 27% by marketed animal products. This value represents about 12% of the value of roundwood, which is significant considering the deficiencies in data collection.

Thus, there seems to be a high latent potential to strengthen the economic viability of rural economies via advancing the NWFP-focused forest management and related business (Huber et al., 2015). However, unlocking the full potential of NWFPs requires new knowledge and tools to optimise the sustainable provision and profitability of NWFPs, for a better understanding of the potential of markets for NWFP and of the role of innovation processes for new products and services (Wong & Prokofieva, 2014).

In this respect, there is a need to design a decision support application for the demands of extension service providers (e.g. forest owners' associations, forestry consultants, researchers) in order to give advice to forest owners on which products to focus upon. Forest owners are considered as specifically relevant for the sustainable management of NWFPs, thus they represent the main target audience (Huber et al., 2015).

In this context, the expert model approach, which was developed by Huber et al. (2015) and applied in this dissertation, aims to provide a tool to support forest owners with regard to the co-production of wood and non-wood forest products in order to:

i. Diversify their product portfolio.

ii. Distribute related socio-economic risks.

iii. Contribute to biodiversity conservation.

iv. Attract other forest owners to engage in new NWFPs businesses and foster the sustainable management of forest resources.

The study area to assess the regional, relevant NWFPs was Alentejo, located in southern Portugal. In the model we used the Analytic Hierarchy Process (AHP), one of many multi-criteria decision making methods, and a Delphi approach to support judgments collected from stakeholders (regional experts) and domain experts. The Delphi panel was composed of Portuguese stakeholders from the StarTree project. The Delphi method was used to gather expert judgments of the AHP hierarchy. This method is one of the few methods that can analyse qualitative data and is primarily used to facilitate the consensual formation of group opinions, identifying patterns accordingly.

AHP, developed by Saaty (1980), is a mathematical method for analysing complex decisions with multiple criteria. Human judgments, and not just numeric information, can be used in decision-making. AHP uses mathematical algorithms to transform qualitative subjective judgments into quantitative data (weights). The AHP is one of the sets of methodologies for assessing and allocating weights and priorities. That particular characteristic makes it an interesting alternative to quantitative techniques (Hartwich, 1999), particularly in the field of forestry research where there are complex decision structures related to multiple criteria.

When applying AHP, a hierarchical decision schema is constructed by decomposing the decision problem into its decision elements. The importance or preferences of the decision elements are compared in a pairwise manner with regard to the element preceding them in the hierarchy (Kurttila et al., 2000). AHP is a decision analysis technique that uses judgments from a group of relevant decision makers/experts along with hierarchical decomposition of a problem to derive a set of ratio-scaled measures for decision alternatives (Hartwich, 1999).

The work of this dissertation is a part of a modelling framework designed and developed by Huber et al. (2015) and applied at six study areas in five European countries (Austria, Finland, Portugal, Romania and Spain). This study was developed under the project StarTree "FP7 Project no. 311919 KBBE.2012.1.2-06 StarTree – Multipurpose trees and non-wood forest products a challenge and opportunity".

1.2. OBJECTIVES

The main goal of this dissertation is to apply a methodology based on the AHP and the Delphi approach that will provide a ranking of seven NWFPs in Alentejo and thus, to get an estimation of their potential for forest owners. In order to give consistency to the analysis and structuring of the decision components, we will:

1. Structure the decision problem for analysis in the following AHP hierarchy: goal – criteria – sub-criteria – alternatives.

2. Use the Delphi approach to incorporate the regional experts' (stakeholders) judgments for criteria and sub-criteria.

3. Apply the AHP pairwise comparisons for alternatives (NWFPs selected) to reflect the expertise of domain specialists.

The more detailed research questions of this dissertation are:

- What are the most promising NWFPs in Alentejo?
- What are the most important criteria to define the potential of NWFPs according to the experts?
- Is the NWFPs ranking influenced by the weights of criteria?

1.3. STRUCTURE

The dissertation consists of five chapters. A brief description of each chapter is given in this section:

1**. Introduction**: introduces a general description of the research background, research aim and objectives.

2**. Study context and key concepts**: presents a literature review of the AHP and the Delphi method. The chapter explores the concepts and definitions, the benefits and the implementation phases of each method.

3**. Data and Methods:** presents the study area and the NWFPs selected, its characterisation, the structure of the problem, data collection and procedures for implementation of AHP and Delphi.

4**. Results**: presents the data collected and the research results.

5**. Discussion and Conclusions**: summarises the thesis and presents the main findings of the research. The chapter also highlights contributions to knowledge and recommends particular areas for future research.

2. STUDY CONTEXT AND KEY CONCEPTS

2.1. THE ANALYTIC HIERARCHY PROCESS A MULTI-CRITERIA DECISION-MAKING APPROACH

We are all fundamentally decision makers. Everything we do consciously or unconsciously is the result of some decision-making process. The information we gather is to help us understand occurrences, in order to develop good judgments to make decisions about these occurrences. Not all information is useful for improving our understanding and judgments (Saaty, 2008a).

A decision is a choice from at least two distinct alternatives. Decision making, on the other hand, can be defined to include the whole process from problem structuring to choosing the best alternative (Kangas et al., 2008). Decision making, for which we gather most of our information, has become a mathematical science (Figuera et al., 2005).

To make a decision we need to know the problem, the need and purpose of the decision, the criteria of the decision, the sub-criteria, stakeholders and other groups affected, and the alternative actions to take. We then try to determine the best alternative, or in the case of resource allocation, we need priorities for the alternatives to allocate their appropriate share of the resources (Saaty, 2008a).

Multi-criteria decision-making (MCDM) refers to making decisions in the presence of multiple criteria and plays a critical role in many real life problems. It is not an exaggeration to argue that almost any local government, industry, or business activity involves, in one way or the other, the evaluation of a set of alternatives in terms of a set of decision criteria. Very often these criteria are in conflict with each other. Even more often, the pertinent data are very expensive to collect (Triantaphyllou & Mann, 1995).

There are many methods available for solving MCDM problems. One of the most used methods for making multi-criteria decisions is the Analytic Hierarchy Process or AHP. It was developed to optimise decision making when one is faced with a mix of qualitative, quantitative, and often conflicting factors and criteria (Alexander, 2012). With the use of the AHP, objective information, expert knowledge and subjective preferences can be considered jointly and simultaneously. It can also take into consideration qualitative criteria, while other methods usually require quantitative values for the selection of the alternatives (Sporcic, 2012). AHP supports collaborative decision making and has been very effective in making complicated, often irreversible, decisions.

The drawback of AHP is related to the number of alternatives to consider. With increasing numbers of objectives and alternatives to evaluate, the additional cognitive burden will contribute to increase the risk for inconsistent judgments (Kangas and Kangas, 2005; Korosuo et al., 2011; Nordström et al., 2010). This may constrain its application to complex forest ecosystem management planning problems that usually have a continuous character and where the number of possible alternatives is consequently very large (Borges et al. in review). Nevertheless, this dissertation addresses a problem – identification of most promising NWFPs in Alentejo – that is associated with a limited number of alternatives (NWFPs). AHP is thus very well suited to address it.

The AHP, originally developed by Saaty (1980), represents an approach that depends on the values and judgments of individuals and is widely used in decision making, operations research, quality engineering, planning and resource allocation, and conflict resolution (Saaty, 2001), as well as in natural resource management. According to Kangas et al. (2008) there are many researchers who have used AHP in forestry applications, e.g. Mendoza et al. (1987); Murray & von Gadow (1991), among others. And the number of applications is continuously increasing, e.g. Rauscher et al. (2000); Vacik & Lexer (2001); Huber et al. (2015). In natural resource management, the AHP has been most frequently applied to planning at the strategic level (Kangas, 1999). AHP has also gained interest among forestry practitioners (Kangas et al., 2008).

In the AHP technique, **analytic** indicates that the problem is broken down into its constitutive elements; **hierarchy** indicates that a hierarchy of the constitutive elements is listed in relation to the main goal; **process** indicates that data and judgments are processed to reach the final result. The basic principle is to decompose the decision problem into a hierarchy of more easily understandable sub-problems (Ávila et al., 2015).

AHP allows decision makers to model a complex problem in a multi-level hierarchical structure showing the relationships of the goal, criteria, sub-criteria, and alternatives (Forman & Selly, 2001). The decision makers can incorporate both objective and subjective, qualitative and quantitative considerations in the decision process. Uncertainties and other influencing factors can also be included. Saaty (1990) explains that this structure serves two purposes: a) it provides an overall view of the complex relationships inherent in the situation; and b) it helps the decision maker to assess whether the issues in each level are of the same order of magnitude, in order to compare such homogeneous elements accurately.

The pertinent data are derived by using a set of pairwise comparisons between each pair of items expressed as a matrix. These comparisons are used to obtain the weight of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion (Triantaphyllou & Mann, 1995). By reducing complex decisions to a series of pairwise comparisons, and then synthesising the results, the AHP helps to capture both subjective and objective aspects of a decision. In addition, the AHP incorporates a useful technique for checking the consistency of the decision maker's evaluations, thus reducing any bias in the decision making process (Mocenni, 2016). The final results provide a cardinal ranking of alternatives, including their relative priorities (Huber et al., 2015).

2.1.1. Phases of AHP

To make a decision in an organised way to generate priorities using the AHP to address decision problems, we need to decompose the decision into the following phases (Bhushan & Rai, 2004; Saaty, 2008a; Kangas et al., 2008; Alexander, 2012):

Phase 1. Define the problem and **state the goal or objective**; determine the kind of knowledge sought.

Phase 2. Decompose the original decision problem into a hierarchy of interrelated decision elements by **structuring the decision hierarchy** (Figure 2) from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of alternatives). This is the most creative and important part of decision making.

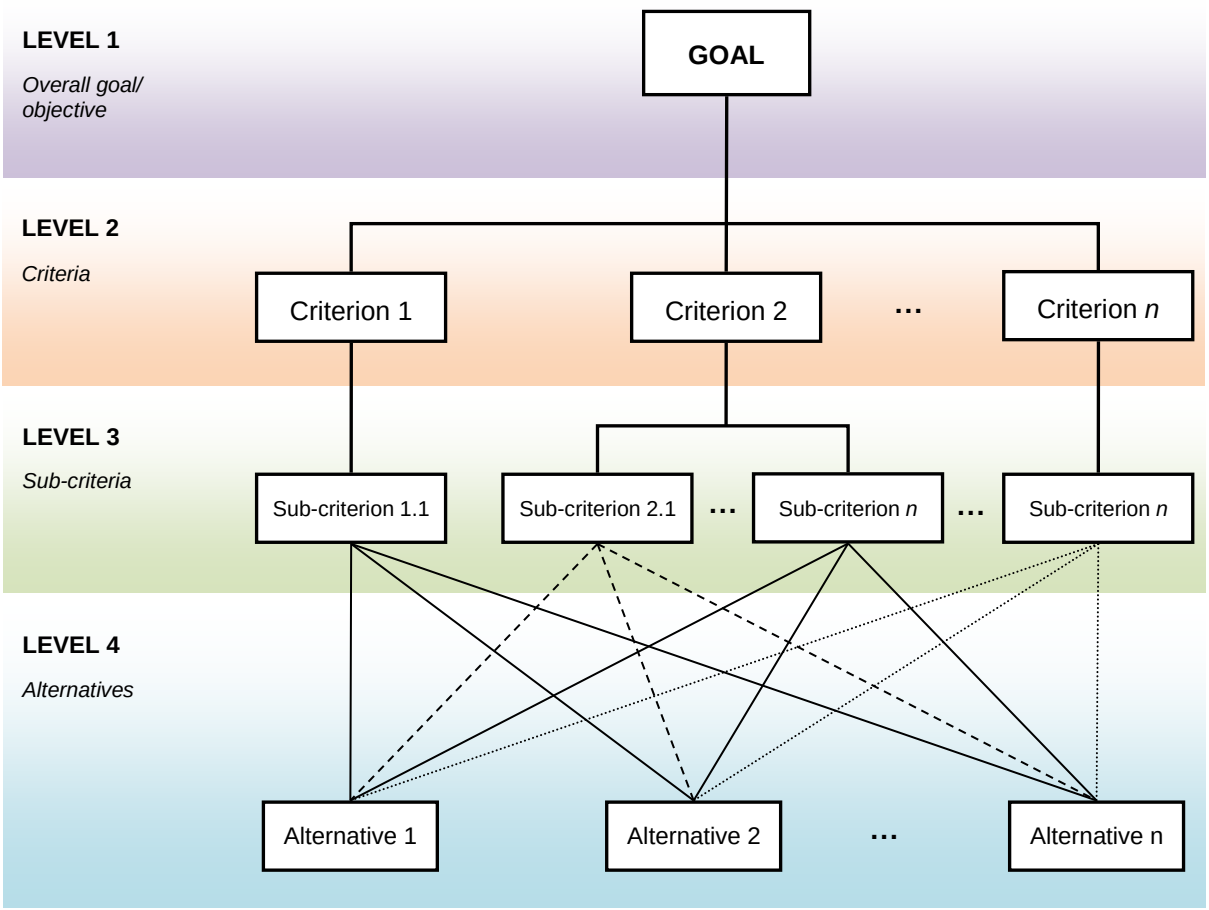


Figure 2. The decision hierarchy (a typical Analytic Hierarchy Process model)

Phase 3. Construct a **set of pairwise comparison matrices**. Pairwise comparisons are made at each level of the hierarchy. Each element in an upper level is used to compare the elements in the level immediately below with respect to it. In making the comparison, the question is: which of the two factors has a greater weight in decision making, and how much greater? Or which of the two decision alternatives is preferred with regard to a certain decision attribute?

To make comparisons we need a scale of numbers. This indicates how many times more important or dominant one element is over another element, with respect to the criterion or property in relation to which they are compared. Saaty (2008a, 2008b) defined a scale of absolute numbers to make comparisons (Table 1).

Table 1. The fundamental scale of absolute numbers

INTENSITY OF IMPORTANCE	DEFINITION	EXPLANATION
1	Equal importance	Two activities contribute equally to the objective
2	*Weak or slight*	*Between Equal and Moderate*
3	Moderate importance	Experience and judgment slightly favour one activity over another
4	*Moderate plus*	*Between Moderate and Strong*
5	Strong importance	Experience and judgment strongly favour one activity over another
6	*Strong plus*	*Between Strong and Very strong*
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	*Very, very strong*	*Between Very strong and Extreme*
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity *i* has one of the above non-zero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*.	A logical assumption (e.g. if x is 5 times y, i.e. $x = 5y$, then $y = x/5$ or $y = 1/5x$)
1.1 - 1.9	When activities are very close a decimal is added to 1 to show their difference as appropriate	Perhaps a better way than assigning the small decimals is to compare two close activities with other widely contrasting ones, favouring the larger one a little over the smaller one when using the 1-9 values.

Sources: Saaty (2008a and 2008b)

Phase 4. Calculate the **ratings for the decision alternatives** based on the relative weights of the decision elements until the final choice is made. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom-most level are obtained.

The higher the weight the more important the corresponding criterion: after the comparison matrix is formed, the AHP generates a weight for each evaluation criterion according to the decision maker's pairwise comparisons of the criteria (technically, this list is called an *eigenvector*).

The higher the score, the better the performance of the alternative with respect to the considered criterion: for a fixed criterion, the AHP assigns a score to each alternative according to the decision maker's pairwise comparisons of the alternatives based on that criterion.

The global score for a given alternative is a weighted sum of the scores it obtained with respect to all the criteria: the AHP combines the criteria weights and the alternatives' scores, thus determining a global score for each alternative, and a consequent ranking.

Phase 5. Evaluate and **check the consistency** of judgments.

Comparisons made by this method are subjective and the AHP tolerates inconsistency through the amount of redundancy in the approach. If this consistency index fails to reach a required level, then answers to comparisons may be re-examined. AHP provides a measure of the inconsistency in each set of judgments. This is calculated by a *consistency index* (CI) and a *consistency ratio* (CR) to measure how consistent the judgments have been relative to large samples of purely random judgments.

If the CR is considerably in excess of 0.10, the judgments are untrustworthy because they are too close for comfort to randomness, and the exercise is valueless or must be repeated. In that case we need to consider revising our subjective judgments. Inconsistency itself is important because without it, new knowledge that changes preferences cannot be admitted.

2.1.2. Implementation of AHP

In this subsection we illustrate the implementation of the AHP in detail, supported in the literature (Triantaphyllou & Mann, 1995; Kangas et al., 2008; Bunruamkaew, 2012; Haas & Meixner, 2015; Mocenni, 2016; IHU, 2016). For that purpose we use a simple multi-criteria decision problem. This illustration is meant to facilitate the reading of the dissertation by students and researchers who have not been exposed yet to the development and implementation of the AHP multi-criteria approach.

Problem: A decision maker wants to buy a laptop. There are a significant number of different models available to choose from. After extensive market research he chooses three different models (A, B and C) that fulfil his needs. The different models are the alternatives. Regarding the laptop preferences, the most important features for him are the battery life, RAM/memory and hard disk (this is the criteria).

1. **Model the problem into a hierarchical structure**. We construct the AHP hierarchy (Figure 3) with the goal, the criteria and the alternatives of our problem.

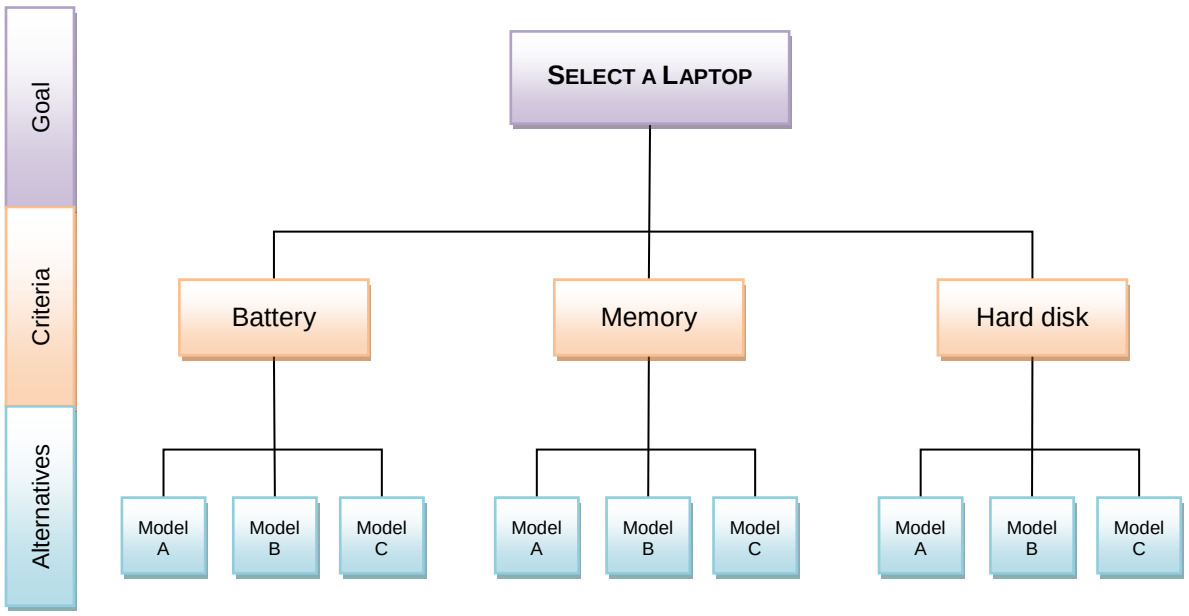


Figure 3. The decision hierarchy for laptop buying decision

2. **Define the relative importance of the criteria**. Comparing each possible pair of criteria and ranking those on the following scale (see Table 1, page 9; Table 2): comparing criterion *i* and criterion *j*, give a value a_{ij} with following meaning:

Table 2. Pairwise comparison values (relative scores)

VALUE OF a_{ij}	INTERPRETATION
1	*i* and *j* are equally important
3	*i* is moderately more important than *j*
5	*i* is strongly more important than *j*
7	*i* is very strongly more important than *j*
9	*i* is extremely more important than *j*

Source: IHU (2016)

Each alternative can be evaluated in terms of decision criteria and the relative importance (weight) of each criterion can be estimated as well. Consider a matrix of pairwise comparison values a_{ij} (*i*=1, 2, 3 and *j*=1, 2, 3) and structure the problem in a decision matrix (Table 3).

Table 3. Decision matrix

			***Criteria** (j)*		
			Battery	Memory	Hard disk
			C_1	**C_2**	**C_3**
Alternative (i)	Model A	**A_1**	a_{11}	a_{12}	a_{13}
	Model B	**A_2**	a_{21}	a_{22}	a_{23}
	Model C	**A_3**	a_{31}	a_{32}	a_{33}

The matrix is required to be reciprocal, i.e. in the matrix if a_{ij} is *m* then $a_{ji} = \frac{1}{m}$. This means that if alternative *i* is twice as good as *j*, then *j* has to be half (1/2) as good as *i*. Each alternative is then indifferent to itself, i.e. when *i* = *j*, $a_{ij} = 1$, so the diagonal elements of the matrix are 1.

Now we compare the criteria in pairs and rate all the criteria with respect to the goal of the problem. For estimating the priorities, the matrix of pairwise comparisons is constructed for each set of comparisons (Table 4).

Table 4. Preferences of the criteria

	Battery	Memory	Hard disk
Battery	1	1/4	3
Memory	4	1	7
Hard disk	1/3	1/7	1

3. **Normalise the priority matrix.** This is made by dividing each element by the sum of the column in which it appears. Then we compute an eigenvector (also called a priority vector or weights) that represents the relative ranking of importance (or preference) attached to the criteria or objects being compared.

   a. Sum the values in each column of the pairwise matrix (Table 5):

$$a_{ij} = \sum_{i=1}^{n} a_{ij}$$

Table 5. Sum of each column

	Battery	Memory	Hard disk
Battery	1	1/4	3
Memory	4	1	7
Hard disk	1/3	1/7	1
Sum	**5.33**	**1.39**	**11.00**

   b. Divide each element in the matrix by its column total to generate a normalised pairwise matrix. The sum of each column is one (Table 6):

$$X_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$$

For example, a_{11} (Table 4) entry would end up as:

$$a_{11} = \frac{1}{1 + 4 + \frac{1}{3}} = \frac{1}{1 + 4 + 0.333} = 0.1875$$

Table 6. Normalised pairwise matrix

	Battery	Memory	Hard disk	**Sum**
Battery	0.1875	0.1795	0.2727	**0.6397**
Memory	0.7500	0.7179	0.6364	**2.1043**
Hard disk	0.0625	0.1026	0.0909	**0.2560**
Sum	**1.0000**	**1.0000**	**1.0000**	**3.0000**

c. Divide the sum of the normalised row of matrix by the number of criteria used (in this example n=3) to generate a matrix with the weights of the criteria (Table 7):

$$W_{ij} = \frac{\sum_{j=1}^{n} X_{ij}}{n}$$

Table 7. Weights of criteria

	Battery	Memory	Hard disk	**Weights[1]** *(eigenvector)*
Battery	0.1875	0.1795	0.2727	**0.2132**
Memory	0.7500	0.7179	0.6364	**0.7014**
Hard disk	0.0625	0.1026	0.0909	**0.0853**
Sum	**1.0000**	**1.0000**	**1.0000**	**1.0000**

We concluded that 70% of the criterion weight is on memory, about 21% is on battery and 9% is on hard disk (Table 7). It is clear that the decision maker prefers the memory over the battery life and hard disk.

[1]Normalized inputs (priority vector)

4. **Checking the consistency.** This can be achieved by the approximation of the consistency index (CI) and the consistency ratio (CR).

Consistency Index (CI)

a. Calculate the consistency vector, Cv_{ij} (Table 8), by multiplying each column of the pairwise comparison matrix (Table 5) by the corresponding weight (Table 7):

For example, Cv_{11} entry would end up as:

$$(1\times0.2132) + (1/4\times0.7014) + (3\times0.0853) = 0.6446$$

Table 8. Consistency vector

	Battery	Memory	Hard disk		Weights *(eigenvector)*		**Consistency vector**
Battery	1	1/4	3		0.2132		**0.6446**
Memory	4	1	7	**x**	0.7014	**=**	**2.1517**
Hard disk	1/3	1/7	1		0.0853		**0.2566**

b. Divide the weighted sum vector (consistency vector) by the criterion weight (Table 9):

For example, Cv_{11} entry would end up as:

$$0.6446 \div 0.2132 = 3.0228$$

Table 9. Consistency ratio

	Consistency vector		Weights *(eigenvector)*		**Consistency ratio**
Battery	0.6446		0.2132		3.0228
Memory	2.1517	**:**	0.7014	**=**	3.0675
Hard disk	0.2566		0.0853		3.0075
Sum	**3.0528**		**1.0000**		**9.0977**

c. The eigenvalue (λ) is calculated by averaging the value of the consistency vector, Cv_{ij}

$$\lambda = \text{average } (9.0977) = \mathbf{3.0326}$$

d. CI measures the deviation:

$$CI = \frac{\lambda - n}{n - 1}$$

where: *n*=dimension of matrix (number of criteria); in this example *n*=3:

$$\boldsymbol{CI} = \frac{\lambda - 3}{3 - 1} = \frac{3.0326 - 3}{3 - 1} = \frac{0.0326}{2} = \mathbf{0.0163}$$

Consistency Ratio (CR)

e. Divide CI value by the random index (RI). The RI is given in Table 10 (in this example *n*=3, so RI=0.58). Allowable CR should be no more than about 0.10 (Saaty, 2008a).

$$\boldsymbol{CR} = \frac{CI}{RI} = \frac{0.0163}{0.58} = \mathbf{0.0281}$$

Table 10. Values of the random index for different values of *n*

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.89	1.11	1.25	1.35	1.40	1.45

Source: Saaty (2008b)

For the criteria of these example the consistency measures are: CI=0.016 and CR=0.03; we concluded that the matrix is consistent.

5. **Evaluate all the alternatives (laptop models) on each of the criterion (laptop features).** Again we normalised the scoring table (for each criterion) dividing each element by the sums of the columns, and by the average across rows to get the relative weights of each model regards to criterion.

For the decision maker battery life of Model A is longer than that of Model B, and the battery of Model C is slightly longer than Model B. The evaluation of alternatives by the decision maker for each criterion is in following matrices: battery (Table 11 and Table 12), memory (Table 13 and Table 14) and hard disk (Table 15 and Table 16). Analysing all matrices we conclude that Model A is the best for battery life (the weight is 62%) and for memory (the weight is 62%). For hard disk Model C is the one with higher weight (62%).

Table 11. Battery scores from each model

	Model A	Model B	Model C
Model A	1	4	3
Model B	1/4	1	1/2
Model C	1/3	2	1

Table 12. Weights of each model related to battery scores

	Model A	Model B	Model C	**Weights**
Model A	0.6316	0.5714	0.6667	**0.6232**
Model B	0.1579	0.1429	0.1111	**0.1373**
Model C	0.2105	0.2857	0.2222	**0.2395**

CI=0.009 and CR=0.02 (matrix consistent)

Table 13. Memory scores from each model

	Model A	Model B	Model C
Model A	1	5	3
Model B	1/5	1	1/4
Model C	1/3	4	1

Table 14. Weights of each model related to memory scores

	Model A	Model B	Model C	**Weights**
Model A	0.6522	0.5000	0.7059	**0.6194**
Model B	0.1304	0.1000	0.0588	**0.0964**
Model C	0.2174	0.4000	0.2353	**0.2842**

CI=0.043 and CR=0.07 (matrix consistent)

Table 15. Hard disk scores from each model

	Model A	Model B	Model C
Model A	1	1/3	1/7
Model B	3	1	1/2
Model C	7	2	1

Table 16. Weights of each model related to hard disk

	Model A	Model B	Model C	**Weights**
Model A	0.0909	0.1000	0.0870	**0.0926**
Model B	0.2727	0.3000	0.3043	**0.2924**
Model C	0.6364	0.6000	0.6087	**0.6150**

CI=0.001 and CR=0.00 (matrix consistent)

6. **Place all the overall weights on the hierarchy model.** This analysis demonstrates how much of each element in the model counts in the final decision.

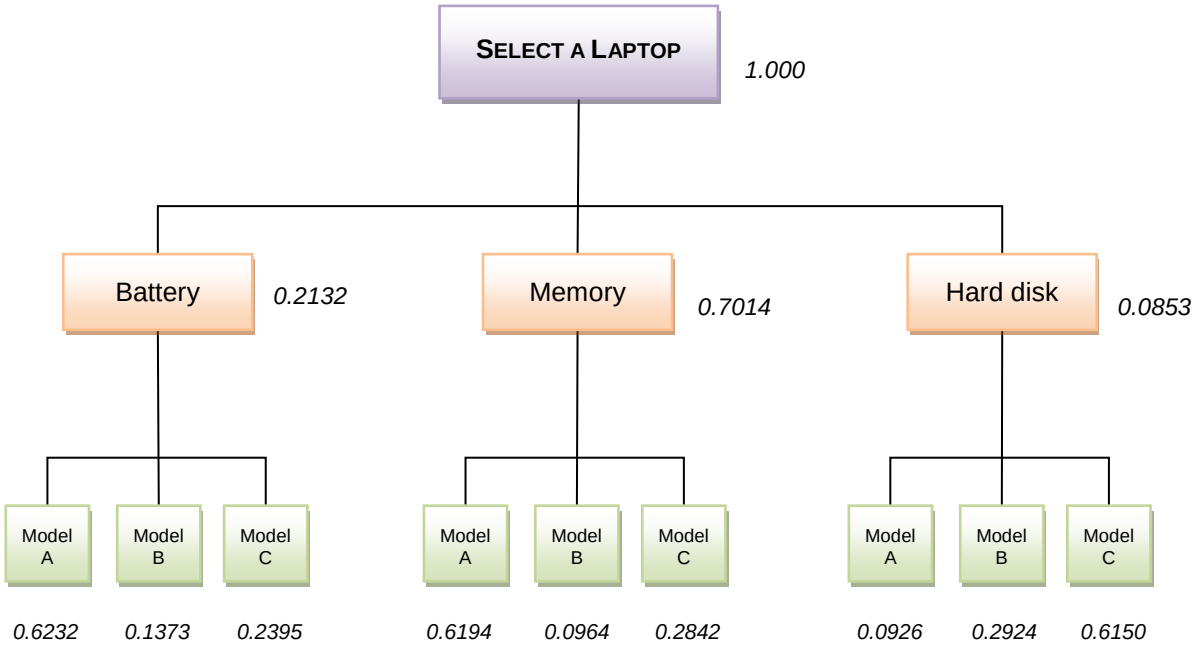


Figure 4. Overall weights for laptop buying decision

7. **Get final rankings for each laptop model.** The rating of each alternative is multiplied by the weights of the criteria and aggregated to get local ratings with respect to each alternative.

For example, for Model A the rating is (Table 17):

$$(0.623\times0.213)+(0.619\times0.701)+(0.093\times0.085)=0.133+0.434+0.008=0.575$$

Table 17. Final rating for each model

	Battery	Memory	Hard disk		Criteria ranking		**Final ranking**
Model A	0.623	0.619	0.093		0.213		**0.575**
Model B	0.137	0.096	0.292	×	0.701	=	**0.122**
Model C	0.239	0.284	0.615		0.085		**0.303**

We concluded that Model A is the one with highest ranking, as it fits 57.5% of the needs of the decision maker compared with the other two models. The AHP produces weight values for each alternative based on the judged importance of one alternative over another with respect to a common criterion. The resulting weights or priorities represent the decision maker's perception of the relative importance or preference of the elements at each level of the hierarchy.

2.2. DELPHI METHOD

The Delphi method was first developed in the 1950s by Olaf Helmer, Nicholas Rescher, Norman Dalkey, and others at the Rand Corporation (Gordon, 1994). The intent of the Delphi, as it was originally conceived, was to create a method, using expert opinions, to forecast long-range trends related to the military potential of future science and technology and their effects on political issues (Somerville, 2008). This method has been applied in various fields such as programme planning, needs assessment, policy determination, and resource utilisation (Hsu & Sandford, 2007).

Delphi is a prospective (also called foresight) method, a systematic interactive technique for obtaining information from a panel of independent experts without the need to meet face-to-face, in order to facilitate an efficient group dynamic process (Erpicum, 2016; von der Gracht, 2012). It is used to help identify issues, set goals and priorities, clarify positions and differences across groups, and identify solutions (Wolf & Kruger, 2010). As it is a procedure to identify statements (topics) that are relevant for the future, it reduces the tacit and complex knowledge to a single statement and makes it possible to make a judgment (Cuhls, 2004). One of the main applications of the Delphi technique is screening the items in operations research problems and of MCDM techniques (Habibi et al., 2014).

The Delphi method allows surveying a panel of experts in an iterative way. A typical Delphi survey consists of at least two rounds of questions. After each round, a moderator – or analyst – shall provide a synthesis that is used as a basis for the drafting of the following questionnaire, therefore allowing for a "controlled feedback" (Erpicum, 2016). Starting from the second round, the feedback given is about the results of previous rounds and the same experts assess the same matters once more, influenced by the opinions of the other experts (Cuhls, 2004).

Because the number of respondents is usually small, Delphi does not, and is not intended to, produce statistically significant results; in other words, the results provided by any panel do not predict the response of a larger population or even a different Delphi panel. They represent the synthesis of the opinions of the particular group – no more, no less (Gordon, 1994). In short, the method allows the best use of currently available formal and informal knowledge in a transparent and robust way (De Las Heras et al., 2007).

2.2.1. Characteristics of the Delphi method

The Delphi technique is a survey technique in order to facilitate an efficient group dynamic process. This is done in the form of an anonymous, written, multi-stage survey process, where feedback of group opinion is provided after each round (von der Gracht, 2012). There are four distinct characteristics of the Delphi method that are important to the process (Rowe & Wright, 2001; von der Gracht, 2012), as follows:

1. **Anonymity**

In Delphi studies, the participants usually do not know each other. Anonymity is guaranteed since the process is coordinated by a moderator. Questionnaires are filled in by the individuals and returned to the moderator, who then analyses the group response. The anonymity assures that:

- Specious persuasion does not occur, since anonymity reduces the effect of dominant individuals;
- There is no socio-psychological pressure on the experts;
- Avoids unwillingness to abandon publicly expressed opinions. Respondents do not have to fear that they may lose face in the eyes of the group when changing a previously expressed opinion.
- Surveys usually lead to higher response rates. Participants probably feel more comfortable giving estimates on uncertain issues in an anonymous form.

2. **Iteration**

The procedure is executed in a series of rounds. The judgments of the respondents are summarised by the facilitator and provided as feedback or basic information for the following round. The iteration of rounds, along with the provision of written feedback, reduces intentional and unintentional noise, such as irrelevant, non-productive, and potentially frustrating communication. In addition, this procedure permits social learning and the modification of prior judgments.

3. **Controlled feedback**

It is termed "controlled" because the facilitator decides on the type of feedback and its provision. After each Delphi round, the survey data is statistically analysed and re-stated in aggregated form.

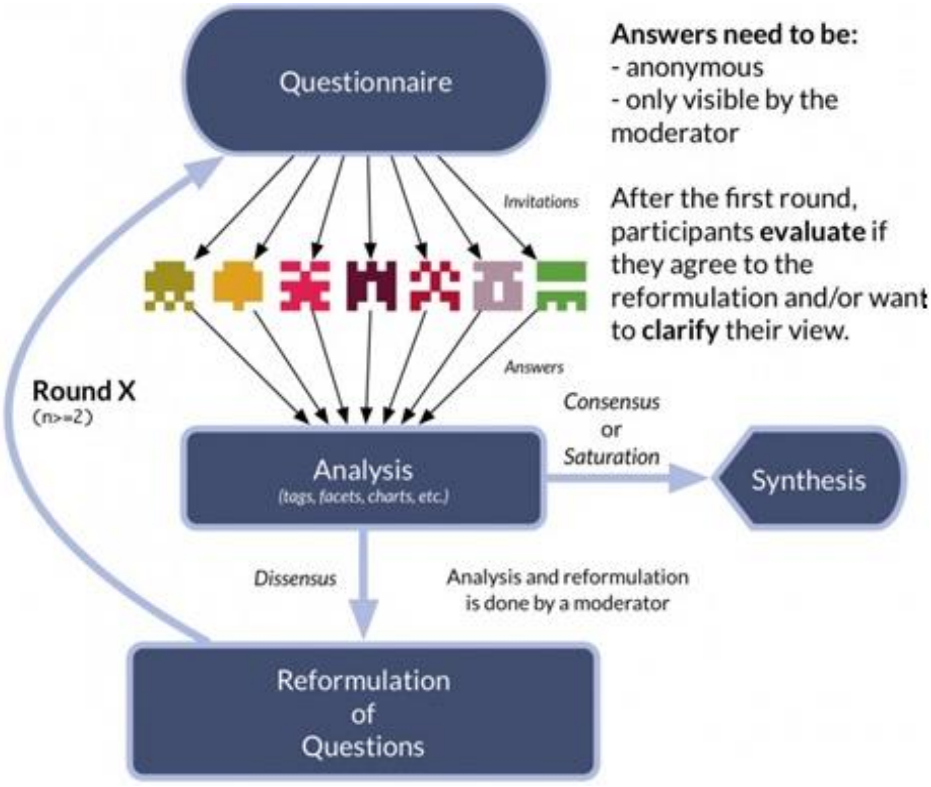
4. **Statistical "group response"**

This can be presented either numerically or graphically, and usually comprises measures of central tendency (median, mean), dispersion (interquartile range, standard deviation), and frequency distributions (histograms and frequency polygons). In some Delphi applications, even comments of respondents are provided.

After reviewing the group statistics, each participant can decide whether to change his or her previous answer or to remain with his or her initial decision. If estimations strongly deviate from the group response, participants usually provide reasons for their unique evaluations of situations. This assures that only profound statements are given. Analysis of the data over successive rounds allows for measuring not only the existence of consensus and its strength, but also the convergence of opinions.

2.2.2. Phases of Delphi

The efficient structuring of a group communication process can be considered the primary goal of a Delphi study. The objective of the Delphi method is to reach consensus in opinions within a group of experts. The Delphi technique implementation includes different phases (Figure 5).



Source: Erpicum (2016)

Figure 5. Main phases of Delphi implementation

To have success with this technique it is important to devise a plan to follow up, identifying the guidelines for a good survey and a quality control, ensuring accurate results. According to recent literature (Rowe & Wright, 2001; De Las Heras et al., 2007; Somerville, 2008; Habibi et al., 2014) the main phases of Delphi implementation are the following:

Phase 1. Definition of the problem. Specify the topic to be investigated, which has a lack of consensus and an imperfect knowledge about it.

Phase 2. Construction of a questionnaire for data collection. Ensuring the clarity of the questionnaire.

Key issues to keep in mind:

- Make questionnaire statements clear, concise, free of ambiguities, and easily to understand by experts from varied backgrounds;

- Provide clearly written instructions to panel members;
- Pre-test the questionnaire and survey procedures;
- Provide experts with a brief account of the origin and purpose of the study.

Phase 3. Selection of experts (Delphi panel). This is one of the most important phases of the method because the validity of the results depends on the competence and knowledge of the panel members.

Key issues to keep in mind:

- Use experts with appropriate domain knowledge. How experts respond to Delphi feedback will depend upon the extent of their knowledge about the topic to be forecasted; this might, for example, affect their confidence in their own initial estimates and the weight they give to the feedback from anonymous experts.
- Use heterogeneous experts. We should choose experts whose combined knowledge and expertise reflects the full scope of the problem domain. Heterogeneous experts are preferable to experts focused on a single speciality. Select panel members based on knowledge of the issue and diversity of perspective.
- Use between five and 20 experts. The size of Delphi panels can vary widely. There is disagreement about what constitutes an appropriate panel size, although panel size clearly will have an impact on the effectiveness of the technique. Larger groups provide more intellectual resources than smaller ones but they also cause conflict, irrelevant arguments, and information overload more likely. With larger panels come greater administrative costs in terms of time and money. To maximise the use of human resources, it is desirable to limit the panel size.
- Ensure that experts perceive that their contributions are valued.
- Communicate to experts that they are members of a group with similar expertise to their own.
- Provide enough incentive to maintain experts' motivation to persist to the conclusion of the study.

Phase 4. First Round Questionnaire. Send the questionnaire to experts. Use an electronic version of the Delphi method, called the "e-Delphi". The time and expense of the process are reduced, data are electronically compiled, and more detailed information can be returned to participants.

Phase 5. Analysis of the first round responses. After gathering the experts' opinions, one method for aggregating the subjective judgments of experts to produce a collective opinion is to simply average participants' responses. Summarise the data resulting from this round. This questionnaire is used as the survey instrument for the second round of data collection.

Phase 6. Second Round Questionnaire. Send to each Delphi expert a second questionnaire with the results of the first round, as feedback. Ask the experts to review the items summarised by the investigators based on the information provided in the first round.

Key issues to keep in mind:

- Allow enough time between rounds to prepare and distribute feedback, but do not allow so much time that experts lose interest;
- Take care to keep the intent of expert responses intact when reporting responses back to other panel members.

Phase 7. Analysis of the second round responses. The phase 6 is reiterated as long as desired or necessary to achieve stability in the results.

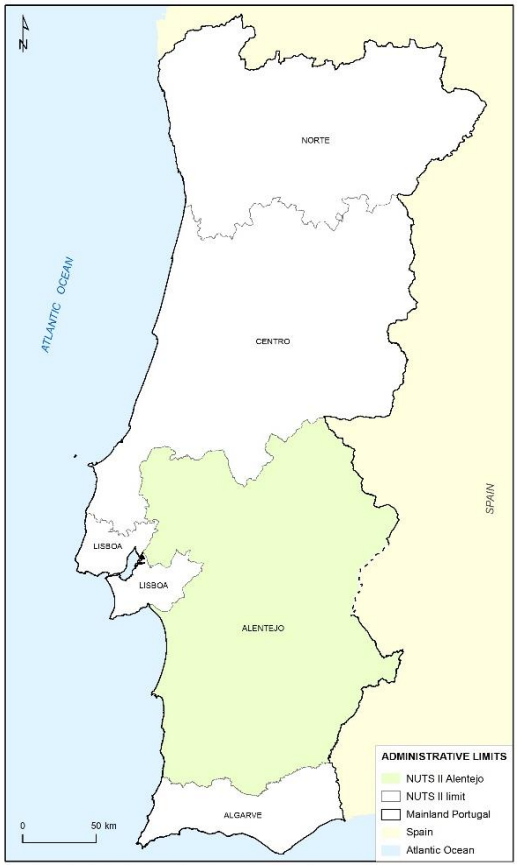
Phase 8. Conclusion. Preparation of a report including the analysis, interpretation, conclusions and presentation of the data.

3. DATA AND METHODS

3.1. STUDY AREA

3.1.1. Geographic context

The study area, the Alentejo region (NUTS II - Nomenclature of Territorial Units for Statistics - PT18), is located in south of mainland Portugal (Figure 9); with a total area of 3,160,490 ha. It is the largest NUTS II Portuguese region spreading across 1/3 of the country's territory. It encompasses the districts of Portalegre, Évora, Beja and part of the districts of Santarém, Lisboa and Setúbal, for a total of 58 municipalities/ counties (Figure 9) and 324 parishes (DGT, 2016). Alentejo is a relatively flat region with the exception of some small mountains, in particular the Serra de Castelo de Vide (762 m), Serra de Marvão (865 m), Serra Selada (823 m), Serra Fria (900 m) and Serra de São Mamede (1027 m), all located in the district of Portalegre and the Serra de Ossa (623 m), located in the district of Évora.



Location of the Alentejo region in mainland Portugal

Distribution of districts and counties in Alentejo

Source: DGT (2016)

Figure 6. Geographic context of study area

The climate of the region is generally warm and temperate. The winters are rainier than the summers. This region is classified as Csa (temperate climate with warm and dry summer) by Köppen and Geiger. The average annual temperature is 14.5°C. About 1065 mm of precipitation falls annually (Climate-Data, 2016).

3.1.2. Social and economic context

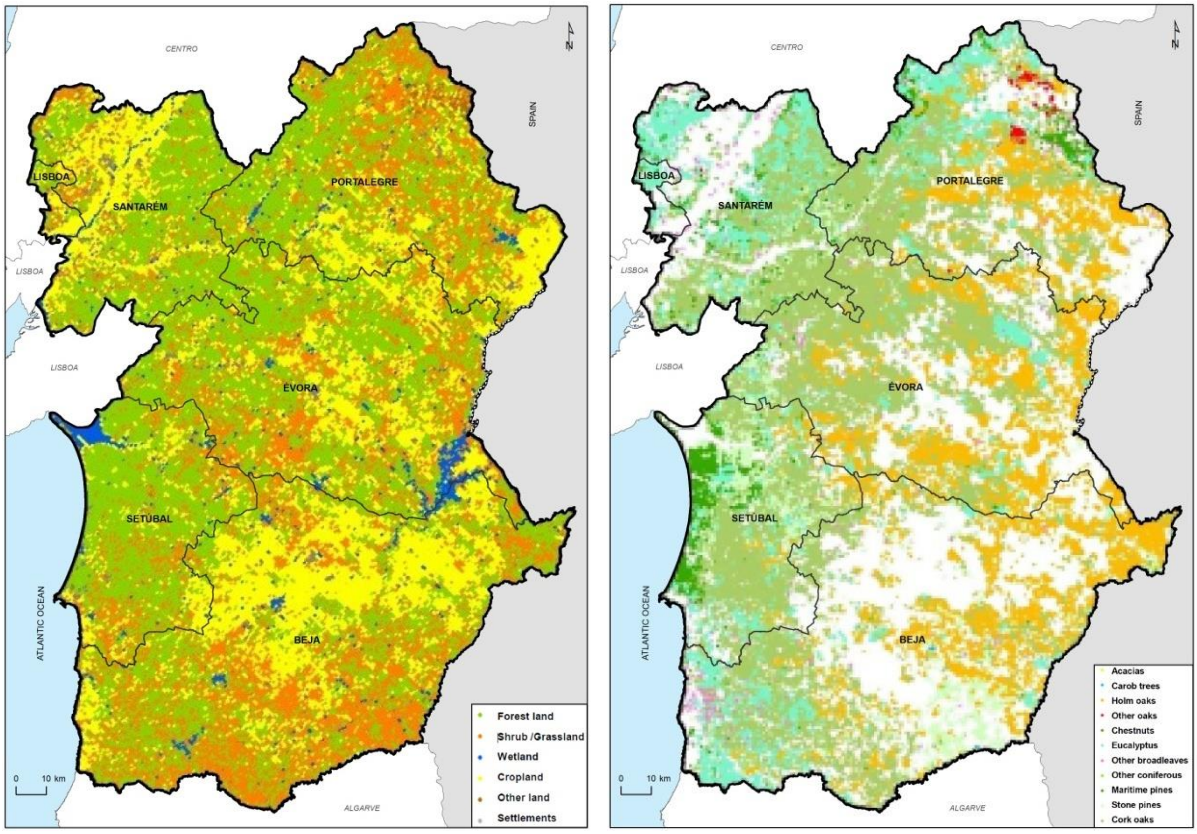
The Alentejo region has 757,302 inhabitants (7.2% of the Portuguese population), which represents a very low population density, about 24.0 inhabitants /km^2 - much lower than the average population density of the country, which is 114.5 inhabitants/km^2 (INE, 2012b). The area is mainly privately owned.

The data on the regional statistics (INE, 2012a) reveal that in Alentejo, the tertiary sector is at the top of the gross domestic product (GDP) structure (about 64% of the total activity), in particular public administration services. The primary sector (agriculture and forest) accounts for 14% of the employed population. According to the Economic Regional Accounts (INE, 2016), in 2014 (preliminary values) the gross value added (GVA) in Alentejo amounted to 6.4% of the national GVA. Exports, in the same year, correspond to 6.0% of national exports, mainly to other member states of the European Union.

3.1.3. Forest context

In Alentejo the forest area extends for about 1.4 million ha (INE, 2015) corresponding to 43% of the region's territory (Figure 7). The cork oak (*Quercus suber*) and holm oak (*Quercus ilex*) stands represent around 71% of the Alentejo forest area. These species may occur in pure or mixed composition, with different spacing and in even-aged or uneven aged stands. Eucalyptus (*Eucalyptus globulus*) plantations and stone pine (*Pinus pinea*) stands extend over about 15% and 9% of the forest area, respectively (Figure 8).

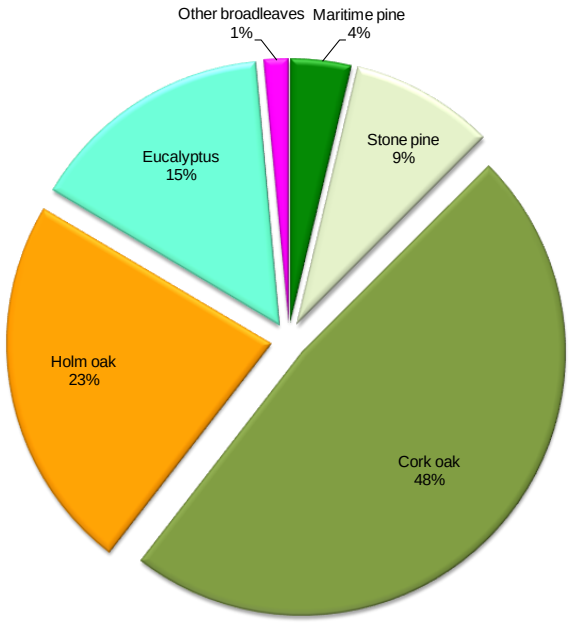
According to the last Portuguese National Forest Inventory - NFI6 (ICNF, 2013) - Alentejo was the only region in Portugal where the forest area increased (about 250 km^2) from 1995 to 2010, mainly as a consequence of planting new cork oak and umbrella pine stands. These forest ecosystems provide wood and non-wood forest products as well as services such as carbon sequestration, nature conservation (biodiversity, geo-monuments), tourism and the protection of soil and water.



Land use ***Forest land (tree species)***

Source: Uva (2014)

Figure 7. Land use and forest land of Alentejo region



Source: INE (2015)

Figure 8. Distribution of tree species in Alentejo

3.2. NON-WOOD FOREST PRODUCTS

The Alentejo region has a wide variety of NWFPs. They are all relevant to forest owners because of their socio-economic contribution to livelihoods of local communities, by promote national industry and guarantee jobs.

In order to facilitate expert knowledge elicitation regarding the pairwise comparisons it was necessary to restrict the number of analysed NWFPs to a maximum of eight products. In selecting the NWFPs we considered the trade, the contribution to socio-economic aspects and regional development for the local population (mainly rural) and also the innovative aspects regarding European markets. Based on FAO classification (see Figure 1, page 1) the NWFPs were organized into four categories:

- **Plants:** Tree Products and Understory plants
- **Fungi:** Mushrooms and Truffles
- **Fauna:** Animal origin

In order to ensure at least one species per category of NWFPs, we selected a total of seven NWFPs for the Alentejo region (Table 14).

Table 18. Non-wood forest products selected for Alentejo region by category

CATEGORY	NON-WOOD FOREST PRODUCT
Mushrooms and Truffles	Boletus (*Boletus edulis)*
Tree products	Cork (*Quercus suber*)
	Pine nuts (*Pinus pinea*)
	Pine resin (*Pinus* spp)
Understory plants	Yellow lavender (*Lavandula viridis)*
Animal origin	Honey from bees (*Apis mellifera*)
	Rabbit - game meat (*Oryctolagus cuniculus*)

3.2.1. Boletus

In Alentejo several edible wild mushrooms are known to occur in forest ecosystems, namely: *Amanita caesarea* (Caesar's mushroom), *Amanita ponderosa* (gurumelo), several species of boletus (e.g. *Boletus edulis*, *Boletus aerus*), *Cantharellus cibarius* (chantarelle) and *Terfezia* spp. (truffles). They were traditionally picked for personal consumption by community members in rural areas. In this study *Boletus edulis* (Figure 9) was selected because it is the most common edible mushroom in cork oak stands.

Over the past two decades, mushroom picking for commercial purposes has increased considerably. Reports underline that about half of the harvested mushrooms are exported mainly to Spain and France (OMAIAA, 2006). However, mushroom picking is mostly conducted without any control mechanisms (e.g. licenses) but there is only little scientific literature/ knowledge available (Santos e Silva, 2014).

Source: DGADR & ICNF (2013)

Figure 9. Boletus

3.2.2. Cork

Portugal is the main producer of cork in the world. In 2010 exports of cork (*Quercus suber*) represented about 2% of total national exports; the number of companies in this sector was 523, generating over 8000 jobs (ENF, 2015). Moreover, in 2011, Portugal reported a production of 100 million tonnes of cork with a value of EUR 203 million (Forest Europe, UNECE & FAO, 2011).

Cork oak stands (Figure 10) usually integrate multifunctional agro-forestry systems (called "montado" in Portuguese), where the production of cork is combined with cattle grazing, acorn production, fire wood, hunting, and mushroom picking (Tomé & Faias, 2014). The environmental services of the “montado” are valued at least EUR 100/ha per year (Antunes et al., 2010).

Cork oak stands[2]

Cork[2]

Figure 10. Cork oak stands and cork

3.2.3. Pine nuts

The pine nut from the stone pine (*Pinus pinea*) is the most important edible fruit in Alentejo forests (Figure 11). The high market prices for pine nuts, the crisis of traditional rainfed crops and EU afforestation subsidies for farmers have increased private initiatives to promote intensively managed stone pine plantations for pine nut yield (Tomé & Faias, 2014). In 2012, the export of pine nuts represented about 0.03% of total national exports. The economic relevance of pine nuts at the national level might be less evident than the one of cork. Nevertheless this NWFP plays an important role in promoting the regional economy (Louro et al., 2014).

Stone pine stands[2]

Pine nuts shelled[2]

Figure 11. Stone pine stands and pine nuts

[2] Author's photos.

3.2.4. Pine resin

The supply of resin (Figure 12) decreased substantially over the past two decades. Yet recently this trend has been reversed (ENF, 2015). In 2013, 750 tonnes of resin with a value of EUR 807 thousand were produced in the Alentejo region (INE, 2015). This is due to recent developments of new tools and extraction methods, combined with breeding programmes, and the increase of world market prices for resin products (Tomé & Faias, 2014).

Maritime pine stands[3]

Pine resin (from maritime pine)[3]

Figure 12. Maritime pine stands and pine resin

3.2.5. Yellow lavender

In Alentejo there are a variety of medicinal and aromatic plants which are one of the flagship products of Alentejo gastronomy. They contribute to the valorisation of food traditions. Medicinal plants are also important for local communities. Their use and commercialisation has recently increased (GPP, 2013). To select one for the study we had the support of a local association ("Associação de Defesa do Património de Mértola"), who indicated the yellow lavender (Figure 13) as a plant with a large market potential because of its uniqueness.

Source: Pereira (2016)

Figure 13. Yellow lavender

[3] Author's photos.

3.2.6. Honey

The largest national area of "protected designation of origin" (DOP - Denominação de Origem Protegida, in Portuguese) of honey is located in Alentejo - "Mel do Alentejo" (Figure 14).

The Alentejo is one of the regions with the largest average size of beekeepers, about 58 hives per beekeeper (the national average is 42 hives per beekeeper). This demonstrates a growing interest of beekeepers on honey quality as well as the success of their marketing efforts (GAPA, 2013).

Figure 14. Honey from Alentejo (produced in Serpa municipality)[4]

3.2.7. Rabbit

Game meat is also an important regional NWFP. About 33% of the national hunting areas are located in Alentejo (ENF, 2015). Property management plans typically include sustainable management measures for game species.

In Alentejo there is a relative abundance of small game species (e.g. rabbit, thrush and partridge), and of some big game species, in particular wild boar and red deer (Pereira et al., 2015). In this study the rabbit was selected because it is one of the most hunted species in the region.

Source: DeBold (2016)

Figure 15. Rabbit

[4] Author's photo.

3.3. ANALYTIC HIERARCHY PROCESS APPLICATION

3.3.1. Structuring the problem

To generate a regionally explicit ranking of NWFPs available in Alentejo, we used the modelling framework designed by Huber et al. (2015) with a goal and multiple criteria, sub-criteria and alternatives. The AHP **goal** (the decision problem under observation) is to "identify the most promising NWFPs in Alentejo region" and has two levels of indicators, **criteria** (specific to the region, i.e. region dependent weights) and **sub-criteria** (specific to the forest owner, i.e. profile dependent), arranged hierarchically (Figure 16).

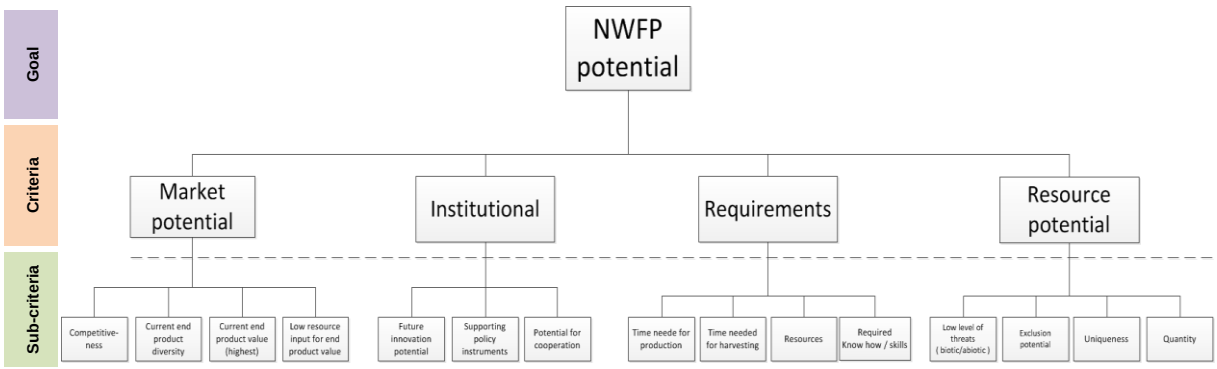


Figure 16. Analytical Hierarchy Process highlighting goal, criteria and sub-criteria

The upper level of the hierarchy (**criteria**) was decomposed into the following four indicators:

- **Market potential:** indicates the current market potential of a distinct NWFP and synthesises existing opportunities for marketing them e.g. local, regional, national, or international markets.
- **Institutional potential:** depicts the institutional potential with regard to a single NWFP and mirrors corresponding supportive or hindering structures (e.g. legislation, norms, action principles, etc.).
- **Requirements:** highlight needs for NWFPs production and harvesting.
- **Resource potential:** gives an estimate of the potential to successfully produce and/or harvest a single NWFP.

For each criterion, the concern was an analysis in view of the Alentejo region, i.e. the weight for each criterion shall be derived via a collaborative exercise with regional experts (stakeholders) who identify preference values amongst those indicators to mirror regional circumstances as regards NWFPs.

The lower level of the hierarchy (**sub-criteria**) is used to further decompose the higher-level criteria in sub-criteria (Table 19) and aims to collect specific perceptions (from stakeholders) about each criterion.

Table 19. Criteria and sub-criteria

CRITERIA	SUB-CRITERIA
Market potential	Competitiveness
	Current end product diversity
	Current end product value
	Low resource input for end product value
Institutional potential	Future innovation potential
	Supporting policy instruments
	Potential for cooperation
Requirements	Time needed for production
	Time needed for harvesting
	Resources (needed investments)
	Required skills/know-how
Resource potential	Low level of threats (biotic/abiotic)
	Exclusion potential
	Uniqueness
	Quantity

Appendix 1 (page 64) provides a more detailed description for both criteria and respective sub-criteria. The spatial scale for the assessment is regional to national (in order to assess the regional potential of selected NWFPs). Only for some sub-criteria the European level has to be taken into account – as indicated in the respective description.

The criteria and sub-criteria were organised in an Excel file to facilitate the analysis by the stakeholders. To elicit preference ratings for the criteria they assigned the relative importance of sub-criteria by giving 10 points in total within a superordinate criterion (up to 10 points at maximum for a single sub-criterion). For criteria ranking the judgment was also assigned by 10 points in total (see Appendix 2.3, page 81). With this type of structure it was possible to understand how important a sub-criterion (or criterion) is when compared with another.

In order to derive a cardinal ranking of **alternatives** (i.e. the seven relevant NWFPs for Alentejo; Table 18, page 29) it was necessary to contact domain experts in order to assess the relative preference of one alternative over the other by means of pairwise comparisons (Figure 17). It was necessary to compare all selected NWFPs against their preferability with regard to each sub-criterion, ensuring that the consistency ratio (CR) was always less than 0.10. As a final result the overall performance was calculated and depicts the preference ranking in relation to the weightings applied.

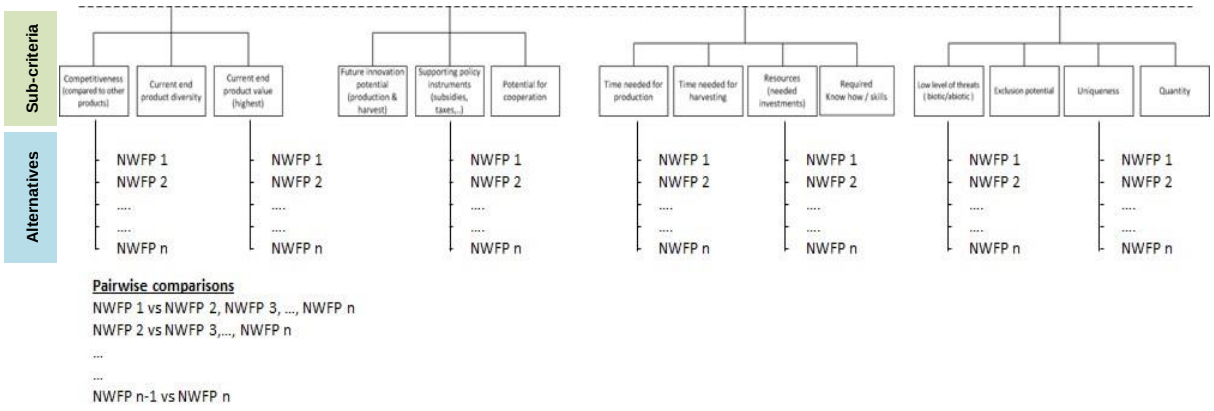


Figure 17. Example for pairwise comparison of alternatives (i.e. non-wood forest products) against Analytic Hierarchy Process sub-criteria

The complete AHP hierarchy for assessing the potential of NWFPs in Alentejo has: one goal, four criteria, 15 sub-criteria and seven alternatives (Figure 18).

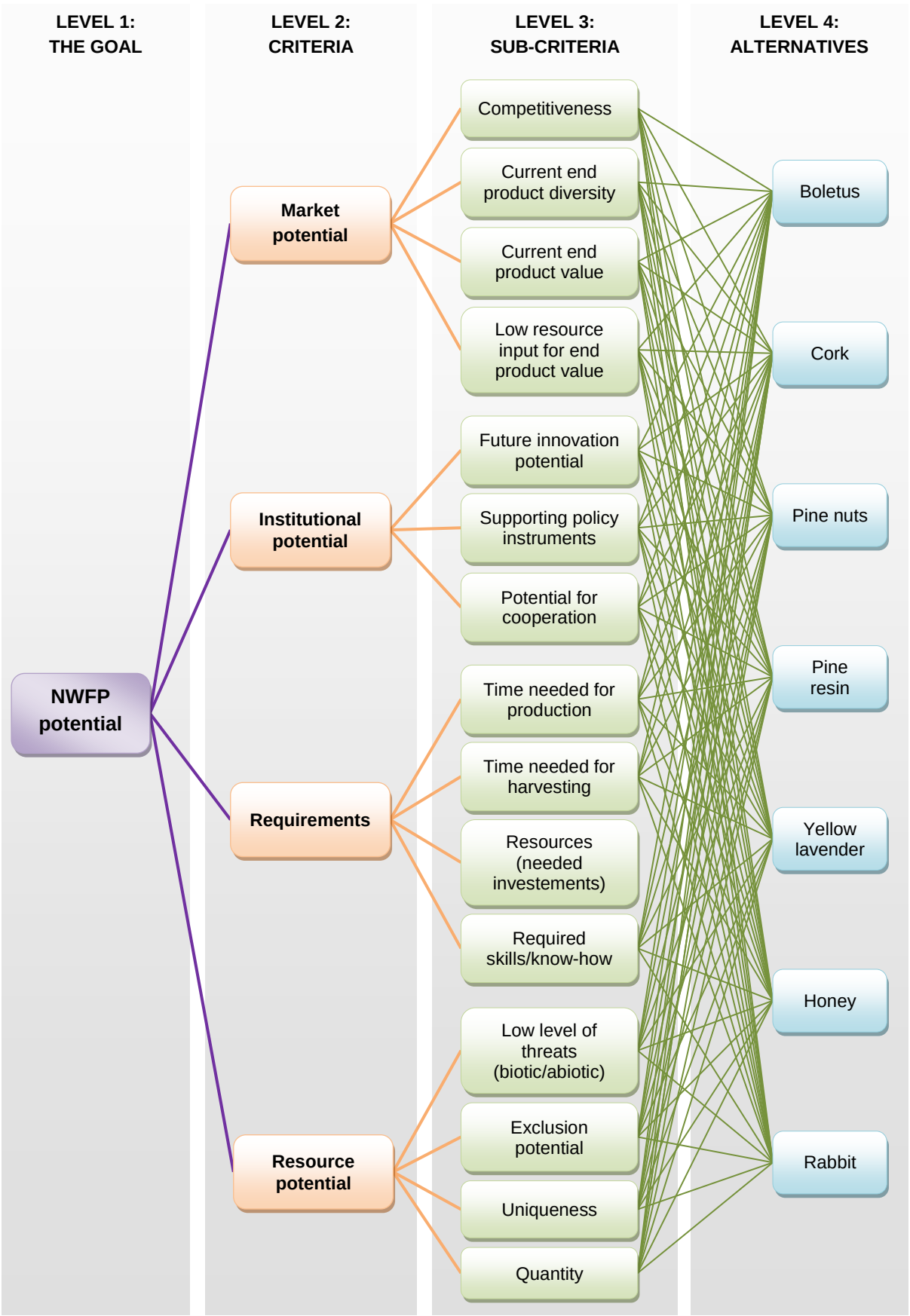


Figure 18. AHP hierarchy for the goal "Identifying the most promising NWFPs"

3.3.2. Expert panel

In order to elicit preference ratings for the criteria and sub-criteria of the AHP (i.e. derive a consensual agreement on the relative importance of both), it was necessary to engage with **regional experts**. So, we needed to identify the experts who are actively involved in NWFPs management in the region. In this study we decided to choose the 12 Portuguese stakeholders from the StarTree Regional Stakeholder Group, because they represent different NWFPs related sectors (Figure 19).

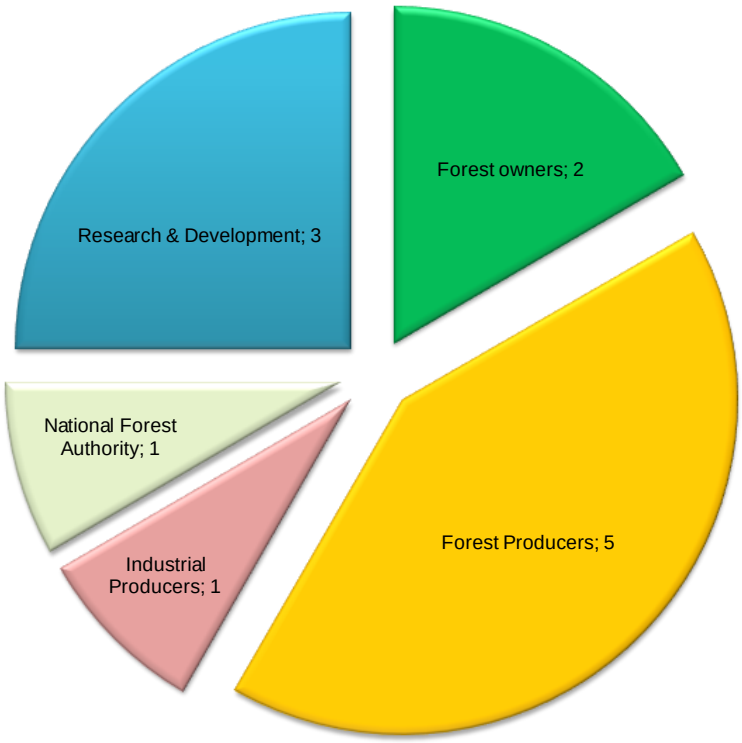


Figure 19. Distribution of stakeholders (regional experts) by type of work area

In order to derive a cardinal ranking of alternatives (i.e. the selected NWFPs) by pairwise comparisons, it was necessary to nominate **domain experts**. In this study we decided to choose two professors and two researchers from the Forest Research Centre - CEF[5].

[5] Research unit of the School of Agriculture (ISA - Instituto Superior de Agronomia).

3.3.3. Stakeholders participation process for regional weightings

For the stakeholder (regional experts) interaction, to derive regionally explicit weightings for the **criteria** and **sub-criteria** we applied the Delphi approach (see "2.2 Delphi method", page 20) because it was not possible to meet the stakeholders jointly (in a physical meeting). The stakeholders are the experts of the Delphi panel. In this method the weights of criteria and sub-criteria were assigned directly by the stakeholders. The application of the Delphi method comprised the following sequence of steps:

Step 1. **First Round Questionnaire [3 November 2015].** The questionnaire (Appendix 2, page 69) was sent by e-mail to all stakeholders.

This was followed by phone contact for clarification of the work ahead, for further description of the files, acknowledgment of the e-mail receipt, and a request for a response within two weeks (date for submission: 13 November 2015). The round was open for 21 days because of the non-respondents who received two calls and one reminder by e-mail. The documents sent and the rules for filling out the questionnaire were the following:

- **Two Word documents** (in Portuguese), a short version, with a one-page summary (Appendix 2.1, page 70) and a long version, with details (Appendix 2.2, page 71). These documents identify the objectives, a brief description of the Delphi method, an explanation of all the steps of the process (first and second rounds) and the deadline to send the questionnaire.

- **One Excel file** (Appendix 2.3, page 81) with **criteria** and **sub-criteria** for rating the relative importance (in English and Portuguese). The stakeholders were asked to judge the relative importance of each sub-criterion and criterion according to the current situation in Alentejo from their perspective. They had to enter values (their judgments) in the respective data cells following the following rules:

  a. Start with **sub-criteria** (starting here gives an overall understanding to analyse the **criteria**);

  b. Assign the relative importance of sub-criteria by giving 10 points in total within a superordinate criterion (up to 10 points maximum for a single sub-criterion).

  c. Judge the **criteria** afterwards, by assigning again 10 points in total.

Step 2. **Analysis of the first round responses [23 November 2015].** After collecting the results from all stakeholders the results were calculated, i.e. mean values per single criterion and sub-criterion across all expert judgements, and merged into a single file. This questionnaire was used as the survey instrument for the second round of judgment.

Step 3. **Second Round Questionnaire [24 November 2015].** By e-mail, a second questionnaire was sent to each stakeholder, with the results of the first round, as feedback, including their first judgment (Appendix 3, page 82). Stakeholders were asked to revise their judgments in order to provide the opportunity to adapt individual ratings according to the general perception (it is optional to adapt). The round was open for seven days (date for submission: 30 November 2015).

Step 4. **Conclusion [1 December 2015].** Collection of the second-round results and calculation of the final results (again mean values per single criterion and sub-criterion).

The weights affect the final results insofar as they put special emphasis on individual criteria and related sub-criteria (i.e. the influence on the NWFP rating is expressed according to the relative weighting of the criteria).

3.3.4. Domain experts participation process for non-wood forest products ranking

The pairwise comparisons of **alternatives** (see Table 18, page 29) follow the next steps:

Step 1. **Ranking of NWFPs by stakeholders [3 November 2015]**. During the Delphi process, with the questionnaires of the first round, the stakeholders also received a file to rank the selected NWFPs (Appendix 4, page 86). This was not originally designed to be filled in by the stakeholders, but it was an asset for the domain experts to have the NWFPs ranked. This information provided valuable insights related to stakeholders perception towards the relevance of selected NWFPs.

- The rank of each NWFP regarding their relative preference per sub-criterion needed to be indicated in numeric characters (i.e. 1 = first, 2 = second, 3 = third,..., n = least preferable).

Step 2. Preparatory exercise to the final meeting [9 December 2015]. The domain experts ranked all selected NWFPs according to their relative preference with respect to each sub-criterion.

- For this exercise the experts used an Excel file (Appendix 4, page 86) and the information from the ranking of stakeholders (regional experts) as a basis for their judgments on the pairwise comparisons.

Step 3. Final meeting to rank selected NWFPs [14 December 2015]. The domain experts had a final meeting with the coordinators of the project, Patrick Huber and Harald Vacik, who conducted the AHP pairwise comparisons process.

- The software used for the pairwise comparisons was Expert Choice.
- All selected NWFPs had to be compared in a pairwise manner regarding their preferability/suitability against each sub-criterion.
- The experts had to indicate the individual preferability of an alternative on a 9-point rating scale (see Table 2, page 12; and Table 20).
- The consistency of each pairwise comparison matrix was ensured (CR< 0.10).

Table 20. Scale of criteria comparison

1/9	**1/7**	**1/5**	**1/3**	**1**	**3**	**5**	**7**	**9**
Extreme	Very strong	Strong	Moderate	Equal	Moderate	Strong	Very strong	Extreme
LEAST IMPORTANT…							**…MORE IMPORTANT**	

Source: Nunes Junior (2006)

Step 4. Calculation of the overall performance of NWFP. Depicts the preference ranking according to the weights applied.

4. RESULTS

On the first round one of stakeholder did not respond to the questionnaire, so we had only 11 questionnaires (response rate 91.7%). On the second round, we targeted those who answered the first round questionnaire. About 45.5% of stakeholders revised their evaluations, and 54.5% maintained their judgments.

4.1. CRITERIA AND SUB-CRITERIA

For the determination of the **criteria** weights the mean ratings from stakeholders' judgments was considered, normalised to one (Table 21). The criterion **"Market potential" has the highest weight** that represents 37.3% of global priorities, and the criterion "**Institutional potential" has the lowest weight** with 15.5% of global priorities.

Table 21. Ranking of criteria in line to the weights assigned according to the level of importance

RANK	CRITERIA	WEIGHT (eigenvector)	OVERALL PRIORITY
1	Market potential	0.3727	37.3%
2	Resource potential	0.2636	26.4%
3	Requirements	0.2091	20.9%
4	Institutional potential	0.1546	15.5%
	TOTAL	**1.0000**	**100.0%**

Stakeholders assigned weights for each sub-criterion (Figure 20). For the criterion "Market potential" the sub-criterion "Low resource input for end product value" has the highest weight (28%). The criterion "Institutional potential" has the "Future innovation potential" as the sub-criterion with the highest weight (43%).

"Required skills/know-how", with 30%, is the most relevant sub-criteria under criterion "Requirements". The "Uniqueness" (35%) is the most important in the set of sub-criteria for the criterion "Resource potential".

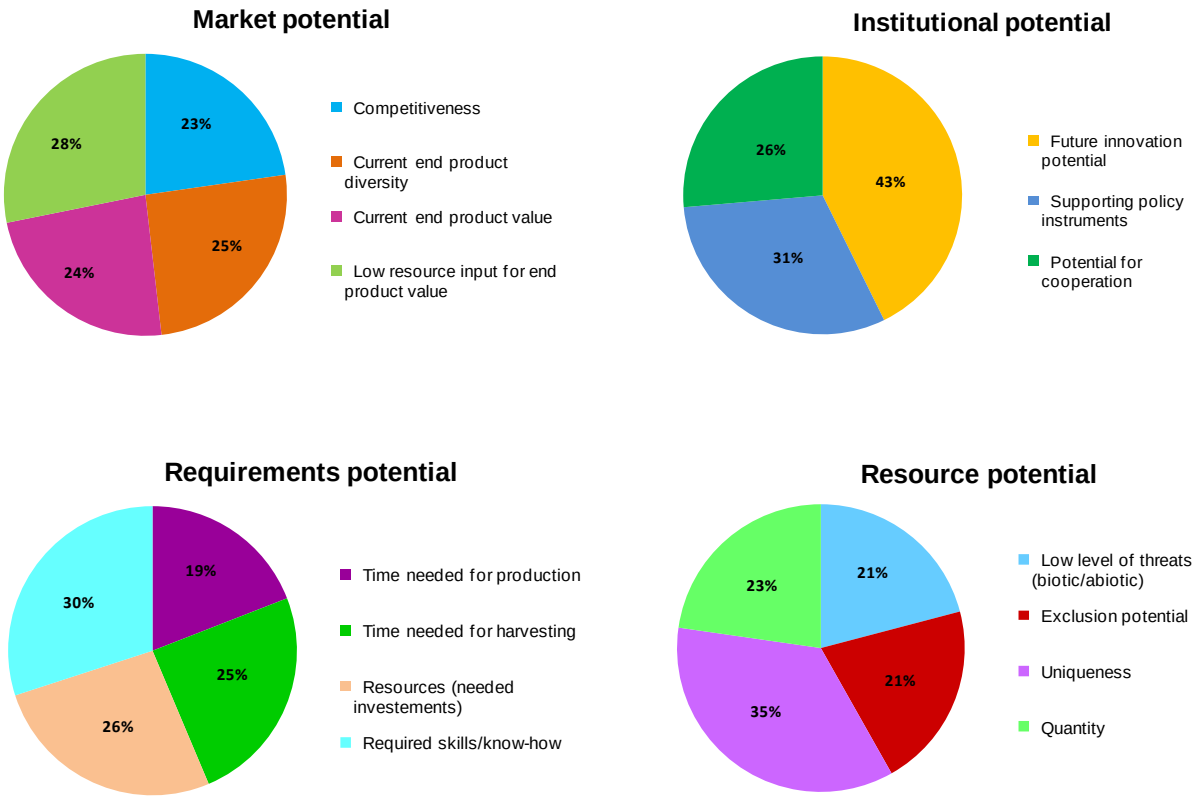


Figure 20. Weights assigned to the sub-criteria of each criterion as a result of the stakeholder's valuation in the Delphi questionnaire

The judgment weights of the **sub-criteria** needed to be adjusted according to their corresponding criterion weight. This is necessary so that each criterion is normalised to allow it to be ranked against other criteria. The weightings of sub-criteria (Figure 21) were calculated by:

a) Averaging the ratings of stakeholders judgments, normalised to one (Figure 20).

b) Multiplying the weight of criterion with its sub-criteria.

The sum of weightings in each level should be equal to 1. Appendix 5 (page 89) presents the details of criteria and sub-criteria matrices (tables and graphs).

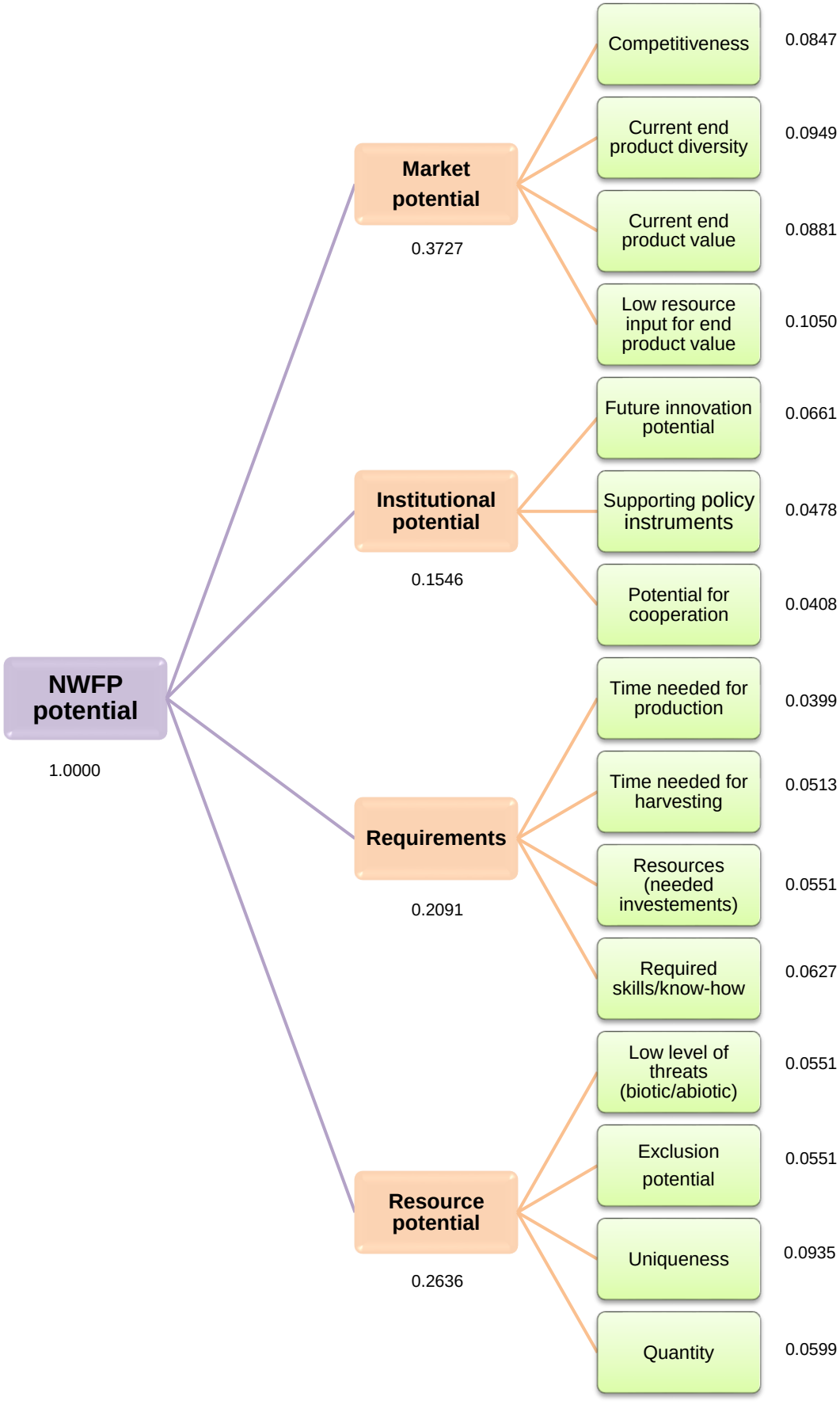


Figure 21. Resulting weighting values for criteria and sub-criteria

4.2. ALTERNATIVES

The pairwise comparisons matrices of **alternatives** (selected NWFPs), i.e. 105 pairwise comparisons with respect to all the sub-criteria, were generated in the software Expert Choice. The matrices were derived in "ideal mode"[6] format. Because the calculations were performed in Excel, the matrices were normalised to one to obtain the "distributive mode"[7] (Appendix 5, page 89). The accuracy of the weight results depends on the consistency of judgments in the pairwise comparisons. The consistency ratio (CR) was used for controlling consistency of each matrix. It was assured by a CR of all matrices below 0.10 (Table 22).

Analysing the alternatives ranking for sub-criteria, with respect to each criterion we concluded that:

- **Market potential** (Figure 22): Pine resin (39.2%) has the highest weight for "Low resource" and cork has the highest weight for the others sub-criteria, "Competitiveness", "Current end product diversity" and "Current end product value".
- **Institutional potential** (Figure 23): Cork has the highest weights for all sub-criteria.
- **Requirements** (Figure 24): Honey (26.7%) and rabbit (26.7%) have the highest weight for sub-criterion "Time needed for production"; cork (37.7%) has the highest weights for "Time needed for harvesting"; and yellow lavender has the highest weights for the other two sub-criteria, "Resources (needed investments) and "Required skills/know-how".
- **Resource potential** (Figure 25): Cork has the highest weights for all sub-criteria except "Low level of threats (biotic/ abiotic)" which is yellow lavender (33.3%). Pine nuts and pine resin have the same weights as cork (25.8%) for the sub-criterion "Exclusion potential".

[6] The "ideal mode" compares each performance score to a fixed benchmark such as the performance of the best alternative under that criterion. This means that with the "ideal mode" the preference for any given alternative is independent of the performance of other alternatives, except for the alternative selected as a benchmark (Saaty & Vargas, 2012).

[7] The "distributive mode" produces preference scores by normalising the performance scores; it takes the performance score received by each alternative and divides it by the sum of performance scores of all alternatives under that criterion. This means that with the "distributive mode" the preference for any given alternative would go up if we reduce the performance score of another alternative or remove some alternatives (Saaty & Vargas, 2012).

Table 22. Consistency ratio of alternatives pairwise comparisons for each sub-criterion

CRITERIA	SUB-CRITERIA	CONSISTENCY RATIO (CR)
Market potential	Competitiveness	0.08
	Current end product diversity	0.04
	Current end product value	0.04
	Low resource input for end product value	0.01
Institutional potential	Future innovation potential	0.03
	Supporting policy instruments	0.04
	Potential for cooperation	0.03
Requirements	Time needed for production	0.05
	Time needed for harvesting	0.06
	Resources (needed investments)	0.08
	Required skills/know-how	0.05
Resource potential	Low level of threats (biotic/abiotic)	0.04
	Exclusion potential	0.03
	Uniqueness	0.02
	Quantity	0.09

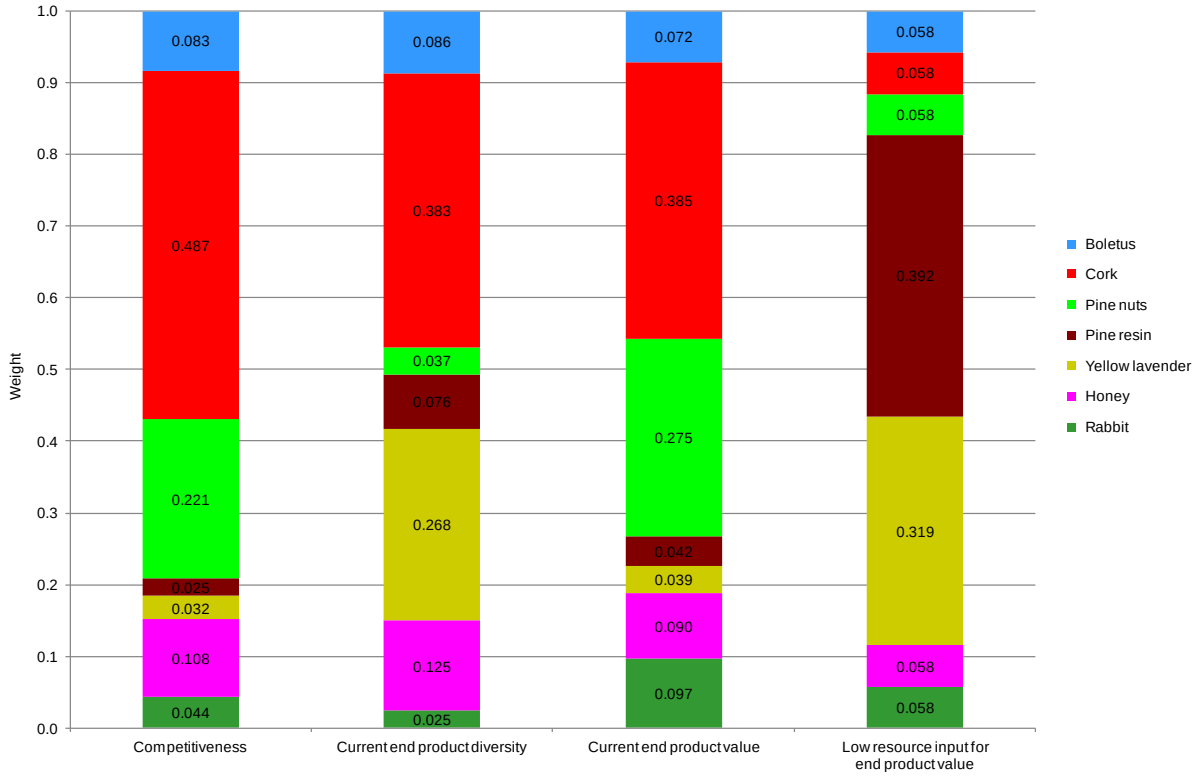


Figure 22. Ranking of non-wood forest products derived via pairwise comparisons across sub-criteria with respect to criteria "Market potential"

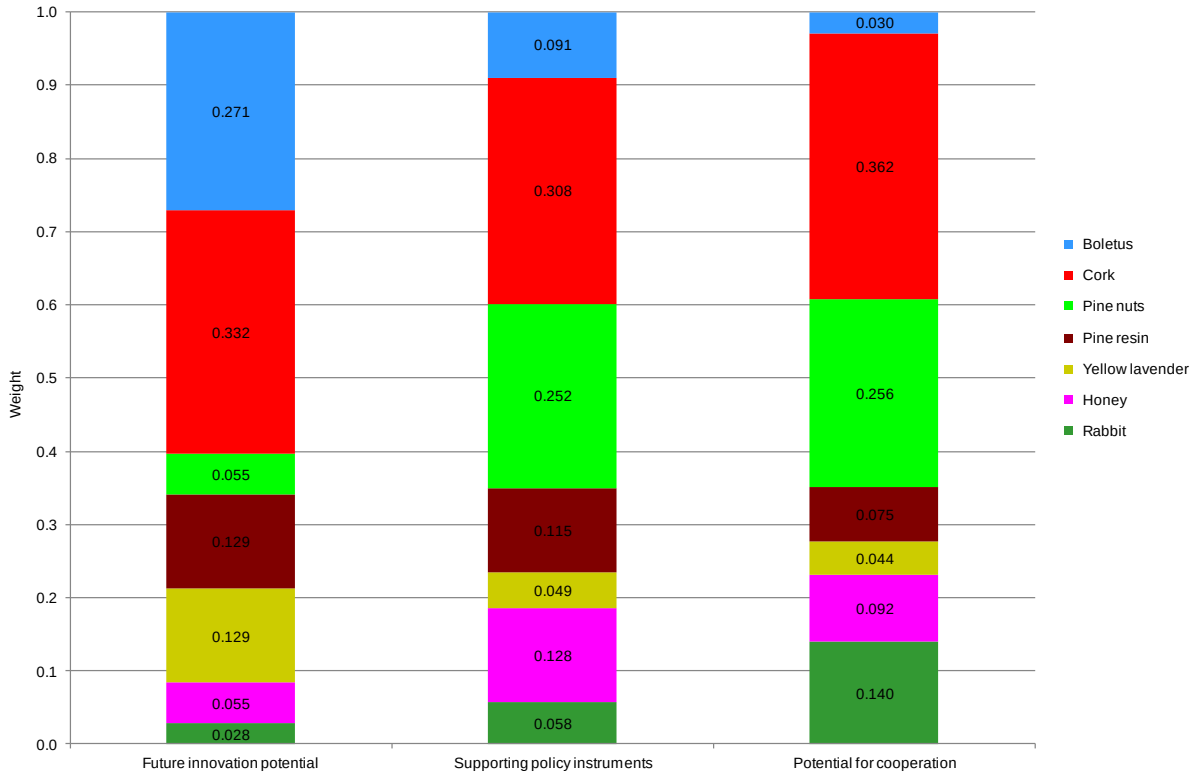


Figure 23. Ranking of non-wood forest products derived via pairwise comparisons across sub-criteria with respect to criteria "Institutional potential"

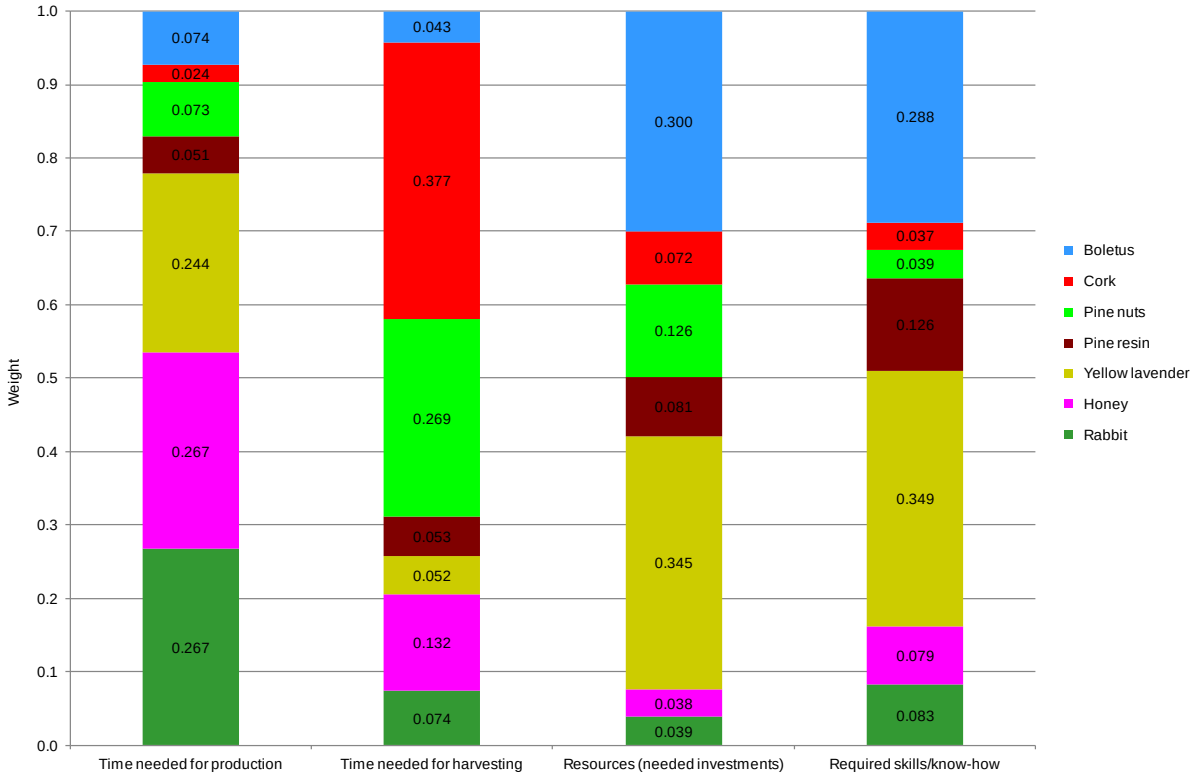


Figure 24. Ranking of non-wood forest products derived via pairwise comparisons across sub-criteria with respect to criteria "Requirements"

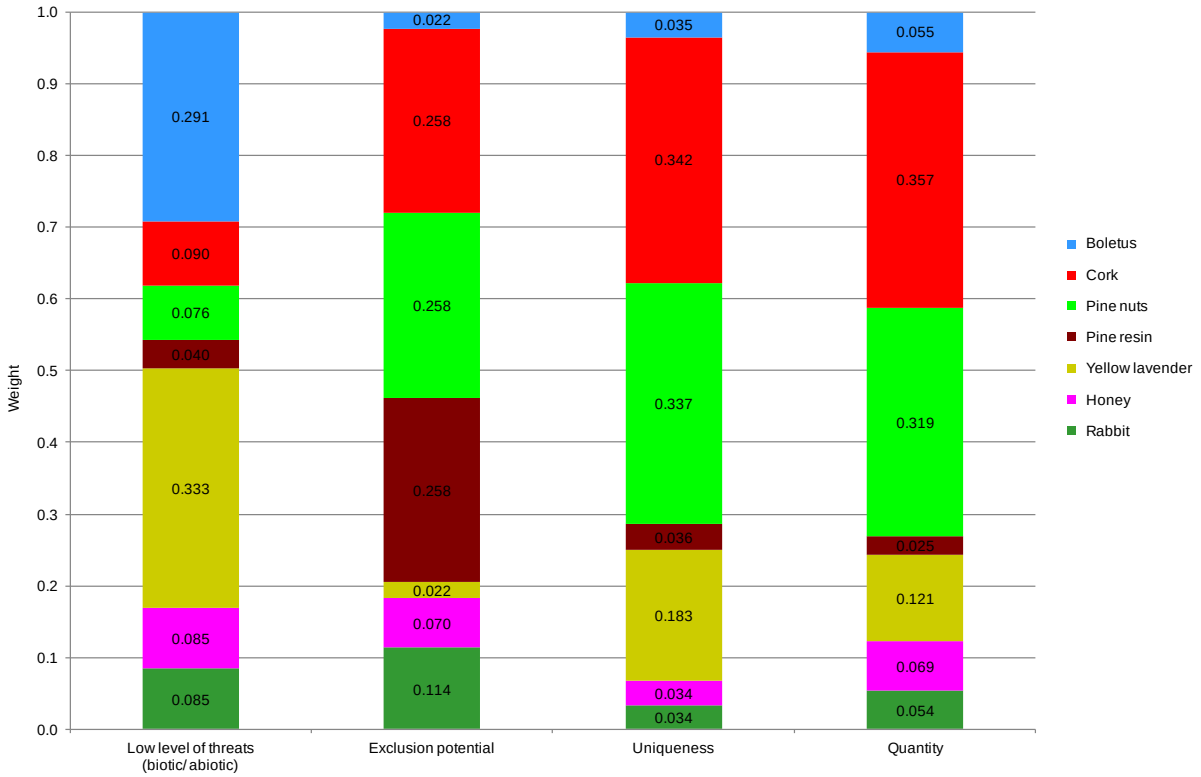


Figure 25. Ranking of non-wood forest products derived via pairwise comparisons across sub-criteria with respect to criteria "Resource potential"

4.3. SYNTHESIS ANALYSIS

Once judgments have been entered for each part of the model, the information was synthesised to achieve an overall preference. The selected NWFPs were ranked according to their performance with regard to criteria, i.e. summarised for the criteria and finally also for the overall goal. The result was a ranking of the alternatives in relation to the overall goal (Table 23). The product **cork has the highest weight (eigenvector) that represents 27.0% of overall priorities**. In a second level of importance we found pine nuts (17.6%) and yellow lavender (16.8%), with about 10% difference to the product cork; boletus (11.2%) and pine resin (10.6%). **Honey (9.3%) and rabbit (7.6%) have the lowest priorities out of analysed NWFPs**; the difference to cork is almost 20%.

Table 23. Ranking of non-wood forest products in line to the pairwise comparisons assigned according to the level of importance

RANK	NON-WOOD FOREST PRODUCT	WEIGHT (eigenvector)	OVERALL PRIORITY
1	Cork	0.2695	27.0%
2	Pine nuts	0.1757	17.6%
3	Yellow lavender	0.1680	16.8%
4	Boletus	0.1115	11.2%
5	Pine resin	0.1062	10.6%
6	Honey	0.0935	9.3%
7	Rabbit	0.0756	7.6%
	TOTAL	**1.0000**	**100.0%**

Analysing the performance of NWFPs (Figure 26) considering the criteria weight (see Table 21, page 42), we can concluded that: "Market potential" is the highest priority criterion for cork, yellow lavender, pine resin and honey. "Resource potential" is important for pine nuts, while "Requirements" is the priority for boletus and rabbit. According to the aggregate rating of each NWFP per criterion, normalised to one (Figure 27), the highest priorities for the criterion "Market potential" are cork (32.8%) and yellow lavender (16.5%). For "Institutional potential" are cork (33.4%) and pine nuts (18.8%), while for "Requirements" the highest priorities are the yellow lavender (24.7%) and boletus (17.6%). For "Resource potential" cork (26.6%) and pine nuts (24.7%) have the highest priorities.

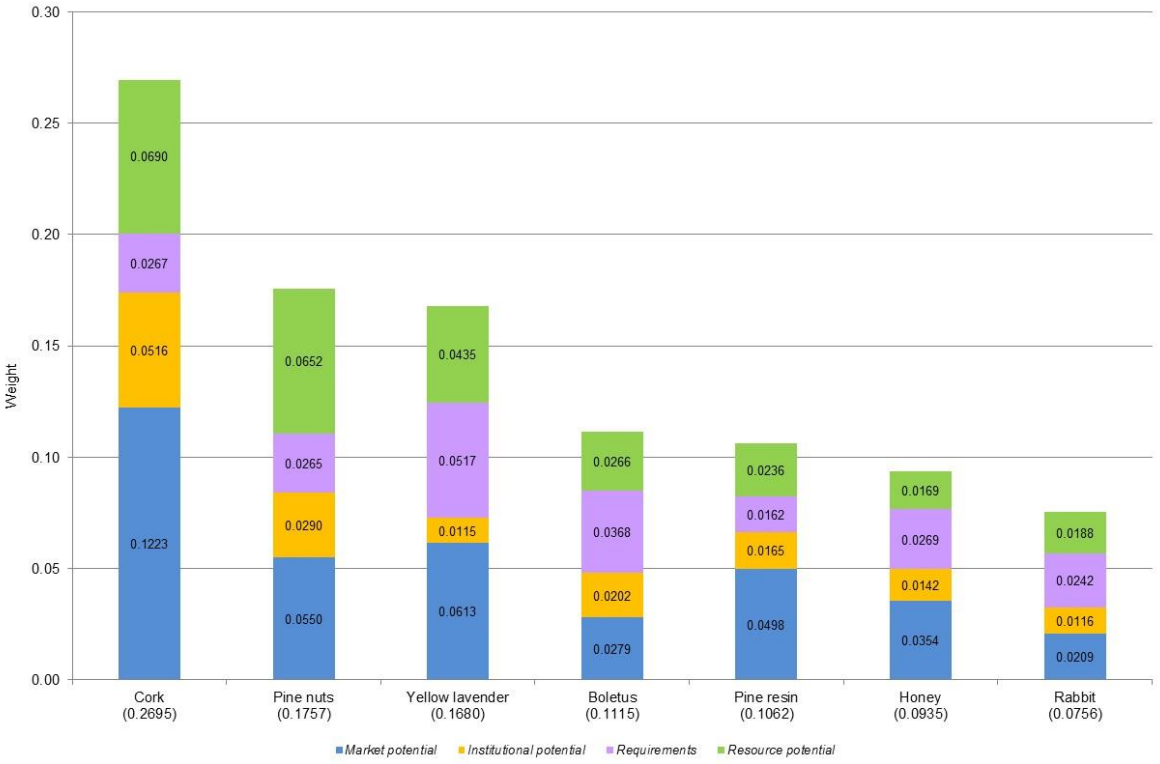


Figure 26. Overall performance of non-wood forest products in Alentejo

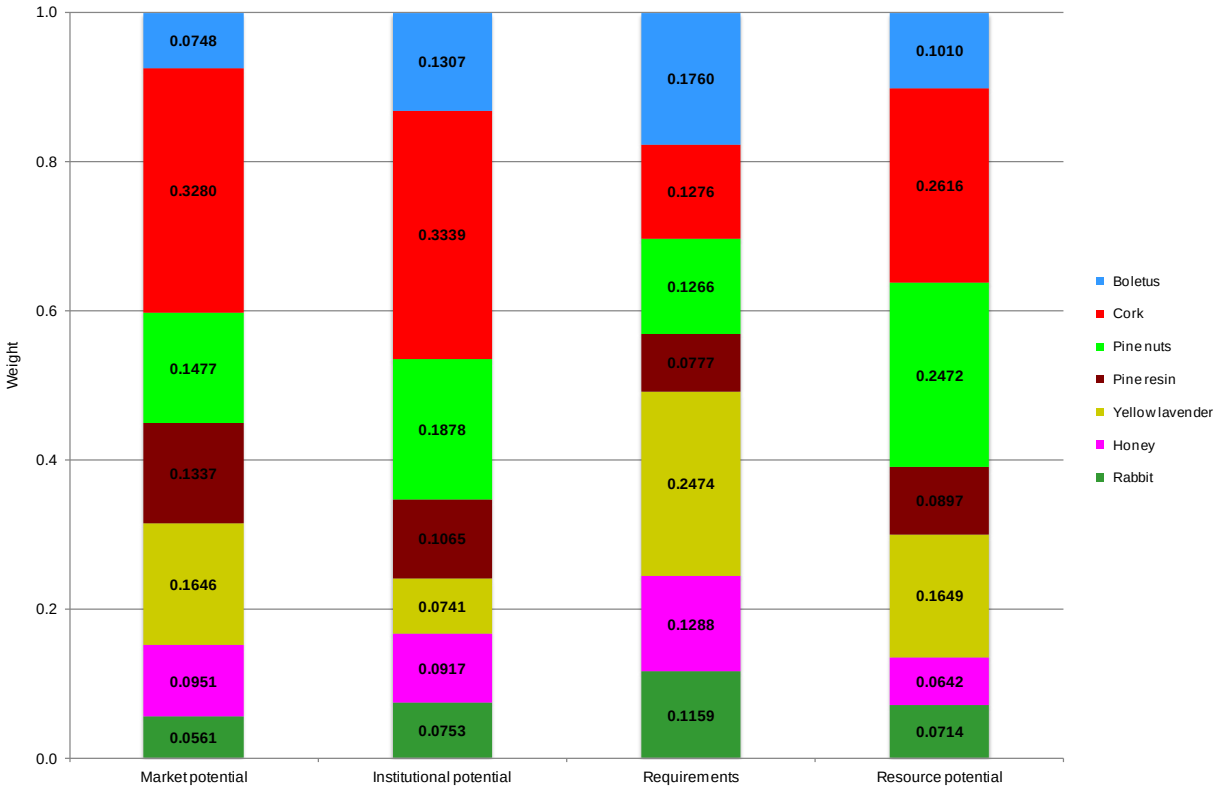


Figure 27. Relative importance of non-wood forest products in each criterion

A **sensitivity analysis** was performed to determine how well the alternatives performed with respect to each of the criterion, as well as how sensitive the alternatives are to changes in the importance of the criteria. If the ranking does not change the results are said to be robust. The sensitivity analysis of the selected NWFPs (alternatives) was performed with the software Expert Choice, with an interactive graphical interface (Figure 28).

The performance sensitivity displays the relative importance of each criterion as vertical bars. The relative preference for each alternative (NWFPs) with respect to each of the criteria is depicted by the intersection of the alternatives line segments with the vertical line at each of the criterion. The overall alternative preferences are shown at the right. The sum of these overall scores is equal to one, in accordance with the AHP methodology.

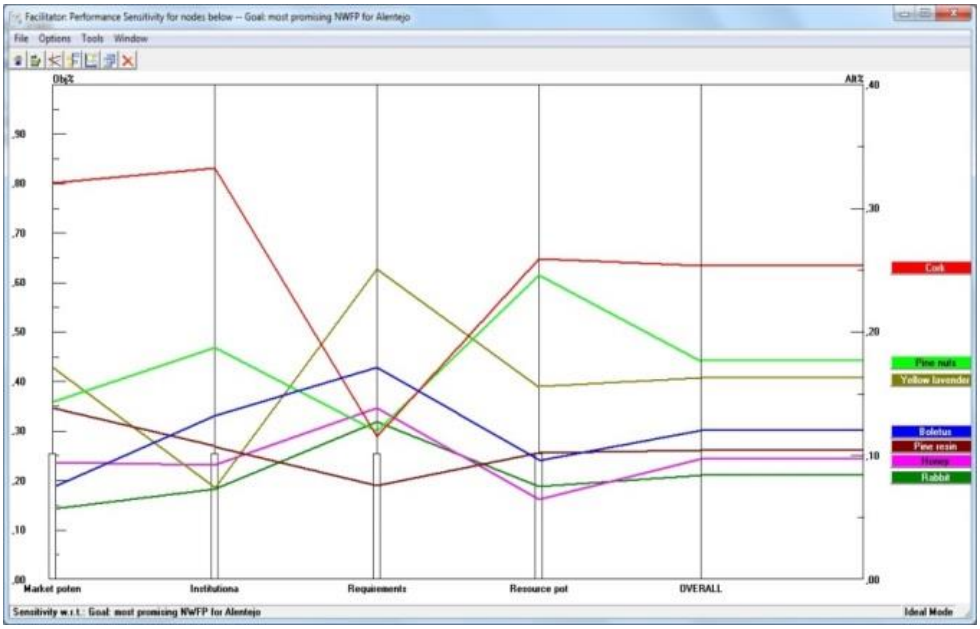
As with all AHP priorities, these priorities are ratio scale priorities meaning that not only do the priorities show order, but differences and ratios are meaningful as well. The criteria weights affect the overall performance of alternatives. We analysed two scenarios (Figure 28):

a) All criteria have equal weights.

b) Criteria weighted by stakeholders interaction (unequal weights).

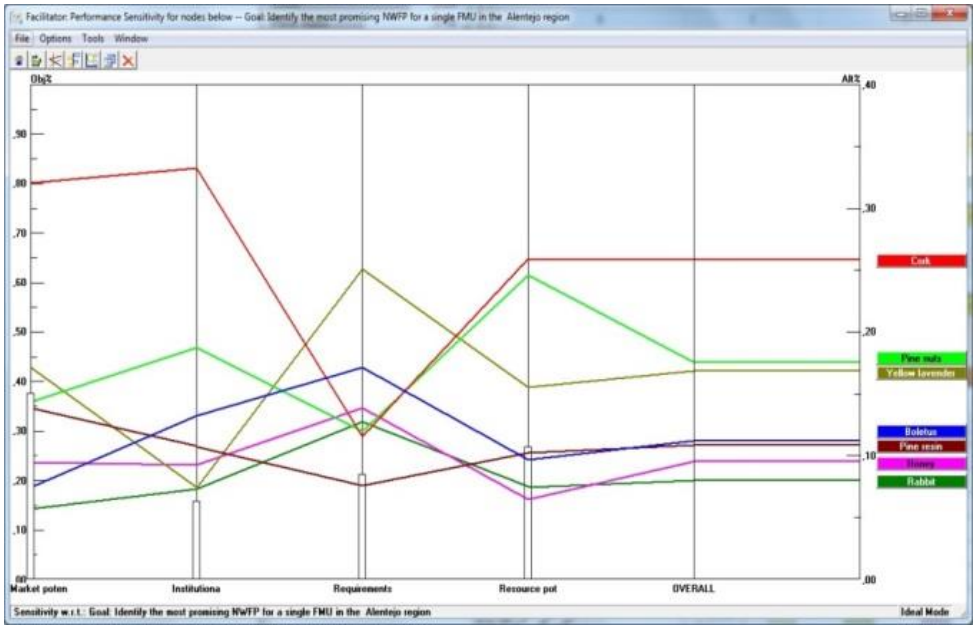
In both scenarios the ranking is the same; cork is the NWFP with best potential overall priority while the rabbit is in the opposite position. However, in scenario b) the yellow lavender has a higher weight; cork and pine resin have a small increase; boletus has a lower weight; rabbit has a slight decrease. The impact of criteria weights in pine nuts and honey are negligible. So, **yellow lavender and boletus are the NWFPs whose importance is most affected by the values of criteria weights**.

a) EQUAL WEIGHTS **RANKING**



1. Cork
2. Pine nuts
3. Yellow lavender
4. Boletus
5. Pine resin
6. Honey
7. Rabbit

b) WEIGHTED (STAKEHOLDERS INTERACTION) **RANKING**



1. Cork
2. Pine nuts
3. Yellow lavender
4. Boletus
5. Pine resin
6. Honey
7. Rabbit

Figure 28. Rankings and individual performances of selected non-wood forest products across criteria under a) "equal weights" and b) "weighted (stakeholder's interaction)" scenarios

5. DISCUSSION AND CONCLUSIONS

In this study, we developed and presented an expert model approach for assessing the potential of seven regionally relevant NWFPs (boletus, cork, pine nuts, pine resin, yellow lavender, honey and rabbit) in Alentejo. This region is located in southern Portugal and extends over 3 million ha. This approach was based on the AHP, a helpful tool for MCDM, and the Delphi method. The judgments were provided by stakeholders (regional experts) and domain experts.

The AHP is useful in synthesising information and results from various analyses and perspectives, in order to make better decisions under conditions of uncertainty. The AHP facilitated the hierarchical structuring of goal-oriented decision (NWFP potential), divided into four criteria, defined concepts of the criteria listed in 15 sub-criteria, and their possible solutions of seven alternatives. The main advantage of the AHP is its ability to rank choices in the order of their effectiveness in meeting conflicting goals. This process allows the decision maker to better understand his/her problem. The further strength of the AHP is its ability to detect inconsistent judgments.

The Delphi method is a research approach to gain consensus using a series of questionnaires and the provision of feedback to participants who have expertise in key areas. This method is especially useful when researchers need to collect ideas from isolated experts on a specific topic and establish agreement to discover the underlying assumptions or perspectives among the experts (Habibi, et al., 2014). We used the Delphi method to collect the judgments (weighting) about criteria and sub-criteria from 12 stakeholders.

For collecting the weighting about the AHP alternatives, four domain experts were asked to make their judgments via pairwise comparisons of selected NWFPs per sub-criteria. It was accomplished using the software Expert Choice. The consistency ratio of all pairwise comparisons matrix was below 0.10.

The final ranking of criteria showed that **"Market potential"** has the highest priority (37.3%) overall. The experts considered as a priority the current market potential of NWFPs and the potential opportunities to market them at different markets level (i.e. on local, regional, national and international). Regarding sub-criteria, the experts assigned the highest weight to the "Low resource input for end product value", i.e. the raw material efficiency, highlighting pine resin and yellow lavender. The cork has the highest weight in all other sub-criteria. Cork and yellow lavender were considered as the most diverse products in terms of end products that can be derived from them.

For criterion **"Resource potential"** (26.4% priority), the sub-criterion "Uniqueness" is the one with the highest weight. The experts considered cork and pine nuts to be regionally more unique compared to the national availability. These two NWFPs are mainly produced in the Alentejo. Furthermore, cork and pine nuts are the products with the highest production cycle (in terms of "Quantity") and pine resin has a lower quantity of production. Concerning threats (biotic/abiotic), yellow lavender and boletus are considered the products with a low level compared to the other NWFPs. The tree products (cork, pine nuts and pine resin) are the ones with high "Exclusion potential", i.e. the general public is excluded from access, harvest and property rights of these products. Boletus and yellow lavender are accessible to the general public.

The criterion **"Requirements"** (20.9% priority) has the sub-criteria "Required skills/know-how" with the highest weight, in particular for yellow lavender and boletus. There is little information available on these two products. Boletus (and mushrooms in general) research related to an integrated forest management is just beginning. For yellow lavender, the research work about its utilisation and production is scarce. Concerning the "Time needed for production" the products with less production time are honey, rabbit and yellow lavender; on the other hand, cork requires a longer production time. The "Time needed for harvesting" is bigger for cork and less for boletus, pine resin and yellow lavender.

The stakeholders have assigned to **"Institutional potential"** of a lower priority (15.5%) relative to other criteria. Cork has the highest weights in all sub-criteria ("Future innovation potential", "Supporting policy instruments" and "Potential for cooperation"). Out of all NWFPs, cork is being fostered by policy instruments that support the production and harvesting, as well as incentives to increase the yield and planted area.

The final ranking, determined by the AHP method, showed that **the three NWFPs with highest potential in Alentejo are cork, pine nuts and yellow lavender**. In a second level of importance we found boletus, pine resin, honey and rabbit. These results further reinforce cork as the product with the greatest potential in the Alentejo. However it appears that yellow lavender has a significant potential and could be seen as an opportunity for forest owners to diversify their product portfolio. This product has almost the same weight of pine nuts, which is a product already exploited on a large scale in the region. Game meat from rabbit is the NWFP with the lowest weight in the ranking; this is probably because its hunt is limited to concession hunting areas and, in some cases, not having a direct financial return for forest owners.

The sensitivity analysis indicates that the final rankings of the selected NWFPs might change if the criteria are weighted differently. The model is robust because, in general, the ranking of NWFPs did not change much with the weights of the criteria, given by the regional experts. **Yellow lavender and boletus are the NWFPs most affected by the criteria weights**.

Results demonstrated the potential of the AHP model as a tool to provide forest owners/decision makers with information about the NWFPs to develop – also – management strategies or to engage in related businesses. This could be: a) diversification of their product portfolio on a sustainable economic perspective; b) distribution of socio-economic risks; c) contribution to biodiversity conservation; d) an alternative strategic like a speciality, a market niche product; e) promotion of NWFPs as complementary synergy with the other products or services (tourism, recreation), i.e. other economic operators.

The purpose was to apply a method to obtain results useful for forest owners to evaluate the potential of NWFPs, and to make more informed and better decisions.

Overall, AHP and Delphi met the objectives of this research. Results demonstrated that employing AHP is a useful way to deal with complex decisions. The AHP technique is accepted as a useful means because it is flexible and allows the participation of different interest groups and experts in the decision-making process. The results also show that AHP can incorporate experts' participation in decision making and increase the transparency and the credibility of the process.

The methodological approach proposed seems attractive, at least for the following reasons. First, it is of practical interest to different groups (forest owners, forest owners' associations, forestry consultants and researchers). Second, the solutions generated by the model can be easily interpreted in utility terms. Thirdly, it is relatively easy to interact with a forest owner/ decision-maker, experts or groups of decision makers in order to derive the weights reflecting the corresponding preferences. Fourth, it is expeditious and low-cost, because it does not require a major financial effort to be applied.

Following the work of this dissertation, the development of this methodology would be of great relevance in other regions of Portugal, for different NWFPs. The results could become important for forest owners, rural populations, associations of forest producers, researchers, and contribute to bio-economy developments.

For future research, it would be interesting to select yellow lavender, the least explored product in the region, but one of top three, and obtain more accurate data about this product. This could be achieved by applying the methodology of this research specifically to yellow lavender, with its own AHP structure: goal – criteria – sub-criteria – alternatives. The indicators of each level could be defined with the support of regional stakeholders who may be interested in developing products from yellow lavender, researching it, or in other uses from this understory plant. Yellow lavender could be an interesting niche product to explore.

Other improvements that can be made for researching the NWFPs in Alentejo more thoroughly, or in other regions, is the simultaneous use of decision support techniques such as a Geographic Information System (GIS) and AHP, or Geostatistics and AHP. With these techniques we could get spatial accuracy, e.g. about the criteria studied (market, requirements) related to NWFPs potential. In the literature, there are many applications of these joint techniques (e.g. Itami & MacLaren, 2001; Temiz & Tecim, 2009; Martins et al., 2011; Poirazidis et al., 2012; Klobucar & Pernar, 2012).

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APPENDICES

APPENDIX 1. CRITERIA (C) AND SUB-CRITERIA (SC) OF AHP STRUCTURE

C 1. MARKET POTENTIAL

Indicates the current market potential of a distinct NWFP and synthesizes existing opportunities to market them (i.e. on local, regional, national, international [European] markets). It consists of:

SC 1.1. COMPETITIVENESS [the higher the better] - European level

Expresses how competitive a single NWFP (i.e. the raw material, not the potential end products) is compared to other products, i.e. substitutes (e.g. organic tannins vs fossil fuel based ones), derivates (e.g. wild berries vs cultivated berries) , other products in the same category (e.g. wild fruits vs fruits in general).

SC 1.2. CURRENT END PRODUCT DIVERSITY [the higher the better]

Reflects the portfolio of final products that can be derived out of a single NWFP (e.g. berries can be marketed raw or processed [e.g. dried, powder, jam, mash, liquor,…]).

SC 1.3. CURRENT END PRODUCT VALUE [the higher the better] – European level

Assesses the range of value added for a single NWFP (e.g. berries sold raw on local markets á € 10/kg and berries sold as distilled liquid for € 70/litre), i.e. the highest price that can be achieved for a distinct end product derived out of a NWFP taking into account its market share on national markets (e.g. high price but low market share would be less preferable than lower price but high market share).

SC 1.4. LOW RESOURCE INPUT FOR END PRODUCT VALUE [the higher the "low resource input" the better]

Considers the raw material input required to generate the respective end product value and mirrors raw material efficiency (i.e. how much of the resource is needed in order to produce a certain output) - it thus relates to the end product assessed under criterion "Current end product value" (e.g. berries sold as distilled liquid = around 40 %, berries sold as powder = 100 %).

C 2. INSTITUTIONAL POTENTIAL

Depicts the institutional potential with regard to a single NWFP and mirrors supportive institutional structures by:

SC 2.1. FUTURE INNOVATION POTENTIAL [the higher the better]

Focuses on the future innovation potential (i.e. within the next 10 years) for production and/or harvesting processes taking into account the current state of knowledge (e.g. new machinery to harvest mushrooms – is it realistic to be implemented within the next 10 years?; cultivation of wild mushrooms – is it realistic to produce *Boletus* on straw within the next 10 years?).

SC 2.2. SUPPORTING POLICY INSTRUMENTS [the more available the better] – European level

Pinpoints existing economic policy instruments that support the production/harvesting of NWFP, like subsidies, taxes, incentives,.. (e.g. LEADER supports projects that foster regional development and was used to create NWFP businesses; tax exemption for NWFP pickers).

SC 2.3. POTENTIAL FOR COOPERATION [the higher the better]

Estimates the current potential to cooperate with other actors in the same field (e.g. association of cork producers provides support for its members).

C 3. REQUIREMENTS

Highlights necessities for NWFP production and harvesting and is split into:

SC 3.1. TIME NEEDED FOR PRODUCTION [the less the better]

Indicates how time consuming the production of a single NWFP may be (e.g. artificial introduction and thus planting, tending,…) – also taking into account the rotation period (i.e. how long it takes to harvest the NWFP for the first time) initiating the production from bare land (but: assuming it was forest land before).

SC 3.2. TIME NEEDED FOR HARVESTING [the less the better]

Mirrors the time needed to harvest a single NWFP in relation to the yield/working hours and only considers the harvesting process (e.g. manually harvest mushrooms, harvest machinery for wild fruits, shoot game).

SC 3.3. RESOURCES (NEEDED INVESTMENTS) [the less the better]

Depicts how much resources would be needed for the management (i.e. production and harvesting as outlined above) of a single NWFP (e.g. mushrooms=knife, basket; game=hunting license, weapon, munitions, car, dogs; honey= beehive, beekeeper´s equipment, honey separator), assuming to start from scratch (everything has to be purchased).

SC 3.4. REQUIRED SKILLS/KNOW-HOW [the less the better]

Estimates the level of knowledge necessary to successfully produce/harvest a single NWFP (e.g. mushrooms = how to sustainably harvest them; game = legal framework, hunting exam, species dependent know-how,…).

C 4. RESOURCE POTENTIAL

Gives an estimate on the potential to successfully produce and/or harvest a single NWFP and comprises of:

SC 4.1. LOW LEVEL OF THREATS (BIOTIC/ABIOTIC) [the "higher" the low-level the better]

Relates to biotic and/or abiotic risks with regard to a single NWFP (e.g. chestnut = chestnut blight, gall wesp, ?; honey = varroa mite, pesticides/insecticides, ?).

SC 4.2. EXCLUSION POTENTIAL [the higher the better]

Indicates the potential to exclude others (i.e. the general public) from production/harvesting of a single NWFP and thus relates to access, harvest and property rights (e.g. berries are a common good in Finland and can be harvested by everybody; berries in Austria may be picked for personal use but the owner has the right to exclude the general public from picking).

SC 4.3. UNIQUENESS [the higher the better]

Refers to the uniqueness of a single NWFP and mirrors ecological aspects (e.g. endemic species -> how unique is the regional availability/existence of the resource compared to the national availability/existence).

SC 4.4. QUANTITY [the higher the better]

Reflects how much of a single NWFP can be produced within one production cycle on a defined spatial scale (i.e. within the region under consideration) and relates to the regional potential of a single NWFP (e.g. the potential to produce bilberry in N-Karelia is quite high – the potential for birch sap even higher); assessing the (practical) realisable potential.

APPENDIX 2. FILES SENT TO STAKEHOLDERS (FIRST ROUND)

Appendix 2.1. Word document (short version), with instructions

AVALIAÇÃO DO POTENCIAL DOS PRODUTOS FLORESTAIS NÃO LENHOSOS (NWFP) PARA OS PROPRIETÁRIOS FLORESTAIS NO ALENTEJO

Objetivo: Avaliação conjunta da importância dos critérios AHP (Analytic Hierarchy Process)

O AHP destina-se a uma avaliação dos produtos florestais não lenhosos, também designado por NWFP (Non-Wood Forest Products) regionalmente relevantes no Alentejo, de acordo com um conjunto de critérios selecionados. A adequação dos diferentes NWFP será obtida por meio da aplicação do método de comparações de pares a ser realizado em cooperação com especialistas nesta área temática.

Para espelhar diferentes ambientes ecológicos e socioeconómicos é necessário o desenvolvimento de cenários de ponderação regional explícitos para os critérios de "Potencial de mercado", "Potencial Institucional", "Requisitos" e "Recurso potencial". O principal objetivo é destacar a relevância de cada critério na região do Alentejo e descrever a sua importância atual para a produção sustentável de NWFP. Os pesos atribuídos afetam os resultados finais, na medida em que colocam especial ênfase em critérios individuais e respetivos subcritérios (ou seja, a influência na classificação dos NWFP é expresso de acordo com a ponderação relativa dos critérios).

Desta forma, **solicitamos a sua participação na atribuição da importância relativa de cada critério e subcritério de acordo com a situação atual no Alentejo, a partir da sua perspetiva** (ver ficheiro excel "1_AHP_Delphi_Alentejo_SH1.xlsx"). Neste questionário, deverá analisar o conjunto dos NWFP e não um individualmente. Agradecemos que tenha em consideração as seguintes regras:

1. .Iniciar com o inquérito com os "subcritérios".
2. Atribuir 10 pontos no total, considerando um critério hierárquico de importância (deverá atribuir uma classificação entre 0 e 10 pontos no máximo por subcritério, considerando que a soma do conjunto dos subcritérios por critério não deverá ser superior a 10). Preencher apenas as células que se encontram amarelo.
3. A seguir, analisar os "critérios", atribuindo novamente uma pontuação total de 10 pontos a distribuir entre os quatro "critérios".
4. Para critério e subcritério encontra-se uma explicação detalhada (passar o rato no canto superior direito de cada célula).
5. No final, salve os dados e envie o ficheiro excel por email para: marlenegm@isa.ulisboa.pt

Assim que todos os questionários sejam rececionados estes serão agregados num único ficheiro o qual será enviado a todos os participantes para uma segunda ronda de julgamento, juntamente com o questionário de resposta da primeira ronda. Nesta segunda avaliação será livre para reconsiderar as suas avaliações e adotá-las para a síntese final, que irá então contribuir para o cenário de ponderação para a região do Alentejo.

Solicita-se o envio do ficheiro até ***13 de novembro de 2015***

Os nossos sinceros agradecimentos pelo seu apoio e colaboração.

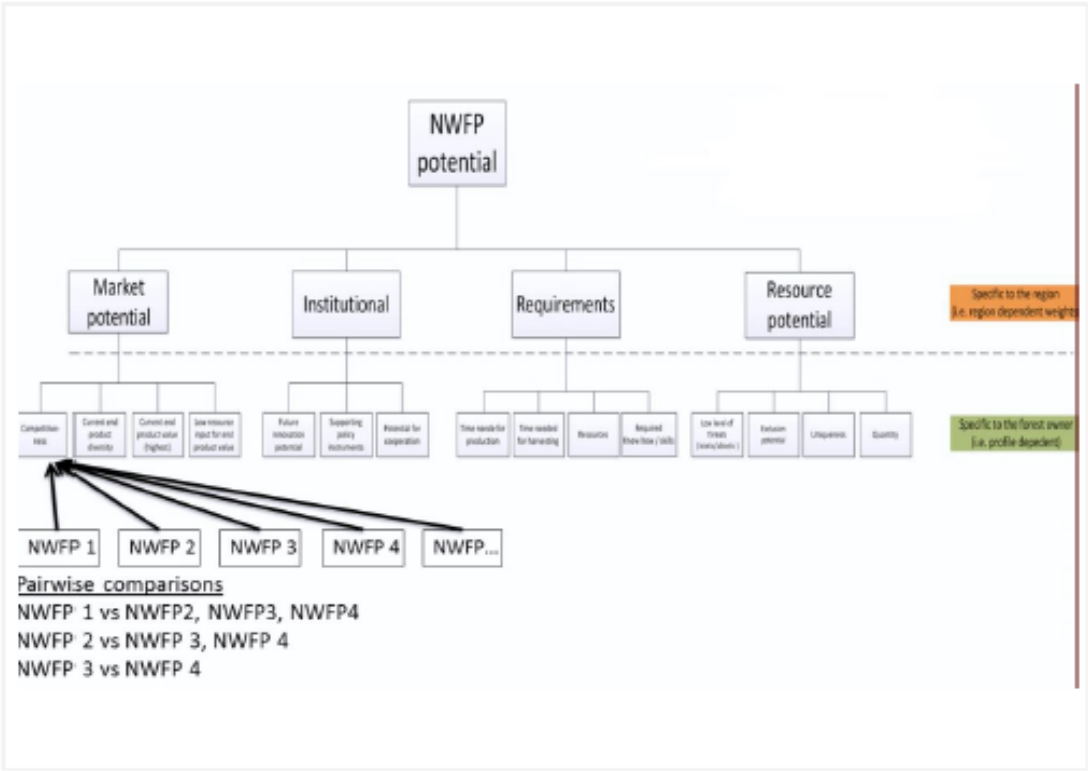
Appendix 2.2. Word document (long version), with detailed explanations of Delphi method and instructions to follow on rating criteria and sub-criteria

Universidade de Lisboa - Instituto Superior de Agronomia

Centro de Estudos Florestais

Avaliação do potencial dos produtos florestais não lenhosos (NWFP) para os proprietários florestais no Alentejo

Marlene Marques, José Guilherme Borges, Margarida Tomé e Luís Fontes



ForChange Forest Ecosystem Management under Global Change

November 2015 Versão 1.0 Questionário Técnico n.º 07/2015

Como citar este Relatório:

Marques, M., Borges, J. G., Tomé, M., Fontes, L. 2015. Avaliação do potencial dos produtos florestais não lenhosos (NWFP) para os proprietários florestais no Alentejo. ForChange Publications - Questionário Técnico n.º 07/2015 (Versão 1.0). Universidade de Lisboa, Instituto Superior de Agronomia, Centro de Estudos Florestais. Lisboa. 9 p.

Título resumido:

Potencial dos NWFP no Alentejo

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ACRÓNIMOS

AHP - Analytic Hierarchy Process

FMU - Forest Management Unit

NWFP – Non-Wood Forest Products

INTRODUÇÃO

Os julgamentos humanos e não apenas informações numéricas podem ser usados na tomada de decisão. O uso do AHP (Analytic Hierarchy Process) como método de tomada de decisão traz vantagens singulares quando elementos importantes da decisão são difíceis de quantificar e comparar.

O AHP converte julgamentos em valores numéricos que podem ser processados e comparados sobre toda a extensão do problema. Um peso numérico, ou prioridade, é derivado para cada elemento da hierarquia, permitindo que elementos distintos e frequentemente incomensuráveis sejam comparados entre si de maneira racional e consistente. Na etapa final, as prioridades numéricas são derivadas para cada uma das alternativas de decisão.

No âmbito do WP2 do projeto StarTree pretende-se aplicar o método AHP com o objetivo de avaliar produtos florestais não lenhosos, também designado por NWFP (Non-Wood Forest Products) regionalmente relevantes no Alentejo, de acordo com um conjunto de critérios selecionados. A adequação dos diferentes NWFP será obtida por meio da aplicação do método de comparações de pares (*pairwise comparisons*) a ser realizado em cooperação com especialistas nesta área temática.

Na recolha da informação para o AHP será utilizado o método de Delphi, o qual permite apurar opiniões de especialistas, neste caso o painel Delphi é composto pelos stakeholders portugueses do projeto StarTree, através da realização de questionários em pelo menos duas rondas. Este método é uma das poucas metodologias que permite analisar dados qualitativos, sendo sobretudo utilizado para facilitar a formação de uma opinião de grupo, identificando padrões de acordo.

Os resultados deste trabalho, de abrangência europeia, irão fornecer uma referência para os proprietários florestais que estão interessados em gerir (também) NWFP ou envolver-se na sua gestão.

Os nossos sinceros agradecimentos pelo seu apoio e colaboração.

1. HIERARQUIA AHP

O objetivo do método AHP consiste na "identificação do NWFP mais promissor para uma unidade de gestão florestal (FMU - Forest Management Unit) na região do Alentejo" e em dois níveis de indicadores dispostos hierarquicamente (ver Figura 1):

1. Critérios (específicos da região)
2. Subcritérios (específicos para o proprietário/ gestor florestal)

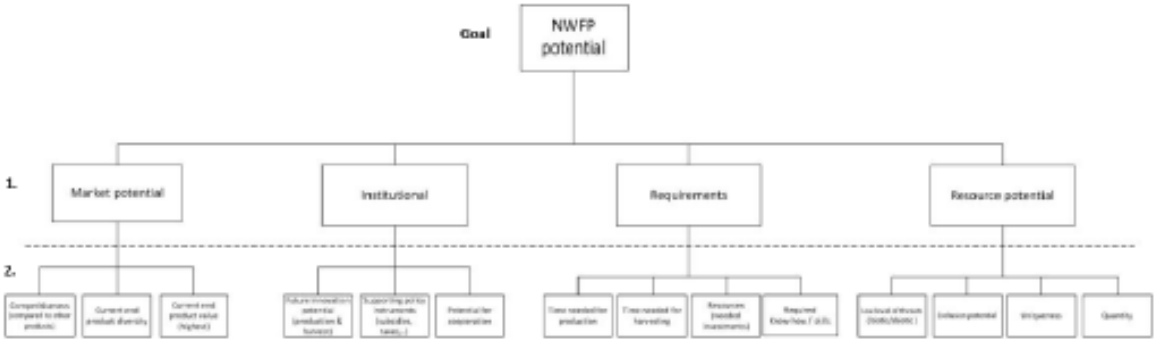


Figura 1. Hierarquia AHP destacando objetivo ("Goal"), critérios ("1.") e subcritérios ("2.")

O nível superior da hierarquia (ou seja, "1. Critérios") é decomposto em quatro indicadores (isto é, Potencial de mercado, Potencial Institucional, Requisitos, Recurso potencial), que deve ser específica para a região, ou seja, o peso para cada critério são derivados através de um exercício com especialistas regionais (stakeholders do projeto STARTREE) que identificam valores de preferência entre os indicadores para espelhar circunstâncias regionais no que diz respeito aos NWFP.

O nível mais baixo da hierarquia (ou seja, "2. Subcritérios") é usado para decompor ainda mais os indicadores de nível superior e deve ser específica para cada proprietário/ gestor florestal, ou seja, de acordo com a análise de diferentes proprietários/gestores florestais são atribuídos pesos diferentes entre os subcritérios. Os perfis dos proprietários/gestores florestais serão avaliados com o objetivo de obter cenários distintos de ponderação.

1.1 ELICITAÇÃO DE CONHECIMENTO ESPECIALIZADO

A fim de obter um ranking cardeal de alternativas (ou seja, todos os NWFP regionalmente relevantes) é necessário avaliar a preferência relativa de uma alternativa (determinado NWFP) sobre a outra através de comparações de pares (*pairwise comparisons*), conforme apresentado na Figura 2.

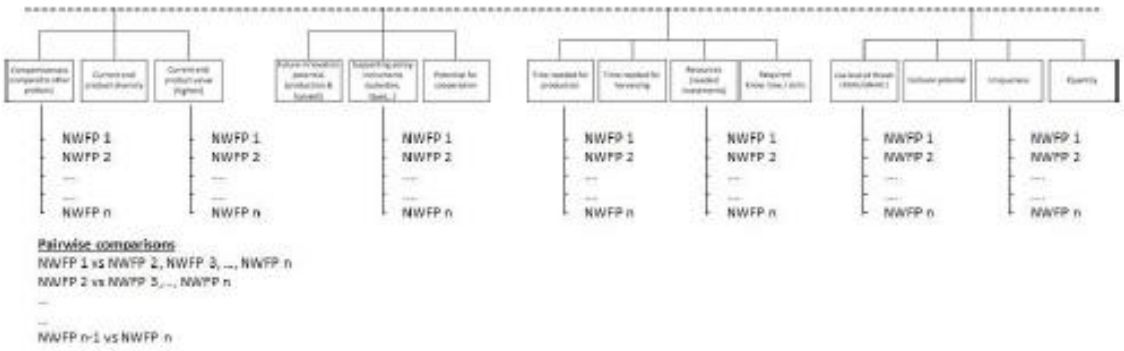


Figura 2. Exemplo das alternativas de comparação de pares (i.e. NWFP) relativo aos subcritérios do AHP

Será necessário comparar todos os NWFP selecionados contra a opção preferível (um determinado NWFP), relativamente a cada subcritério. A escala espacial para a avaliação é normalmente regional para nacional (a fim de avaliar o potencial regional de NWFP selecionados). Apenas para alguns subcritérios deverá ser considerado o nível europeu.

2. MATERIAL E MÉTODOS

2.1 AHP

Para espelhar diferentes ambientes ecológicos e socioeconómicos é necessário o desenvolvimento de cenários de ponderação regional explícitos para os critérios de:

- Potencial de mercado;
- Potencial Institucional;
- Requisitos;
- Recurso potencial.

O principal objetivo é destacar a relevância de cada critério na região do Alentejo e descrever a sua importância atual para a produção sustentável de NWFP. Os pesos atribuídos afetam os resultados finais, na medida em que colocam especial ênfase em critérios individuais e respetivos subcritérios (ou seja, a influência na classificação dos NWFP é expresso de acordo com a ponderação relativa dos critérios).

Desta forma, solicitamos a sua participação na atribuição da importância relativa de cada critério e subcritério de acordo com a situação atual no Alentejo a partir da sua perspetiva (ver ficheiro excel "1_AHP_Delphi_Alentejo_SH1.xlsx"). Neste questionário, deverá analisar o conjunto dos NWFP e não um individualmente. Agradecemos que tenha em consideração as seguintes regras:

1. Iniciar com o inquérito com os "subcritérios".
2. Atribuir 10 pontos no total, considerando um critério hierárquico de importância (deverá atribuir uma classificação entre 0 e 10 pontos no máximo por subcritério, considerando que a soma do conjunto dos subcritérios por critério não deverá ser superior a 10).
3. Preencher apenas as células que se encontram amarelo.
4. A seguir, analisar os "critérios", atribuindo novamente uma pontuação total de 10 pontos a distribuir entre os quatro "critérios".
5. Para cada critério e subcritério encontra-se uma explicação detalhada respeitante ao que se refere, com nalguns exemplos (passar o rato no canto superior direito de cada célula).
6. No final, salve os dados e envie o ficheiro excel por email para: marlenegm@isa.ulisboa.pt

A escala espacial para a avaliação é normalmente regional para nacional, apenas para alguns subcritérios deverá ser considerado o nível europeu, o qual se encontra na descrição detalhada.

Assim que todos os ficheiros sejam enviados pelos stakeholders, estes serão agregados num único ficheiro e realizada a devida análise estatística (gráficos).

O ficheiro agregado será enviado a todos os participantes para uma segunda ronda de julgamento, juntamente com o questionário que respondeu na primeira ronda. No quadro da segunda avaliação será livre para reconsiderar as suas avaliações e adotá-las para a síntese final, que irá então contribuir para o cenário de ponderação para a região do Alentejo.

Como resultado pretende-se derivar um acordo consensual da importância relativa dos critérios analisados.

*Solicita-se o envio do ficheiro até **13 de novembro de 2015***

2.2 COMPARAÇÃO DE PARES

Para analisar potencial de sete NWFP selecionados para a região do Alentejo (cogumelos, cortiça, pinhão, resina, plantas medicinais/ aromáticas, caça e mel) solicita-se o preenchimento do ficheiro "2_AHP_alternative_ranking_Alentejo.xlsx".

Pretende-se que proceda a uma comparação de pares dos NWFP de acordo com a sua preferência/ adequação para cada um dos subcritérios. Assim, solicita-se que classifique cada um dos NWFP da tabela do ficheiro de acordo com a preferência relativa em relação a cada um dos subcritérios e em relação aos restantes NWFP (ou seja, 1 = primeiro, 2 = segundo, 3 = terceiro, ..., 7 = último). Preencha apenas as células que se encontram amarelo

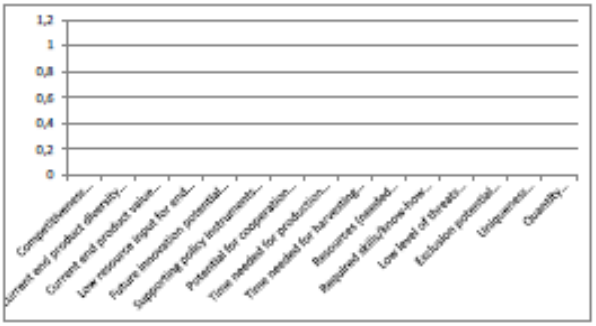
Nota: Para um determinado subcritério, diferentes NWFP poderão ter a mesma classificação (ex a cortiça e os cogumelos poderão ter o mesmo peso e serem classificados com 1, o que significa que o NWFP seguinte deverá ter a classificação 3). Para os cogumelos, plantas aromáticas e caça, caso disponha de informação mais específica, indique a espécie que teve em consideração na análise.

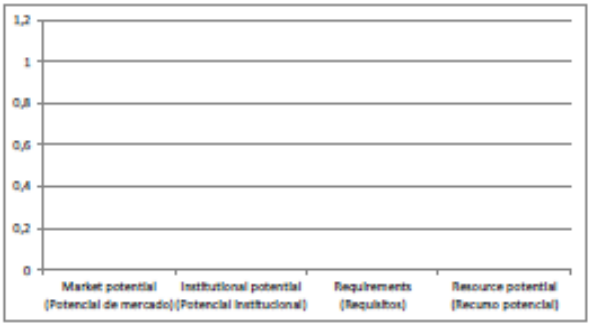
No final, salve os dados e envie o ficheiro excel por email para: marlenegm@isa.ulisboa.pt

*Solicita-se o envio do ficheiro até **13 de novembro de 2015***

Appendix 2.3. Excel file with criteria and sub-criteria for rating the relative importance (from 1 to 10) and instructions to help the judgments

1.º) Iniciar o inquérito com o preenchimento da tabela dos subcritérios SUBCRITÉRIOS - específicos para o proprietário (visão integrada dos produtos florestais não lenhosos - NWFP: cogumelos, cortiça, pinhão, resina, plantas aromáticas/medicinais, caça e mel)		2.º) Preencher após concluído o preenchimento dos subcritérios CRITÉRIOS - específicos para a região do Alentejo	
Nota: Para cada subcritério e critério existe uma explicação detalhada relativa ao que se refere, com exemplos. Para ter acesso a esta explicação passe o rato no canto superior direito da célula do subcritério ou critério que pretende analisar			
Subcriteria (Subcritério)	**Rating** (Classificação)	**Criteria** (Critério)	**Ranking** (Posição)
Competitiveness (Competitividade)		Market potential (Potencial de mercado)	
Current end product diversity (Diversidade corrente de produtos finais)			
Current end product value (Valor corrente de produtos finais)			
Low resource input for end product value (Baixa entrada de recursos para o valor final do produto)			
	Sum needs to be 10 current 0		
Future innovation potential (Potencial de inovação futura)		Institutional potential (Potencial institucional)	
Supporting policy instruments (Instrumentos de apoio de política florestal existentes)			
Potential for cooperation (Potencial de cooperação)			
	Sum needs to be 10 current 0		
Time needed for production (Tempo necessário para a produção)		Requirements (Requisitos)	
Time needed for harvesting (Tempo necessário para a colheita)			
Resources (needed investements) (Recursos - investimentos necessários)			
Required skills/know-how (Requisitos de conhecimento/ saber fazer)			
	Sum needs to be 10 current 0		
Low level of threats (biotic/abiotic) (Baixo nível de ameaças - bióticas / abióticas)		Resource potential (Recurso potencial)	
Exclusion potential (Potencial de exclusão)			
Uniqueness (Singularidade)			
Quantity (Quantidade)			
	Sum needs to be 10 current 0		Sum needs to be 10 current 0





APPENDIX 3. FILES SENT TO STAKEHOLDERS (SECOND ROUND)

Appendix 3.1. Word document, with results from first round and instructions for second round

AVALIAÇÃO DO POTENCIAL DOS PRODUTOS FLORESTAIS NÃO LENHOSOS (NWFP) PARA OS PROPRIETÁRIOS FLORESTAIS NO ALENTEJO – RESULTADOS DA 1.ª RONDA

No âmbito do trabalho de análise do potencial dos produtos florestais não lenhosos na região do Alentejo decorreu entre 3 e 13 de novembro de 2015 a primeira ronda do inquérito pelos doze stakeholders do projeto StarTree. O inquérito encontrava-se organizado em dois níveis de indicadores dispostos hierarquicamente:

1. Critérios (específicos da região)

2. Subcritérios (específicos para o proprietário/ gestor florestal)

O nível superior da hierarquia (ou seja, "1. Critérios") é decomposto em quatro indicadores (isto é, Potencial de mercado, Potencial Institucional, Requisitos, Recurso potencial), específico para a região, ou seja, o peso para cada critério é derivado através da identificação de valores de preferência entre os indicadores para espelhar circunstâncias regionais no que diz respeito aos NWFP.

O nível mais baixo da hierarquia (ou seja, "2. Subcritérios") é usado para decompor ainda mais os indicadores de nível superior, sendo específico para cada proprietário/ gestor florestal, ou seja, de acordo com a análise de diferentes proprietários/gestores florestais são atribuídos pesos diferentes entre os subcritérios.

Assim, foi solicitado, a cada stakeholder, a atribuição da importância relativa a cada critério e subcritério, de acordo com a situação atual no Alentejo, a partir da sua perspetiva. Os resultados apurados e agregados de todos os stakeholders, referentes à primeira ronda, apresentam-se na Figura 1 (critérios) e na Figura 2 (subcritérios).

Assim, no quadro da segunda ronda será livre para reconsiderar as suas avaliações e adotá-las para a síntese final, que irá então contribuir para o cenário de ponderação para a região do Alentejo. Como resultado pretende-se derivar um acordo consensual da importância relativa dos critérios analisados. O ficheiro excel ("AHP_Delphi_Alentejo_SH2_stakeholder_2round.xlsx"), que se envia em anexo, encontra-se organizado da seguinte forma:

- Coluna "Rating/ Raking (first round)" – a sua avaliação, referente à primeira ronda;
- Coluna "Rating/ Raking (all stakeholders)" – resultado das avaliações agregadas de todos os stakeholders, relativas à primeira ronda;
- Coluna "Rating/ Raking (second round)" – para alterar, caso pretenda reconsiderar as suas avaliações da primeira ronda, face aos resultados agregados que se apresentam na coluna anterior.

*Solicita-se o envio do ficheiro da segunda ronda até **30 de novembro de 2015***

Os nossos sinceros agradecimentos pelo seu apoio e colaboração.

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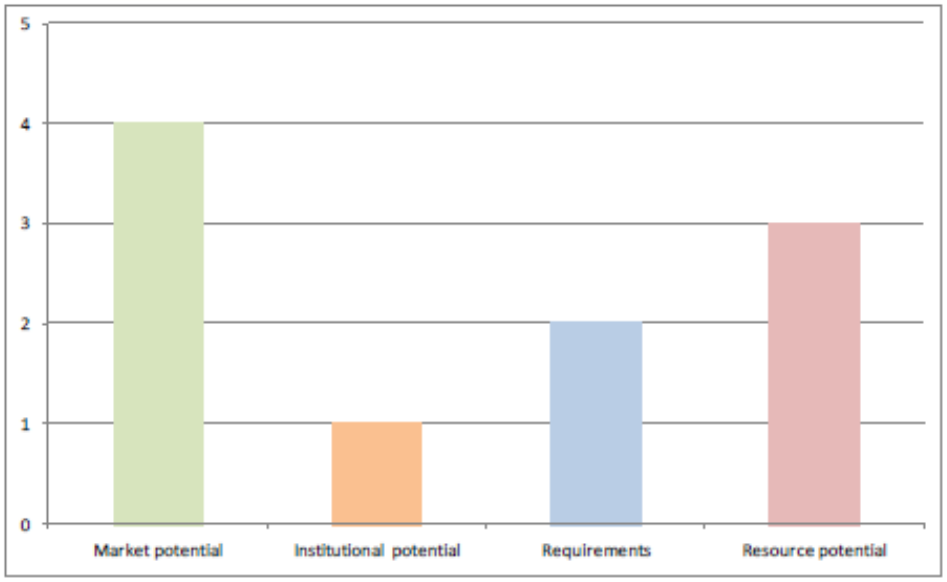


Figura 1. Critérios

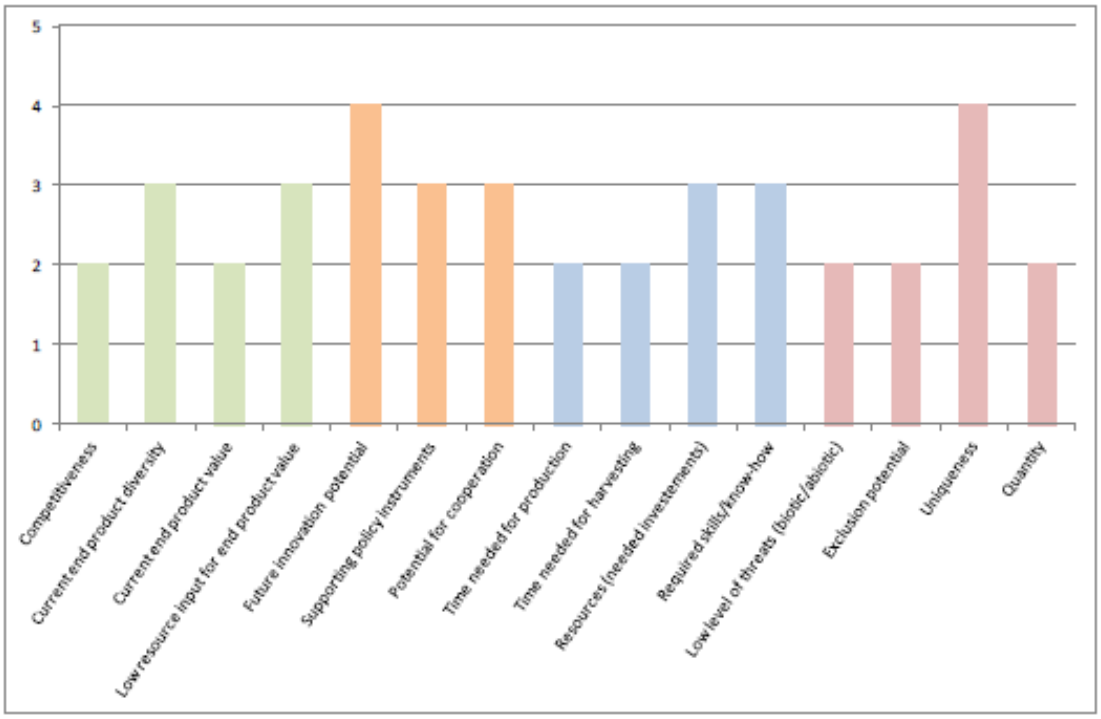
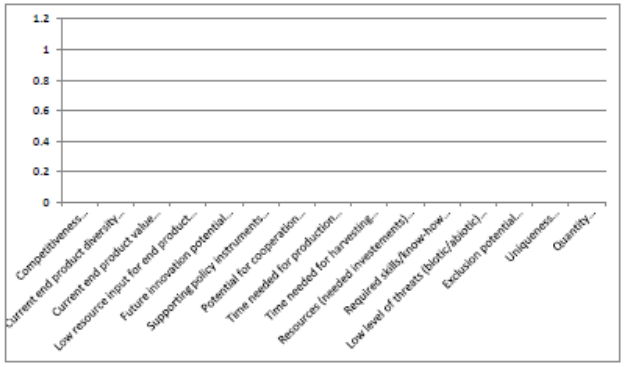
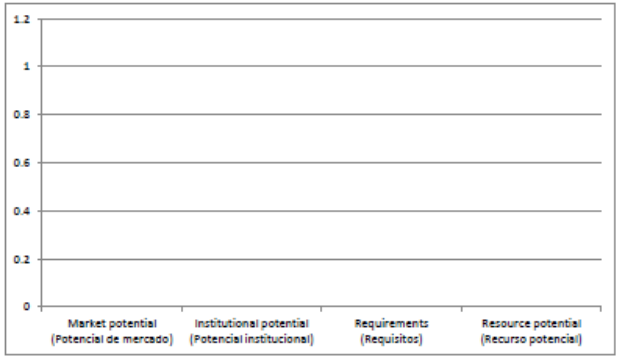


Figura 2. Subcritérios

Appendix 3.2. Example of excel file from a stakeholder, with the judgments and results of first round (average of the judgments of all stakeholders who responded)

Subcriteria (Subcritério)	Rating (first round)	Rating (all stakeholders)	Rating (second round)	Criteria (Critério)	Raking (first round)	Raking (all stakeholders)	Raking (second round)
Competitiveness (Competitividade)	3	2		Market potential (Potencial de mercado)	5	4	
Current end product diversity (Diversidade corrente de produtos finais)	2	3					
Current end product value (Valor corrente de produtos finais)	3	2					
Low resource input for end product value (Baixa entrada de recursos para o valor final do produto)	2	3					
	OK	OK	Sum needs to be 10 current 0				
Future innovation potential (Potencial de inovação futura)	4	4		Institutional potential (Potencial institucional)	2	1	
Supporting policy instruments (Instrumentos de apoio de política florestal existentes)	3	3					
Potential for cooperation (Potencial de cooperação)	3	3					
	OK	OK	Sum needs to be 10 current 0				
Time needed for production (Tempo necessário para a produção)	2	2		Requirements (Requisitos)	1	2	
Time needed for harvesting (Tempo necessário para a colheita)	4	2					
Resources (needed investements) (Recursos - investimentos necessários)	2	3					
Required skills/know-how (Requisitos de conhecimento/ saber fazer)	2	3					
	OK	OK	Sum needs to be 10 current 0				
Low level of threats (biotic/abiotic) (Baixo nível de ameaças - bióticas / abióticas)	1	2		Resource potential (Recurso potencial)	2	3	
Exclusion potential (Potencial de exclusão)	1	2					
Uniqueness (Singularidade)	6	4					
Quantity (Quantidade)	2	2					
	OK	OK	Sum needs to be 10 current 0		OK	OK	Sum needs to be 10 current 0





APPENDIX 4. FILES SENT TO STAKEHOLDERS FOR SUPPORT THE PAIRWISE COMPARISONS

Appendix 4.1. Word document, with instructions for pairwise comparisons

AVALIAÇÃO DO POTENCIAL DOS PRODUTOS FLORESTAIS NÃO LENHOSOS (NWFP) PARA OS PROPRIETÁRIOS FLORESTAIS NO ALENTEJO

Objetivo: Adequação dos diferentes NWFP através da aplicação do método de comparações de pares

Para analisar o potencial de sete NWFP selecionados para a região do Alentejo (cogumelos, cortiça, pinhão, resina, plantas medicinais/ aromáticas, caça e mel) solicita-se o preenchimento do ficheiro "2_AHP_alternative_ranking_Alentejo.xlsx".

Pretende-se que proceda a uma comparação de pares dos NWFP de acordo com a sua preferência/ adequação para cada um dos subcritérios. Assim, solicita-se que classifique cada um dos NWFP da tabela do ficheiro de acordo com a preferência relativa em relação a cada um dos subcritérios e em relação aos restantes NWFP (ou seja, 1 = primeiro, 2 = segundo, 3 = terceiro, ..., 7 = último).

Nota: Para um determinado subcritério, diferentes NWFP poderão ter a mesma classificação (ex a cortiça e os cogumelos poderão ter o mesmo peso e serem classificados com 1, o que significa que o NWFP seguinte deverá ter a classificação 3).

Para os cogumelos, plantas aromáticas e caça, caso disponha de informação mais específica, indique a espécie que teve em consideração na análise.

No final, salve os dados e envie o ficheiro excel por email para: marlenegm@isa.ulisboa.pt

Solicita-se o envio do ficheiro até ***13 de novembro de 2015***

Os nossos sinceros agradecimentos pelo seu apoio e colaboração.

Appendix 4.2. Excel file for pairwise comparisons of selected NWFPs

Criteria		Subcriteria	Mushrooms *(Boletus edulis)*	Cork *(Quercus suber)*	Pine nuts *(Pinus pinea)*	Resin *(Pinus spp)*	Medicinal/ Aromatic plants *(Lavandula viridis)*	Bees ***(honey)***	Game meat ***(rabbit)***
Market potential *(Potencial de mercado)*	1,1	Competitiveness *(Competitividade)*							
	1,2	Current end product diversity *(Diversidade corrente de produtos finais)*							
	1,3	Current end product value *(Valor corrente de produtos finais)*							
	1,4	Low resource input for end product value *(Baixa entrada de recursos para o valor final do*							
Institutional potential *(Potencial institucional)*	2,1	Future innovation potential *(Potencial de inovação futura)*							
	2,2	Supporting policy instruments *(Instrumentos de apoio de politica florestal*							
	2,3	Potential for cooperation *(Potencial de cooperação)*							
Requirements *(Requisitos)*	3,1	Time needed for production *(Tempo necessário para a produção)*							
	3,2	Time needed for harvesting *(Tempo necessário para a colheita)*							
	3,3	Resources (needed investements) *(Recursos - investimentos necessários)*							
	3,4	Required skills/know-how *(Requisitos de conhecimento/ saber fazer)*							
Resource potential *(Recurso potencial)*	4,1	Low level of threats (biotic/abiotic) *(Baixo nível de ameaças - bióticas / abióticas)*							
	4,2	Exclusion potential *(Potencial de exclusão)*							
	4,3	Uniqueness *(Singularidade)*							
	4,4	Quantity *(Quantidade)*							

APPENDIX 5. MATRICES AND GRAPHS OF CRITERIA, SUB-CRITERIA AND ALTERNATIVES

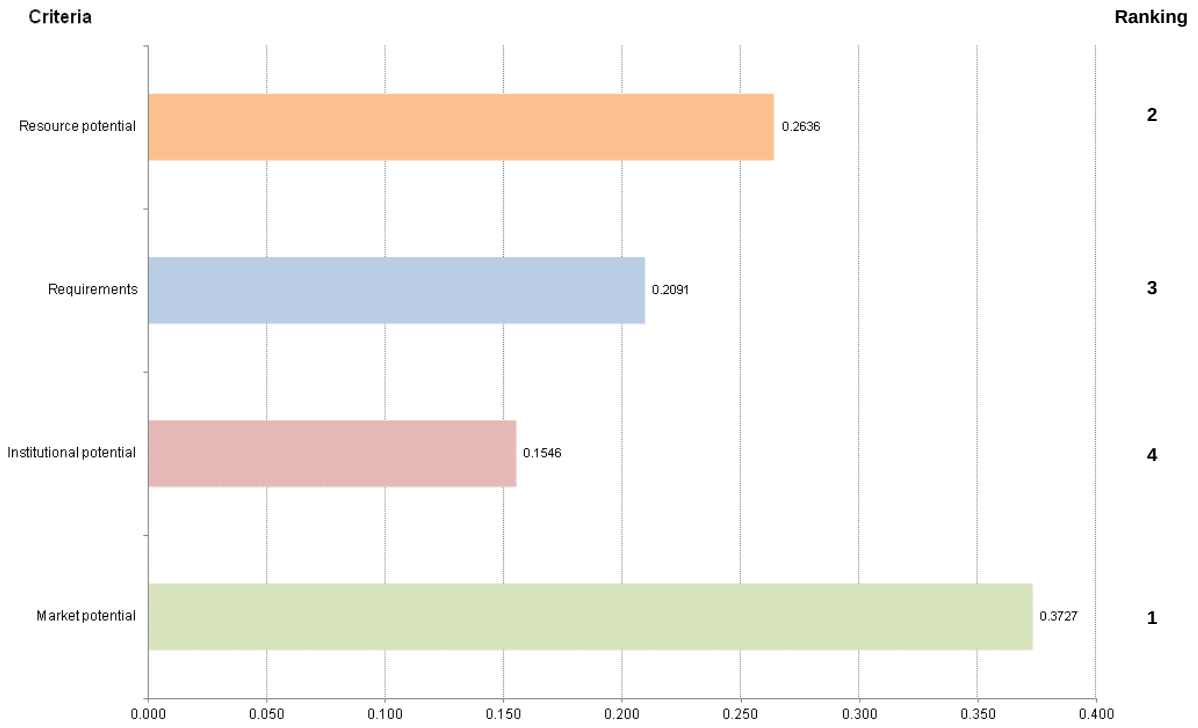
Appendix 5.1. Matrices and ranking of criteria and sub-criteria

Weights from Delphi method						
CRITERIA	**Weight**		*Delphi*	**Ranking**		
Market potential	0.3727	37.3%	*3.727273*	1		
Institutional potential	0.1546	15.5%	*1.545455*	4		
Requirements	0.2091	20.9%	*2.090909*	3		
Resource potential	0.2636	26.4%	*2.636364*	2		
Total	**1.0000**	**100.0%**	*10.000000*			
Market potential	**0.3727**		*Delphi*	**Weighting**		**Ranking**
Competitiveness	0.2273	22.7%	*2.272727*	0.0847	8.5%	4
Current end product diversity	0.2545	25.5%	*2.545455*	0.0949	9.5%	2
Current end product value	0.2364	23.6%	*2.363636*	0.0881	8.8%	3
Low resource input for end product value	0.2818	28.2%	*2.818182*	0.1050	10.5%	1
Total	**1.0000**	**100.0%**	10.0000	**0.3727**	**0.3727**	
Institutional potential	**0.1546**		*Delphi*	**Weighting**		**Ranking**
Future innovation potential	0.4273	42.7%	*4.272727*	0.0661	6.6%	1
Supporting policy instruments	0.3091	30.9%	*3.090909*	0.0478	4.8%	2
Potential for cooperation	0.2636	26.4%	*2.636364*	0.0408	4.1%	3
Total	**1.0000**	**100.0%**	10.0000	**0.1546**	**0.1546**	
Requirements	**0.2091**		*Delphi*	**Weighting**		**Ranking**
Time needed for production	0.1909	19.1%	*1.909091*	0.0399	4.0%	4
Time needed for harvesting	0.2455	24.5%	*2.454545*	0.0513	5.1%	3
Resources (needed investements)	0.2636	26.4%	*2.636364*	0.0551	5.5%	2
Required skills/know-how	0.3000	30.0%	*3.000000*	0.0627	6.3%	1
Total	**1.0000**	**100%**	10.0000	**0.2091**	**0.2091**	
Resource potential	**0.2636**		*Delphi*	**Weighting**		**Ranking**
Low level of threats (biotic/ abiotic)	0.2091	20.9%	*2.090909*	0.0551	5.5%	3
Exclusion potential	0.2091	20.9%	*2.090909*	0.0551	5.5%	3
Uniqueness	0.3545	35.5%	*3.545455*	0.0935	9.3%	1
Quantity	0.2273	22.7%	*2.272727*	0.0599	6.0%	2
Total	**1.0000**	**100%**	10.0000	**0.2636**	**0.2636**	
			Total Sum	**1.0000**		
Subcriteria	**Weights by criteria**		**Delphi**	**Overall weights**		**Overall Ranking**
Competitiveness	0.2273	23%	*2.272727*	0.0847	8%	5
Current end product diversity	0.2545	25%	*2.545455*	0.0949	9%	2
Current end product value	0.2364	24%	*2.363636*	0.0881	9%	4
Low resource input for end product value	0.2818	28%	*2.818182*	0.1050	11%	1
Future innovation potential	0.4273	43%	*4.272727*	0.0661	7%	6
Supporting policy instruments	0.3091	31%	*3.090909*	0.0478	5%	13
Potential for cooperation	0.2636	26%	*2.636364*	0.0408	4%	14
Time needed for production	0.1909	19%	*1.909091*	0.0399	4%	15
Time needed for harvesting	0.2455	25%	*2.454545*	0.0513	5%	12
Resources (needed investements)	0.2636	26%	*2.636364*	0.0551	6%	9
Required skills/know-how	0.3000	30%	*3.000000*	0.0627	6%	7
Low level of threats (biotic/abiotic)	0.2091	21%	*2.090909*	0.0551	6%	10
Exclusion potential	0.2091	21%	*2.090909*	0.0551	6%	10
Uniqueness	0.3545	35%	*3.545455*	0.0935	9%	3
Quantity	0.2273	23%	*2.272727*	0.0599	6%	8
Total	**4.0000**	**4.0000**	**40.0000**	**1.0000**	**1.0000**	

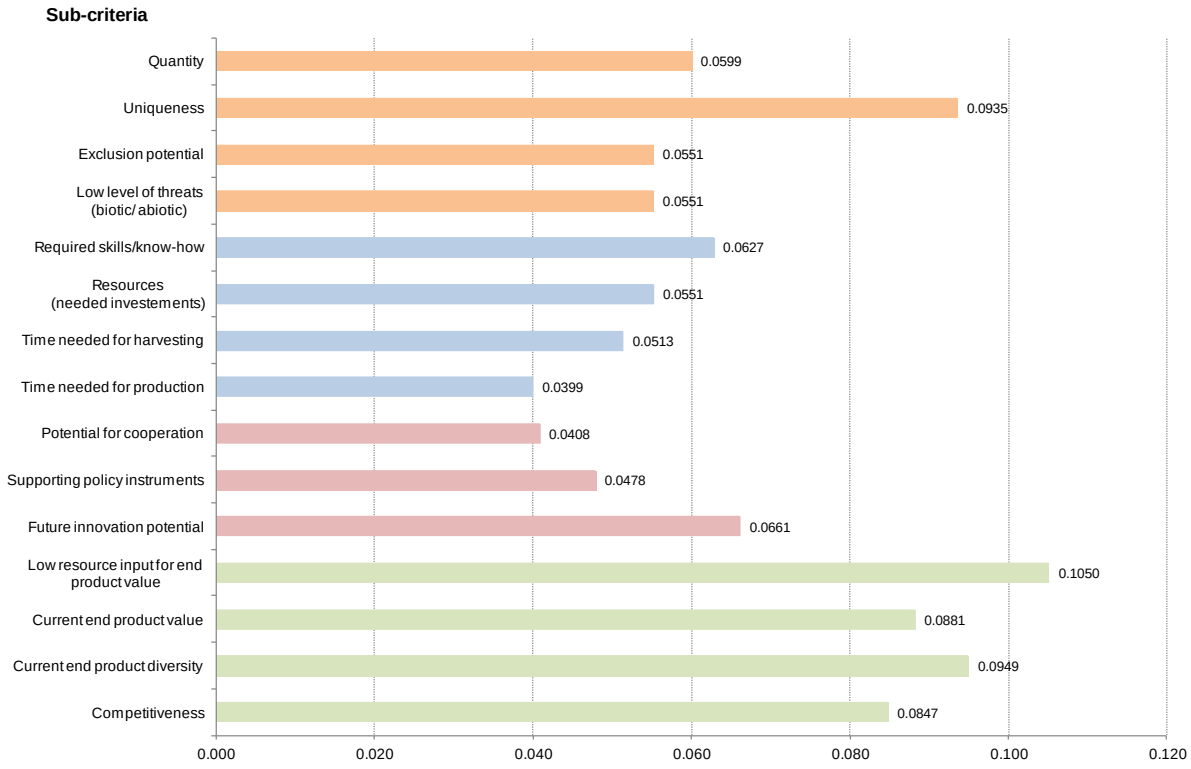
Appendix 5.2. Matrices and ranking of criteria, sub-criteria and alternatives performance

CRITERIA	Market potential						Institutional potential				
	0.3727						0.1546				
SUB-CRITERIA	Competitiveness	Current end product diversity	Current end product value	Low resource input for end product value	SUM	Ranking (Criteria)	Future innovation potential	Supporting policy instruments	Potential for cooperation	SUM	Ranking (Criteria)
(criteria x subcriteria)	0.0847	0.0949	0.0881	0.1050	**0.3727**	1	0.0661	0.0478	0.0408	**0.1546**	4
Global weights	0.2273	0.2545	0.2364	0.2818	**1.0000**		0.4273	0.3091	0.2636	**1.0000**	
ALTERNATIVES	***Matrices from "Expert Choice" (ideal mode)***				***Sum***	***Average***	***Matrices from "Expert Choice" (ideal mode)***			***Sum***	***Average***
Boletus	0.1710	0.2260	0.1870	0.1470	0.7310	0.1828	0.818	0.295	0.083	1.196	0.399
Cork	**1.0000**	**1.0000**	**1.0000**	0.1470	3.1470	0.7868	**1.000**	**1.000**	**1.000**	3.000	1.000
Pine nuts	0.4540	0.0970	0.7140	0.1470	1.4120	0.3530	0.167	0.819	0.707	1.693	0.564
Pine resin	0.0520	0.1980	0.1080	1.0000	1.3580	0.3395	0.389	0.375	0.207	0.971	0.324
Yellow lavender	0.0660	0.7010	0.1000	**0.8140**	1.6810	0.4203	0.389	0.160	0.122	0.671	0.224
Honey	0.2210	0.3260	0.2350	0.1470	0.9290	0.2323	0.167	0.416	0.253	0.836	0.279
Rabbit	0.0910	0.0650	0.2530	0.1470	0.5560	0.1390	0.085	0.187	0.387	0.659	0.220
SUM	**2.0550**	**2.6130**	**2.5970**	**2.5490**	**9.8140**	**2.4535**	**3.015**	**3.252**	**2.759**	**9.026**	**3.009**
ALTERNATIVES	***Matrices normalized (distributive mode)***				***Sum***	***Average***	***Matrices normalized (distributive mode)***			***Sum***	***Average***
Boletus	0.0832	0.0865	0.0720	0.0577	0.2994	0.0748	0.271	0.091	0.030	0.392	0.131
Cork	**0.4866**	**0.3827**	**0.3851**	0.0577	1.3120	0.3280	**0.332**	**0.308**	**0.362**	1.002	0.334
Pine nuts	0.2209	0.0371	0.2749	0.0577	0.5906	0.1477	0.055	0.252	0.256	0.563	0.188
Pine resin	0.0253	0.0758	0.0416	**0.3923**	0.5350	0.1337	0.129	0.115	0.075	0.319	0.106
Yellow lavender	0.0321	0.2683	0.0385	0.3193	0.6582	0.1646	0.129	0.049	0.044	0.222	0.074
Honey	0.1075	0.1248	0.0905	0.0577	0.3805	0.0951	0.055	0.128	0.092	0.275	0.092
Rabbit	0.0443	0.0249	0.0974	0.0577	0.2242	0.0561	0.028	0.058	0.140	0.226	0.075
SUM	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**4.0000**	**1.0000**	**1.000**	**1.000**	**1.000**	**3.000**	**1.000**
ALTERNATIVES	***Ranking (Sub-criteria)***				***Ranking (Criteria)***		***Ranking (Sub-criteria)***			***Ranking (Criteria)***	
Boletus	4	4	5	3		6	2	5	7		3
Cork	**1**	**1**	**1**	3		**1**	**1**	**1**	**1**		**1**
Pine nuts	2	6	2	3		3	5	2	2		2
Pine resin	7	5	6	**1**		4	3	4	5		4
Yellow lavender	6	2	7	2		2	3	7	6		7
Honey	3	3	4	3		5	5	3	4		5
Rabbit	5	7	3	3		7	7	6	3		6

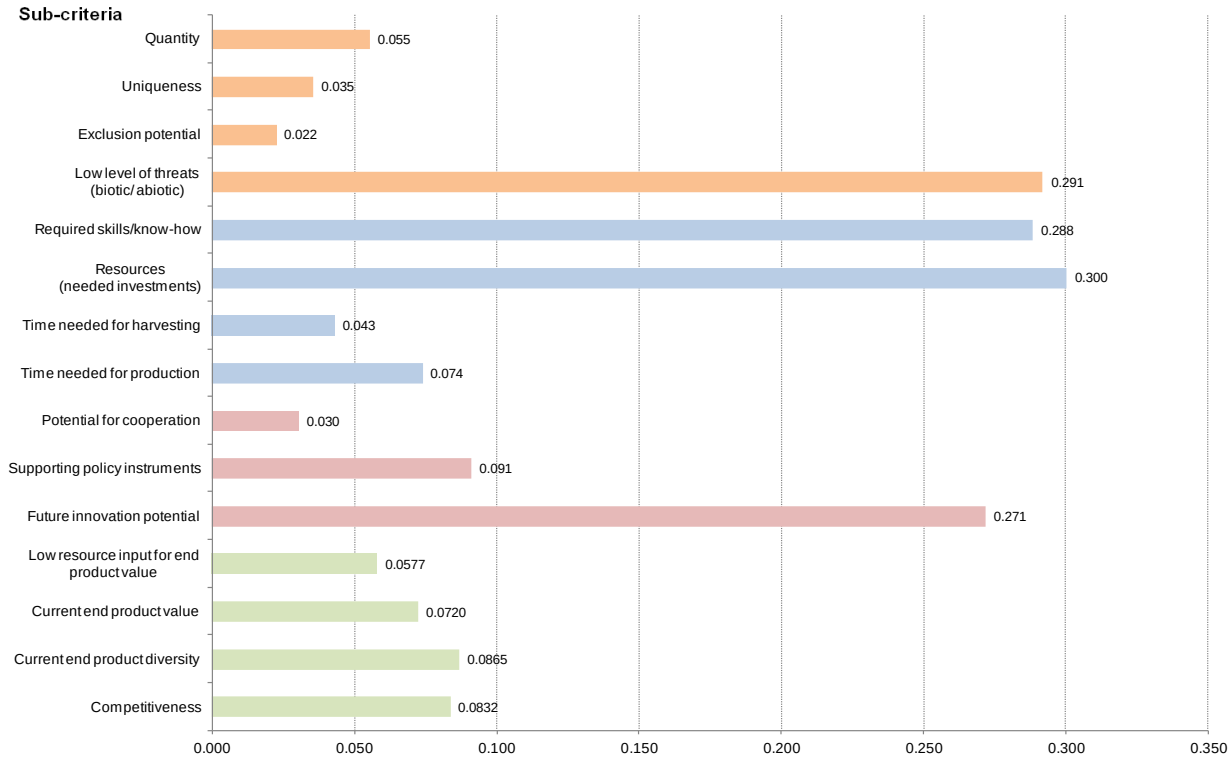
CRITERIA	Requirements 0.2091						Resource potential 0.2636					
SUB-CRITERIA	Time needed for production	Time needed for harvesting	Resources (needed investments)	Required skills/know-how	*SUM*	*Ranking (Criteria)*	Low level of threats (biotic/ abiotic)	Exclusion potential	Uniqueness	Quantity	*SUM*	*Ranking (Criteria)*
(criteria x subcriteria)	*0.0399*	*0.0513*	*0.0551*	*0.0627*	***0.2091***	*3*	*0.0551*	*0.0551*	*0.0935*	*0.0599*	***0.2636***	*2*
Global weights	*0.1909*	*0.2455*	*0.2636*	*0.3000*	***1.0000***		*0.2091*	*0.2091*	*0.3545*	*0.2273*	***1.0000***	
ALTERNATIVES	***Matrices from "Expert Choice" (ideal mode)***				***Sum***	***Average***	***Matrices from "Expert Choice" (ideal mode)***				***Sum***	***Average***
Boletus	0.275	0.113	0.870	0.826	2.0840	0.5210	0.875	0.086	0.103	0.154	1.2180	0.3045
Cork	0.089	**1.000**	0.210	0.106	1.4050	0.3513	0.270	**1.000**	**1.000**	**1.000**	3.2700	0.8175
Pine nuts	0.272	0.713	0.365	0.112	1.4620	0.3655	0.227	**1.000**	0.985	0.893	3.1050	0.7763
Pine resin	0.191	0.140	0.235	0.361	0.9270	0.2318	0.120	**1.000**	0.105	0.071	1.2960	0.3240
Yellow lavender	0.914	0.138	**1.000**	**1.000**	3.0520	0.7630	**1.000**	0.086	0.536	0.339	1.9610	0.4903
Honey	**1.000**	0.349	0.109	0.226	1.6840	0.4210	0.255	0.270	0.098	0.193	0.8160	0.2040
Rabbit	**1.000**	0.197	0.113	0.238	1.5480	0.3870	0.255	0.441	0.098	0.150	0.9440	0.2360
SUM	**3.741**	**2.650**	**2.902**	**2.869**	**12.1620**	**3.0405**	**3.002**	**3.883**	**2.925**	**2.800**	**12.6100**	**3.1525**
ALTERNATIVES	***Matrices normalized (distributive mode)***				***Sum***	***Average***	***Matrices normalized (distributive mode)***				***Sum***	***Average***
Boletus	0.074	0.043	0.300	0.288	0.7038	0.1760	0.291	0.022	0.035	0.055	0.4038	0.1010
Cork	0.024	**0.377**	0.072	0.037	0.5105	0.1276	0.090	**0.258**	**0.342**	**0.357**	1.0465	0.2616
Pine nuts	0.073	0.269	0.126	0.039	0.5066	0.1266	0.076	**0.258**	0.337	0.319	0.9888	0.2472
Pine resin	0.051	0.053	0.081	0.126	0.3107	0.0777	0.040	**0.258**	0.036	0.025	0.3588	0.0897
Yellow lavender	0.244	0.052	**0.345**	**0.349**	0.9895	0.2474	**0.333**	0.022	0.183	0.121	0.6596	0.1649
Honey	**0.267**	0.132	0.038	0.079	0.5153	0.1288	0.085	0.070	0.034	0.069	0.2569	0.0642
Rabbit	**0.267**	0.074	0.039	0.083	0.4635	0.1159	0.085	0.114	0.034	0.054	0.2856	0.0714
SUM	**1.000**	**1.000**	**1.000**	**1.000**	**4.0000**	**1.0000**	**1.000**	**1.000**	**1.000**	**1.000**	**4.0000**	**1.0000**
ALTERNATIVES	***Ranking (Sub-criteria)***				***Ranking (Criteria)***		***Ranking (Sub-criteria)***				***Ranking (Criteria)***	
Boletus	4	7	2	2		2	2	6	5	5		4
Cork	7	**1**	5	7		4	3	**1**	**1**	**1**		**1**
Pine nuts	5	2	3	6		5	6	**1**	2	2		2
Pine resin	6	5	4	3		7	7	**1**	4	7		5
Yellow lavender	3	6	**1**	**1**		**1**	**1**	6	3	3		3
Honey	**1**	3	7	5		3	4	5	6	4		7
Rabbit	**1**	4	6	4		6	4	4	6	6		6



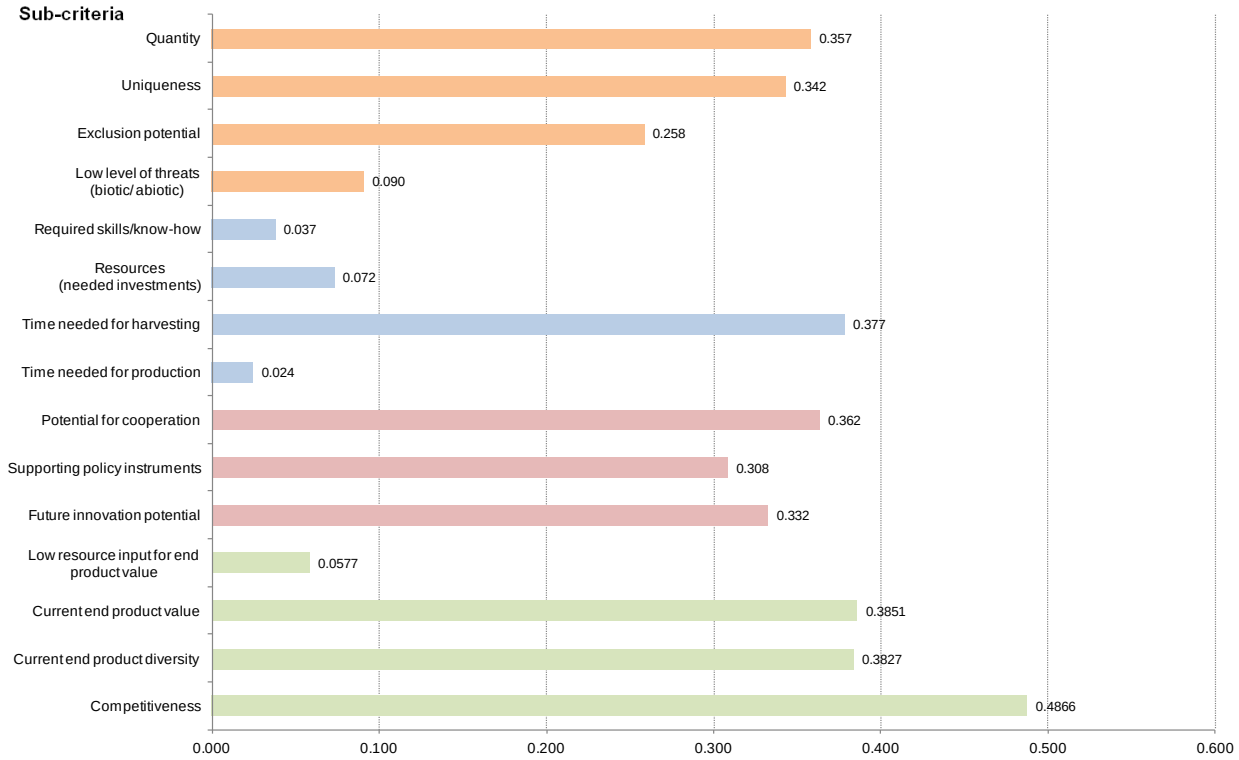
Appendix 5.3. Overall priority weights of criteria



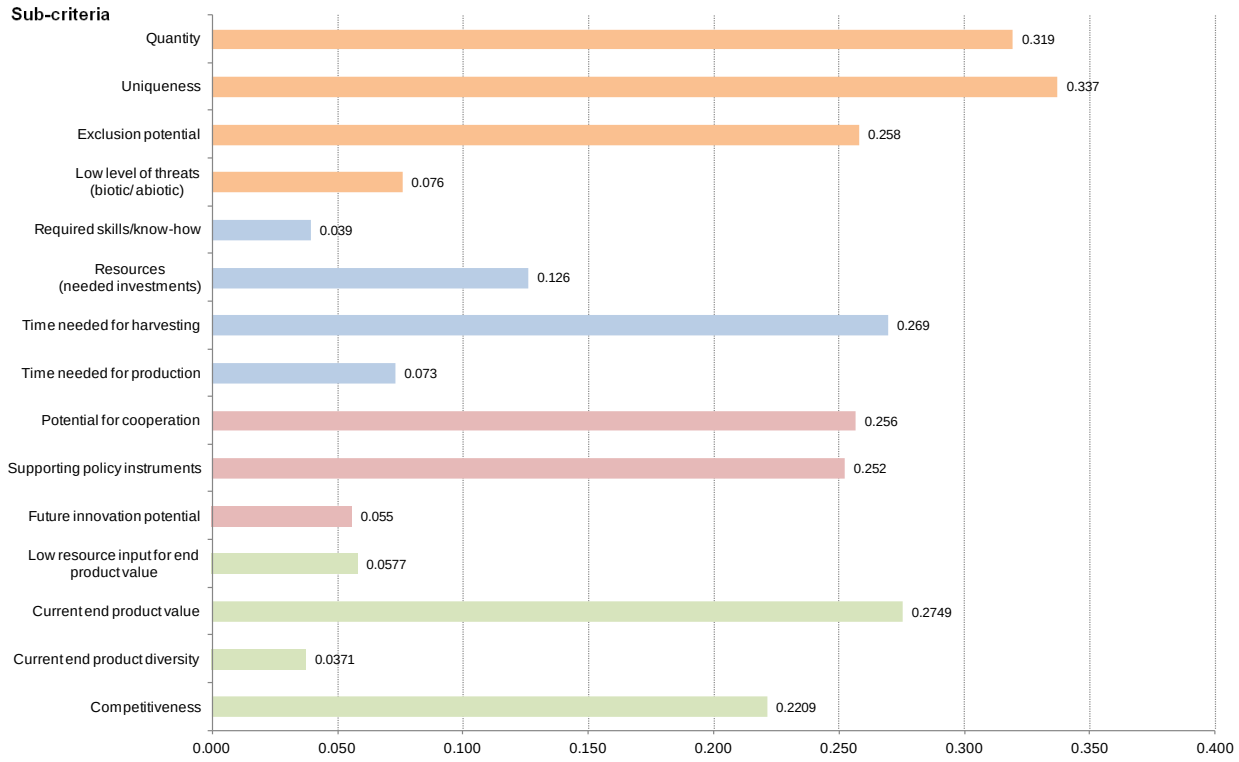
Appendix 5.4. Overall priority weights of sub-criteria (green: "Market potential"; red: "Institutional potential"; blue: "Requirements"; orange: "Resource potential")



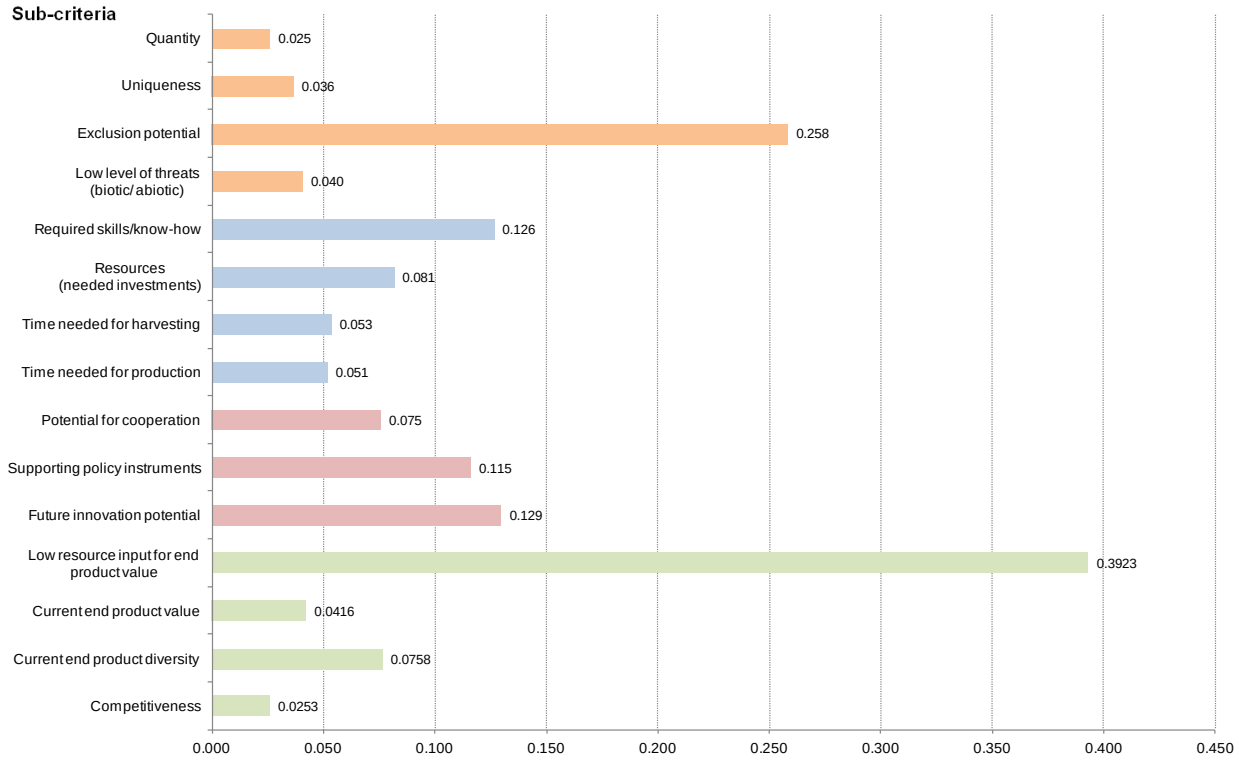
Appendix 5.5. Overall priority weights of boletus (green: "Market potential"; red: "Institutional potential"; blue: "Requirements"; orange: "Resource potential")



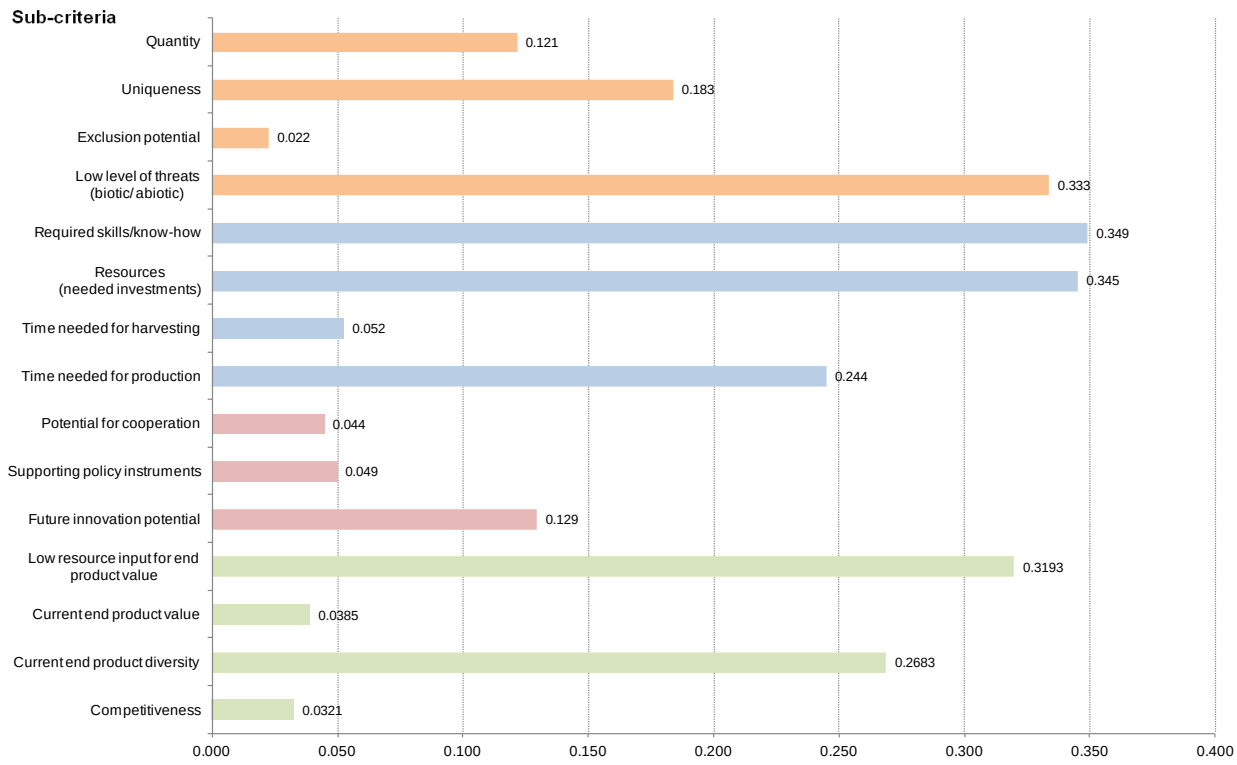
Appendix 5.6. Overall priority weights of cork (green: "Market potential"; red: "Institutional potential"; blue: "Requirements"; orange: "Resource potential")



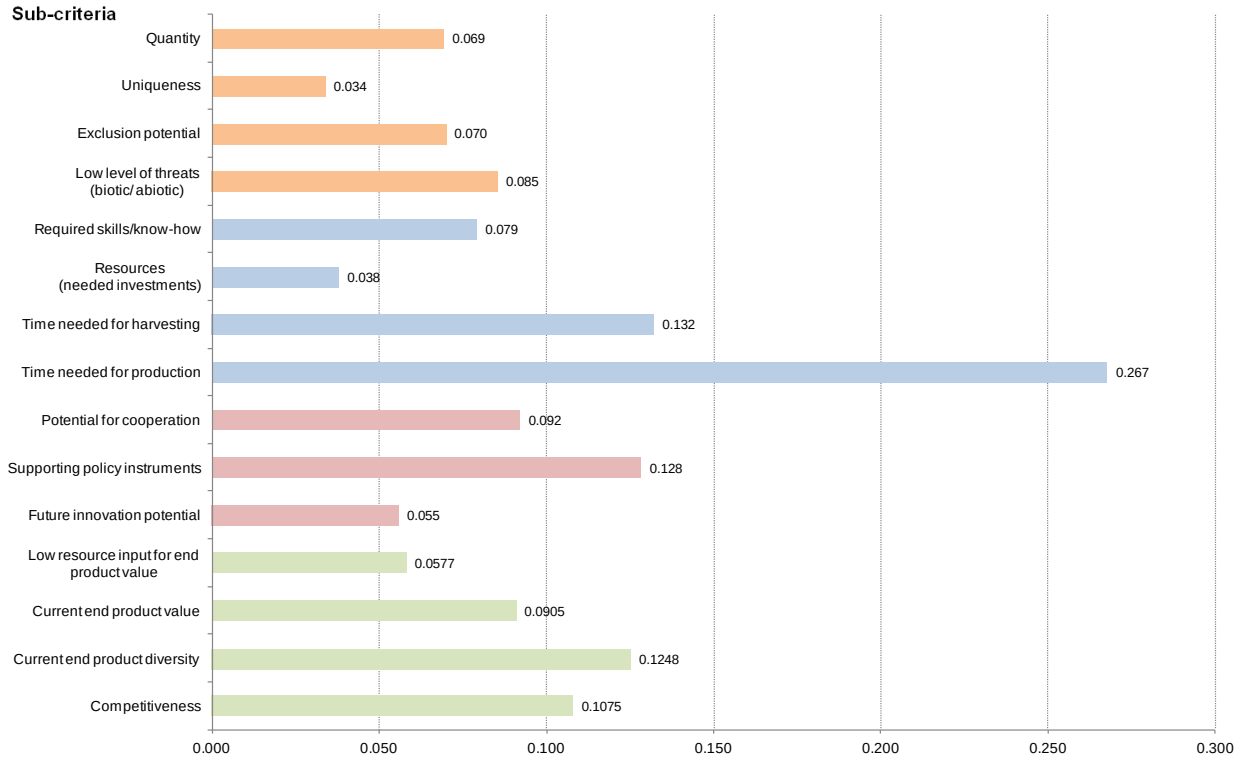
Appendix 5.7. Overall priority weights of pine nuts (green: "Market potential"; red: "Institutional potential"; blue: "Requirements"; orange: "Resource potential")



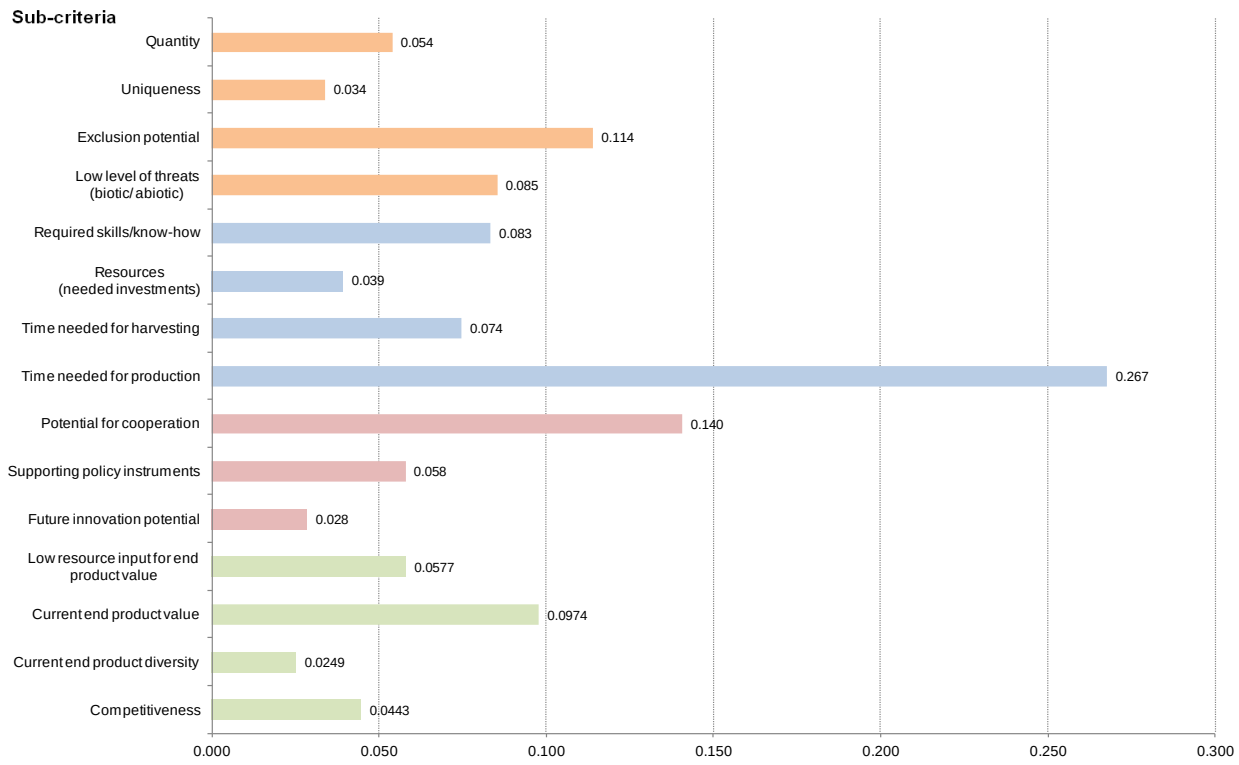
Appendix 5.8. Overall priority weights of pine resin (green: "Market potential"; red: "Institutional potential"; blue: "Requirements"; orange: "Resource potential")



Appendix 5.9. Overall priority weights of yellow lavender (green: "Market potential"; red: "Institutional potential"; blue: "Requirements"; orange: "Resource potential")



Appendix 5.10. Overall priority weights of honey (green: "Market potential"; red: "Institutional potential"; blue: "Requirements"; orange: "Resource potential")



Appendix 5.11. Overall priority weights of rabbit (green: "Market potential"; red: "Institutional potential"; blue: "Requirements"; orange: "Resource potential")