

## A participatory approach to design a toolbox to support forest management planning at regional level

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### Abstract

*Aim of the study:* Forest management planning in a region typically involves multiple stakeholders. Decisions processes are idiosyncratic, driven by individual goals and supported by segmented forest-based information. Nevertheless, stakeholders' decisions do impact one another leading to complex interaction networks where communication, cooperation and negotiation play a key role. This research addresses the need to develop decision tools to support these roles. Emphasis is on the integration of participatory planning tools and techniques in the architecture of a regional decision support toolbox.

Area of the study: The proposed approach was applied in the Chamusca County in Central Portugal although it is easily extended to other regions.

*Material and methods:* This research proposes an Enterprise Architecture methodological approach to design a toolbox that may address distinct stakeholders' interests and decision processes, while enabling communication, cooperation, negotiation and information sharing among all those involved in the regional interactions network.

*Main results:* the proposed approach was tested in a regional network involving decision processes and information shared by 22 entities clustered into 13 stakeholders groups, including industrial owners, and non-industrial private forestland owners (NIPF) —acting individually or grouped into associations and federations—, national and regional offices of the forest authority, forest services providers, non-governmental organizations and research centers. Results suggest that the proposed approach may provide a toolbox that may effectively address stakeholders' decision processes and goals and support the regional interaction network.

**Key words:** forest management; multiple stakeholders; decision support systems; enterprise architecture; participatory process.

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### Introduction

Forest resources management in a region is typically conducted by individual stakeholders acting mostly independently. Decisions are thus idiosyncratic. They are framed by individual economic, ecological and/or social objectives within specific institutional arrangements and organizational structures (*e.g.* non-industrial private forestland owners (NIPF), industrial owners, associations, private companies or public administration). The decision-makers organizational context dictates the spatial-temporal scales used for forest planning. The decisions reflect the stakeholders unilateral perceptions of the regional forest sector, often based on

imperfect, outdated and un-shared information. Sophisticated models and tools are available to support individual decision-making and help address current as well as emergent forest management planning problems (*e.g.* Borges *et al.*, 1999; Falcão and Borges, 2002; Falcão *et al.*, 2006; Palahi and Pukkala, 2003; Nieuwenhuis and Tiernan, 2005; Dias-Balteiro and Romero, 2008; Constantino *et al.*, 2008; Toth and McDill, 2008; Vainio *et al.*, 2009; Pukkala *et al.*, 2009; Costa *et al.*, 2010; Forsell *et al.*, 2009; Ferreira *et al.*, 2011; García-Gonzalo *et al.*, 2011).

However, stakeholders' decisions do impact one another leading to complex interaction networks that these tools can hardly acknowledge, if used within unilateral frameworks. For example, the selection of forest species by a NIPF will affect later in time the availability of raw material to the neighbouring trans-

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formation centres, further impacting in the goals related with the forest species coverage set in regional forest plans by the public administration. Similarly, NIPF harvesting decisions are impacted by demand requirements and will in turn affect the regional availability of harvest equipment, regional employment and landscape configuration. Conversely, the lack of equipment or unfavourable prices may influence the postponement of his harvesting decisions. Moreover, the social and ecological impacts of these decisions may be considered unacceptable to local communities.

The lack of acknowledgement of these interdependencies within the management planning framework may lead to unnecessary conflicts and sub-optimal resources utilization (Grimble and Wellard, 1997; Martins and Borges, 2007).

The development of regional toolboxes that may integrate models/methods, procedures/documents and tools currently available to support individual decision-making as well as facilitate communication, cooperation, negotiation and information sharing techniques between stakeholders thus emerges as a pertinent research problem. To our knowledge, no such regional toolboxes (RgTbx) have been developed. Our RgTbx concept has similarities with group decision support systems (GDSS). The latter, rely on collaborative technologies and enable distributed meetings and group work. Korpela *et al.* (2001) applied a GDSS-based approach to the analysis of the strategy of forest industries. The RgTbx concept extends these functionalities.

The number of agents involved in regional forest planning suggests the need to use participatory planning techniques to strengthen stakeholders' involvement in the toolbox design. This will be influential for adequate representation of communication and cooperation processes to be supported by the toolbox. In fact, participatory planning techniques have been successfully in the context of collective forest planning, particularly when the objectives and planning processes are ill-structured or the information is scarce (*e.g.* Martins and Borges, 2007; Ananda and Herath, 2003; Kurtilla and Pukkala, 2003; Purnomo *et al.*, 2005; Kangas *et al.*, 2008; Hjorts, 2004). These techniques may also be used within a multi-criteria decision analysis framework to help assess strategies and plans (*e.g.* Díaz-Balteiro and Romero, 2008; De Steiguer *et al.*, 2003; Sheppard and Meitner, 2005; Teclé *et al.*, 1998; Schmoldt *et al.*, 2001; Nordström *et al.*, 2009).

Finally, and of specific interest to this research, participatory planning techniques may be very helpful for

information systems design, *e.g.* within an Enterprise Architecture approach. Ribeiro *et al.*, (2005) and Marques *et al.* (2010a) applied such techniques with the technical profiles of Portuguese pulp and paper companies during the workshops for designing corporative forest management decision support systems. Marques *et al.* (2010b) and Marques *et al.* (2012) also used participatory planning processes to design an interoperability platform between the multiple information systems that are used by those involved in the wood supply chains.

In this research we propose a novel stakeholders engagement plan that is a participatory planning process used in the context of an Enterprise Architecture framework, to involve the stakeholders in the design a regional toolbox (RgTbx). The stakeholders' engagement plan aims to explicit and document their knowledge, concerns and requirements. No *a priori* assumptions are made about individual decision processes and network interactions so that the toolbox may effectively address stakeholders' needs and successfully accommodate the human dimension into its development.

The proposed approach is an extension of the Enterprise Architecture methodology firstly presented by Spewak and Hill (1992) and applied in forestry contexts by Ribeiro *et al.* (2005) and Marques *et al.* (2010a). Specifically, the approach relies on modeling information, forest decision processes and interactions networks in the framework of Process Architecture workshops with the stakeholders. This approach thus provides a collective and consensual vision representing both the individual decision processes and the interactions networks. Moreover, it enables the identification of the RgTbx components, including the tools required to support individual forest planning processes and the data elements handled by the stakeholders. A complete specification of the RgTbx is influential for the alignment between the forest management decision processes and the IT function (Sousa and Pereira, 2005; Sousa *et al.*, 2005).

The proposed EA methodology was tested on Chamusca County, located in Central Portugal. The stakeholders involved in the design of the RgTbx included industrial owners and NIPF acting individually or grouped into associations and federations. It further included national and regional offices of the forest authority, responsible for managing public forests as well as providing regulatory frameworks for forest management planning. Representatives of forest services providers, forest industries, forest investment funds,

non-governmental organizations and research centers were also involved.

## Material and methods

### The Chamusca county case study

The Chamusca county is a rural and low population density municipality, extending over 74,599 ha in the Central Portugal. Forests extend over 51% of the county territory. Eucalypt and maritime pine plantations extend over 62% of the county forest area while cork and holm oak multi-functional forests occupy 35% of this area. The remaining 3% corresponds to protection areas.

The forest in this region is predominantly private. Pulp and paper companies and a few large-scale NIPF manage 73% of the forestland while the remaining area is held by more than 2,200 NIPF, some with holdings with less than 1 ha. These stakeholders can act individually or grouped into forest associations and federations. Typically, NIPF sell stumps and cork to local trade entrepreneurs. Often, the latter own the harvesting equipment and rely on local workers hired for the harvest season. The transportation of forest products is typically outsourced to logistic operators or individual carriers.

Forest operations are regulated by the regional office of the forest authority according to the regional plan and forestry policies. The regional office is also responsible for managing the public forests in the county. Recently and as a response to the 2003 wildfires that burned  $20 \times 10^3$  ha of the county's territory, the local municipality also plays a key role in developing and supervising forest wildfires prevention plans as well as in coordinating the forest wildfires suppression

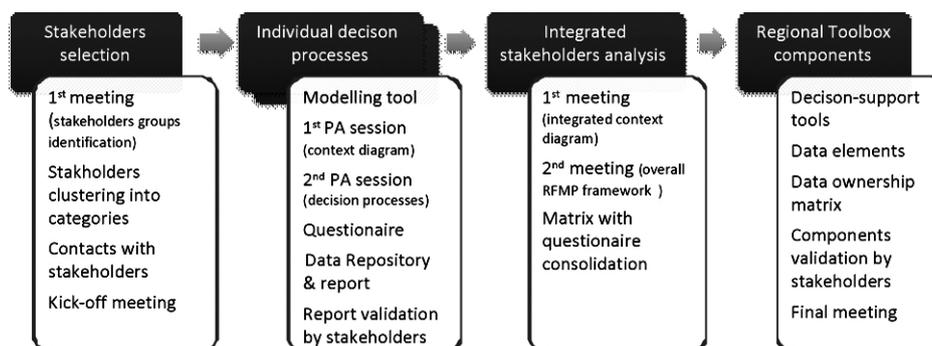
efforts. Other stakeholders include forest investment funds, non-governmental organizations, local communities and forest research agencies.

### Methods

The stakeholders' engagement plan, anchored in the Enterprise Architecture methodology, consisted in four main stages for the design of the toolbox for regional forest planning (Fig. 1). The first stage of this participatory process tackled the selection of stakeholders. The research team responsible for the design of the RgTbx identified a key stakeholder in the region. The local forestland owners association ACHAR, acted as a local project promoter and helped in the selection of the relevant entities *i.e.* forest stakeholders in the county.

These entities were clustered into groups and functional categories to be addressed in separate process architecture workshops. Afterwards, at least one representative designated by each entity took part in the kick-off meeting. One forest practitioner from ACHAR was further included in the project team in order to strengthen the contacts with the stakeholders and provide technical support to the moderator during the workshops.

The second stage of the proposed engagement plan encompassed a series of Process Architecture workshops to identify individual decision processes. These workshops used the post-It method for designing a 3-level hierarchical top-down process architecture, over two consecutive half-day sessions. During the first session, participants in each stakeholders' group were asked to identify, in Post-It notes, the entities they interacted with and to display them in the organization-centric context diagram, closer or farther from the



**Figure 1.** Forest stakeholders' engagement plan for designing the regional forest management toolbox.

center according to their business relevance (Marques *et al.*, 2010a).

The information flows among entities were further identified in this first level of processes' representation, differentiating paper and electronic carriers. The identification of the information flows was influential for highlighting the interactions' network among the stakeholders involved in forest management in the region. It further provided the basis for the developing the Business Model for each stakeholders group that was the second level of the processes' representation. The Business model emphasized the business processes conducted by each stakeholders group. Only the processes directly related to forest management activities were further detailed.

The third level processes' representation consisted in flowcharts built in a Business Process Modeling Notation during the second session with each stakeholder group. The flowcharts depicted the sequence of activities performed by the stakeholder as well as the information used and produced in the course of the forest management activities. The outcome of the individual PA workshops was displayed on a HTML data repository, enabling dynamic navigation throughout the representations, providing easy access to the objects descriptions and semi-automatic reporting.

The stakeholders were asked to validate the outcomes of the PA workshops. At the time of validation, stakeholders were further asked to reply to an open-end questionnaire on current and future perspectives about their role within the regional forest management planning framework. The questionnaire addressed 21 items in five main groups *e.g.* the forest management planning setting, the resources allocation, the implementation of forest operations, the usage of computerized-tools, and other context elements. The three first groups encompassed management planning activities. The fourth addresses the way these activities were automated and supported by computerized tools while the fifth included specific regional network elements. The answers to the questionnaires provided valuable information to characterize the management planning problems that were prevalent in the region. Furthermore, the questionnaires highlighted the roles and the activities conducted by each stakeholder group to tackle them.

The third phase of the engagement plan used the previous results for the integrated stakeholders' analysis. For this purpose, the research team merged individual context diagrams into a complex integrated context

diagram. This was influential to develop the Regional Forest Management Planning (RFMP) Framework as well as to identify the roles played in it by each stakeholder at Chamusca region. The four-level integrated diagram displayed the main decision-makers at the center. The stakeholders involved in consultation, regulation or implementation of the decision were displayed at the next level. The stakeholders that are just informed about the decisions were represented next. All other entities were represented at the level farther from the center. The characterization of roles played by each stakeholder in the RFMP Framework was based on the generic responsibility assignment matrix (*e.g.* PMI 2011), as well as on the answers to individual questionnaires.

The results this third stage helped mapping individual decision processes in the overall framework of forest management planning in the Chamusca county. They further provided information to develop the communication and cooperation mechanisms needed to support the regional interactions networks, thus contributing to enhance data sharing among the entities engaged in forest planning in the region.

The fourth stage identified the RgTbx components. During this phase, the research team listed the data and decision support tools used or required by the stakeholders groups. Additionally, the team developed a new data ownership matrix to show how each stakeholder group handled each data and information element (*e.g.* create, read, update and delete). This matrix was driven from the individual decision processes and helped identify the actual data and information needs by each stakeholder group. It further suggested techniques for enhancing communication, cooperation, information sharing and exchange within an adequately regulated access to the RgTbx. The results were subjected to validation by the representatives of the stakeholders groups and further discussed in the project final meeting.

## Results

The first stage of the stakeholders engagement plan led to the selection of 22 entities that were classified into 13 stakeholders groups and 4 functional categories (*i.e.* private sector, public sector, non-government organization, research agencies). They represented about 900 people with direct interests in the Chamusca county forest sector. The entities included both active and passive stakeholders, *i.e.* those who affect/deter-

**Table 1.** Stakeholders categories and groups

Category	Group	Entity	N° representatives	Workshops	
Private Sector	Non-industrial private forestland owner (NIPF)	Large-scale intensive	5	WS1	
		Medium scale	2	WS2	
		Small-scale	0		
		Multifunctional	1	WS2	
	Forest associations (FA)	ACHAR-Associação dos Agricultores da Charneca		3	WS3
		Forest federations (FF)	Forúm Florestal	1	WS4
	UNAC-União da Floresta Mediterrânica		1	WS4	
	Industrial private forestland owner (IPF)	Silvicaíma		2	WS5
		Forest-based industry (I)	Grupo Portucel-Soporcel	1	WS6
	Public Sector	Forest Services Provider (FSP)	BETA	1	WS7
Forest Investment IFund (FIF)		Floresta Atlântica	2	WS8	
Chamusca Municipality (M)		Forest technical office		1	WS9
	Civil Protection		1	WS9	
	Forest Authority	DRFLVT-Regional Office (FAn)	1	WS10	
		AFN-National Office (FAr)	4	WS11	
Non-Government organization	Local communities (LC)		3	WS12	
	Non-Governmental Organization (NGO)	WWF Mediterranean Programme Office	1	WS13	
Research Agencies	Forest Research Centre (FRC)	CEF-Centro de Estudos Florestais	2	WS14	
Total	13	22	32	14	

mine a decision or action and those that are affected by it (Grimble and Wellard 1997, Martins and Borges 2007) (Table 1). Most representatives took part on the kick-off meeting. Nevertheless, smaller-scale owners did not participate in this meeting. They usually do not rely on technical forestry support thus their contacts were not available at ACHAR at that moment. Yet they did participate in subsequent PA workshops.

The private sector category included industrial owners, NIPF, their associations and federations, forest-based industries, forest service providers and the forest investment fund. The public sector category encompassed the Chamusca municipality, one parish representing local communities and the forest authority (both national and regional offices). Finally, one non-governmental organization and one forest research center were also selected.

The forest holding structure as well as the management objectives and practices motivated the definition of 4 sub-groups of NIPF. Accordingly, the large-scale intensive sub-group included owners with forestry as their main economic activity (*e.g.* timber and/or cork and pine nut production) and, typically, with holdings with more than 500 ha. The owners in the medium-

scale intensive sub-group considered forestry as their secondary economic activity and their holdings had an area between 100 and 500 ha. Nevertheless they conducted regularly management operations according to their forest management plan (PGF). The owners of the small-scale sub-group (< 100 ha) considered forestry as a residual activity and usually did not conduct any forest operations. Lastly, the multifunctional sub-group included owners that focused mostly on other non-wood products and market services, such as mushrooms production, apiculture, hunting and tourism. Each sub group was further characterized according to planning constraints and regulations (*e.g.* wildfire protection and wildlife conservation frameworks) to the management of their holding, landowner age, academic degree and technical competences.

The identification of individual decision processes within prevalent management planning problems, during the second stage of the engagement plan, underlined the contribution of each stakeholder group to the overall forest management planning framework in the Chamusca County. Forestland owners play a key role in forest management planning in the region. The PA workshops confirmed that the sophistication of the

planning process tends to increase with the holding size. In fact, both the industrial owners and the large-scale NIPF usually develop strategic (long term) plans at forest level. Typically, these plans are developed by a single decision-maker, target multiple objectives and include both wood, non-wood productions and services.

The decision-maker managing large holdings is most often supported by skilled forest practitioners that configure the plan to meet the requirements of the legally binding forest management plan (PGF). The first years of the strategic plan provide the input for the operational plan aiming to provide actual resources allocation, budgeting and detailed specifications for the forest operations implementation. The operations are further clustered into work-orders, implemented with outsourced resources and controlled by the owner. The management planning processes are frequently supported by computerized-tools with adequate growth & yield models powered by updated forest inventory data. Optimization techniques embedded on decision support systems to help search for the most profitable plan have also start been used, mostly by the industrial owners (*e.g.* Borges *et al.*, 1999).

The medium-scale NIPF, the managers of public forests and the other forestland owners technically supported by Forest Associations address similar strategic problems. The forest public administration is further responsible for the development of regional forest plans (PROFs). These plans are the outcome of a participatory planning process where the stakeholders are involved in the discussion of the main forest goals in the region. The goals are tied to the territory through the definition of sub-regions that are homogeneous according to dominant forest functions (*e.g.* production, conservation). The PROFs further suggest management goals, species selection and prescriptions to be adopted by individual management plans (PGF).

Small-scale NIPF usually conduct long-term planning at stand level and target wood or cork production. Both small-scale NIPF and the managers of public forests confirmed concerns with other non-wood products and services with an increasing importance on the region, such as fruits (*e.g.* pine nuts), mushrooms, fishing and hunting. Yet multiple productions are often not addressed fully by the planning process as few production functions are available. Decisions regarding the supply of these products and services are unstructured and supported mostly by empirical insights and traditional silviculture models. No computerized-tools other than geographical systems, databases or spreadsheets are

used to support those activities. Tactical and operational planning is often absent as the implementation of forest operations is usually outsourced to service providers.

The role of the recently created forest investment fund was further highlighted. The fund buys or rents forest properties, acting like both the owner and the manager of forest properties just like in the case of the industry. The problems faced by the fund are mainly related to the acquisition of new properties. After acquisition the fund properties face management planning problems that are thus similar to the large-scale NIPF owners and the industry problems.

The identification of individual decision processes further underlined the role of the local forest association, ACHAR. It provides consultancy and technical support to help NIPF develop their plans. Moreover, it often provides the resources needed to implement the individual plans. ACHAR may further impact the regional forest management planning framework as it represents the landowners' interests on national and regional forestry forums.

These actors—industry, NIPF owners, forest investment fund, forest association and managers of public forests—develop individual decision processes to address forest management problems. Yet these processes are impacted by a large number of stakeholders within a vast interaction network.

This research developed context diagrams, business models as well as a detailed characterization of individual processes for all stakeholder groups. Yet for conciseness we will illustrate results focusing mostly on ACHAR. Its context diagram (Fig. 2) displayed the regular contacts of the Forest Association with 13 other entities. For example, the regional office of the forest authority is responsible for checking whether the individual management plans (PGF) developed by ACHAR for his associates meet the regional forest plan (PROF) guidelines. Additionally, ACHAR interacts frequently with the Chamusca municipality in the context of the wildfire prevention and suppression initiatives. Moreover, both ACHAR and the forestland owners have regular contacts with forest service providers as they often outsource harvesting and cork and timber transportation operations. These small-scale enterprises play a key role in the regional forest logistics and operational planning. Nevertheless, they seldom use computer-based tools to address their management planning problems. The information flows between ACHAR and other stakeholders are supported mostly by oral communications and paper requests

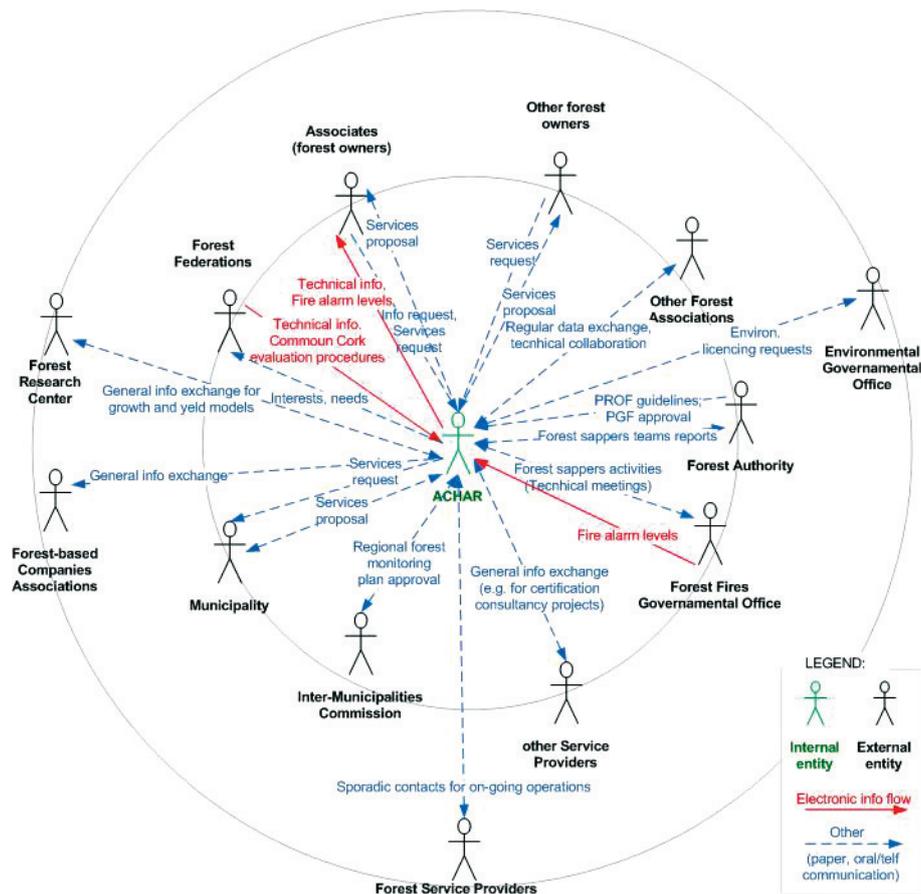


Figure 2. ACHAR context diagram.

rather than by the use of templates or numbered documents on an electronic format.

The PA workshops underlined that the participation of stakeholders such as ACHAR in the RFMP Framework extends beyond the support to forestland owners decision-making. In the case of ACHAR, only two business processes in its business model (Fig. 3) were directly related with providing management planning services to the forest owners (P1) or with providing support to their forest products commercialization (P4). The first process included the development of forest management plans (P1.1), forest resources inventory (P1.2), cartography (P1.3), forest operations follow-up (P1.4), forest products evaluation (P1.5), sanitary control (P1.6) and forest investment projects formatted for application of public subsidies to forest activities (P1.7). Other business processes by ACHAR included the support to the regional wildfire prevention infra-structure (P6) and non-commercial activities, such as outreach activities (P2), associates' representation activities (P3), research and development acti-

vities (P5), cooperation for local development (P7) and administrative management (P8).

Lastly, the analysis underlined the sequence of activities usually conducted in the framework of each process. For example, the development of the forest management plan, according to existing forestry regulations, encompasses a number of activities carried out by the ACHAR forest technicians at the request of an associate (P1.1.) (Fig. 4). According to the sub-process flowchart (third level representation) it starts with an expedite site characterization based on data publically available (e.g. at the forest authority offices) such as forest cover maps and PROF guidelines and recommendations for the zone where the property or set of properties is located. If needed, it may include visits to the forest site to collect forest inventory data.

Afterwards, the property is classified into homogenous management units. The identification of management goals generally takes place in a meeting with the owner. Typically they address revenue concerns and they thus focus on the supply of the most important

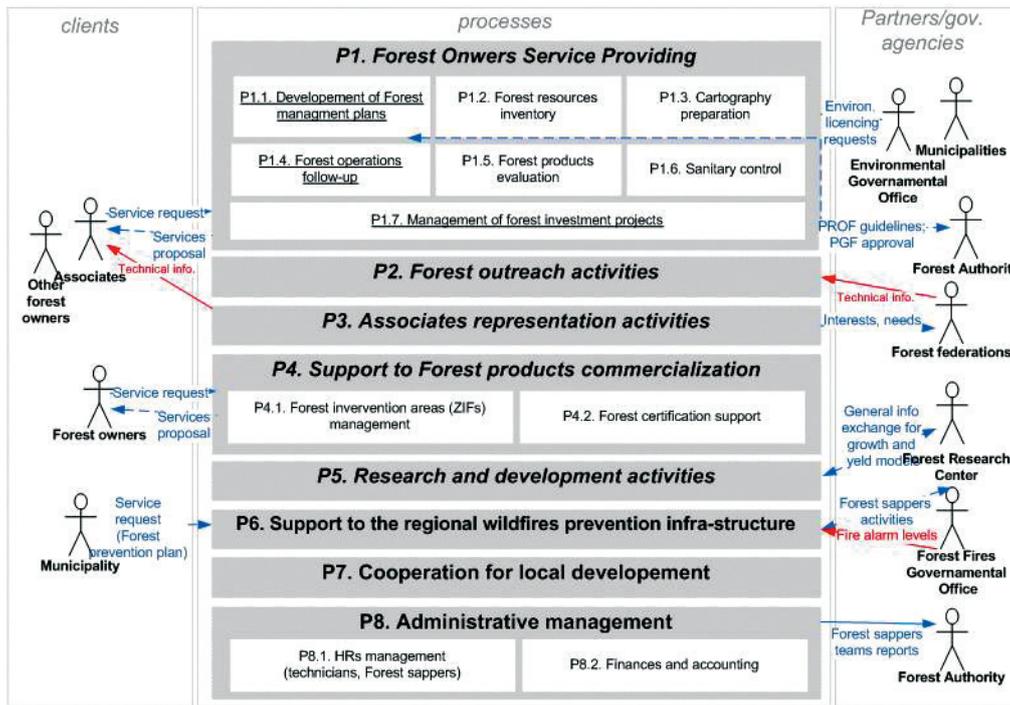


Figure 3. ACHAR business model.

market products (timber and cork). Yet, the ACHAR technicians may highlight the economic benefits of new prescription models, alternative species and other non-wood productions and services. Environmental and social concerns are typically met through the compliance with PROF guidelines. In the end, the management plan (PGF) suggests one prescription for each stand and provides a rough estimate of the operations/investment costs.

The integrated stakeholders' analysis conducted under the third stage of the engagement plan provided an overall interpretation of the contribution of all the stakeholders in the RFMP Framework. In particular, the integrated context diagram represented 42 distinct entities and over 85 information flows exchanged among them (Fig. 5). The complexity of this diagram made it hardly readable outside the dynamic HTML repository. It reinforced the key role of the industry

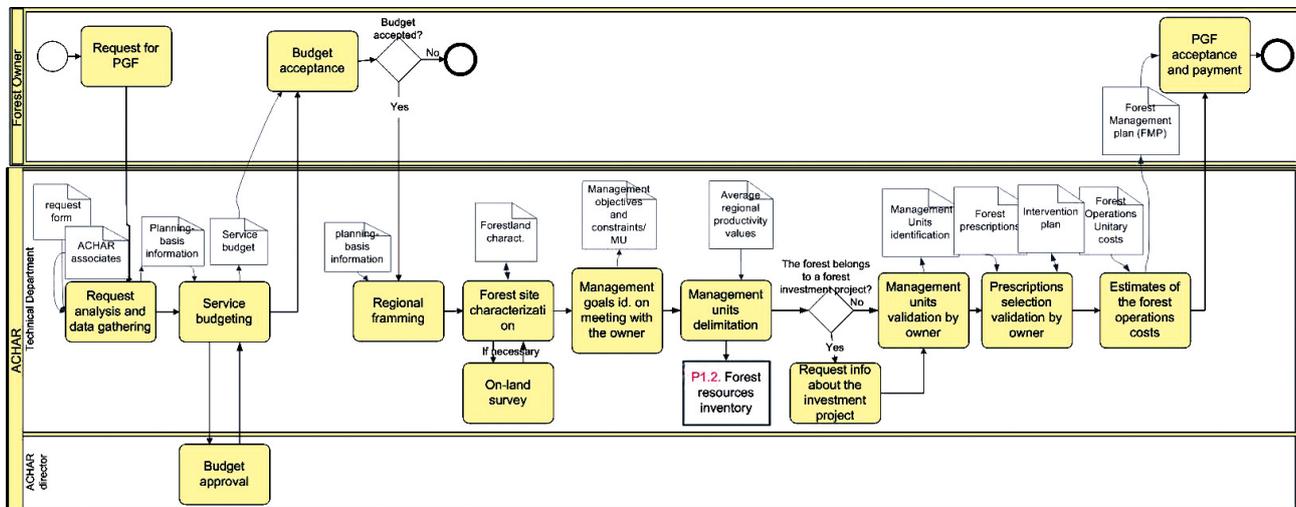


Figure 4. Process of preparing the Forest management plan (P1.1) by ACHAR after forestland owner request.

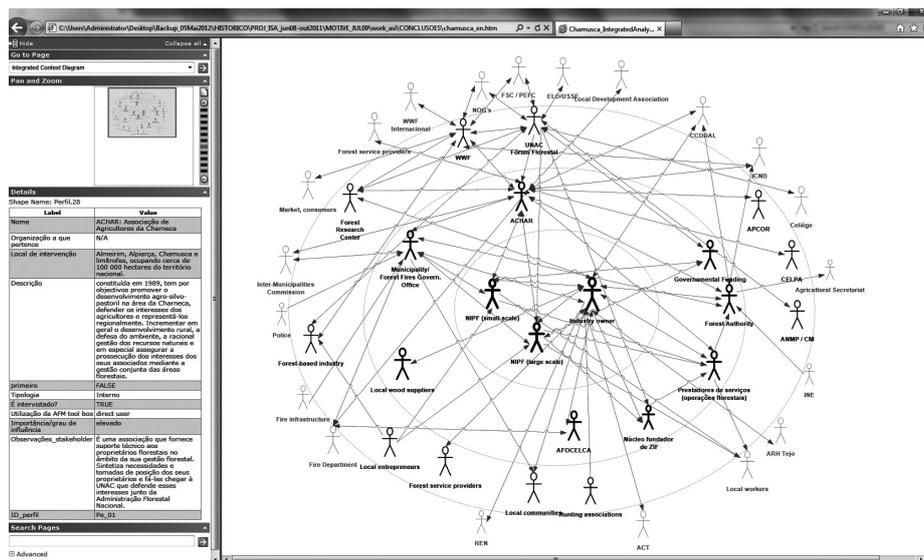


Figure 5. Integrated context diagram for the stakeholders involved in forest planning at the Chamusca county.

and the NIPF as the main decision-makers, represented at the centre of the diagram. Other decision-makers included the forest investment fund and the managers of public forests.

The simplified version of the overall RFMP Framework (Fig. 6) highlighted the main individual decision processes addressed by the key decision-makers (industry, NIPF, forest investment fund and regional office of the forest authority) as well as their interaction network. There are few explicit interactions between the first-level stakeholders. They are more prone to happen in the interface between NIPF and the forest fund in the case of forest properties included in the fund. Yet, implicit interactions were reported among NIPF, namely regarding the setting of prices in forest products selling agreements.

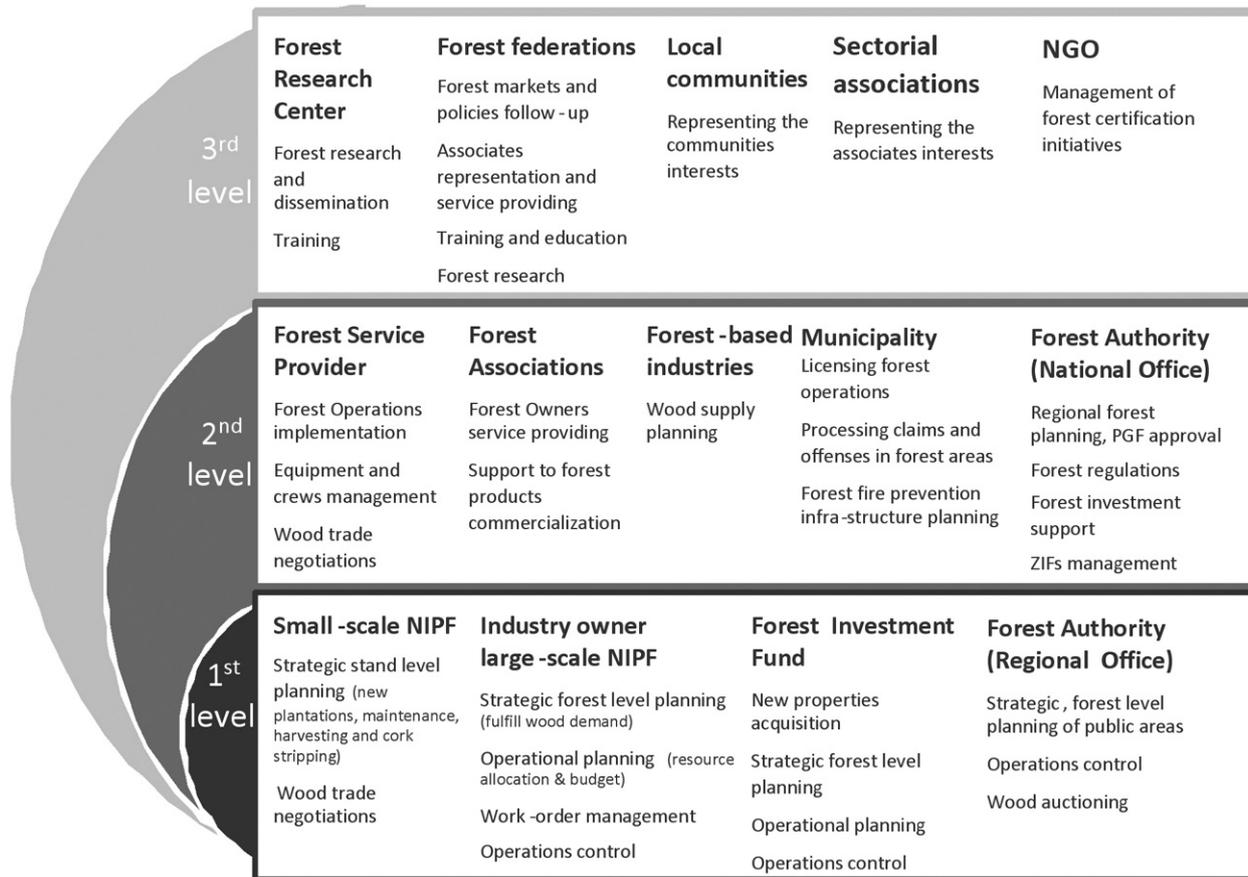
At some extent, all first-level stakeholders are influenced by the stakeholders at the second level of the RFMP Framework. Specifically, the industry owners relies on wood supply levels agreed with the forest-based industries, while the harvesting decisions of the NIPF are conditioned by the negotiations with cork and timber trade entrepreneurs and forest service providers. The wood harvested impacts the demand requirements of the neighboring transformation centers. Additionally, both forest owners and the forest investment fund interact with the Chamusca municipality for licensing their forest operations according to regional and national regulations (e.g. deriving from PROF). The forest authority supports the municipality

in the application of the forest regulations and usually also intervenes on some PGFs approval. This is, for example, the case when the property is part of a collectively managed area (such as the ZIF) or when the manager is applying for public funding.

These network of interactions mainly relies as verbal contacts and oral agreements although document exchange may also occur. Electronic information exchanges are rare, while data sharing and exchange through integration of information systems owned by distinct stakeholders are inexistent.

The third level of the RFMP Framework includes passive stakeholders (e.g. local communities, forest research centers, non-governmental organizations, forest federations, industry associations and hunting associations). These entities do not interact so frequently with the first-level stakeholders and yet they provide information and support to enhance forest management planning at the Chamusca County. For example, the forest owners’ federations and the forest research centers conduct regularly outreach activities (e.g. training courses, experimental development and demonstration of novel computerized-tools to support forest planning) to address first-level stakeholders interests and requests.

The stakeholders groups involved on the PA workshops further reported 20 other national and international entities (e.g. police department and international sectorial associations) indirectly engaged in forest management planning in Chamusca. These are repre-



**Figure 6.** Simplified version of the Regional Forest Management Planning Framework, including the main individual decision processes of the stakeholders groups engaged in forest management planning in the Chamusca county.

sented at the fourth level of the integrated context diagram.

The integrated stakeholder analysis further focused on the roles of the stakeholders within the RFMP Framework (Table 2). Results highlighted that each activity involved an average of 7.4 stakeholders. As an example, the definition of management planning constraints involved up to 10 stakeholders groups. This set included 4 first-level stakeholders groups (decision-makers), 2 second-level stakeholders groups (responsible for the setting up of constraints within national and regional planning) and 2 additional groups to be consulted about this issue (e.g. forest associations). At another extreme were the activities involving only one stakeholder group e.g. the selection of service providers that are exclusively undertaken by the forest owners.

Moreover, the results reported in the role matrix confirmed the importance of first-level stakeholders, which are directly involved in 90-95% of the RFMP

Framework problems and activities. The Chamusca municipality and the forest authority are the only stakeholders that address the RFMP Framework activities through an approval role. The forest research centre and non-governmental organizations address these problems and activities through a consultancy role while the forest association may play several roles (e.g. decision-maker, implementation and consultancy).

The stakeholder groups' replies to the questionnaire handled during the last stage of the engagement plan led to the listing of 20 tools needed to support their current and future individual decision processes within the forests management planning problems prevalent in the region (first part of Table 3). This was influential to define the RgTbx components. Only 21% of the tools listed are already in use. Specifically, the growth and yield models (Q2) and the harvest planning models (Q6) are often embedded in the information systems used by industrial owners, large-scale NIPF and forest associations. The prescription models (q1) and forest

**Table 2.** Matrix identifying the role of each stakeholder group in the regional forest management planning framework. It lists the roles using the categories: Responsible for developing the activity (R), Approves/regulates activities (A), Implements activities (E), Informed about activities (I) and Consulted/provides guidelines for activities (C). The stakeholders groups were: Non-industrial private forestland owner (NIPF), industrial owner (IPF), Forest Investment Fund (FIF), Forest Authority regional office (FAr), Forest Service Provider (FSP), Forest Association (FA), Forest-based industry (I), Municipality (M), Forest Authority national office (FAn), Forest Research Center (FRC), Forest Federation (FF), Local community (LC) and Non-Governmental Organization (NGO)

Forest management planning framework	Stakeholders groups													Total
	NIPF	IPF	FIF	FAr	FSP	FA	I	M	FAn	FRC	FF	LC	NGO	
<i>Forest management setting</i>														
A1. Defining Management Units	R	R	R	R		E			C	C				7
A2. Defining Production Objectives	R	R	R	R		C	C		C	C	C			9
A3. Defining Other Management Objectives	R	R	R	R		C			C	C	C			8
A4. Defining Management Constraints	R	R	R	R		E		A	A	C	C		C	10
A5. Defining Conservation Actions	R	R	R	R		C				C	C			7
A6. Defining Erosion prevention actions, forest diseases, forest fire prevention	R	R	R	R		E		E	A	C	C			9
A7. Defining Infrastructure maintenance	R	R	R	R		E			A	C	C			8
<i>Resources allocation</i>														
B1. Forest species selection	E/R	R	R	R		R/E		A	A	C	C			9
B2. Forest prescriptions selection	E/R	R	R	R		R/E			R	C	C			8
B3. Equipment and operations protocol selection	E/R	R	R	R	R/E	0		C		C	C			8
B4. Service providers selection	R	R	R							C				4
B5. Forest products usage and commercialization	R	R	R	R		0	C	C	C	C			C	10
<i>Forest operations implementation</i>														
C1. Timing of maintenance operations	R	R	R	R		0			I	C				6
C2. Timing of harvesting operations	R	R	R	R		0		R	I	C				7
C3. Timing of cork-stripping operations	R	R	R	R		C			I	C				7
C4. Timing of forest inventory activities	I	R	R	R		R/E			R	C				7
<i>Usage of computerized tools</i>														
D1. FM optimization	E/R	R	R	R		R/E				C				6
D2. FM tools	E/R	R	R	R		R/E				C	R			7
D3. Risks and climate change simulator	R	R	R	R		C			C	C				7
<i>Context elements</i>														
E1. Local communities interaction	R	R	R	R	C	0		I		C		R		8
E2. Forest policies and strategies def.		C				C			R/E	C	C			5
Total %	20 95%	21 100%	20 95%	19 90%	3 14%	15 71%	2 10%	7 33%	15 71%	21 100%	11 52%	1 5%	2 10%	

**Table 3.** Components of the forest management planning RgTbx. It includes the models/methods and the procedures/documents needed to support both individual processes developed by stakeholders groups and the stakeholders' network interaction. It further describes the way each stakeholder group interacts with each data and information elements classified as Create (C), Read (R), Update (U); Delete (D). (\*: GIS-based information); The stakeholders groups were: Non-industrial private forestland owner (NIPF), industrial owner (IPF), Forest Investment Fund (FIF), Forest Authority regional and national offices (FAr, FAn), Forest Service Provider (FSP), Forest Association (FA), Forest-based industry (I), Municipality (M), Forest Research Center (FRC), Forest Federation (FF), Local community (LC) and Non-Governmental Organization (NGO)

Decision Support tools	Stakeholders groups													Total
	NIPF	IPF	FIF	FAr	FSP	FA	I	M	FAn	FRC	FF	LC	NGO	
<i>Models/methods</i>														
Q1. Forest productivity zoning	x	x	x			x	x		x	x				6
Q2. Regional growth and yield models	x	x	x	x		x				x				6
Q3. Fruit production estimation model	x	x	x	x		x			x	x				7
Q4. Cork quality & quantity prediction models	x	x	x	x		x				x				6
Q5. Harvesting/stripping opt. Models	x	x	x	x		x				x				6
Q6. Impacts of fertilization into production	x	x	x	x		x				x				6
Q7. Forest market evolution models	x	x	x	x		x	x		x	x	x		x	9
Q8. Product distrib. Routing, storing,...		x	x	x		x	x			x				5
Q9. Optimal equipment allocation models		x	x	x		x	x			x				5
Q10. Risk prediction models		x	x	x						x				4
<i>Procedures/documents</i>														
q1. Forest operations and prescriptions for market goods, Prescription models/ productivity classes	x	x	x	x		x			x	x				7
q2. Forest operations and prescriptions for non-market goods and services	x	x	x	x		x			x	x				7
q3. Forest Management standard procedures	x	x	x	x	x	x			x	x	x			10
q4. Conservation prescriptions	x	x	x	x		x			x	x	x			8
q5. Participatory techniques for public forests management and ZIF management	x			x		x		x	x	x	x		x	8
<i>Other tools</i>														
t1. Training courses on planning tools	x	x	x	x	x	x	x		x	x	x			10
t2. Training and support on non-wood products and services management	x			x		x				x	x			5
t3. Collective forest equip. owning/renting	x					x	x			x	x			5
t4. Portable devices for forest surveys	x	x	x	x	x	x	x		x	x	x			10
t5. Online Forum	x	x			x	x		x	x	x	x	x	x	10
<i>Data and information elements</i>														
i1. Municipality Management Plan*	R	R	R	R		R		CRUD		R				8
i2. Protected Areas*, meteo.*, land uses*	R	R	R	R		R		R	R	R				8
i3. Hunting areas*	R	R	R	R		R			CRUD	R				7
i4. Forest Intervention Zones (ZIF)*	R	R	R	R		CRUD		R	RU	R				8
i5. Historic record of the area burned annually	R	R	R	R		R		R	CRUD	R				8
i6. Regional Forest Management Plan*	R	R	R	R		R	R		CRUD	R				8
i7. BD Regional forest inventory data*	R	CRU	CRU	CRU		CRUD			CRU	R				7

**Table 3 (cont.).** Components of the forest management planning RgTbx. It includes the models/methods and the procedures/documents needed to support both individual processes developed by stakeholders groups and the stakeholders' network interaction. It further describes the way each stakeholder group interacts with each data and information elements classified as Create (C), Read (R), Update (U); Delete (D). (\*: GIS-based information); The stakeholders groups were: Non-industrial private forestland owner (NIPF), industrial owner (IPF), Forest Investment Fund (FIF), Forest Authority regional and national offices (FAr, FAn), Forest Service Provider (FSP), Forest Association (FA), Forest-based industry (I), Municipality (M), Forest Research Center (FRC), Forest Federation (FF), Local community (LC) and Non-Governmental Organization (NGO)

Decision Support tools	Stakeholders groups													Total
	NIPF	IPF	FIF	FAr	FSP	FA	I	M	FAn	FRC	FF	LC	NGO	
i8. BD product prices	RU	R	R	R	R	CRUD	R		R	R			R	10
i9. BD forest operations costs	RU	R	RU	R	RU	CRUD			R	R			R	9
i10. General info. on forest product markets	R	R	R	RU	R	R	R		CRUD	R	CRU		R	11
i11. BD Service providers characterization	RU		RU		R	CRUD	R			R	R			7
i12. Technical forest bibliography				RU		R	R			CRUD	RU			5
i13. BD Properties and forest operations*	CRUD	CRUD	CRUD	CRUD	R	CRUD		R	RU	R	R			10
i14. BD forest investment support	R	CRUD			R	CRUD			CRUD	R	R			7
i15. Legislation analysis	R	R	R			R	R	R	CRUD	R	CRUD	R		10
i16. Forest sectorial statistics				R			R		CRUD	R		R		5
i17. BD ownership structure	R	R	R			CRUD		RU	R	R	R	R		9
i18. BD conservation interests	RU	CRUD	CRUD	CRUD		CRUD		RU	RU	R	R		R	10
i19. Watercourses and water repositories*	RU	RU	RU	RU		CRUD			R	R	R			8
i20. Forest fires prevention plans*	R	R	R	R		R		CRUD	R	R	R			9
i21. Forest roads*	R	RU	RU	RU		CRUD		R	R	R	R			9
i22. BD Administrative info.	CRUD	R	R	R	CRUD	CRUD					CRUD			7
i23. BD equipments	R	R	R	CRUD	R	CRUD	R			R	R			9
i24. BD licensing requests & Infractions	R	R	R	R		CRUD		CRUD	CRUD			R		8
i25. Wood demand estimates	R	R	R	R	R		CRUD							6

management standard procedures (q3) are also used by most first-level stakeholders.

Most stakeholders pointed out to the lack of updated data and information about forest product prices. In fact, the forest authority out-dated web information site on reference prices was considered very useful.

The forest association most pressing requirement was the availability of adequate forest productivity zoning maps and regional forest production models. According to ACHAR, this would help save forest inventory costs thus reducing the forest management plans production costs. It would further provide information needed to project forest products supply over the planning horizon.

Logistics optimization models were not directly requested by first-level stakeholders as they focus mostly on strategic forest-level planning and outsource forest operations to second-level stakeholders. Yet according to the forest research centre, the use of these models might contribute to reduce operations costs and increase revenues especially in the case of integrated

supply chain management. The forest service providers could also benefit from these models but their small-scale operation may preclude the investment in the development of these tools.

Additionally, new procedures and manuals were required by most stakeholders groups in order to address issues like biodiversity management and conservation, forest operations best-practices, procedures for product certification and management models for conservation areas. These tools should address the specificity of the management planning problems prevalent in the region. Proper training and the availability of technical bibliography were also a major requirement.

Still in the fourth stage of the engagement plan, the core information needed by individual processes and further exchanged within the regional interactions network was classified into 25 data and information elements to be address by the RgTbx (second part of Table 3). 48% of the data elements were already being used, namely by first-level stakeholders. These included mostly thematic Geographical Information System

(GIS)-files (*e.g.* the geographical limits of main land uses at the county level (i1), the protected areas, meteorology data, and forest cover type areas (i2), hunting areas (i3), forest intervention zones (i4), burned areas (i5), PROF sub-regions (i6), hydrology (i19), forest wildfire prevention plans (i20) and forest roads (i21)).

ACHAR, the forest investment fund and the industry owners also used tailored information systems to manage forest inventory data (i7), forest properties and record forest operations implementation (i13). The handling of data and information elements by stakeholders (Table 3) further highlighted the relative importance of stakeholders' groups in the RFMP Framework. As expected, the first-level stakeholders handled most data and information elements (*e.g.* ACHAR accessed 23 data and information elements, 14 of them with editing permissions). The forest research center can access —on a read-only basis— the elements related with its research interests while local communities and non-governmental organizations cannot edit any of the elements to be supported by the RgTbx.

The current data and information handling scheme by the stakeholders' network may lead to redundancy and inconsistency. In fact, each data and information element is handled by an average of 7.8 stakeholder groups; 75% of the elements may be created and updated by more than 1 group. Each stakeholder follows independent procedures for acquiring data and producing information and the outcome is not shared. For example, the same forest property boundary (i13) may be delimited by a wide range of entities for distinct purposes, *e.g.* by individual forestland owners to support forest planning, by the forest investment fund to support property acquisition negotiations and by the regional office of the forest authority for taxing purposes. This contributes to controversies over the actual boundaries and the property official area.

Another example is the forest inventory data (i7). Forest associations conduct forest inventory to support the development of PGF, while the forest research centre collect inventory data to support experimental research and demonstration projects (*e.g.* development or adjustment of growth and yield models). Additionally, the forest authority conducts a periodic national forest inventory evaluation. The inventory protocols are often different and the results are not promptly shared by stakeholders.

The data and information redundancy problem is further compounded by the way each stakeholder accesses the information managed by another. Access

privileges and procedures vary and this leads to significant differences in the quality and quantity of information used to conduct activities in the individual processes. As a consequence the outcomes of similar management planning processes may be different thus complicating in turn the comparison between distinct planning exercises.

Therefore, communication, cooperation, information sharing and exchange techniques to be added to the RbTbx will be instrumental for supporting the regional FMD interactions network. The development of these techniques was based on the way each stakeholder handles each data and information element. For example, proper system integration interfaces were suggested for importing the data and information elements produced by external entities [*e.g.* protected areas maps, meteorological data and forest cover type maps produced by the public administration (i2)]. The latter were to be accessed as “read-only” by the toolbox users. Similar integration interfaces were designed for accessing data and information elements managed by external proprietary information systems owned by users of the RgTbx.

Providing external systems with easy access to the data and information elements managed within the RgTbx was also a major concern. Therefore, this research produced initial guidelines for the development of a Service Oriented Architecture for the RgTbx. Accordingly, the information services provided by the RgTbx modular components should be the basis for all information exchanges. These services should be directly mapped to the data elements. They should rely on general transaction standards for the forestry sector (*e.g.* Papinet 2011). Their technical documentation should be easily accessible by the developers of other external systems.

It further produced security policies to ensure that each stakeholder has full control over the access to his information, thus preserving data confidentiality. Specific access control modules were suggested to parameterize the access permissions of all other users after a new data input by a stakeholder. Stakeholders may only access instances of information when both its owners provide explicit access permission and the information element itself is relevant to his individual decision processes. This security architecture was key to sustain the confidence of stakeholders on the toolbox and thus to contribute to its use to support their planning processes namely the implementation and the record of the management outcomes.

Furthermore, special attention was given to the data and information elements editable by more than one stakeholder group. As an example, both ACHAR and the forest service providers needed to Create, Update, Delete new equipment or equipment characteristics (i23). The future data and information governance models should include the identification of a unique stakeholder group responsible for each data element, thus contributing to information consistency.

It further identified the potential users of each data element according to the integrated stakeholder analysis. In the case of data and information elements managed by more than one stakeholder group, automatic workflow procedures were recommended to ensure both that the data instance could not be simultaneously changed by different stakeholders and that any input or update is validated by all the stakeholders involved before it became effective. For example, when the boundaries of a forest property are being updated, the system should trigger a procedure to prevent other stakeholders from editing these boundaries. Afterwards, the proposed boundaries update should be accepted by other relevant stakeholders so that, for example, it does not conflict with other existing boundaries.

Lastly, data consolidation mechanisms were suggested to enhance cooperation among stakeholders. As an example, the information about forest intervention zones (i4) kept by ACHAR could be aggregated into macro indicators (such as total forest area covered by ZIFs). This will help support forest strategy and regulation processes conducted by the national forest authority with the participation of the forest federations.

## Discussion

The proposed approach for developing a regional forest management planning toolbox (RgTbx) addressed the need to acknowledge both the forest management decision processes by individual stakeholders and the complex regional interactions network. The RgTbx resulting from the application of this approach may enhance the development of individual decision processes by providing access to innovative decision support tools (e.g. models, methods and procedures). It may further support the stakeholders' regional interaction network with adequate communication, cooperation, negotiation and information sharing

procedures and techniques. It will thus be influential for improving forest management planning at regional level.

The engagement of stakeholders in the design of the RgTbx was a major concern of this research. Therefore, participatory planning techniques were applied, particularly during the process architecture workshops, according to the enterprise architecture methodological approach. This approach has been used in Portugal for designing individual decision support systems, especially for forest-based industries (e.g. Marques *et al.*, 2010a,b) as well as for addressing interoperability between systems used to support the pulp and paper supply chain (Marques *et al.*, 2010b; Marques *et al.*, 2012). Yet, this research extended the EA methodology to the architecture of a regional toolbox to be used in a multiple stakeholders' context. The research challenges here the development of an approach to both ensure the representativeness of the stakeholders involved in the process and consolidate the results of the individual process workshops in an integrated stakeholders' analysis.

Thus, the proposed four-stage stakeholders' engagement plan encompassed stakeholders' selection, workshops involving the stakeholders groups for individual decision processes design, integrated stakeholders analysis, and the identification of the RgTbx components. Special attention was given to the stakeholders' selection stage in order to ensure representativeness and transparency. This stage is often a bottleneck to the development of the participatory planning processes. In order to overcome it, the project team must identify the relevant players and promote their active involvement in the workshops. The cooperation with a key regional stakeholder (ACHAR) was instrumental for the success of the engagement plan by this research. ACHAR promoted the project locally, made the contacts with the other relevant stakeholders and provided support to the research team moderator during the workshops. The forest owners association was also the main promoter of the project outcomes and may contribute decisively to the implementation of the RgTbx.

The 13 stakeholders groups and the 22 entities directly involved proved to be representative of the regional forest planning context. They included the industrial owners, the private forestland owners, their association and federations, the national and regional offices of the forest authority, the forest investment fund, the Chamusca municipality, the forest services providers, the non-governmental environmental orga-

nizations and a research centre. The lack of involvement of the small-scale NIPF group was carefully considered as it could pose as a limitation to the representativeness of the results. Yet, recent studies on the behavior of forest owners in Portugal (*e.g.* Batista and Santos, 2005; Novais and Canadas, 2010) provided the adequate rationale for their individual decision processes. The project team representations were validated afterwards with the forest association and the local communities. Nevertheless, the research dissemination results could be enhanced by the active involvement of these forest owners.

The PA workshops were instrumental for documenting the stakeholders' current decision processes as well as for identifying their concerns and expectations. They further provided the opportunity to discuss with the forestland owners the rationale of traditional and out-dated management practices and emphasize the advantages of the adoption of new processes and new computerized-tools to support them.

The outcome of such interactive meetings was highly dependent on the moderator ability to clearly define the meeting objectives, establish a solid trust relationship and frame their participation in the workshop. The experience with Chamusca county proved that these PA workshops should start with a brief project presentation, emphasizing its objectives and the expected outcomes (specifying what is and what it is not expected) to avoid misleading the participants and raising false expectations. This presentation should further provide a clear description of the method to be used during the sessions, including a reference to the terminology as well as to the graphical representations to be obtained. These representations were built by the moderator on a paper board according to the answers of the stakeholders to the research questions. They were complemented by notes taken by the remaining members of the project team. Alternatively, classical interview methods were used whenever there was evidence of lack of abstraction capacity by stakeholders. Yet these approaches did not encourage such an active involvement of the participants.

The results of all the sessions were documented on a modeling tool (MS VISIO). The tool was not used during the workshops since it could interfere negatively with the meeting dynamics. This tool was also used to automate the generation of reports to be delivered afterwards to the participants for content validation. The workshop with each stakeholder group encompassed at least two sessions. The first focused on the context

diagram while the second addressed the individual decision processes, based on a draft proposed by the team after the first session. In some cases, additional sessions were conducted for validating the reports since most stakeholders did not reply when non-face-to-face methods were tried.

The individual and the integrated context diagrams provided a good representation of the complexity of the regional interaction network. The analysis of these diagrams further raised issues that can be properly addressed by forthcoming projects. The first issue was related to the quantity, quality and the format of the RgTbx information to be accessed by the first-level stakeholders. The content of current information flows should be screened during the development of the RgTbx data model to avoid superfluousness and low quality.

The second issue was the reported scarce use of computerized-tools by some stakeholders groups. Lack of training, small business size and specific business requirements not easily met by commercial systems were among the explanations provided. Yet other factors may be behind the potential resistance to computerized-tools utilization, such as ineffective dissemination or inadequate forest extension services. The acknowledgement of these factors may be instrumental for promoting the use of the RgTbx. The ongoing projects involving industrial owners, forest owners associations, National Forest Authority and the forest research centre aiming at the development of forest management decision support systems may suggest potential collaborative approaches. Furthermore, the list of required computerized-tools highlights future research opportunities.

The third issue was the lack of cooperation practices within the interaction network between stakeholders belonging to each group as well as between stakeholders at the same level in the context diagram. The implementation of the RgTbx should involve periodic meetings and discussion forums to enhance communication and cooperation between stakeholders.

An additional concern to be addressed by the RgTbx implementation is the need to reflect on the toolbox the changes of stakeholders roles that result from ongoing initiatives for reorganizing the forestry sector. The integrated stakeholder analysis highlighted the prominent role of forestland owners in forest management planning in the region. However, this scenario is likely to evolve. The importance of other stakeholders groups is prone to increase in order to address emer-

gent regional and forest wide concerns (*e.g.* with wildfires). In this context, in the future forest associations may play a more active role in forest management planning as they will become directly responsible for managing the newly created intervention forest zones. The latter may also lead to a more active role in the development of commercialization strategies and circuits. Recently, local communities and NGO have acquired technical skills to participate and lead forest certification schemas. This may contribute to increase their influence on management planning decisions as well as on national and regional forest regulations.

The use of the RgTbx will trigger significant changes to the Chamusca forest planning context. The use of the toolbox components will enhance the decision processes by individual stakeholders. The optimization methods for evaluating alternative options and for comparing the practices with other innovative solutions will contribute to increase the efficiency and the effectiveness of forest management planning. These models will address other non-wood productions and forest services as well as the economic and social sustainability of the regional forestry sector. Additionally, the toolbox will facilitate the communication, cooperation and information sharing between the stakeholders, through the adoption of adequate system integration and exchange mechanisms.

Nonetheless, the toolbox will foresee data access control features to be used by the data owners to regulate the utilization of their information by others, thus overcoming the potential negative effects related with the release of key business information considered strategic and confidential.

This research also underlined the need for rules governing the procedures and tools to support the network. Specifically, it suggested the development of an adequate organizational structure that could promote the discussion about data governance models with the stakeholders. This new entity would be directly responsible for maintaining and updating the RgTbx and for providing training and support to the users. Its governance board should include representatives of the stakeholders groups and the decision process within this board should reflect the relative contribution of each stakeholder. Namely it should reflect the amount and relevance of data and information elements kept by the stakeholder but accessible by other users. This aspect is of particular relevance since the RgTbx implementation should include a schema for financing the production of certain information elements.

## Conclusions

In this article, a regional toolbox was designed to address both the individual decision processes and the complex interactions networks between stakeholders involved in forest management planning in a region. To the best of our knowledge, such a regional toolbox has not been suggested in the forestry literature.

The stakeholders were actively involved in the toolbox design. The proposed stakeholders engagement plan extended the enterprise architecture methodological approach of Marques *et al.* (2010a,b) to apply participatory planning tools and techniques during interactive workshops to elicit decision processes within forest management planning problems prevalent in a region.

The identification of the RgTbx components was built upon these processes representations. Specifically, it included a set of decision support tools (*e.g.* models, methods and procedures) already used or else that were required to address the stakeholders' individual decision processes. It further included a list of data and information elements needed to support decision-making. The RgTbx further included communication, cooperation, information sharing and exchange techniques aiming at supporting the regional interactions network.

The proposed stakeholders engagement plan for designing the regional toolbox was tested in the Chamusca county, located in Central Portugal. The set of stakeholders included 22 entities, divided among 13 stakeholders groups, representing more than 900 people with direct interests in the region. The results show that the proposed methodology may be used to provide representations of the individual decision processes. The representation of the information elements exchanged and shared among stakeholders did provide a clear vision on the complex regional interactions networks. Complementary, the integrated stakeholders analysis highlighted the key role of the forest owners, forest investment funds and regional offices of the forest authority in the forest management planning framework in the region.

Interactions and data exchange among these stakeholders were rare. Yet, all first level stakeholders were influenced by the other stakeholders groups (*e.g.* the forest service providers, forest associations, forest based-industries, Chamusca municipality and the national office of the forest authority), acting mainly as consultants or regulators. More than 20 other passive

stakeholders groups were indirectly engaged in forest management planning in Chamusca, including forest research centers, local communities, sectorial associations and NGO.

These results were instrumental for identifying 20 decision support tools and 25 data and information elements to be included on the RgTbx. 21% of these tools and 48% of the data elements were already used by the stakeholders.

The potential problem of data redundancy and inconsistency was characterized. This was influential for the suggestion of the communication, cooperation, information sharing and exchange techniques to be added to the RgTbx. These techniques included system integration interfaces and Service Oriented Architecture features to regulate communication between the RgTbx and other external systems. Both data governance models and access policies were further suggested for managing the data and information elements within the RgTbx in order to avoid redundancy, inconsistency and preserving data confidentiality. Additionally, data consolidation mechanisms were suggested to enhance cooperation among stakeholders.

Future research will divide the RgTbx into functional sub-systems and provide their detailed functional specifications. It will follow the enterprise architecture approach where these specifications emerge from the confrontation between the presented Process Architecture and the subsequent Information Architecture, therefore assuring the alignment between the decision processes and the IT function.

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